



SCENE DESIGN AND **STAGE LIGHTING**

TENTH EDITION

R. CRAIG WOLF • DICK BLOCK

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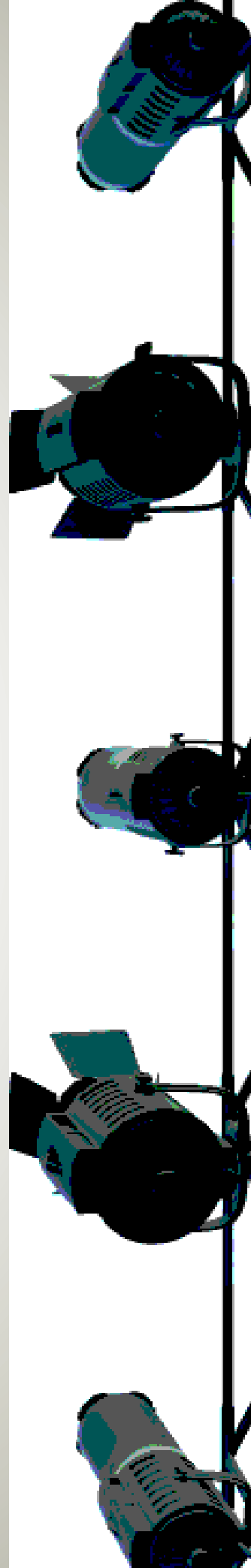
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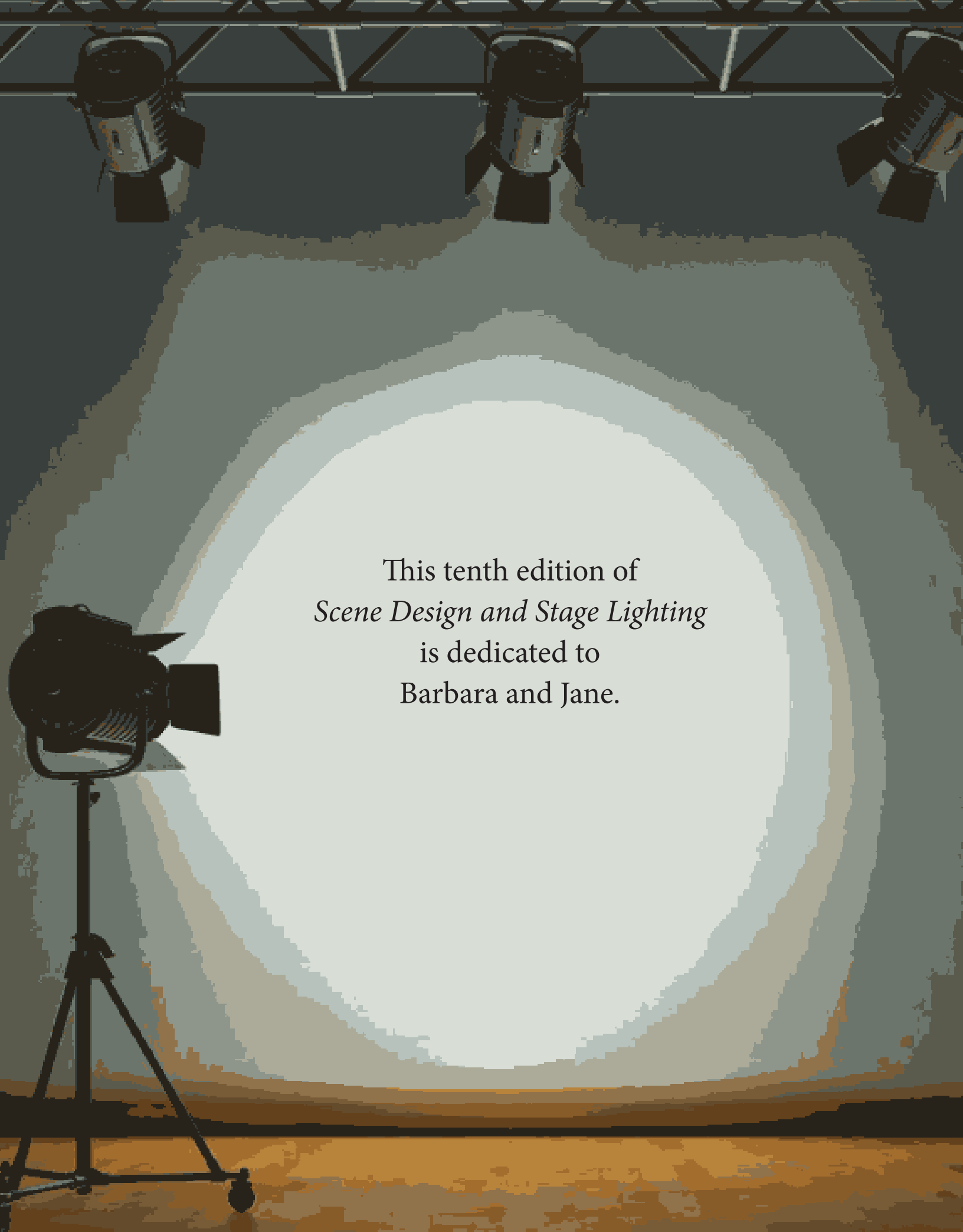
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This tenth edition of
Scene Design and Stage Lighting
is dedicated to
Barbara and Jane.



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About the Authors

R. Craig Wolf is a professional lighting designer as well as an educator. Mr. Wolf's designs have been seen nationwide, including productions for San Diego's Old Globe Theatre, San Diego Repertory Theatre, Dance Theatre Workshop in New York, Virginia Shakespeare, Richmond Ballet Company, Theatre Artaud in San Francisco, and Japan America Center and Odyssey Theatre Ensemble of Los Angeles. He is currently resident lighting designer for Native Voices at the Autry in Los Angeles and recently designed for Cygnet Theatre in San Diego. Craig has served two terms on the board of directors of the United States Institute for Theatre Technology (USITT), was vice-chair of their publications committee and lighting commissioner for five years. In 2011 he was awarded "Distinguished Educator of the Year" by USITT's Education Commission. He became a lighting associate member of the United Scenic Artists Design Union in 1977. Mr. Wolf has taught at the University of Michigan and University of Virginia and is currently professor of design, MFA graduate adviser, and head of the design program in the School of Theatre, Television, and Film at San Diego State University.

Dick Block has worked as a freelance scene designer and a scenic artist for more than 25 years. He has designed for AMAS, Columbia Artists, and TheatreWorks USA, all in New York, and for the Virginia Stage Company, the Shakespeare Theatre of New Jersey, the Weston Playhouse (Vermont), and the Human Race (Ohio). Additional regional credits include work at the McCarter Theatre in Princeton, the American Repertory Theatre in Cambridge, Center Stage in Baltimore, Opera Theatre of St. Louis, as well as the Pittsburgh Playhouse and the Pittsburgh Public Theatre. Mr. Block is also active with the United States Institute for Theatre Technology (USITT), having served as scene design co-commissioner and on the board of directors, and with the Kennedy Center/American College Theatre Festival both regionally and nationally, having served as the first national design chair. He is the recipient of the Kennedy Center Medallion for Distinguished Service. Mr. Block received his MFA from Northwestern University. After teaching at the University of Michigan and Cornell, he began teaching at Carnegie Mellon University in the School of Drama and is currently the Associate Head.



Preface

It has only been five years since the ninth edition of this book, and we are amazed at how much the theatre world has changed in so short a time! Sections of *Scene Design and Stage Lighting* that we might have thought warranted little updating turned out to be those most in need. Technological advances have brought about new methods of producing theatre, potential venues for employment are rapidly developing, and the concern for environmentally-friendly production continues to grow. While addressing these and other issues in this tenth edition, we continue our emphasis on the collaborative nature of theatre. Throughout the text, the marginal glossary has been expanded to reflect new terminology from developing technologies. Illustrations and photographs have been updated, design processes have been examined with a new eye, and we have added two new chapters: Projection in the Theatre (Chapter 12) and Automation in the Theatre (Chapter 13). However, we are most excited about the fact that this tenth edition is our first full-color text.

The value of full color should be apparent: Our readers will be able to see the influence of one of the most important design elements in the photographs and illustrations. One of our favorite responses from a colleague to the announcement of a full-color edition was “Well what do you know, a design text in color!” We are confident that instructors using this new text will find that their students learn design concepts quicker and better, more fully understand photographs and illustrations, and more readily discover the huge impact that color has in the world of design.

We felt that the addition of the two new chapters was critical. Automation of both scenery and lighting is a relatively new and vastly important element in production, and projection has grown into its own design form, analogous to scenery, lighting, costume, and sound. Because these two elements have a huge impact on both scenery and lighting, we have placed these new chapters in the center of the book (Chapters 12 and 13).

There are a number of updates in the scenic design chapters. Chapter 3 on the composition of design now includes images in the abstract as well as specific design examples. Chapter 4 on the design process includes almost all new images and a stronger emphasis on script analysis, including examples. While the description of the basic design process remains the same, we include information about other methodologies that are now common. As well, we have added a section in Chapter 4 on the process of looking for a job as a new designer. The chapter on drafting (Chapter 6) has seen some changes as well—nearly all of the drafting examples are new. More importantly, there is no longer any differentiation between hand and computer drafting; rather, the emphasis is on communication of the material, whatever method is used.

The addition of full color in the lighting chapters has made a world of difference. The examples in Chapter 16 (Color and Light), are much clearer and more informative. The chapter on lighting fixtures (Chapter 17) has been greatly altered to include the newest LED technologies, including color mixing. Our lighting design chapters (Chapters 19 and 20) pay more attention to the use of automated fixtures and LED sources. Chapter 21 (Power Distribution and Control) considers a theatre that is much less dependent on dimmers and more concerned with power and control distribution. Of course, Chapter 23 on light sources has changed dramatically to include LED and

other new sources. Finally, in Chapter 25 we have added a new “Designers at Work” interview with concert designer Marc Janowitz, along with many examples of his work.

Students can find additional materials on the book’s companion website, which can be accessed at **www.CengageBrain.com**. These useful resources include chapter-specific quizzes, a glossary, flash cards, relevant Web links, and larger versions of several images from the text (allowing closer study).

As with any text of this magnitude, we have relied on experts in many fields to guide us, all of whom have contributed in substantial ways to this edition. This collaboration has been particularly significant because technology has changed so rapidly.

Any number of scenic designers were extremely gracious and generous in providing many images of their work. In particular, Linda Buchanan, Steve Gilliam, Ron Keller, Pam Knauert Lavarney, Lynne Koscielniak, Charles Murdock Lucas, Anne Mundell, Scott C. Neale, Kevin Rigdon, and Todd Rosenthal gave us far more images than we could possibly use, making it difficult to choose. Wendall Harrington and Peter Nigrini were incredibly generous in discussing their work and theories of projection design, as was Rachel Keebler of Cobalt Studios in helping with the scenic painting chapter.

The “Working Professionals” interviewees provide insight into how theatre-makers and television and film designers operate, and we thank them: Scott Bradley, Robert Elliott, Chris Kennedy, John Shaffner, Joe Stewart, and Thomas Walsh.

The scenery section of the chapter on automation could not have been written without the help of David Boevers and Kevin Hines, who was also instrumental in updating the chapters on the construction and moving of scenery. Likewise, thanks go to Jon Ward on props, Ben Carter on tools and especially metal-working, and Beth Zamborsky, who painted the series of samples that we use in the scene-painting chapter.

As always, thanks also go to our lighting “Designers at Work” interviewees: Donald Holder, Mark Janowitz, York Kennedy, Lynda Montgomery, Robert Shook, and Dennis Size. In addition, we have been very fortunate to be able to include the work of Ann Archbold, Ken Billington, Michelle Caron, Ralph Funicello, Cindy Limauro, Chris Parry, David Segal, and Mary Tarantino as well as many other designers. Thanks go to Mike Wood for his informative and insightful information on LED sources.

Peter Nordyke was instrumental in advising on the sound chapters of this and several past editions. For this edition, he additionally reworked illustrations, updating and coloring them for clarity. Finally, this edition would not have been possible without the tireless and splendid work of our associate in lighting, Michelle Caron. She handled the complex task of securing images and illustrations, as well as the often frustrating job of obtaining permissions.

The following instructors generously reviewed the ninth edition of the text and made suggestions for this edition: Professor Joan Arhelger, San Francisco State University; Jeromy Hopgood, Assistant Professor of Entertainment Design & Technology, Eastern Michigan University; and Michael Ramsaur, Stanford University.

Many thanks of course to the expert professionals who worked on the production of this edition, but especially to our terrific editor, Ed Dodd, as well as Kate Mannix and Matt Rosenquist at Graphic World Inc., and Michael Lepera and Michael Rosenberg at Cengage Learning.

And, most of all, we acknowledge with great love and thanks the incredible support of our partners, Barbara and Jane, who helped make this edition a reality.

R. Craig Wolf
San Diego, California

Dick Block
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Introduction

Design in the theatre may branch into various areas of specialization, including **scenery, costumes, lighting, sound, and projection.**

The paths leading to a career in theatre design are numerous and varied. They may come from within the theatre itself or from elsewhere. Many a would-be actor has discovered more excitement in design; directors with a strong visual sense have sometimes become designers. Architects, fine artists, and other trained visual artists equipped with the practical ability to draw and paint and possessing a strong desire to be in the theatre have forged careers as designers.

A student standing at the threshold of training for a career in design for the theatre may wonder what the future holds. Never before has theatre training made more sense; today, people with a solid grasp of theatrical design are being hired and are working in myriad related industries. The discipline, dedication, organization, and sense of collaboration that theatre requires are qualities that easily transfer to any number of fields. The sudden but transitory flush of excitement involving one's first experiences in the theatre should not, however, obscure the need for a long-range artistic commitment to hard work. Anyone interested in achieving creative and personal fulfillment as a scene, costume, lighting, sound, or projection designer must first thoroughly understand the complexity of theatre as an art form.

Theatre is ever evolving, even in definition. During the 20th century it faced significant changes in its literary, physical, and theatrical form; these reflect evolution in the views of society as well as advances in technology. A wide range of influences has affected theatre. Multiculturalism and globalization have enabled us to understand and appreciate the lives of those with different backgrounds. The attempt to be inclusive has allowed the audience to be more directly involved physically and emotionally and us to consider wholly new theatre forms. Other expectations have also changed, so a much wider array of venues is now acceptable for performance spaces.

Television and film are one obvious influence, as more and more playscripts are written as a series of short scenes in numerous locales and more "live theatre"-trained students are pursuing careers in this arena. Computer and digital technology have made the most profound impact. This technology has allowed for increased control of complex physical movement of scenery and light, and revolutionized the way sound is manipulated. In many cases, it has changed the way that designers conceptualize, develop, and present their work. In addition, newer forms of storytelling, such as webcasts, podcasts, and YouTube, have increasingly become part of our daily lives. Consider how these have affected designers and their function in the theatre; *theatre* design has really become, more broadly, *entertainment* design.

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This book deals mostly with training in “live theatre.” Although other methods of storytelling are addressed, solid understanding of live theatre will provide the basis for a designer to move into other venues.

Theatrical Form

Theatrical form in its simplest description is the communication of ideas between two groups: performers and audience. These ideas may range from the ancient to the most topical, from the profound to the absurd, and be either sentimentally obvious or intellectually obscure.

Good theatre, whatever the form, is about telling a story. In live theatre, the personality of the actors, the physical form of the space, and the dynamic of the audience itself all affect its success. The challenge is to tell the story in an exciting, intriguing, and provocative way.

All types of theatrical forms affect the work of the designer. The most obvious are the literary form, or drama, in which the spoken word is emphasized; the musical form, including opera, book musicals, and revues, in which music tells part of the story; and ballet and modern dance, in which sight and sound, rather than the spoken word, matter most. There are many other possible outlets for design that should not be overlooked, including film and television, trade shows or “industrials” (promoting a product or company), themed entertainment (rock concerts, videos, restaurants, and theme parks), museum and display design, and performance art. Additional forms are constantly evolving.

Of these forms, the literary form has historically so dominated theatre that the word *drama* has nearly become synonymous with *theatre*. A major portion of a designer’s training for the theatre is spent learning to interpret the ideas of the playwright and finding a method to express that interpretation visually, physically or aurally. This can’t be overemphasized because it is the basis for all design in the theatre—finding a way to tell the playwright’s story.

Theatre artists have led the way as audiences have gotten more sophisticated. The search for meaning in a play, musical, or opera is all-important. We expect the design to reflect that search in a way that enhances the experience for the audience. At the same time, people attend commercial theatre—a theatre in which the primary objective is to make a profit, for example, Broadway—today for *spectacle*, or theatre that impresses by the use of sophisticated technology, such as *Spider-Man: Turn Off the Dark*. The digital age has made this much easier, allowing for more complex media, rapid changes of scenery and lighting, and far more control of stage movement. There is nothing intrinsically wrong with theatre being sheer entertainment, but audiences attend theatre for a variety of reasons: as a social event, for entertainment, or as an intellectual challenge. For a theatre-maker, any reason to attend theatre is valid.

The Total Dramatic Effect



DESIGN BASICS

The Five Elements of Theatre Design

- Scenery
- Sound
- Costumes
- Projection
- Lighting

The creation of an environment in which the action of the play happens is very exciting. By responding to the text, the designers and the director provide a physical, visual, and aural world for the play. The written words of the playwright are transformed for the audience through the collaboration of these many minds.

Theatre design is concerned with the total visual and aural effect of a dramatic production. This overall effect is the sum of all the elements that provide an audience with clues about the play’s meaning and purpose and the world in which its action takes place.

All the elements must support the spoken “word” (however presented) of the dramatic form. Careful consideration of all five design areas is critical as it takes the combination to be successful. Everything onstage, whether large or small, obvious or subtle, tangible or intangible, should embody the world of the play that one is trying to create for the audience. This is true whether the visual requirements of a script are as simple as those of Thornton Wilder’s *Our Town* or as complicated as those of Jerome Kern’s *Showboat*.

Qualities of Designers

Beginning designers are expected to know so many things at once that they may wonder where to begin. They soon find that anyone who aspires to be a designer needs the vision and imagination of the creative artist and the ingenuity and skills of the stage artisan, as well as the knowledge and sense of theatre of the actor, director, and playwright. Above all, a designer’s success depends upon the ability to work effectively in collaboration with his or her peers. This is true no matter whether they choose to design lighting, sound, costumes, projections, or scenery.

To function as creative artists in the theatre, designers must display talent in their use of line, color, and form. To successfully bring meaning and significance to a stage picture, they must possess a visual vocabulary developed through study of art, history, and literature. In addition, designers must be keenly aware of the world around them. Imaginative and creative qualities are enhanced by training in the nonverbal techniques of design, drawing, and painting. As stage artisans, designers must be able, through the use of unique materials and theatrical techniques, to bring substance to their ideas with skill and dispatch and within the structural limitations of their medium. To create a design that can be wholly realized, the scenic designer must know the structure of scenery, the limitations of resources, and the methods of shifting scenic pieces. Likewise, the lighting designer must have a working knowledge of available equipment and the latest technologies. The same is true for costume, projection, and sound designers, although the specifics are different. In all cases, designers must have at least a basic understanding and appreciation of the other areas of design.

The study of dramatic structure and perception of the playwright’s intent allows the designer to bring an appropriate visual interpretation onto the stage. Understanding the ideas of the play and remaining true to the intent of the playwright while allowing an artistic vision to develop is a difficult but vital part of the designer’s job. A successful visual interpretation requires an understanding of all the physical and textual elements, the actor’s needs, and a sense of space and movement.

Design Collaboration

Most productions involve a scene designer, a costume designer, a lighting designer, and a sound designer; some require a projection designer. Working in collaboration with the director, they form an artistic team to create the world of the play.

In fact, none of the designers can, with integrity, design without concern for the work of their colleagues. Attention should be paid to consistency in style of all the design elements. The design should function in a way that accommodates the practical needs of the production. Each designer must acknowledge the needs of the other design areas in order to accomplish these common goals. For these reasons, involvement of all designers in the initial stages of conceptualization is highly desirable. Constant communication among the designers and with the director is critical throughout the production process.

Each designer has unique responsibilities. Although the final action and staging of the actors is the prerogative of the director, the arrangement of the scenic pieces has a direct bearing on everything that happens in that space. Part of the scene designer’s job is

to assist the director in creating theatrical pictures by arranging the actors within the setting in a manner appropriate to the telling of the story. A successful floor plan indicates a logical physical arrangement of actors onstage.

Light brings atmosphere and focus to a production as well as a flexible means of modifying color and modeling scenic forms. The lighting reveals or hides what is necessary—sometimes subtly, sometimes blatantly. It is innately theatrical. A good lighting designer illuminates the actors and the set in such a way that members of the audience sense the mood and the tone of the moment, often without being aware of how they are being manipulated. The scene designer must be aware of the design potential of light in the theatre and provide the lighting designer ample opportunity to achieve that potential.

The color, line, and period style of the costumes must be appropriate to the intent of the playwright and complement the other design work. Costumes help define the individual characters, placing them in proper relationship to the world of the play.

Sound in theatrical production is a powerful means of establishing locale and reinforcing the action of a play. Like lighting, it can establish mood in a way unnoticed by the audience.

Projections, when they are used, encompass the use of visuals created by film or digital means, which enhance the production in the same manner as the other design elements. It can be used to set locale, establish mood, comment on the action, or even as a light source itself.


Each of the designers must work to bring all their contributions together to form one whole. If the design team has successfully created the world of the play in a given production, they have done their jobs well. This can happen only through a series of discussions in which each member of the artistic team brings ideas to the table. It is the melding of these ideas and their development that allows theatre to happen. One of the most exciting times for the designer is that point at which the director or fellow designer has taken an idea and developed it in a different direction than was initially conceived. This exploration of the ideas of the play through visual means is what makes theatre immediate, unique, and alive for the designers as well as for the audience. The more fully developed the ideas of the artistic team, the more fulfilling the production will be for the audience.



PART I | CREATING THE DESIGN

- 2 | Scene Design and the Theatre Space
- 3 | Scene Design as a Visual Art
- 4 | The Design Process
- 5 | Color in the Design
- 6 | Drafting the Design

- 7 | The Scene Shop, Tools, and Equipment
- 8 | Building the Scenery
- 9 | Painting Scenery
- 10 | Handling Scenery
- 11 | Stage Properties and the Designer



“ I have often found that the set is the geometry of the eventual play, so that a wrong set makes many scenes impossible to play, and even destroys many possibilities for the actors. The best designer evolves step by step with the director, going back, changing, scrapping, as a conception of the whole gradually takes form. . . .

This is the essence of theatrical thinking: a true designer will think of his designs as being all the time in motion, in action, in relation to what the actor brings to a scene as it unfolds. ”

Peter Brook

The Empty Space



2 Scene Design and the Theatre Space

Many things influence the form of a final design for the theatre. The text itself (the raw material) and the conceptual work done by the artistic team (the interpretation of the text) are equally necessary and form the basis for the design. As part of the overall dramatic form of theatre, however, design does not stand alone. It is part of an event only if it includes and involves the audience as well. A scene designer may draw sketches or make models, but designs do not reach a full state of expression until they are onstage and inhabited by actors in front of an audience. As a result, the scene designer is concerned with not only the manner in which the design is presented to the artistic team but also how it will be used in production and the physical space in which it will be presented.

The Theatrical Medium

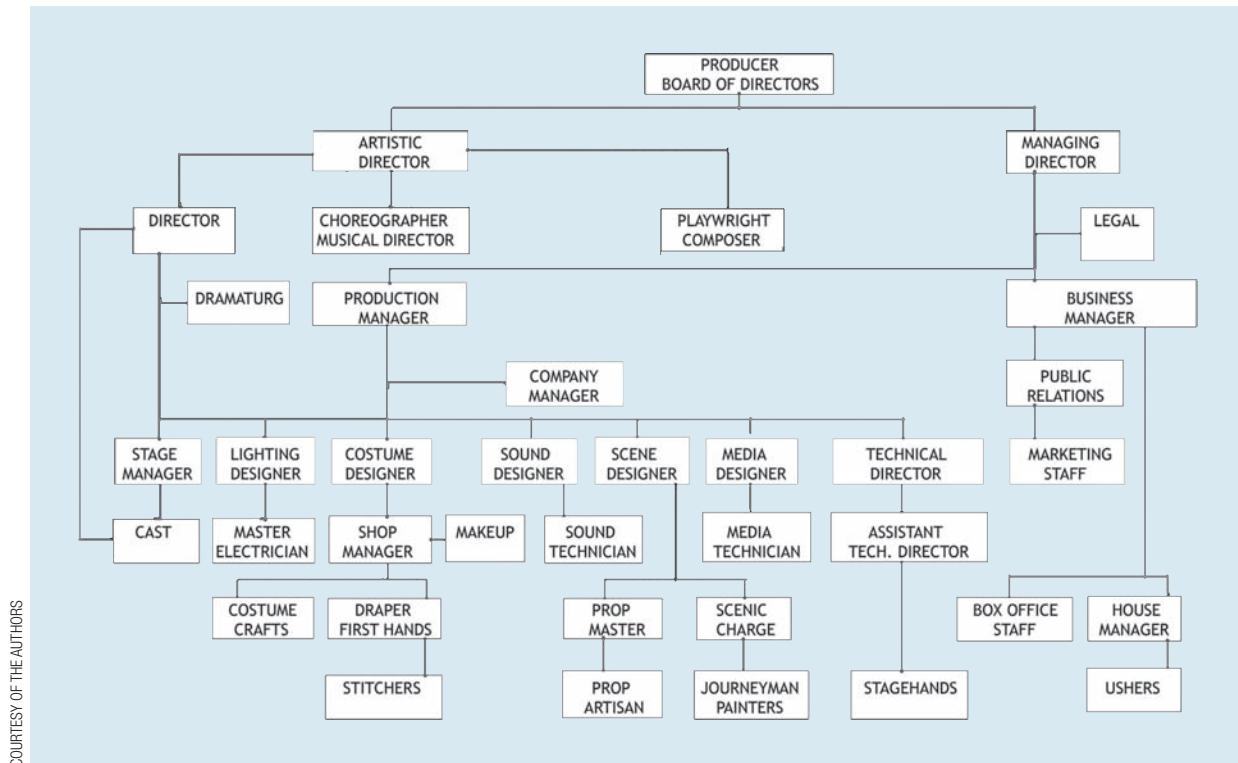
Because audiences respond to their physical surroundings, an intelligent designer will regard the theatre itself as a medium of expression. Therefore, variation in terms of the physical space available determines in part the manner in which design work is done. The physical space also affects the different ways theatre functions: as a complex organized business, a form of entertainment, and a technological machine. Each of these functions presents opportunities as well as limitations to designers.

Theatre as an Organization

The preparation of any production requires the close cooperation and collaboration of many specialists. The theatrical medium brings together the writer, actors, directors, designers, and audience. Regardless of the level of theatre, certain elements are critical to ensure the success of a play. The producing organization must always be efficient in (1) selecting a play; (2) casting and rehearsing the actors; (3) designing the scenery, lighting, costumes, sound, and projection (if needed); (4) producing the physical production (that is, building and painting the sets, designing the costumes, lighting the production, and creating the sound and projection); and (5) promoting the play to an audience. Professional theatres, as well as some college, university, and community theatres, must also consider procuring financial backing, establishing the budget, and selecting a theatre; a hierarchy of positions allows this to happen (See Figure 2-1). Lack of cooperation or understanding from personnel, complicated by faulty planning, can weaken the production as a whole.

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2-1 A Producing Theatre's Organizational Chart This is typical; specifics concerning personnel and hierarchy vary by the particular needs and types of productions of individual theatres.

To function well, any organization must have a guiding force or chief interpretive artist. This could be the director, producer, department chair, or another leader, depending on the given situation. It is the director's overall approach, however, that most often brings a unifying control to the production, including the visual elements, acting style, and literary interpretation. The designers' contributions to the production are the visual statements. As each designer functions as a part of the organization and its collaborative effort, this may mean subordinating personal glory to the good of the whole. When the goal of the production is placed above individual gain, great moments of theatre are more likely.

In addition to being aware of their general relationship to the overall production plans, designers need to know the specifics of their own area of the theatre, such as how the physical space backstage is set up, the standard theatre equipment that is available, and any limitations in terms of time and use of the space. A thorough knowledge of backstage and scene shop organization leads to a more efficient production as well as a more faithful reproduction of design ideas. The scenic designer collaborates directly with the artisans in the various shops, particularly the technical director, the scenic painter, and the props person. Just as important, the designers must be able to work with all the other areas of the theatre organization, including the production manager, the actors, the public relations staff, and the box office. Because of their specialized nature, the personnel and organization of design and technical production are discussed in Chapter 10.

Theatre as Entertainment

The designer's awareness of theatre as entertainment emphasizes the temporal quality of scenery, the dramatic qualities of the visual elements, and above all the sense of joining with an audience to give a performance. Because theatre is of the moment, there is a unique relationship with the audience that other art forms do not provide. A theatrical

performance without an audience is no more than a rehearsal. The audience and its participation are vital parts of the theatrical moment. Consequently, the theatre's almost total dependence on an audience gives it a quality of immediacy that becomes an intrinsic part of the medium.

This quality brings about a specific attitude toward scene design and the structure of scenery; although scenery may look solid for the most part, it must be lightweight and portable to move easily from scene to scene or from audience to audience. The specifics will, of course, vary depending on a number of factors, including the length of the production's run. Scenery built to tour, for example, must be stronger and last much longer than scenery built for a production that will have only ten performances. But ultimately, when the production reaches its last curtain, the usefulness of the scenery ends. It is doomed to storage, (hopefully) recycling, or destruction.

Theatrical success depends on teamwork. Any sense of achievement lies in the reaction of the audience to a good performance, "performance" in the broad sense of all personnel involved. Most audiences respond to the overall experience rather than to any individual element.

The designer achieves the dramatic quality of scenery mainly through the creative manipulation of the visual art forms, initially, in the use of proportion and scale. Because theatre more than other art forms is an overstatement, a realistic play is drawn to be a little sharper and greater than life. Even a relatively small idea, stated theatrically, can affect an audience. The way in which the visual elements are used depends partly on the theatre's size and the distance of the audience from the performers, which in turn influences the scale of the scenery. In a large theatre, with the audience at a great distance from the performers, the scenery has to take on an increased scale just to be in proportion to the size of the auditorium and the stage. The size of a theatre for most musical productions tends to be rather large, in part to accommodate a larger cast, an orchestra, and often more scenery. A two-hander (a play with only two characters) would get lost in a large space, denying the audience any connection to the characters; a smaller, more intimate venue providing closer proximity makes more sense. Whatever the physical circumstances, it is the responsibility of the theatrical medium to touch the emotions of the audience in electrifying ways.

Theatre as a Machine

Although other people control the technological aspects of the theatre, the designer should be aware of the backstage operations. Scenery-moving techniques, whether occurring onstage and in full view or hidden from the audience, should guarantee the smooth run of the production. The effortless movement of scenery is part of its theatrical magic, which can be justified as a part of the action of the play or moved in view of the audience as an accepted feature of theatrical form.

Typical scenery-moving machines include rigging systems, which allow scenery to fly; tracked wagons for lateral or diagonal movement; a turntable or revolving stage; and elevators and sliding pallets, all of which might be built into the stage. All these systems might have an influence on the production scheme.

The Physical Stage and Its Auditorium

The most important step for beginning designers in learning their new medium is to become acquainted with the physical stage. Knowledge of the actual shape and physical makeup of the performance area is a must, for they define the space in which a designer must work.

PHOTO COURTESY SCOTT J. KIMMINS



2-2 Proscenium Theatre This proscenium house, the Victoria, in Dayton, Ohio, was originally built for vaudeville performances. Like many theatres of its day, it was eventually used as a movie house. It has since been fully renovated and returned to its old glory and is now a small touring house. The set onstage is for *Alone Together*, designed by Tammy Honesty.

Proscenium Theatre

In the contemporary theatre, the stage takes on various forms based on the relationship of the audience to the stage. The most common form is the proscenium type of theatre, where the audience is arranged on one side of a raised stage area, divided by an implied “fourth wall” (Figure 2-2). The enclosed stage is visible to the audience through the proscenium opening. This allows for a more formal “presentation” of a play and, for the designers, a bit more control over what the audience can and cannot see. Early proscenium openings were surrounded by a decorative frame to separate the audience from the play in an artificial and often unrelated manner. The proscenium wall of the modern stage is often much simpler, functioning as architectural masking to hide stage machinery, lights, and stored scenery.

The Proscenium Opening The modern proscenium theatre attempts to minimize the frame of the opening separating the audience from the stage. It is less of a demarcation than were the old picture-frame prosceniums. The relationship of the design space to the proscenium opening is an early and critical decision for the designer because it is the first statement of scale. Does the setting relate or attach to the frame of the opening, hold free in an open staging manner, or pierce the opening to extend onto the apron? Figure 2-3 provides some examples. Each has different visual and staging capabilities. Closing in the opening reduces the scale of the production but may provide more backstage space for the storage of scenery. Little or no framing expands the design space into open staging, allowing for more “air” around the set. And piercing the opening by extending the stage reaches toward the audience as if to break through the plane of the opening.

In most proscenium theatres, there is a **fire curtain** directly upstage of the proscenium arch. The fire curtain is a fireproof curtain that covers the entire opening of the arch when closed. It is rigged to fall quickly in the event of a fire, sealing the stage from the house, thus protecting the paying public. Although the fire curtain does not usually affect the design, designers must know its exact position and depth. More importantly, it is the responsibility of the production (starting with the designer) to adhere to the fire codes of the particular city in which the play will be presented, particularly in terms of the permissibility of crossing the fire-curtain line with scenery.

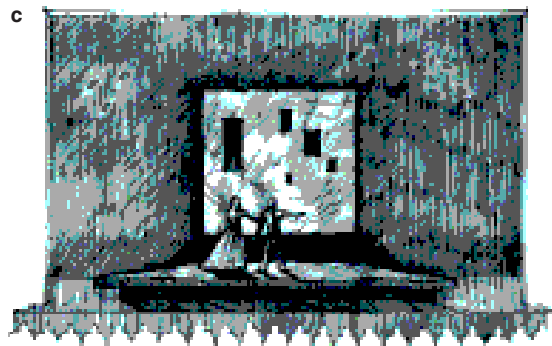
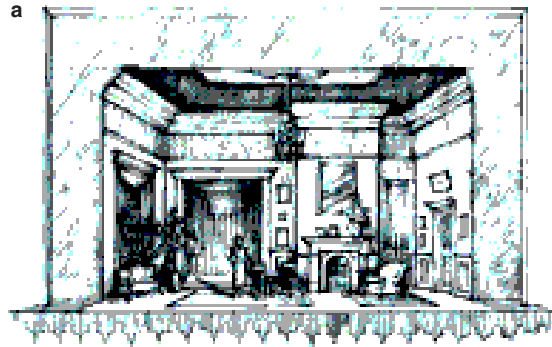
Changing the Proscenium Opening Sometimes it is desirable to close in or change the shape of the proscenium opening. This is done with a **false proscenium**, which is usually neutral in design (often black). If the portal is designed to make a visual statement that sets the tone of the show, used visually to tie together multiple sets, or in any other way created to refer to the design of a specific production, it is referred to as

fire curtain A fireproof wall-like structure that is built to drop quickly in the event of a fire so that it encloses the entire proscenium opening, separating the stage house from the auditorium.

false proscenium A neutral frame, most often black, that either reduces the opening of the proscenium arch or alters its shape.

2-3 The Proscenium Opening These drawings show three variations in the use of the proscenium opening.

- a One can alter the proportions and the shape of the proscenium to fit the scale and the style of design. Here, the designer has lowered the horizontal frame and narrowed the right and left frames. The corners are shaped to conform to the cornice in the design of the room.
- b Having a portion of the set push through the proscenium arch achieves a different sense of the environment.
- c The complete lack of the proscenium arch establishes a surrounding environment that may be harmonious or in contrast to the scenic elements.



a-c COURTESY ANNE MUNDELL

show portal A decorative frame designed for a particular production and used either to pull together multiple sets visually or to help establish the character of the production.

border Overhead masking, usually in reference to opaque black fabric, hanging from a batten and running laterally across the stage.

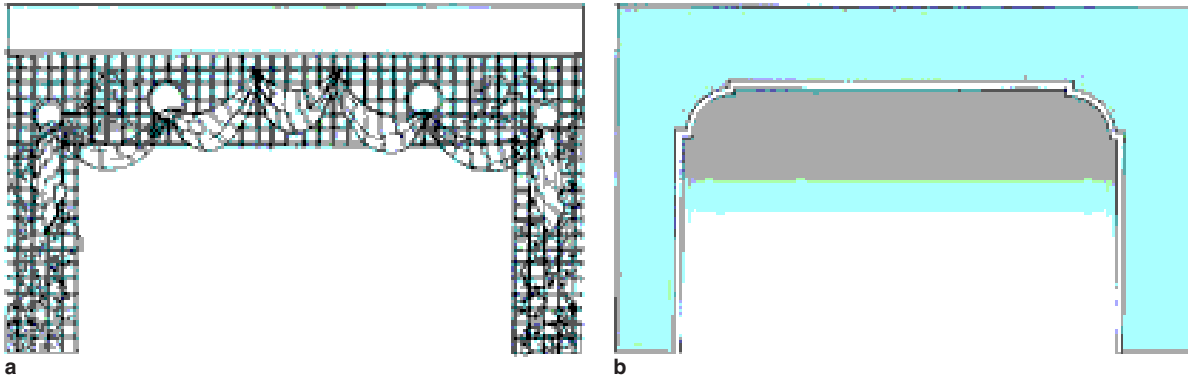
leg Side masking, usually in reference to opaque black fabric, hanging from a batten and running vertically to the floor.

a **show portal**. The false proscenium or show portal is usually hung just upstage of the proscenium arch (Figure 2-4).

The proscenium opening can also be reduced in proportion by lowering an inner overhead drape known as a **border** and by closing in the side drape using a **leg**.

Staging for the Proscenium Theatre

When planning the staging, the designer in collaboration with the director maps out the arrangement of properties, levels, and a general floor plan that facilitates the easy flow of the play's action. The staging is much more than just a traffic pattern for the actors; it requires the designer to think like a director. A successful ground plan allows the director to create appropriate stage pictures, bringing into focus each scene or moment in the play with the proper degree of importance relative to the other moments. It can also help the director establish relationships among characters, enhancing the storytelling.



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2-4 The Show Portal/False Proscenium Both the show portal and the false proscenium are located upstage of the fixed proscenium arch.

- a** The *show portal* is a decorative frame that not only changes the size and/or shape of the opening but also frames the production in the style of the design.
- b** Most often neutral or black in color, the *false proscenium* is a frame that simply changes the size and/or shape of the opening. It can be used to bring unity to a variety of scenes.

Because actors and audience essentially face each other, directions can become confusing. On the stage, all directions relate to the actors' right or left as they face the audience. **Stage left** is to the actors' left, and the reverse holds for **stage right**. Because stage floors historically sloped down toward the audience, **downstage** is toward the audience and **upstage** is away (Figure 2-5). **Offstage** refers to the right and left areas out of view, and **backstage** is the entire area behind the proscenium. (The same directions apply to the thrust stage, discussed shortly. In an arena space, where the audience sits on all sides of the performer, however, this system does not work. In this case, the stage directions are commonly given in terms of the hands of a clock, the position of "12" being an arbitrary choice.)

The designer, through composition of the visual elements, can alter the basic value of any stage area. Because of their relative position on the bare stage and the way in which we perceive objects, certain areas tend to be stronger than others. The nature of the proscenium theatre makes an actor standing downstage nearer the audience more important than an actor in an upstage position.

There are a number of devices that can increase the importance of a stage area that is normally weak. Raking or angling the side walls of a set forces the upstage action toward the center; careful placement of furniture can bring important scenes downstage or more toward the center; using levels in the upstage areas can increase their importance.

When the stage is divided by a series of portals or large arches, the staging becomes more two-dimensional. It falls into a series of horizontal planes related to the portals, each traditionally referred to by number, beginning at the **apron** (Figure 2-5b).

Sightlines

After learning the size and shape of the stage area, the designer must review the **sightlines** of the auditorium to determine how much of the stage is in view. The designer uses the sightlines of a theatre to guarantee two things: (1) that everyone in the audience can see the necessary action of the play and (2) that no one in the audience can see anything that is not pertinent to the environment as designed—what is seen through an open door, for example, must relate to the design as opposed to the backstage. The proscenium theatre has a characteristic sightline problem that varies only slightly with different patterns of seating arrangements. If the flare of the seating arrangement is very wide, people

stage left Direction to the actor's left as he or she faces the audience.

stage right Direction to the actor's right as he or she faces the audience.

downstage Direction toward the audience.

upstage Direction away from the audience.

offstage (1) Direction away from the center of the stage. (2) The stage areas to the right and left of the set.

backstage All the area upstage of the proscenium arch; often used synonymously with *offstage*.

apron The area of the stage just in front of the proscenium arch; synonymous with *forestage*.

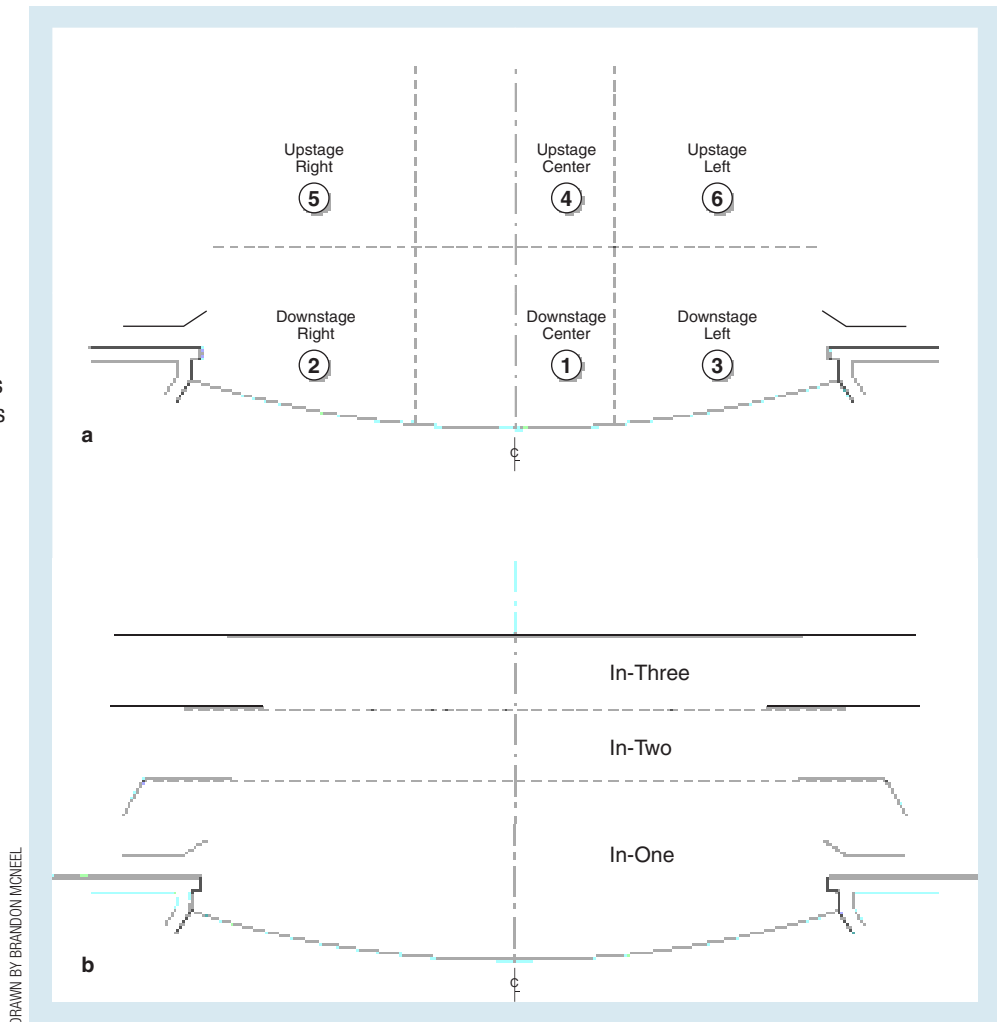
sightline Line of sight from an audience seat to a point onstage.

2-5 Stage Areas

a For easy identification, the stage area is divided into basic areas that are numbered here in order of relative importance:

- 1 Downstage center.
- 2 Downstage right.
- 3 Downstage left.
- 4 Upstage center.
- 5 Upstage right.
- 6 Upstage left.

b A second method of dividing the stage is a series of horizontal planes determined by the location of portals or wings and numbered from downstage to upstage. They are often referred to as “in-one,” “in-two,” “in-three,” and so on.



sitting on the extreme right side of the auditorium (referred to as house right) see very little of the stage left side of the stage, and vice versa. Similarly, persons sitting in a steep second balcony see very little of the back wall of the setting. If the auditorium floor is flat without a gradient, or if the stage floor is unusually high, the audience does not see the stage floor and even sees little of the actors' legs as they walk upstage.

The designer must know these extreme sightline conditions in order to plan a setting that allows the most important areas to be in view of all the audience. Designers need to find the sightlines for only the extreme or critical locations, not every seat in the house. The extreme horizontal sightlines are drawn from the first row of seats farthest house right and left. The horizontal sightlines are located on the plan of the stage and auditorium. The extreme vertical sightlines, located in the section view (see Chapter 5), are drawn from the front row upward and from the last row in the balcony downward. When a large balcony overhangs a considerable portion of the orchestra, the designer must determine a vertical sightline from the last row of orchestra seats.

From the pattern of extreme sightlines, the designer can see how much of the stage is in view to each member of the audience. In Figure 2-6, for example, the horizontal sightline shows the designer how far onstage a person sitting in the far house-right and house-left seats can see and how much offstage space cannot be seen. Figure 2-7 shows that portion of the stage that everyone in the house can see—a considerably smaller area. In this manner, the designer consults the sightlines of an auditorium in relation to the design (Figure 2-8), making the most efficient use of stage areas for staging the action of the play.



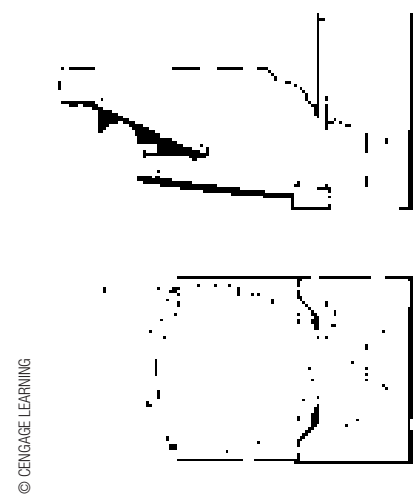
2-6 Sightlines—Area Visible to Someone

These drawings (plan and cross-sectional views of auditorium and stage) show the amount of stage area that is visible to at least one person in the house, using the extreme house right and left seats in the front row of the audience. The shaded area is the visible portion.



2-7 Sightlines—Area Visible to All

These drawings (cross-sectional view and plan of auditorium and stage) show the amount of stage area (shaded) that is visible to everyone in the audience. The sightlines are from the closest and lowest seats and from the farthest back and highest seats (in the balcony).



2-8 Sightline with a Set These drawings (cross-sectional view and plan of auditorium and stage) show how the sightlines of a specific set are checked from the extreme seats in the house.

Staging in Front of the Proscenium

The extended apron and the thrust stage evolved as variations of the proscenium theatre, inspired by the desire to reduce the distance between the audience and the actor. Each is a part of the movement away from the romantic theatricality of the past, which depended on a certain aesthetic distance to complete its illusion. Although the extended apron and the thrust stage are not new forms in the theatre, they are very much a part of present-day staging and represent spaces in which today's stage designer must be prepared to work.

Extended Apron The **extended apron**, or forestage, breaks the proscenium line, bringing the action farther downstage without losing the “picture frame” sense of the opening. The seating arrangement is similar to that of the proscenium theatre with only slight differences in sightlines. The extended apron is often equipped with access openings or doors flanking each wall downstage of or next to the proscenium opening. The forestage area may be used in conjunction with proscenium staging, allowing elements of the scene to spill out onto the **side stages**, or in a more formalized manner, with all action originating on the apron.

The most flexible form of extended apron is illustrated in Figure 2-9, which shows how the area downstage of the proscenium opening can be modified by the use of elevators or removable platforms and seats to one of three variations: (a) full extended apron, (b) side stages with orchestra pit, or (c) regular proscenium staging with additional seats.

Thrust Stage The **thrust stage**, as the name suggests, has the acting area jutting out into the audience (Figure 2-10). With seats arranged on three sides of the acting space, the bulk of the audience is closer to the actors than it would be in proscenium seating, resulting in a sculptural rather than pictorial setting. To keep an actor in full view, the house must have a steeper rise in each successive row of seats. This is referred to as **arena seating**. Scenery or an architectural background makes up the fourth side of the theatre.

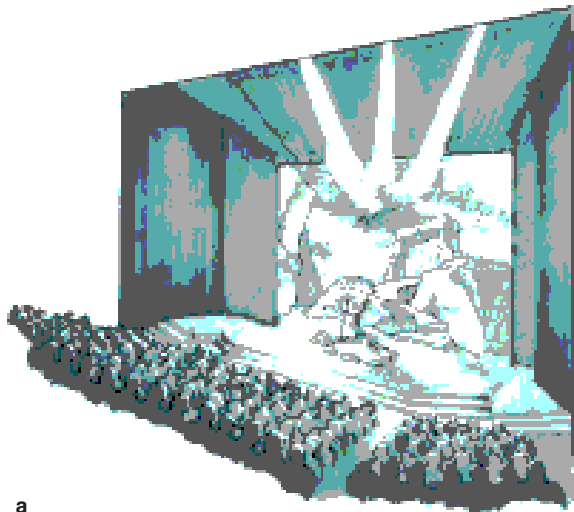
Although the thrust stage appears structurally similar to the proscenium theatre, its chronological development stems from the arena theatre. The long-felt need of

extended apron An apron that projects out into the house.

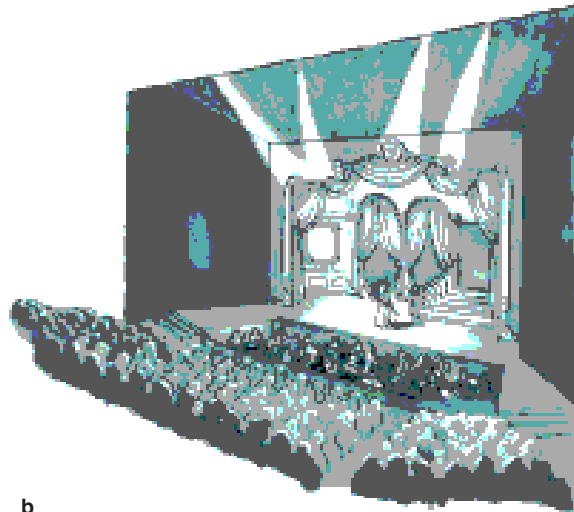
side stage The area right and left and in front of the proscenium arch; sometimes used as acting area.

thrust stage A stage in which the acting area juts out into the audience; it usually has audience on three sides.

arena seating Also referred to as *stadium seating*, whereby the slope of the audience seating is quite steep; most often found in arena and thrust theatres (as well as in sports stadiums).



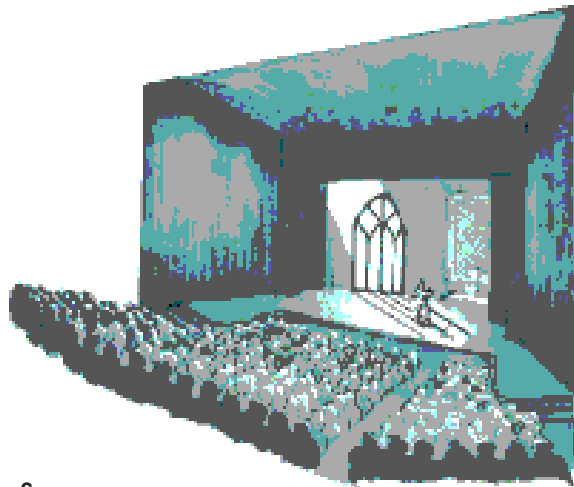
a



b

2-9 Extended Aprons Here is a proscenium theatre equipped with a flexible apron that when raised or lowered can assume several different shapes.

- a With the apron raised to stage level, the apron extends well beyond the proscenium arch, allowing for entrances from the front and side.
- b The apron has been lowered to orchestra pit level for a musical.
- c The apron at house level allows for extra seats and for the audience to be closer to the action of the play.



c

a - c © CENGAGE LEARNING

theatre-in-the-round for greater variety of staging and a stronger axis of visual composition led to a semicircular grouping of seats around the thrust stage. At the same time, the widely diversified sightlines are an obvious improvement over the limited viewing angle of the proscenium theatre.

The strong visual axis, however, has its shortcomings. The people sitting in the end seats of the right and left sides have a radically different compositional view. This effect increases if the seating arc is greater than a semicircle, in which case the audience in the extreme side seats may find themselves enjoying a vista that approaches a rear view. The ideal configuration is slightly less than semicircular, thereby providing a more equitable distribution of seats without losing the sense of close contact with the actors, which is so much a part of both the thrust stage and the arena theatre concepts.

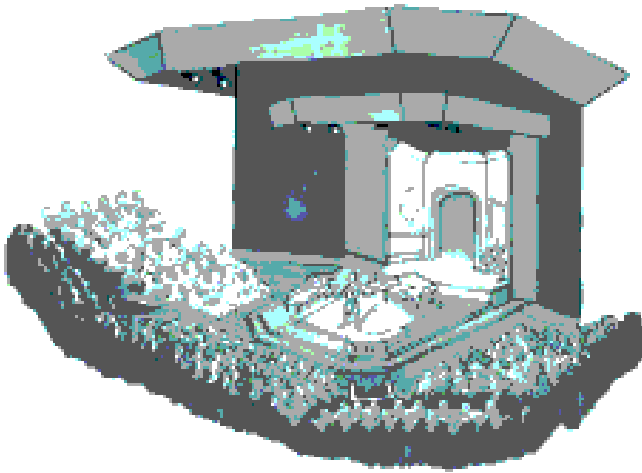
The features of an ideal thrust stage that influence design are the extreme conditions of both the horizontal and vertical sightlines. The abnormally wide horizontal sightlines force the location of large scenic pieces to the back wall and support the use of furniture and prop to establish the locale. The steeper rake of the audience makes the floor treatment a more important part of the design. As well, the use of detail and a stronger reliance on props are necessary to help establish locale and atmosphere.

2-10 Thrust Stage

a With seats on three sides of the stage area, the thrust stage and its background can assume a great variety of forms other than the conventional living room interior shown here. Entrances can be made from the audience (usually below the audience from tunnels called *voms*, or *vomitories*), from the sides, from the back, or through traps in the stage floor.

b Todd Rosenthal's design for *A Skull in Connemara* in a thrust theatre.

c Not really a thrust and not really an arena, this stage is three-quarter round. The design onstage is *Frankie and Johnny in the Clair de Lune* designed by Mark Halpin for The Human Race, Dayton, Ohio, 2002.



a

© CENGAGE LEARNING



b

COURTESY TODD ROSENTHAL



c

PHOTO COURTESY SCOTT J. KIMMINS

Because of their exposed positions, both apron and thrust stages work most easily with one fixed setting or relatively simple modifications during act changes. Because the audience will see it, any change of locale requires highly specialized technology or clever staging by the director.

Arena Theatre

Apart from arena seating, the **arena theatre**, where the audience encircles the acting area (Figure 2-11) has become a familiar stage form. The scale of an arena stage can vary from an intimate theatre-in-the-round to an arena the size of Madison Square Garden.

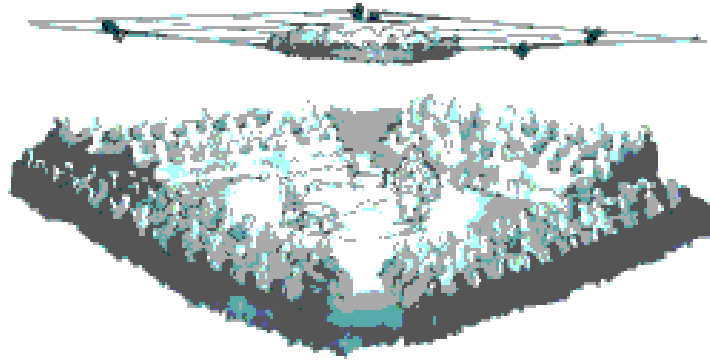
The sightlines of arena staging differ drastically from the proscenium type of theatre and present a unique set of challenges and opportunities to the designer. Hiding actors, props, and machinery is much more difficult in arena than in proscenium staging. The visual elements normally have to be confined to small, low units or open pieces that can be seen through. Scenic units above the acting area are commonly used. As with the thrust stage, there is more of an emphasis on the design of the floor.

Details, often in the form of props, become more important because of the intimacy of the theatre and the lack of larger elements of scenery in the composition. Design for this type of stage is often intentionally simple, sometimes depending on a suggestion of scenery to set the scene and stimulate the audience's imagination to fill in the rest.

arena theatre A theatre space in which the audience encircles the acting area; sometimes referred to as *theatre-in-the-round*.

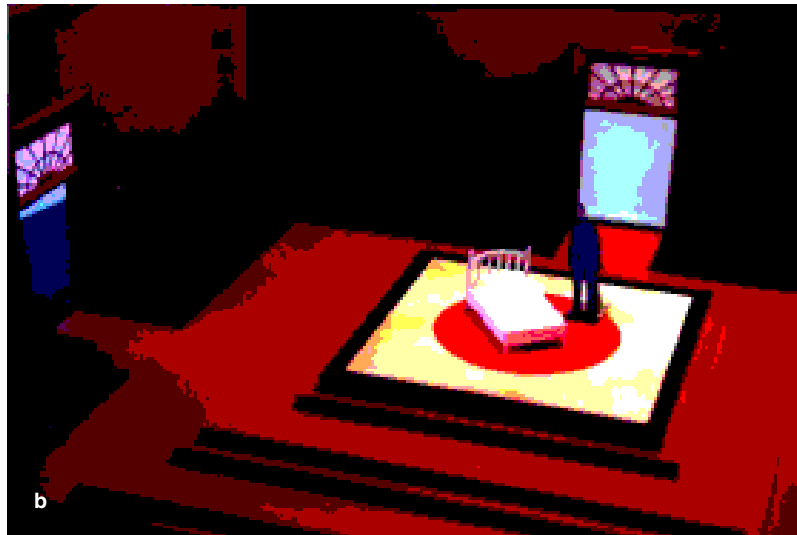
2-11 Arena Stage

- a** The audience surrounds the stage area in an arena stage. The acting area may or may not be raised. Any use of scenic elements is limited because of obvious sightline issues.
- b** An arena production of *Cat On a Hot Tin Roof*, designed by Lynne Koscielniak.



a

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b

COURTESY LYNNE KOSCIELNIAK

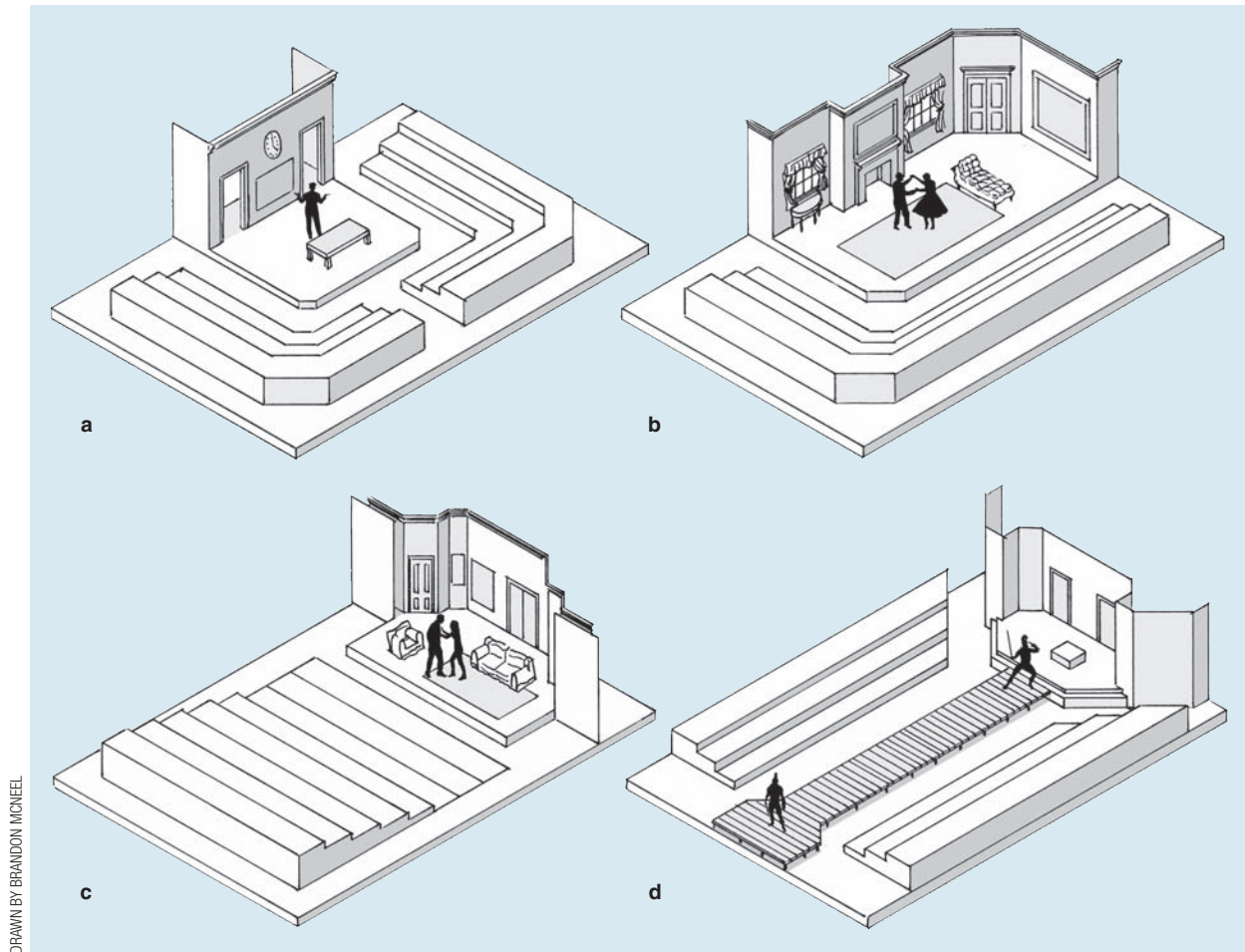
Flexible Staging

Every type of theatre has advantages and disadvantages. Some plays lend themselves to one particular type of acting space, whereas others allow for broader approaches. Flexibility of the physical space allows the director and the designer a wide range of conceptual possibilities in creating a production.

Flexible stages are associated with the **black box theatre** form, which provides an area for easy changing of the stage–audience relationship (Figures 2-12 and 2-13). This kind of flexible space can be altered from arena staging to three-quarter round or to proscenium-type staging. The possibilities are limited only by the imagination of the director and the designers (keeping in mind the needs of the play). Sightlines will vary, of course, with each unique arrangement of the space.

Flexible staging offers many exciting design and directing possibilities. Its main drawback, because these theatres tend to be small, is the relatively small audience capacity, which limits its commercial use. A more serious handicap arises because changing the theatre from one arrangement to another requires significant time and energy. It is, however, an excellent staging medium for experimenting with new dramatic forms and for establishing greater intimacy between the actors and the audience.

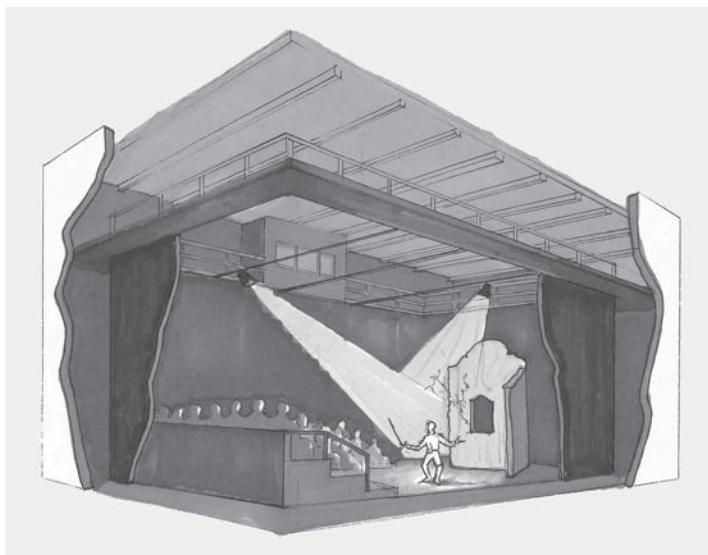
black box theatre A theatre that is usually small and that allows flexibility in the arrangement of audience to acting space; so named because the walls are usually painted black.



DRAWN BY BRANDON MCNEEL

2-12 Flexible Staging The moveable seat platforms and stage can facilitate a variety of audience–actor configurations. Depending on the arrangement, the audience may partially surround the stage area, limiting the potential for scenery.

- a U-shaped arrangement with the audience on three sides of the stage.
- b L-shaped arrangement.
- c Proscenium arrangement.
- d Stage arrangement with the audience split on the sides of the acting area.



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2-13 The Black Box Theatre This cutaway section reveals the basic areas of the flexible theatre. The corridor or passageway surrounding the audience–performance space has adjustable openings to provide entrances and exits to accommodate a specific arrangement. The encircling catwalk provides easy access to the tension-wire grid covering the entire theatre space. Flexible lighting positions are available as well as limited flying or hanging of scenic elements.

Unusual and Site-Specific Spaces

It is no longer rare for a theatre to be created in a structure not built to house performances (Figure 2-14). In recent years, the audience–performer arrangement has been altered to fit into an old garage, a deserted warehouse, a gymnasium, a ballroom, an out-of-use church, a swimming pool, and many other unexpected locations. The often unusual relationship between the seating arrangement and the performance area, to say nothing of a unique ambiance, is part of the theatrical experience and can function as an element of the production. Unconventional arrangements free the audience and the performer from any preconceived notions of what will be seen or heard or accomplished.



COURTESY WARELLE SIBSONS



COURTESY OF THE AUTHORS

2-14 Unusual and Site-Specific Theatre Spaces

- a The Mill City Museum ruin is used as a performance space for the Mill City Summer Opera.
- b Shakespeare Theatre of New Jersey, Greek Theatre. One of the few Greek amphitheatres in the country.
- c Amphitheatre on the campus of Carnegie Mellon University.



COURTESY OF THE AUTHORS

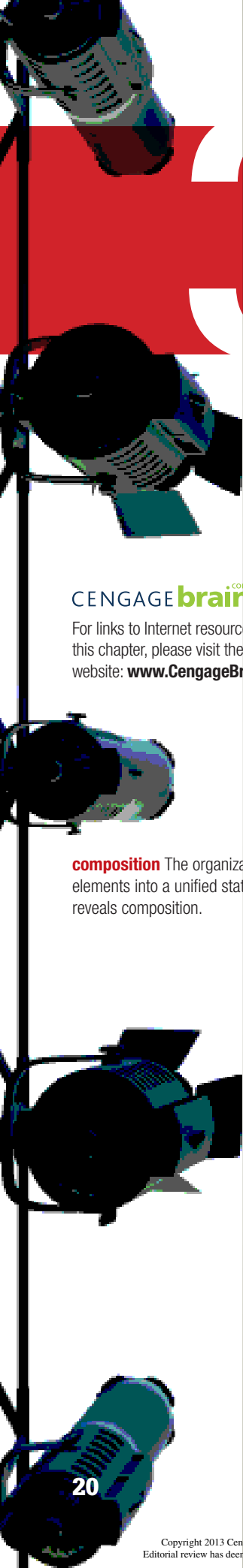


DESIGNING FOR THE REAL WORLD ■ Working with the Physical Space

Because every production is unique, the designer must receive basic information about the theatre in which he or she will be working. Any well-run theatre will provide drawings of the physical space as well as a “spec sheet” of equipment and limitations to its use. This sheet most often will come from the production manager. Before venturing too far into the design of a production, the designer should check the stage and performance area for the following:

- Floor plan drawn to scale showing onstage and offstage space
- Section showing heights and flying system (number of lines and spacing; see Chapter 10)
- Indication of any line sets that are moveable or not
- Indication of any line sets that are not available
- Position and size of traps, if any
- Sightline positions
- Lighting positions
- Overhead or offstage obstructions (ducts, vents, storage areas, and so on)
- Load-in door—size and access to stage
- Local fire-code restrictions (for example, is it allowable to break the fire-curtain line?) This is particularly important if the designer is responsible for arranging audience seating.

Clearly, designers need to be aware of the physical aspects of each theatre they work in, from sightlines to fire codes. They also need to have a thorough understanding of the three functions of theatre mentioned at the start of this chapter—as business, as entertainment, and as machine—and how they are affected by the idiosyncrasies, oddities, and physical hindrances of the given space.



3

Scene Design as a Visual Art

The exciting interplay of line, color, and form in a vibrant stage setting or the subtle refinements of an inconspicuous scenic background do not happen by chance. To create a setting, the scene designer uses, either consciously or intuitively, well-established rules and the fundamentals of design common to all the visual arts. The beginning designer should have knowledge of these fundamentals to aid in the development of any design.

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Design and the Designer

We think of design as an orderly creation produced by an artist. Artists uniquely bring two things to their work: emotion and intellect—both of which are expressed in the feeling and rationale of a work of art. The emotional aspect of creating is individual and introspective, hard to quantify, and impossible to teach. This relatively intangible quality is often referred to as “talent.” The intellectual side of design, however, can be measured and defined in terms of **composition**. Although emotion or feeling, desire, imagination, and a sense of theatre are essential to creativity, it takes the intellect to cultivate the practical skills as well as the conceptual and interpretive powers of design. The merging of emotion and intellect is the beginning of the creative process that spawns the design form in terms of composition, the point being to guide and control the eye of the audience.

Beginning designers may wonder how this abstract definition of design applies to their special interest in the theatre. It means that during the process of designing, two forces are at work—a personal vision or feeling for the final design form and the practical realities that are tempered by thoughtful judgment and taste. As with all aspects of design, both forces are regulated by the needs of the play and the production. In other words, emotion and feeling become the *ideal*, thought and intellect the *reality*—the first being the *goal* and the second the *realization*. The greater the skill and the ability to realize the ideal, the more successful the designer.

composition The organization of design elements into a unified statement. Light reveals composition.

Composition and the Elements of Design

Composition, in general terms, is the organization of the elements of design into a unified visual statement. The result may be simple or complex, primitive or sophisticated. The elements of design are the basic factors that make up the visual statement, whether it be two-dimensional or three-dimensional. Museums provide an excellent place to examine the use of composition. Careful analysis of how an artist guides the spectator's eye through a painting or sculpture can inspire ideas for new designs and for controlling the elements of design.

These elements can also be thought of as forces that, by manipulation, can singly dominate a composition and help to give it meaning. The reason for, or meaning of, any visual form provides the composition with a unity of purpose that is particularly important in the theatre. After all, plays are about ideas. The meaning attached to the design of a visual form may be dictated from the outside, or it may come from within the artist, often formulated by the simple desire for personal expression.

Here are the elements of design that make up a visual form:

- Line
- Shape
- Scale
- Color
- Texture
- Light

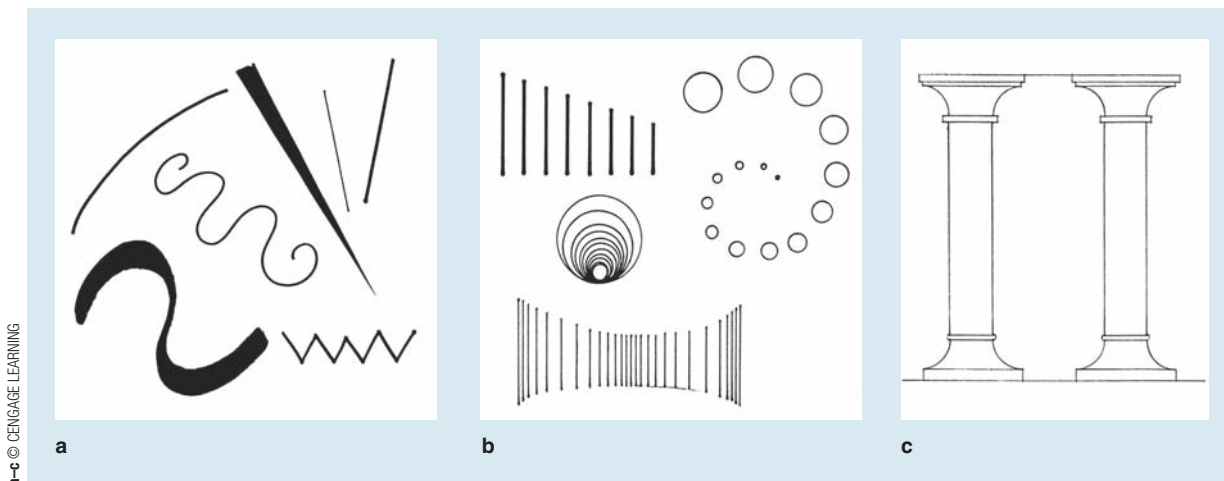
Of these elements, line and color are often the most forceful, but any one of them may be emphasized. All the elements interact, one influencing the others as the composition takes shape. Although none are mutually exclusive, each has unique features that contribute to the overall effect sought by the designer.

Line

Line defines form. Its importance in composition stems from its versatility: the character of a line is very expressive. Line can enclose space as *outline* and create shape (two-dimensional form), or it can suggest three-dimensional form. It can appear as a *real line* in many different modes (straight, curved, spiral, and so on), as *linear shapes* that take on a linelike quality, or as *suggested lines* simulated by the eye as they follow a sequence of related shapes (Figure 3-1). Line also has different qualities: direction, length, and thickness.

Line is a path of action and therefore cannot help but take on a sense of *direction* and sometimes *movement*. Because we tend to relate these characteristics to humans,

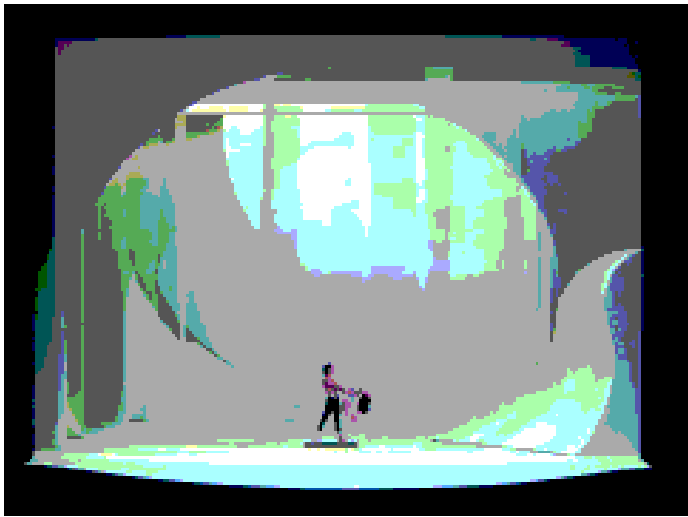
line A straight geometric figure consisting of a series of points that has direction, length, and width, although the width is often so narrow it is usually not recognized.



3-1 Line Types and Linear Shapes

- a** Examples of different kinds of line: straight, curved, thin, thick, subtle, strong, jagged, curvilinear.
- b** Line can enclose shape or suggest shape. The eye will follow a line suggested by repetition or shape, parallel lines, concentric circles, gradation of size or color, or a shape that points.
- c** Negative space. The space between two or more shapes can create a focal point of negative space.

COURTESY JAMES EDWARD BURNS



3-2 Line in Composition In this design for *Afternoon of a Faun* by James Edward Burns, the strong curves that we see suggest the graceful movements of a dance piece.

balance, and gravity, horizontal lines suggest calm and repose; vertical lines suggest strength and balance. Horizontal and vertical lines follow the direction of the frame and therefore suggest no movement. Diagonal lines, in contrast, suggest action. In an arrangement of several linear shapes, the lines not only assume a direction but also take on an *attitude* toward one another, be it one of harmony or opposition. Because of this association with movement and attitude, the use of line, suggested line, and shape with linear characteristics becomes a vital force in any arrangement of forms. A composition may use line as a dynamic force with a sense of violent action or as a static force with a feeling of strength and stability (Figure 3-2).

The tendency of the viewer, for example, to interpret a diagonal line extending from the lower left to the upper right of a composition as an upward motion is a product of the left-to-right orientation common to Western languages. It also involves the human association of a top and a bottom to all composition.

Shape

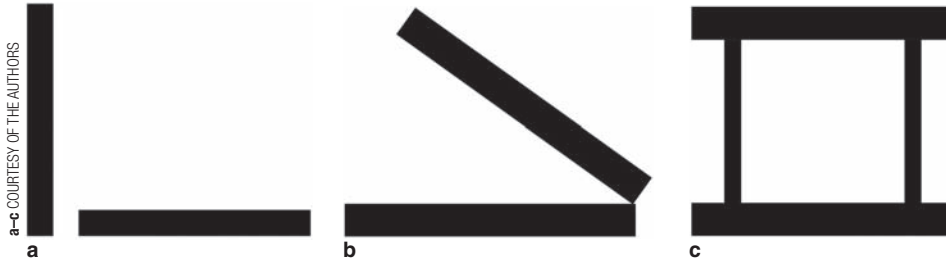
Line ultimately creates shape (or form). Shapes can be geometrical, such as circles, squares, and triangles, or they can be organic. The more geometrical they are, the more formality they tend to suggest. Shape can be used to suggest metaphorical ideas about a script. For example, a square might suggest a boxing ring as a metaphor for *Who's Afraid of Virginia Woolf*; overlapping circles might help the audience understand the three disparate worlds of *A Midsummer Night's Dream*. Shape can be also used to create patterns in the actor's movement, which is particularly useful to a director in staging scenes. Consider the difference between a simple, straight-line cross from one side of the stage to the other as opposed to a cross in which obstacles get in the way. Manipulation of shape allows a designer to help frame an actor or provide an overall focus for a composition (Figure 3-3).

It is not by accident that the proscenium opening is a rectangular frame. This “shape” is the first visual statement that the audience sees. Although quite formal, it literally creates a physical boundary—and frame—that separates the audience from the actors, a factor that can prove both positive and negative.

As with the use of *line*, horizontal shapes tend to feel restful, vertical shapes tend to suggest majesty, and diagonal shapes suggest action. Consider the difference between a bench and a tall stool. Both pieces are used to sit on (and essentially rectangular in shape), yet we respond quite differently to them and have different expectations of the kinds of action that are likely to take place on or near them. A wall that is standing upright does not elicit the same response as one that is leaning (perhaps the difference between a rectangle and a parallelogram?).

Shapes can also create what is called **negative space**, or that area between shapes, which can be just as powerful, if not more so, than the shapes that flank it. In Figure 3-1c, in many ways the more interesting space is that between the two columns. Certainly it creates a strong frame for an actor and a point of focus. A form's prominence or recession, as well as its size and mass, are of course influenced further by the use of color, light, and texture. The proportional relationship between negative space and mass also begins to establish a rhythm or a sense of movement.

negative space The space between two or more forms.



3-3 Shape in Composition

- a** Two rectangles of the same size will elicit different reactions simply due to their directionality. The horizontal rectangle suggests less power than the vertical rectangle suggests.
- b** By placing one rectangle on a diagonal, we automatically assume some action is about to take place (gravity is in play here) or at least that “this world” is more dynamic than the previous drawing.
- c** Here the negative space is actually the focus and therefore is more appealing and interesting to the viewer than the rectangles creating that space.
- d** In Pam Knauert Lavarway’s design for the ballroom in *Lady Be Good*, she uses the circle as a strong statement throughout, as is obvious in the photograph.
- e** The paint elevation of the backdrop for Lavarway’s *Lady Be Good* uses circles as well, but they are not quite so obvious.



Scale

Scale is the *size* or *mass* of shape in relation to the human figure. As an element of design, scale is also concerned with the relationship of one shape to another—large to small, large to larger, and so forth—properly called **proportion**. Actual dimensions are ultimately less important.

This relationship is crucial to understand. A theatre that seats only 50 people, in which the audience is only feet away from the actors, is going to provide a completely different kind of theatrical experience than will a performance in an arena that seats 15,000. Huge concerts provide enormous screens so that audience members far from the stage can actually see the performer and feel like they are part of the action. The same is

scale The size or mass of a form.

proportion The size of a form relative to another form.

3-4 Statement of Scale Scale, at its simplest, is just a function of size; for theatre purposes, the relation is to a human form. The amount of air and space surrounding a human figure changes the way in which an audience will respond.

- a** *Conversations with an Executioner*, designed by Scott C. Neale.
- b** *Crazy for You*, Deadrock Main St. scene; designed by Steve Gilliam.



COURTESY SCOTT C. NEALE



COURTESY STEVE GILLIAM

often done in large conference rooms. Without video screens showing the performer or speaker, audience members are likely to pay less attention.

One of the first decisions a designer makes is the scale of a production, based always on the relationship of the stage to the actor (Figure 3-4). Although the proscenium arch establishes an architectural limit, it can be adjusted with the use of a false proscenium, which then becomes the designer's initial statement of scale. Some plays require a larger space, whereas others may need a smaller one to capture an intimate feel.

Scale can be used to create theatricality. We expect objects to be a familiar size. Increasing the scale of a common object can help establish an atmosphere that is overwhelming, or perhaps oppressive, in part by making the actor seem small and insignificant onstage. Conversely, decreasing the scale of an object makes the surroundings seem larger than normal.

Color

hue The name of a color; scientifically, the color's wavelength or position in the spectrum.

value The presence of white or black in a color; the lightness or darkness of a color.

chroma The purity of a color or the amount of adulteration (neutrality); often referred to as *intensity* or *saturation*.

Because of our emotional associations, color most often generates the strongest response of all artistic elements. It is a powerful stimulus that can change the dimension of shape, reverse the direction of line, and alter the interval between forms. Color in the theatre comes from two basic sources: pigment on the surface of the form or color transmitted by light.

Color in either light or pigment has three variants: **hue**, **value**, and **chroma**. A specific color can be thought of in terms of its *hue*, which, simply put, is the name of the color (technically, the color's wavelength or position in the spectrum); its *value*, indicating

the amount of black or white present; and its *chroma*, indicating the color's degree of purity (saturation) or freedom from neutrality.

Warm colors such as yellows, reds, and oranges generally evoke happiness, whereas cool colors such as blues and greens suggest sadder emotions. These generalizations are useful but run the risk of becoming trite. (For more on color, see Chapter 5.)

Nonetheless, an understanding of the general emotional response to color is helpful to any designer. Although it is impossible to predict exactly how an audience might respond to any given color or groups of colors, there are *logical* and often *expected* reactions that can prove useful. Since part of designing is learning how to manipulate the elements of design in order to help an audience understand a text, the power of color should not be underestimated.

Although value has been defined as a variant of color, it is an important medium of expression on its own. Suggested form can be modeled on paper in shades and highlights using only black-to-white tones, as illustrated in Figure 3-5. Value should be explored early in the process of designing scenery. Many designers do preliminary work in the form of value sketches in order to get a sense of shape and proportion without having to worry about color until later in the process.

Texture

The composition of a design takes on a tone partially inspired by the makeup of its texture, the *tactile* aspect of form. As a design feature, it adds interest by giving character to the finished form. The manner in which light reflects on a surface, often referred to as surface tension, may vary from the extremes of highly polished to rough/natural in quality. Different surfaces stimulate different emotional responses (Figure 3-6).

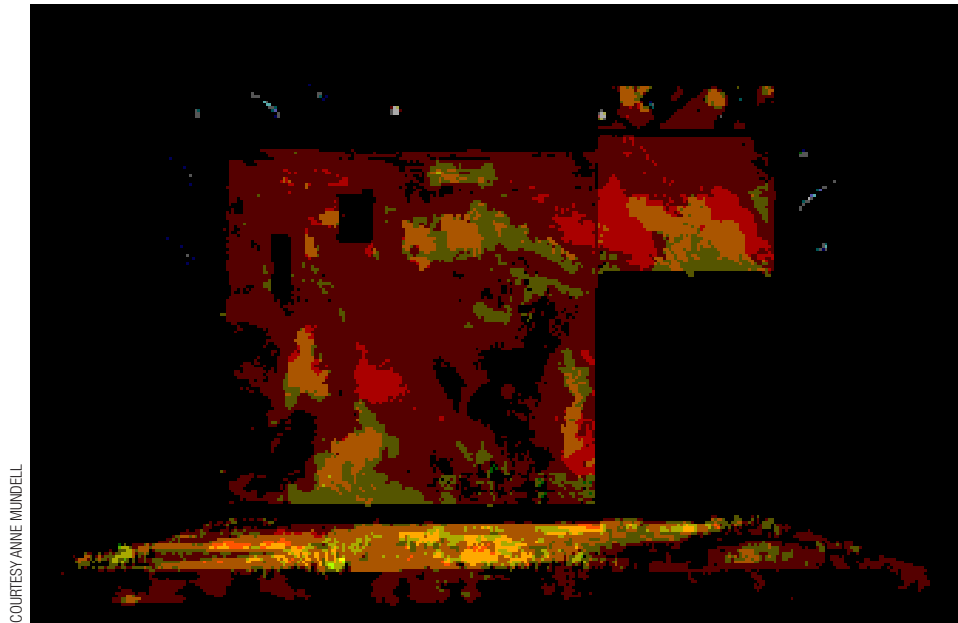
Real texture is three-dimensional, as in the use of fabricated brick, stucco, or plastic leaves (Figure 3-7a). *Simulated* texture is two-dimensional but suggests a third



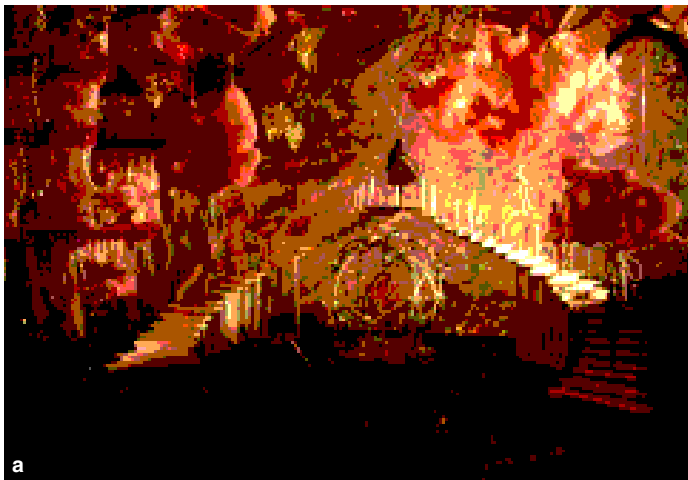
3-5 Value Sketch *Untitled*, sketch by Adam Koch.

COURTESY ADAM KOCH

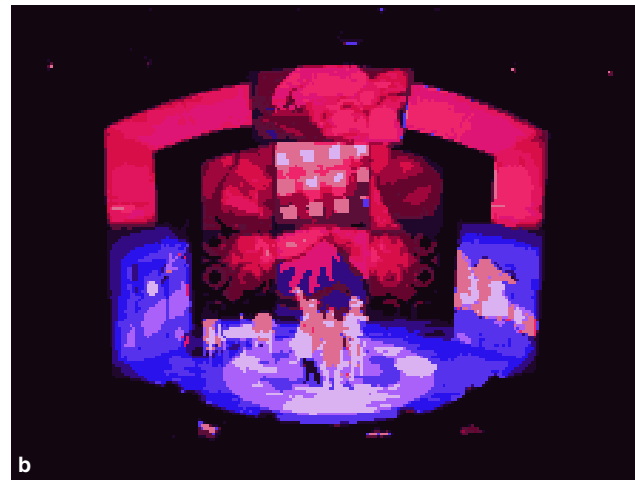
3-6 Texture Onstage *King Lear*, set designed by Anne Mundell.



COURTESY ANNE MUNDELL



COURTESY LYNNE KOSCIELNIAK



COURTESY ADAM KOCH

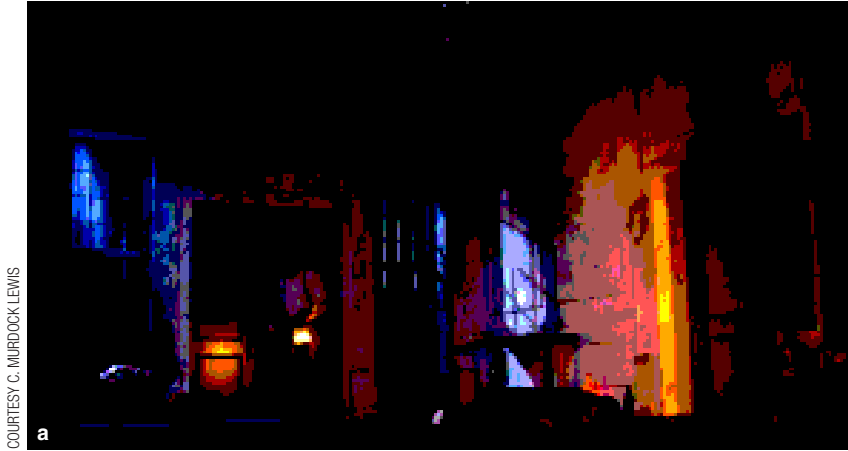
3-7 Real and Simulated Texture

- a** Real texture on the model for *The Nutcracker Suite*, designed by Lynne Koscielniak.
- b** Simulated (projected) texture for *Five Course Love*, designed by Adam Koch.

dimension most commonly achieved by painting or projection (Figure 3-7b). Wallpaper, parquetry, and other patterns can be used as well to suggest texture.

The reason for using texture in a scenic design is to catch, interrupt, and reflect light. The irregular shadows and highlights of a textured surface enrich a design form; thus, the dependency of texture on light is a crucial component of design.

Light Revealing Texture Real texture is best revealed by directional side-lighting, whereas painted texture appears more real under a wash of light without a strong sense of direction. A wash of light is shadowless and therefore does not expose the simulated texture as a painted surface. Conversely, a wash of light on a textured detail such as a cornice or molding will deny its three-dimensionality and sometimes require the addition of painted shadows and highlights to create the appearance of reality.



COURTESY C. MURDOCK LEWIS

3-8 Designing for Light

- a** *The Whipping Man*, designed by C. Murdock Lucas.
b *A Streetcar Named Desire*, designed by Todd Rosenthal.

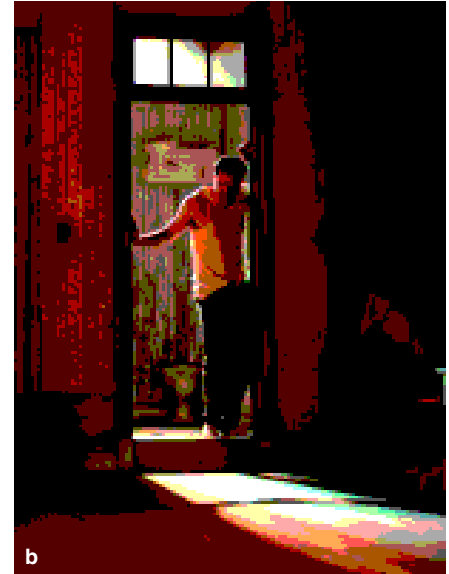


PHOTO BY T. CHARLES ERICKSON, COURTESY TODD ROSENTHAL

It is important to realize the power that light can have in revealing (or hiding) texture (Figure 3-8). This supports the necessity of scenic and lighting designers working closely together throughout the design process.

This leads us to the last element of design, lighting.

Light

Light is not typically considered one of the elements of design. However, given the importance of light and scenery working in sync to create the kind of theatrical world that is desired on stage, it is worth consideration here. It must be considered from the beginning of the creative process, not something to be added later. It is not possible to overestimate the importance of designing scenery with lighting in mind as light not only reveals form, it also establishes mood.

Light can be thought of in three different ways: first, as *real light* capable of revealing form; second, as real light having its *own design form*; and third, as *simulated light* since it might appear in a two-dimensional representation of a three-dimensional form.

Physical Characteristics of Light There are four physical characteristics of light that are essential to creating a design: intensity, color, distribution, and movement.

Intensity is the actual or comparative brightness of light. The focus of the audience will tend toward the brightest object onstage.

Color modification and the mixing of colored light can determine mood and atmosphere.

Distribution refers to both the direction and the quality of light. The sharp- versus soft-edged quality of a light beam, coupled with its degree of brightness, gives an innate *texture* to light. The use of highlight, shade, shadow, and texture in composition will drastically affect the on-stage atmosphere. Moreover, exposed light sources such as lamps, chandeliers, and other practical fixtures, can help establish time period, locale, and economic status. Also, depending on the production, it may be decided that the lighting units themselves should be visible to the audience.

The fourth variant of light is *movement*, defined as the visible change of any or all of its other three qualities. Stage lighting involves a nearly constant state of motion. A subtle change of intensity, the use of a follow spot, or the change of color in a sky or background can alter the focus or modify the atmosphere or mood of a scene. It can also have a dramatic or emotional impact on the audience, such as that experienced during the vibrant movement of light in a rock concert.

A first-hand knowledge of what light can and cannot do will allow a scenic designer to utilize its potential. Light should be present in the designer's sketch, showing its function in the composition. Although *line* and *shape* are used first to represent three dimensions, the use of light and its shades and shadows is the designer's most effective way of representing three-dimensional form in a sketch.

Light and the Scene Designer Because lighting technique is covered in great detail later, here we simply point out its general influence on the scenic designer and the overall production. The two most active and vital components that make up a stage composition are the actor and the light. It is critical that the scenic designer and the lighting designer communicate their ideas from the beginning stages of the design in order to be in sync with each other. If the design of the lighting comes late in the planning of a design, the entire visual picture suffers. Lighting is too important not to be considered from the start.

Lighting provides designers a greater flexibility in composition than any other visual art form. This can easily be explored in a model of the set. The scene designer must consider in advance how lighting will affect his vision. Aside from its design possibilities, light on the stage has an unavoidable effect on the structure and materials of scenery, which, if controlled, can be extremely exciting. Light can be used to create opaque, translucent, or transparent scenery; it can transform the color or the atmosphere of a set.

Principles of Composition

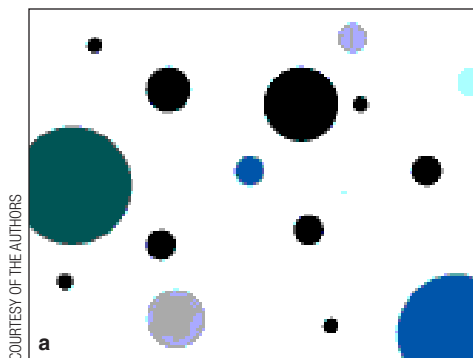
The *elements* of design are the raw materials ready to be brought together into some order or purpose, creating a *composition*. The *principles* of composition are the various ways the designer can control and use the design elements to bring interest and meaning to the stage. A good composition consciously brings into play **harmony** and **contrast**. Expertise in the handling of variation, emphasis, and gradation enables the designer to skillfully manipulate the visual statement that is desired.

harmony A pleasing or congruent arrangement of scenic forms, creating an aesthetic unity, often achieved through repetition.

contrast In scenery, dissimilarity of forms used to create interest. In lighting, a difference in color, intensity, or distribution.

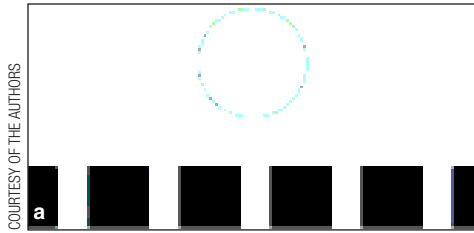
Harmony

The simplest act of bringing order to disorder is sorting unrelated objects into groups that have some sequential relationship or continuity. The objects may have similar shapes, colors, and/or textures. Control is often achieved through repetition. The repeated use of linear forms, for example, can dominate a composition even though other elements, such as contrast, are present. (As with the elements of design, the principles of composition are not mutually exclusive.)



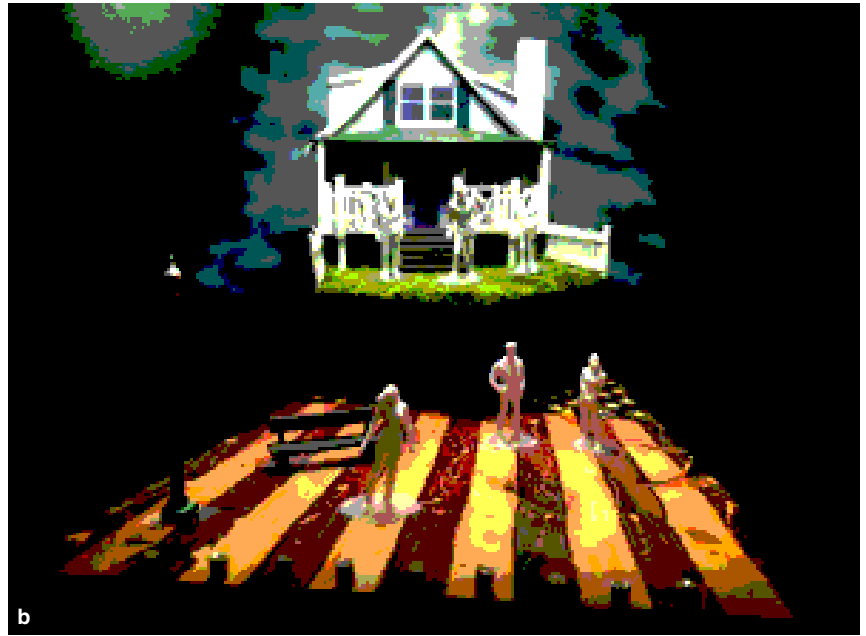
3-9 Harmony

- a** It is the repetition of the circle that pulls all of the objects together. The variety in size and color provides interest.
- b** For his design of *The Marriage of Figaro*, Frank Ludwig uses the musical score of Mozart as well as pictures of the composer as decoration as a way to pull all of the elements of his design together.



3-10 Contrast

- a** The circle stands out here as a shape in contrast to the steady row of squares.
- b** Christopher Ash uses color, shape, texture, and elevation to contrast two different exterior locations that appear simultaneously for his design of *The Seven Deadly Sins*. His heavy use of “line” on the floor helps guide our eye to the gloating house facade.



Although repetition is one of the easiest and quickest ways to bring harmony to a composition, it suffers the danger of becoming monotonous. This can be relieved with contrast or variation.

Contrast

The designer depends on contrast to create form and interest; without it, form cannot be revealed. In nature, the protective coloration of an animal or a bird reduces contrast to the point of making it invisible against its habitat. But in the theatre, such lack of contrast—an actress in a red gown sitting on a matching sofa—would be disastrous. Between the two extremes lie infinite variations.

The most visible example of harmony and contrast is found in the use of color and value. A design with a single color scheme would be harmonious. The farther apart colors are in the spectrum, the greater the contrast. The same thing occurs with value coupling. Black and white, for example, are extreme value contrasts. (Again, refer to Chapter 5 for further discussion on color.)

Variation

When the repetition of one element produces monotony, a **variation** of one or more of the other elements can add interest to the composition. In Scott C. Neale’s design for *Home/Land* (Figure 3-11b), it is in part the variety and direction of the multitudes of suitcases that provide much of the visual interest.

Emphasis

Without a **focal point** or **emphasis**, the audience does not know where to look. The means by which one creates a focal point can be obvious or subtle. In addition, secondary areas of interest, as well as intriguing bits of detail within the composition, may hold the audience’s attention without detracting from the main focus. Although a stage



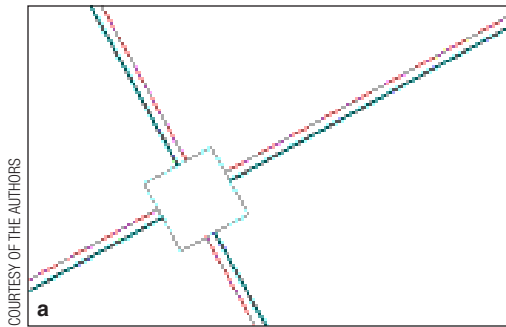
3-11 Variation

- a** Any of the elements or principles of design can be used to create variety. In this case, it is achieved by a variation in color.
- b** Scott C. Neale’s design for *Home/Land*. It is the change in size, shape, directionality, and color that makes this an intriguing space to look at.

variation Slight or major changes in the elements or principles of a form that prevent monotony.

focal point Center of interest.

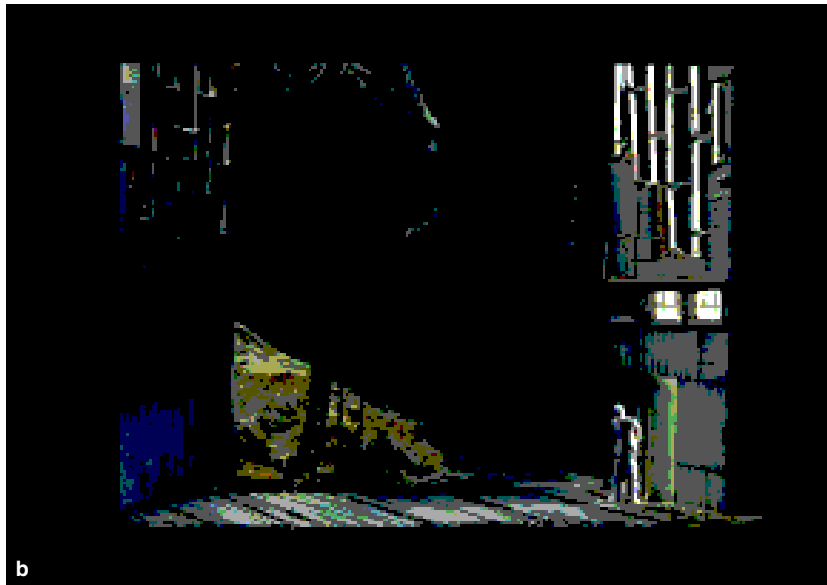
emphasis Visual prominence using the elements and principles of design to guide the viewer to a specific area of the design.



COURTESY OF THE AUTHORS

3-12 Emphasis

- a The square sitting on the diagonal is the obvious point of emphasis made stronger by the diagonal lines that seem to point to it.
- b *Of Mice and Men*, designed by Todd Rosenthal. In this design, he uses light plus a series of implied diagonal lines to create an emphasis on the actor.



COURTESY TODD ROSENTHAL

setting is usually designed around a strong focal point with important secondary areas, the true center of interest in the total picture must be the actor and will change according to the direction of the play.

To create emphasis, designers use both the elements and the principles of design. Contrast provides perhaps the easiest means of doing this. If all but one of the scenic pieces are small, our eye logically goes to the large piece, creating emphasis by use of contrast in scale. One single light object in a picture of dark objects creates emphasis by contrast in value.

Isolation or placement can also create emphasis. Within a frame such as a proscenium, the center of the space is the strongest point. Careful framing can guide our eye right to the point of interest. Placing one object away from everything else can also achieve this.

Stage lighting, costume colors, and the movement of actors all help to make any change of emphasis rather simple. Dimming most of the lights and brightening one area, using a follow spot, and dressing one actor in white while all others are dressed darkly are tried and true methods of creating focus to a specific point on the stage. The movement of the actor will also change the center of focus. The mobility of the actor allows the director to use groups of actors as a compositional tool for focusing the interest of the audience on any portion of the stage setting.

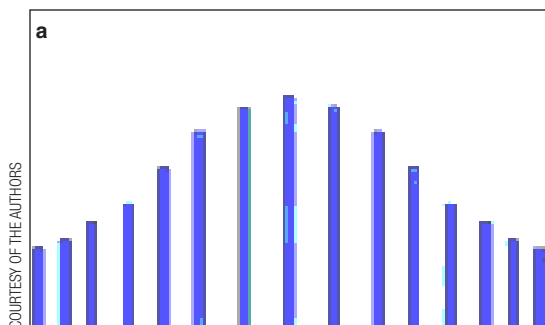
Gradation

Designers often want to establish a feeling of movement or change in a stage setting through relatively subtle means. Sharp contrasts can be reduced by the use of **gradation**, which softens contrasting elements in transitional steps yet brings a feeling of movement into the stage picture. The graded wash of a sky drop, with the dark blue at the top gradually becoming lighter near the bottom, is an example of gradation of value. The use of gradation may occur in line, shape, or any other element of design (Figure 3-13).

gradation Transitional steps in a sequence used to create emphasis and a feeling of movement in a design.

Composition, Space, and Depth

Space is to the scene designer what a block of wood or stone is to the sculptor. The spaces in and around the stage become an area to enclose or leave open, to light or leave dark, to flatten out or deepen. It is the province of the designer to define the space that the actors



3-13 Gradation The use of gradation can help focus the audience.

a A variation of the bell curve is perhaps an obvious example of gradation. In this example, the space between the lines is also an example of how gradation can be used. The gradation of straight lines can help to suggest shape and focus.

b *The Sound of Music*, as conceived by Steve Gilliam, uses a series of Nazi flags in various widths to create a central focus.

will ultimately be using; without definition, space has no meaning. An actor standing alone without any limiting device stands in a vacuum.

One of the first devices that the designer uses to define the relationship of actor to stage is frame. The proscenium arch (or the stage deck in the cases of arena and thrust theatre) is just that—a large frame. Compositionally, the ideal frame is the circle. Placing the actor in the center creates a clear focus—but this is not practical. The next best shape is the square, but here, too, there are problems. So we are left with the rectangle as the common shape for most proscenium arches.

Within that particular architectural limit, the designer will find many ways to frame the actor. A series of portals is the most obvious choice, but there are an infinite number of others. A set of columns, arches, a doorway, a trellis, or whatever draws our focus to an actor in a particular place on the stage can be effective (Figure 3-14). The type and size of the frames will start to define the nature of the space that is appropriate for the production.

Depth defines three-dimensional space. As figures or large shapes are overlapped, the illusion of depth can be achieved. According to the principles of perspective, as objects move away from us, they appear smaller, have less color, and lose detail. So, creating a



3-14 Frame In this set for *Crime and Punishment* at Playhouse in the Park, Kevin Rigdon very cleverly creates a circle (within the frame of a rectangle) centered in the set to frame the table, but a series of rectangles on the sides helps frame other actors.



3-15 Perspective Drawing This perspective sketch of *A Delicate Balance* is designed by Travis George.

series of arches that diminishes in size is one easy way to suggest depth. Reducing the intensity of color, the sharpness of line, and the amount of detail works as well.

In the planning stages of a design, the strongest tool available to the designer wanting to show depth is perspective drawing, which creates the illusion of literally breaking through the plane of the paper. Perspective and the shadows of directional lighting are combined to achieve a total effect, a feeling of space in a two-dimensional form (Figure 3-15).

Composition and Unity

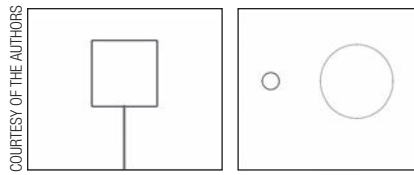
The composition of a stage setting is expected to bring unity to the overall arrangements of the visual forms. The strength of unity depends on more than harmony, however. The compositional unity of scene design depends first on *balance and movement* and then on *proportion and rhythm*. At first glance, balance and movement may seem identical to proportion and rhythm; however, a closer analysis will show that, although related, they are not the same. Balance and movement are the outward, more obvious expressions of the subtler, more sensitive effects of proportion and rhythm.

Unity suggests a *balance* of the forces within the composition. These are the forces of tension, attraction, and attention that exist among the forms of a stage design. This balance involves *movement*, or how forces and forms change over time. Further, all scenery forms have mass and size (scale), which means that their *proportion* must be considered. And lastly, the proportional relationship between forms cannot help but bring *rhythm* into the composition, whether it is static or dynamic in feeling.

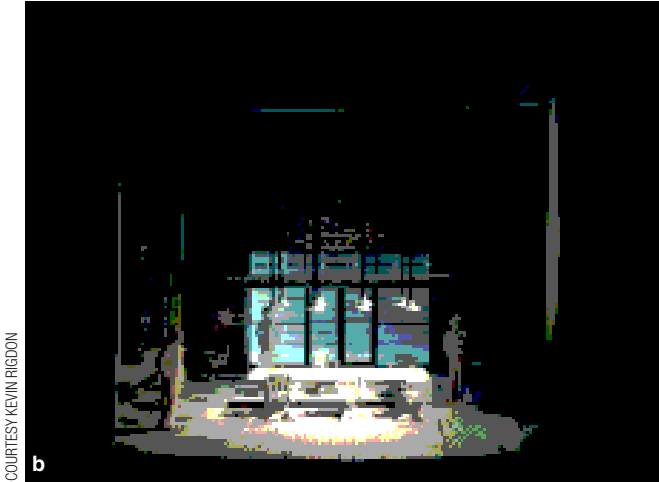
Balance and Movement

balance Equalization of visual weight or opposing forces within a composition.

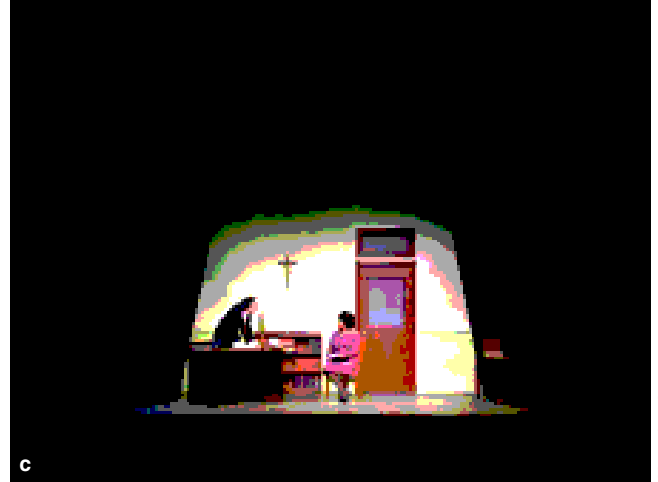
Balance is described as the relationship of forces within a composition. One of those forces, tension, is found in the spacing of scenery masses, the grouping of furniture, or the relationship of the actor to the scenery and furniture. The degree of tension depends on the interval or space among forms and creates a feeling of balance or imbalance. For example, the space between the finger of God and Adam gives life to man in Michelangelo's fresco in the Sistine Chapel. If the fingers were touching, or moved farther apart, there would be no tension.



a



b



c

3-16 Balance

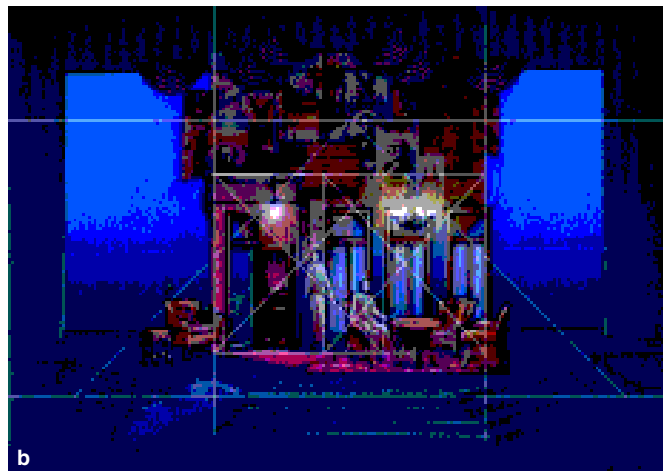
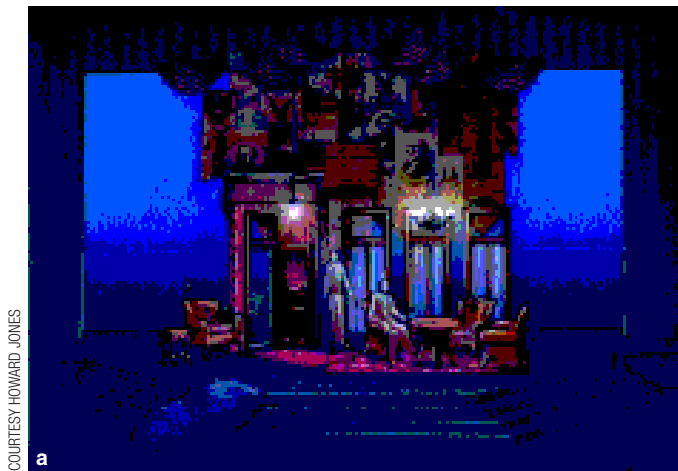
- a** The box on the left shows symmetrical balance; the box on the right is asymmetrical. Note that one way to achieve balance is to place a larger or heavier object closer to center with a smaller or lighter object farther from center.
- b** The model of the set for *Race* done by Kevin Rigdon is a good example of symmetrical balance—one side is the mirror image of the other.
- c** Although not symmetrical, this set for *Doubt* by Michael Riha is still balanced. The vertical of the door stage left is balanced by the horizontality of the table stage right.

Gravity is the other force in composition, made important by the viewer's unconscious reaction to it. Gravity has probably the greatest effect on balance. A viewer reacts to visual signs with an organic sense of balance schooled by a lifetime of living with the pull of gravity. Because of this, an unsupported heavy object may seem to be falling, as does a leaning object, unless its center of gravity holds it in balance. Also, a recognizable shape in an unnatural position may cause a feeling of imbalance. Such imbalance makes us feel as if there is something wrong, a problem that can be useful in a design (Figure 3-16).

Movement can change the balance over a period of time. In the theatre, as has been noted, the time–movement relationship is quite apparent. The actors move from area to area; the lights dim and brighten; scenery changes position—all of which should be carefully controlled and coordinated. Because movement catches the eye—an audience will automatically look toward a moving versus a static object—it can detract from the focus of a scene as easily as it can enhance it. Ask any actor who has been “upstaged” by the innocent waving of a handkerchief by another actor.

It is not unusual and often extremely helpful to analyze a sketch (or a model, for that matter) in terms of frame, geometric shapes, and diagonals to ensure that serious consideration is given to the composition of the entire design and that the designer is guiding the eye of the audience in the same way a painter does on a canvas. See Figure 3-17 for an example.

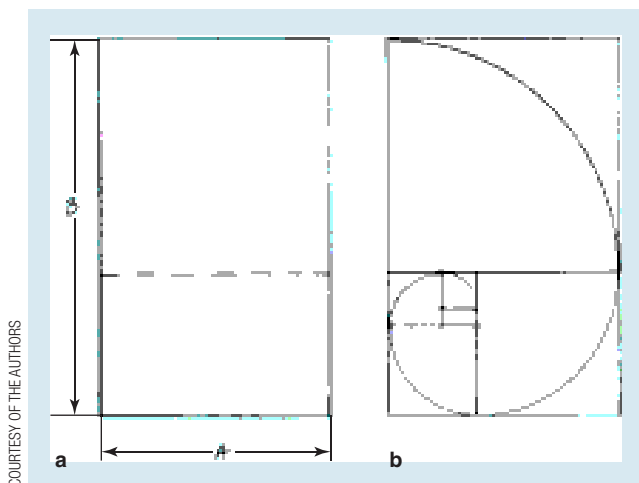
All these are part of the composition of the dramatic form and involve the element of time. Time, however, exists in a fixed composition. There is an interval of time as the eye follows the pattern of movement through a composition. The interval is minute, of course, when compared with the broader movements onstage. Visual changes can lead the eye, abruptly or gradually, over the movement of a composition, again, trying to create a focal point or series of focal points.



3-17 Geometric Composition in a Design

a The design for *Ah, Wilderness*, by Howard Jones.

b The same design with an overlay of the geometric composition. It is now clear how the designer has used a series of squares or near squares to frame the actors and focus our attention mostly on the center of this room. Perspective and the determination of placement of objects, including furniture, on stage will help create these geometric shapes (although most designers learn to do this instinctively). This is certainly not the only purpose for determining where objects live on stage, but it can be a useful tool.



3-18 Golden Section

a This rectangle is an example of the Golden Section, a ratio considered by the Greeks to be the perfect proportion: the ratio of the short side (A) to the long side (B) is the same as the ratio of the long side to the sum of the two sides: $A:B = B:A + B$. Drawing a square with each side equal to B leaves a rectangle of the Golden Section.

b By continuing the drawing of squares within each Golden Section, a spiral is created. This is known as the Fibonacci Curve, and it is found in nature (pine cones, flowers, etc.).

Golden Section Also called the Golden Mean; a ratio, such as in a rectangle, in which the short side to the long side is the same as the long side is to the sum of the short and long sides, approximately 3:5.

Proportion and Rhythm

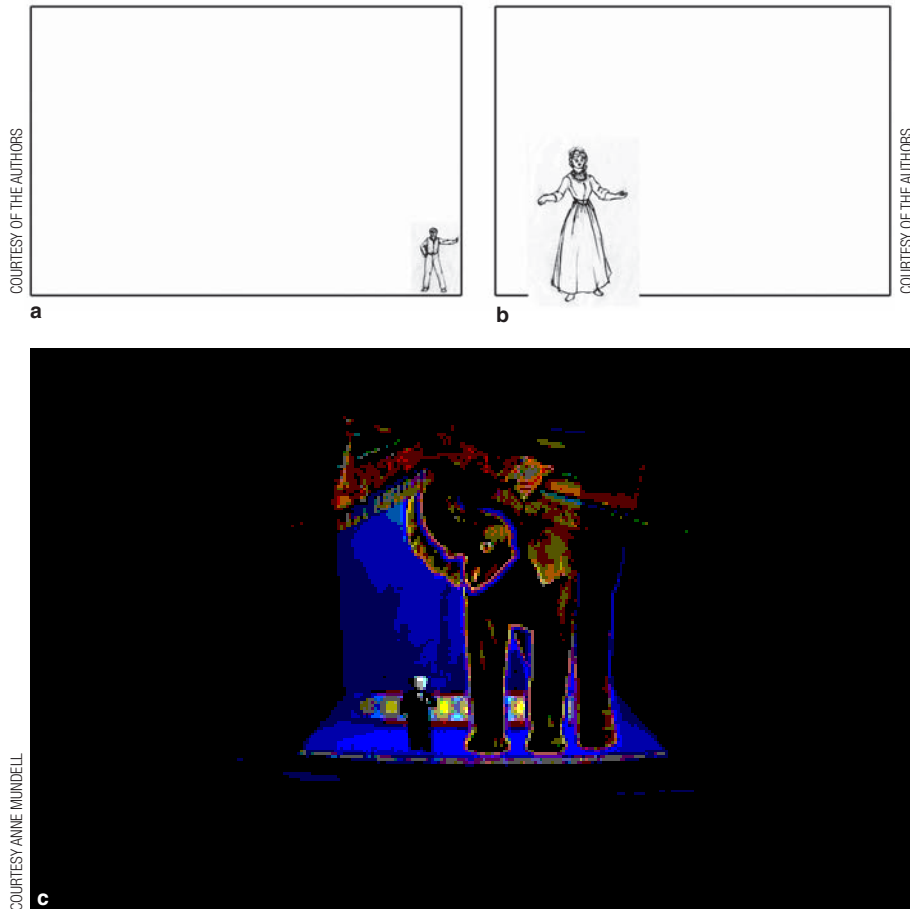
A second means of obtaining unity in a composition is through the use of proportion and rhythm. Proportion can be linked to the reason or function of a visual form. The proportion of a chair as a visual form depends on how the chair is to be used. A simple dining room side chair is small when compared with the scale and grandeur of a canopied throne. That same chair next to a small stool will seem much larger and probably more important.

If the proscenium arch (or perhaps the false proscenium) is our first statement of frame, then the proportions of its opening are important. There is no consensus as to the ideal opening proportionally, but the standard is close to a ratio of 2 to 3 (or 24 feet by 36 feet). The ancients used the **Golden Section** (sometimes referred to as the Golden Mean) as the ideal proportion. This is defined as a ratio of a short line to a long line that is equal to the ratio of the long line to the sum of the short and long lines. This ratio is approximately 3 to 5 (Figure 3-18).

Although the primary concern regarding proportion on-stage is how it relates to the human figure, a proportional relationship exists between one form and another and among the spaces between forms (negative space). Perhaps more important is the proportional relationship of forms to their surrounding space. The rhythm and proportions of a sculptural arrangement

of forms set in an unbound space may seem different from a similar arrangement of shapes framed or confined within a rectangular shape, such as the proscenium opening (Figure 3-19).

Scene design is concerned with this rectangular frame as well as with the freer compositions of the nonproscenium stage. Designing for nonproscenium theatre requires more sculptural techniques to create a desirable proportional relationship among forms.



3-19 Proportion Without a specific size reference, and in a theatre drawing that means the human figure, it is impossible to know the size of the image.

- a** The scale figure (assuming an average 6 foot tall person) indicates a very large proscenium frame.
- b** The scale figure in this frame indicates a considerably smaller proscenium frame.
- c** This sketch by Anne Mundell for *Barnum* clearly shows the relationship of Tiny Tim, the tiniest man in the world, and Jumbo, the largest elephant in the world.

Whereas the composition within a proscenium frame is viewed pictorially, nonproscenium scenic forms have to be composed satisfying viewers from all directions.

As balance is linked to movement, so proportion relates to **rhythm**. Rhythm is a type of movement that recurs at intervals or creates a cycle. The space among forms and the attitude of one shape to another create a rhythm in the composition. The subdivision of a single form does the same. Rhythm may appear in the quiet dignity of a formal arrangement or in the vigorous movement of a dynamic composition. It may be expressed in the rhythmic flow of harmonious forms or in the nervous staccato organization of shapes.

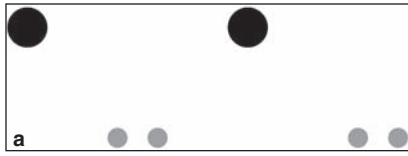
Rhythm as a unifying factor is usually expressed in the lines or linear qualities of a stage composition. The use of actual lines or the feeling of a line caused by the position and direction of one shape in relation to another results in a rhythmic movement that may be as strong or as subdued as the designer desires. Diagonal lines give a greater sense of movement than the use of strong horizontal and vertical lines, which tend to stop movement.

Although the rhythm of straight lines is bolder than that of curved lines, the latter provide infinitely greater variety. The rhythm of a curved line may have the grace of flowing lines, the turbulence of reverse curves, the whirl of a spiral, as well as the repetition and order of interlaced geometric curves such as circles and ellipses.

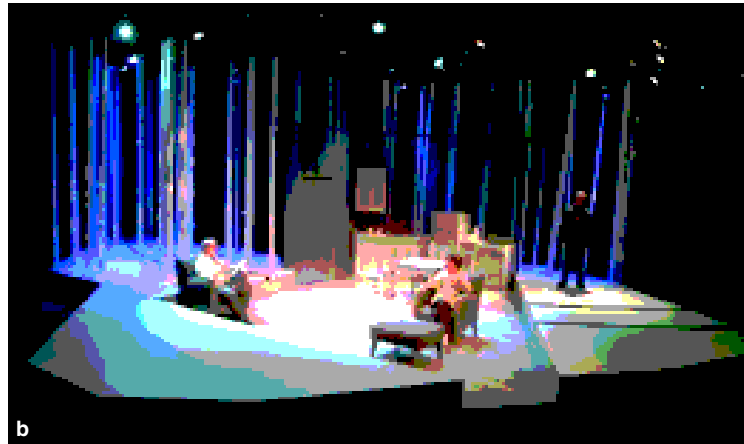
Whether dominated by straight or curved lines, the rhythm of a stage composition eventually becomes a part of the basic movement plan. Likewise, the proportional relationship of forms, which determines the rhythm, forms a balance, resulting in a greater feeling of unity, especially when the rhythm is obviously repetitious (Figure 3-20).

rhythm Patterns of repeated visual movement.

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**3-20 Rhythm**

- a** The circles in this box suggest a rhythm both horizontally and vertically. This can be very similar to what happens in a music score, both aurally and visually.
- b** In *The Retreat from Moscow*, David Centers spaces the trees in the background to create a rhythm that not only surrounds the house but helps provide emphasis on it.



COURTESY DAVID CENTERS

Composition and Interest

In addition to maintaining unity in a stage composition, the designer tries to bring interest and meaning to the setting. Any meaning attached to the scenic form of the composition is, of course, part of the designer's interpretation of the play or an attempt to bring visual substance to the playwright's ideas.

The manner in which a designer achieves balance in composition also accounts for one design being more appealing than another. A mechanical balance of the design forms has unity but still can be monotonous. A better composition varies or stretches the balance into a more exciting arrangement of forms without losing unity.

It is important to realize that knowing the elements and principles of design is not “the answer” but only a start. Only by exploring all possible visual ideas and testing them against the point of the story and the method of its telling can a designer fully succeed.

Creating an exciting setting is desirable, but it is more important to be true to the text of the play. There is always a danger that the conceptual work will overwhelm the play in order to create visual stimuli. The storytelling aspects of the play must take precedence over any design.

The Design Process

4

A design is concerned first with the function it will perform. A scenic idea may warrant pure decoration, as for an awards program, the fanciful background for a ballet, or a realistic environment for a detergent commercial. A costume may be contemporary, everyday clothing, an otherworldly fantastic garment, or a leotard and tights allowing complete freedom of movement. Lighting may realistically establish time of day and season or suggest a surreal world. Sound can amplify an announcer's voice or evoke atmosphere or mood. Whatever the form of design, its most important function is to serve the unfolding story line.

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Function of Scene Design for Drama

The creation of an environment to fulfill a purpose in scene design is linked to the dramatic form it serves. The basic concept of present-day theatre as a union of playwriting and production has brought scenery out of the "pretty background" class into full partnership with the production of a play. The scene designer brings to the production a visual interpretation and expression of the author's aim. The first and most basic question the designer must ask herself is "What is the play about?" Without an answer to this question, the scene designer is unable to do his job: fusing a visual statement and the intent of the play into a single dramatic impression. However, by itself, the visual suggestion of an idea does not separate the design disciplines from another; although they must all work together to create a cohesive world for the play, each area of design (scenery, costume, lighting, sound, and projection design) must approach the play's meaning in its own distinctive way.

Creating a single dramatic impression is difficult and requires great skill, thought, and vision. This alone is a daunting task, but it is made considerably more difficult by the need to meld with the other designers and the director and to consider the actors. Such collaboration is what makes success in the theatre extremely difficult but also rare and exciting.

We can best see the function of scene design by looking at the dramatic form of the play itself. The form of the play should enable the designers to understand the relationship of scenery to the action and the actors, the dominant mood, the theme, and the story in general.

Placing the Action

If scene design is supposed to bring to the play a visual expression of the author's intent, the designer must first examine the *action* of the play and the kind of people involved. Unless completely abstract, every play (or any other storytelling theatrical form) presents a conflict. "Conflict" can be seen simply as: a character wants something, and someone or something is

preventing him from getting it. Out of the conflict comes the action of the play, the force that moves it forward and makes it a living, breathing form. Dramatic action is a combination of physical action, visual movement, dialogue, and characterization. Characterization creates sympathy or repulsion in the audience for the figures involved in the action. The characters either create the conflict or are shaped by the conflict in the ensuing action. Careful analysis of the action and characters can help lead the designer to understand the playwright's intent.

The Environment Scene Design produces more than just a place where events happen. It generates an environment that helps the audience understand the tone and the purpose of the story being told. Sometimes the scene or elements of the scene become a part of the action, such as in the frankly theatrical use of scenery in a musical comedy. The turntable that was frequently used in the original Broadway production of *Les Misérables* provided movement for the scenery that suggested the rich and the poor of this society constantly circling around, unable to escape each other. Alternatively, the scene may recede into the background and be more felt than seen—a witness to the action. Although good design is never neutral, it should not call attention to itself. It will always comment on the people or action of the play.

Characterization Character development bears an important relationship to the environment of the scene. The people in the action react in accordance with, or in opposition to, their surroundings as well as one another. Note how strongly an actor reacts the first time he steps onto the actual set. The “air” is different, and the physical space suddenly takes on more meaning. In reverse, the influence the characters have on scene design can be subtle, obvious, or on occasion symbolic but always of great importance. When the setting is an interior, a study of the inhabitants gives the designer many important clues. The family of Grandpa Vanderhof and his bizarre relatives in Kaufman and Hart's *You Can't Take It with You* certainly contribute a wealth of detail about the kind of house and collection of curios that make up the environment of the play. Alternatively, in *Romeo and Juliet*, the actions of the characters suggest, in a much more poetic way, the nature of the environment.

Time and Place The action of the play usually occurs in a specific *time* and *place*, which are calculated by the author to establish the proper atmosphere for the action. Place, even though it may be limbo, makes a visual impression on the audience. A specific time in the historical past can prepare a state of mind in the audience as much as the absence of a specific time or place can. Although time and place are linked with the overall atmosphere, the connection is sometimes rather loose and may merely suggest a place that connotes the atmosphere inherent in the play.

Establishing Mood

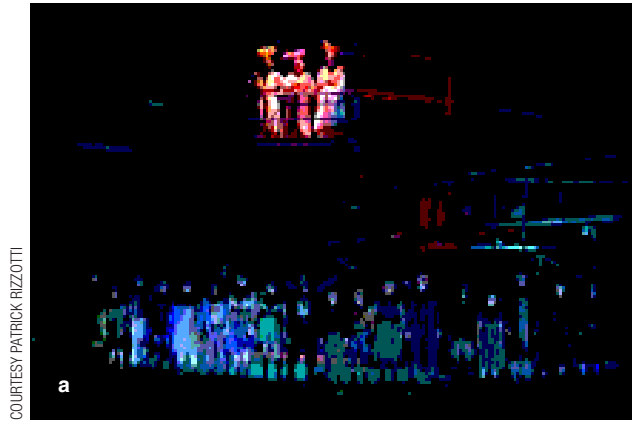
The second function of scene design is to use the visual elements of the environment to establish an expression of the dominant feeling, or *mood*, and its relationship to the action and characters. **Mood** can be described as the quality of a play that, when properly transmitted, creates a state of mind and emotional response in the audience. It can be expressed in such words as *sparkling*, *warm*, *gloomy*, *violent*, *earthy*, *mystic*, and so forth. The terms *tragedy*, *comedy*, and *farce* refer to **genre** but suggest as well a broader idea of atmosphere and mood. Figure 4-1 provides four illustrations of how good design can establish different moods.

Arguably, a play is the dramatization of a mood, a theme, and a story. All three elements are always present in a play, but one may be emphasized over the other two. Hence, plays may primarily dramatize mood, with theme and story in a secondary position; such plays seem to be at the extreme ends of the emotional scale. A tragedy is usually a mood-dominated play, as is a low comedy or farce.

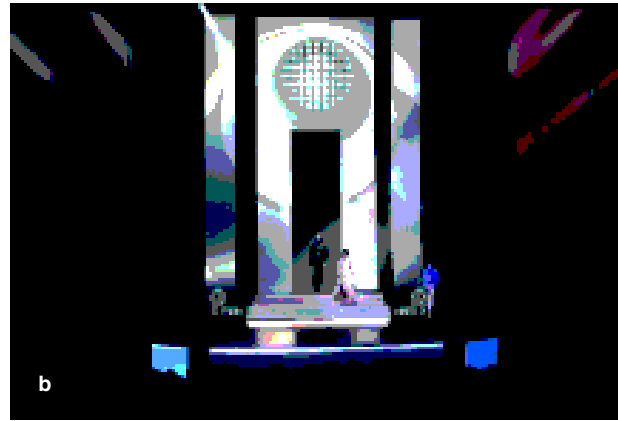
The relationship of mood to action matters in any play. Occasionally, the atmosphere established visually contrasts with the apparent mood of a play. For example, comedy scenes

mood The quality of a play that, when properly transmitted, creates a state of mind or emotional response in the audience.

genre A general category, such as farce, mystery, and tragedy, distinguished by form, style, content, and other characteristics.



COURTESY PATRICK RIZZOTTI



COURTESY ANNE MUNDELL



COURTESY WILLIAM BOLES



COURTESY TRAVIS GEORGE

4-1 Establishing the Atmosphere and Mood In all of the examples here, the playwright provides a great deal of information about the world of the play through the language of the characters without explicit descriptions. The set starts to fill the gaps.

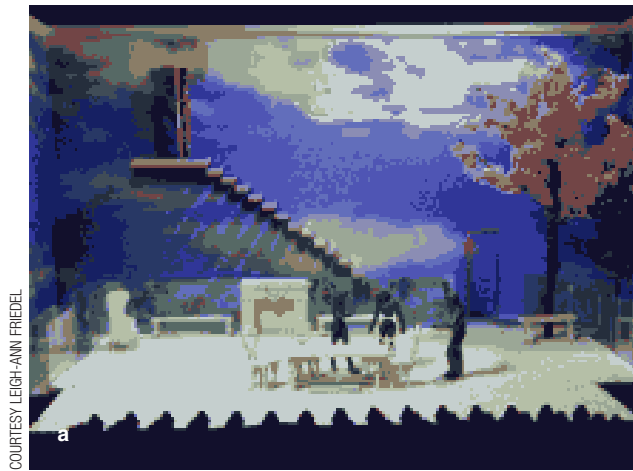
- a** This set for *The Good Person of Szechwan* suggests a world that is mystical (note the gods above) and probably a bit dangerous. Designed by Kevin Rigdon.
- b** Design for *A Midsummer Night's Dream* by Anne Mundell—a fanciful, romantic, and magical world.
- c** Dramatic use of light is seen in this photograph of *Ghosts*, designed by William Boles.
- d** A different mood is seen in this sketch for the setting of *The Turn of the Screw*, designed by Travis George.

are sometimes played against a haunted house, or tragedy against a raucous street carnival. The contrasting moods combine into a single dramatic impression. *The Pillowman* is a great example of a play that is set in a large, cold room, where it appears to be deadly serious. Although the story does deal with serious issues, it is told through much humor. Tragedy frequently begins in a lighter mood that may or may not be expressed in the surroundings. A festive scene may have an air of foreboding that anticipates the approaching tragedy.

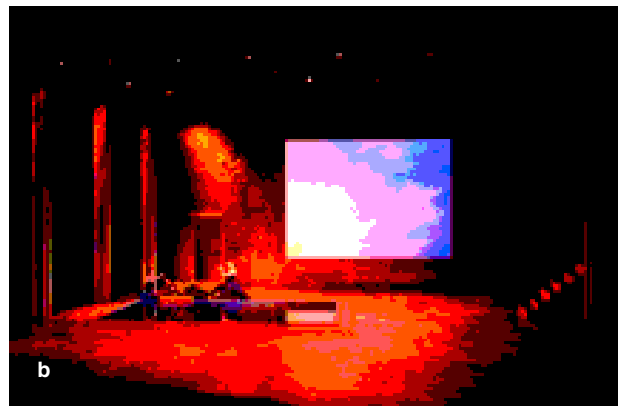
Reinforcing the Theme

Theme is, of course, closely linked with mood as well as with the storytelling part of the dramatic form. *Theme* is defined as the main idea of a play, or the main point that the author wants the audience to realize. The theme in some plays is clear, especially if the author is using the dramatic form as a soapbox or as a satirical commentary. Comedy can carry a serious message to an audience as effectively as other forms of drama do. Because one can convey a thematic statement in so many ways, the collaborative efforts of the artistic team determine the specifics for each production and they can vary drastically (see Figure 4-2).

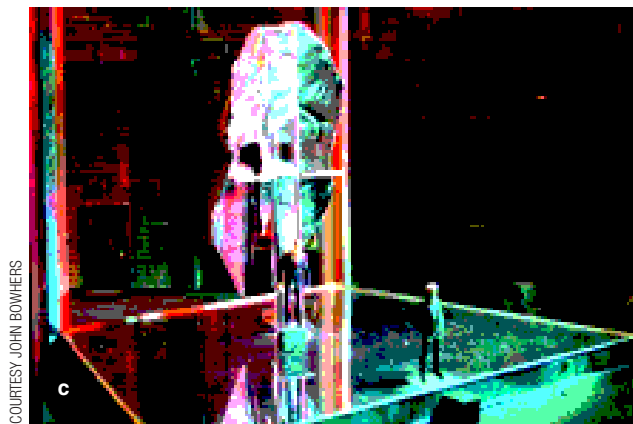
The expression of theme in scenery is not always easily achieved. More often, the theme is treated with subtlety, achieved through elements known only to the designer and his muse.



COURTESY LEIGH-ANN FRIEDEL



COURTESY CHRIS PICKART



COURTESY JOHN BOWHERS



COURTESY JAMES EDWARD BURNS

4-2 Theme Any artistic team brings its own sensibility to a production, so any two or more versions of the same play might differ greatly while expressing the same themes. This is particularly true in a play such as Shakespeare's *Twelfth Night* or *Oedipus*, in which the themes are universal.

- a** This photograph shows a production of *Twelfth Night* that is very fanciful and light while clearly capturing the natural aspects and delicacy of the play. Set designed by Leigh-Ann Friedel.
- b** This approach to *Twelfth Night* is quite different and is quite a bit harsher than the other two and yet still captures a sense of nature, but more controlled by humankind. Set design by Chris Pickart.
- c** *Oedipus* is another commonly produced play that is done in numerous ways. This design by John Bowhers suggests the iconic nature of the title character in a cold, isolated, and austere world.
- d** James Edwards Burns' design for *Oedipus* is even more stark and isolated but establishes the environment in a very different way.

The most obvious example of a theme-oriented play is found in political theatre. Removed from the fictional format of literary theatre, political theatre is free to move to its objective with dramatic and theatrical directness. Much of the work of Václav Havel, Bertolt Brecht, and other eastern European playwrights of the late twentieth century falls into this category.

To determine the theme of the play, designers need to understand the playwright's background as well as the time period in which (and sometimes about which) the play was written. Plays comment on the human condition, which changes over time and in relation to varying social and political ideas, so a strong sense of a given society and its customs is important.

Determining the theme also involves looking beyond the words of the play and examining the overall structure, language, and ideas that are expressed through the characters and the action. In some plays, this does not require much thought; in others, several readings of the play and background reading may be necessary to determine the theme. Close examination of the text is always critical, even when the play seems to be very straightforward.

Staging the Story

Story is a thread of related incidents that are held together and given continuity by dramatic form. Story is probably more important to the theatre than to other art forms. The expression of an idea in the theatre depends on having and holding the audience's attention every moment. If confused, the theatre audience cannot go back and reread a passage for clarification, the way a novel reader can. A clear and exciting story, however, can hold an audience spellbound. Mood can create the atmosphere for a story enabling the storyteller to make a point or suggest themes. A play that is dominated by the dramatization of story is primarily dedicated to telling a compelling tale, whether it be of love, adventure, or intrigue.

When the environment of a story-dominated play is real, what we would call the design problem becomes one of selection of realistic details and forms that place the action and establish the mood. This, more often than not, has already been accomplished by the author through the choice of a realistic location for the action. More important than realistic detail is the manner in which the director fits the action of the play to the stage space, for which the designer provides logical choices. Called **staging**, this involves the placement and movement of actors within and around the physical environment of the set. Successful staging helps ensure the continuous flow of action necessary to telling a good story. The importance of staging cannot be overemphasized; the set designer's input is essential.

staging The arrangement of actors in the environment, creating stage pictures that help to tell the story of the play.

“Designing is directing” Because the physical space of the plan is so vital, the scene designer ultimately makes a large number of staging decisions when creating the ground plan. Often without the designer's realizing it, the plan will suggest (or sometimes even require) certain scenes to be staged in a specific way. This is just the most obvious reason why it is absolutely critical that the scene designer and the director communicate with each other often and clearly.

Every choice that the designer makes in the design, especially the ground plan, both limits and provides opportunities for the director in terms of movement patterns and stage pictures. The decision to use an overstuffed armchair instead of a simpler tall-backed wooden chair, for example, means that the director will not be able to move the chair easily during the course of a scene. However, it might instead allow the director to perch an actor on the arm or the back of the chair or even “bury” an actor in the padding.

Sometimes a director will ask the designer for a “bare stage.” Because this can mean many things, the designer and director must define it clearly. If, for example, a single chair is needed on the bare stage, the specific placement of that chair becomes critical. The direction that the chair faces also becomes significant. If two chairs are used, their relative position is important. The fewer pieces onstage, the more important each becomes.

The responsibility the scene designer has in establishing the physical space makes the importance of collaboration with the director critical when working out the ground plan. Although at times they may seem minor, all these decisions have a direct effect on



CHALLENGE ■ Design Questions

Whatever type of theatrical event a designer may be asked to do, essentially the same questions are appropriate:

1. What is the reason for the event? (commercial, charity function, historical celebration, and so on)
2. What is the atmosphere or mood? (happy, serious, and the like)
3. What is the playwright's intent in writing this play? What is the theme? (How will scenery, costumes, lighting, and sound help convey it?)
4. How and in what type of venue will it be staged? (theatre, stadium, on the street, and so on)
5. What is the style? (entertainment, documentary, pageant, and so forth)

the staging. Consider how different in feeling a love scene might be when staged with two chairs only a foot apart compared to the same scene with the chairs on opposite sides of the stage or that face away from each other.

Design and Other Theatrical Forms

Theme and mood are present in any theatrical form. The high-tech lighting of a rock show imparts an atmospheric theme as it supports and enhances the music. Ballet's decorative background, which sets the locale and the mood of the dance, sometimes gives way to limited scenery or stylized properties, more expressive of theme than anything else. Performance art is often the same. Whatever the theatrical situation, we come back to the question discussed earlier—"What is this play about?" The answer informs the designer how best to proceed.

Working Through the Design Process

Like any other art form, scene design is a personal method of expression. Because every designer approaches the process subjectively and intuitively, setting down universal rules for developing a design idea is impossible. Each designer must develop her own method of reaching the inner reservoir of creative ideas. Although we can make recommendations and point to examples of good design, the evolution of an idea is the designer's individual struggle.

Of course, the design does not find its complete expression until the play becomes a production and the written word becomes dialogue and visible action. Design is the individual expression of artistic imagination, theatrical sense, and technical ingenuity through the visual control of line, color, and form. The design concept, whether subtle or evident, is a visual theme with variations that weave through a complicated setting or series of settings, bringing unity of thought to the whole. Although the designer must be able to articulate the approach that is taken with a production, the audience does not necessarily need to be able to do so. If the designer's approach is consistent with that of the director and the rest of the design team, the ideas will be inherent in the production and will help guide the audience to a fuller understanding of the play and stimulate an intellectual or emotional response. Good design is the result of logical and imaginative thinking and intuition expressed through an idea or a central theme.

But how does one get an idea for a design?

Ideas can come from anywhere. A good designer is always open to moments of inspiration. Some designers carry a notebook; some keep sketch books to capture ideas on paper. Others simply keep new ideas on file in their minds. The trick is to recognize an exciting idea and be open to surprises and varied ways of thinking.

There are many ways that can help a designer find an idea. Gather as many images as possible even though many of them will ultimately not prove useful—at the beginning of the process it is impossible to know what will be needed. The designer should be surrounded with images that are inspiring or music that is part of the play—anything that will help get into "the world" of the play is useful. Exploring these images by drawing them can provide insight as to why they felt connected to the text. Look at the variety of ways in which the images might be used and don't reject anything immediately.

Analysis of the Script, Libretto, or Scenario

The Script Because most parts of a production are based on the written words of the play, the designer logically begins his conceptual work with the study of the play's text through a series of readings. Each subsequent reading of the script likely leads to a better understanding of the play.

This first reading of the play is for its *content*. The designer should react as a member of the audience, avoiding any preconceived image of the scenery other than the playwright's description. (Some designers ignore even that on initial reading.) In this way, a first impression can serve as an overall response that will help explain the feeling and action of the play, the environment that is required, and the kind of conflict that is involved. Writing down one's first impressions of a script is a good idea. Over the course of developing a design, one can easily forget this initial response, and it is impossible to re-create it. Having a record of it can remind a designer of her original reaction to the play.

The atmosphere and the mood of the play can usually be determined from the first reading. The playwright's description often gives us plenty of information. Williams's description of the Wingate home in *The Glass Menagerie*—"one of those vast hivelike conglomerations of cellular living units that flower like warty growths in overcrowded urban centers"—describes the atmosphere with great clarity.

The second, more careful, reading is for the play's *intent*. Designers must read "between the lines" to get a full picture of the tone of the play and the reasons an audience might be intrigued. The language of the play is important. Poetic speech suggests a different kind of world than does everyday vernacular. Consider the life outside of the immediate environment, repeated images, and patterns. The imagery in particular serves as a strong guide to the designer in developing ideas. It may lead to a metaphor for the play that can be quite useful as an approach to a production. A good playwright also provides clues to the degree of reality of the scenic environment. Even the determination of whether the play is set in a public or a private space is informative.

The designer should feel free to mark up the script in any manner that provides useful information. Highlighting specific descriptions, references of the environment, props, characters or even images will help provide a fuller understanding of the play. Many designers write notes in the margins or mark in other ways important speeches or phrases. (See Figure 4-3.)

A certain amount of organization is usually necessary in order to understand a play for design purposes. It might be as simple as a list of the various locales in the play; it could be a graphic of the relationships among the characters in a complex story. (See Figure 4-4.) Determining the structure of the play also helps. As the play tells a story, so does each act and even each scene. Articulating the purpose and idea of each scene can tell the designer a great deal about the structure of the play and help determine patterns. This effort inevitably leads to ideas about the theme. Once a theme or intent has been determined, rereading the play once more allows now-important images and patterns to come to light.

All the elements just discussed help designers use their medium to create the world of the play. Designers typically continue rereading the play throughout the production process.

The Opera Libretto The **libretto** is the text or dialogue of an opera, sung rather than spoken. Like plays, operas vary widely from those that are stilted and void of drama to those that are full of action and are highly theatrical. Because the music contains most of the excitement and atmosphere, the only way to comprehend the full dramatic intensity of an opera is to listen to it. It is the music that provides the emotion of the piece.

libretto The text or dialogue of an opera.

Opera is a "larger than life" performance style; therefore, the designer looks for more than a functional background attempting to find a visual image or metaphor in the music that supports the theme of the piece.

The Ballet Scenario Because ballet is a stylized performance technique relying on movement to tell the story, the scenery is often highly decorative and atmospheric. The *scenario* of a ballet is an outline of the story with an occasional description of the action,

4-3 Script Mark-up This is a page from Shakespeare’s *The Tempest*, Act I, Scene 2. In this example, a highlighter was used to mark any references to locale or specific scenic and props in yellow, character and costumes in orange, lighting in green, and images in pink. As well, there are notes and questions written in the margin. It is important to remember that this is only one way to mark up a script. Every designer has his own method.

ACT I SCENE 2

(Enter Prospero in his magic cloak, with a staff, and Miranda)

1	Miranda	If by your art, my dearest father, you have	
2		Put the wild waters on this sea, ally them	<i>Blasphemy of Gods</i>
3		The sky, it seems, would pour down stinking pitch,	
4		But that the sea, mounting to th' welkin's cheek,	
5		Dashes the fire out. O, I have suffered	<i>Miranda is sympathetic</i>
6	<i>Lighting</i>	With those that I see suffer a brave vessel,	<i>My creature</i>
7		Who had, no doubt, some noble creature in her,	
8		Dashed all to pieces: O, the very did knock	<i>Miranda must have some knowledge of them & what they</i>
9		Against my very heart! Poor souls, they perished	
10		Had I been any god of power, I should	
11		Have sunk the sea within the earth, or ere	
12		It should the good ship so have swallowed and	
13		The freighting souls within her.	
14	Prospero	Be comforted	<i>Prospero appears totally</i>
15		No more amazement. Tell your pious heart	<i>indignification to the sailors & light in contrast to Miranda</i>
	Miranda	Once the day!	
	Prospero	No harm:	
16		I have done nothing but in care of thee,	
17		Of thee, my dear one, thee, my daughter, who,	<i>Miranda knows little of Prospero's past</i>
18		Art ignorant of what thou art, though knowing	
19		Of whence I am, nor that I am more better	
20		Than Prospero, master of a full poor cell,	
21		And thy no greater father.	
22	Miranda	More to know	
		Did never meddle with my thoughts.	
23	Prospero	'Tis time	
		I should inform thee farther. Lend thy hand,	
24		And pluck my magic garment from me. So,	<i>Miranda is in fear</i>
25		Lie there, my art — Wipe thou thine eyes; have comfort.	
26		The careful spectacle of the wreck, which touched	
27		The very virtue of compassion in thee,	
28		I have with such provision in mine art	<i>Prospero has magical control of weather, what else?</i>
29		So safely ordered that there is no soul —	
30		No, not so much perdition as an hair	
31	<i>Sybil</i>	Belid to any creature in the vessel,	
32		Which thou heard'st cry, which then saw'st sink. Sit down,	
33		For thou must now know farther.	
34	Miranda	You have often	
		Begun to tell me what I am, but stopped	<i>Miranda kept ignorant</i>
35		And left me to a boundless inquisition,	
36		Concluding "Say; not yet".	
37	Prospero	The hour's now come.	<i>The moment of truth</i>
		The very minute bids thee open thine ear.	
38		Obey and be attentive. Canst thou remember	<i>what does "cell" really mean?</i>
39		A time before we came unto this cell?	
40		I do not think thou canst, for thou wast not	
41		Out three years old.	
42	Miranda	Certainly, sir, I can.	<i>How Miranda somehow learned about the past? From whom?</i>
	Prospero	By what? By any other house or person?	

COURTESY OF THE AUTHORS

all of which provides minimal information for the designer. However, many classical ballets are based on familiar stories that can be researched for additional background.

As with opera, the ballet designer should listen to the music, which will convey the mood and tempo of the piece, and learn from the choreographer the movement patterns that will be used. Hence, the designer must not only be familiar with the scenario and the music but also rely heavily on the choreographer for information and inspiration.

Determining the Visual Style

Style can be defined as the degree of reality expressed in the writing or literary form of the play, which in turn influences the mode of the production and the form of the scenery and costumes. Because style in the theatre is felt, heard, and seen in so many different ways, it is difficult to pinpoint clearly. Literary, acting, directing, visual styles, and

GYPSY - Act One Scene Breakdown

early 20's to early 30's, various cities throughout the country

Act 1

Sc. 1	"Uncle Jocko's Kiddie Show tacky vaudeville theatre	Seattle	"May We Entertain You"
Sc. 2	"Home Sweet Home" kitchen of a frame house, later that night	Seattle	"Some People"
Sc. 3	A road (in front of the curtain) on the road to Los Angeles cut out of a "fancy touring car"		
Sc. 4	"Don't call us' Los Angeles" Backstage of a vaudeville house	Los Angeles	"Small World"
Sc. 5	"Baby June and Her Newsboys" Typical vaudeville street drop w/newspaper kiosk	Los Angeles/Akron	"Baby June and Her Newsboys"
Sc. 6	"Happy Birthday" Two plaster-cracked hotel rooms	Akron	"Mr. Goldstone, I Love You" "Little Lamb"
Sc. 7	"Table for Two" Section of a gaudy Chinese restaurant	New York	"You'll Never Get Away From Me"
Sc. 8	"Grantiger's Palace" Stage of a good theatre	New York	"Dainty June and her Farmboys"
Sc. 9	Ornately Gothic office with a door center		"If Mama Was Married"
Sc. 10	"Dream of Glory" Theatre alley with steps up to stage door	Buffalo	"All I Need is the Girl"
Sc. 11	"Terminal"	Omaha	"Everything's Comin' Up Roses"

a

	Millicent, 39	Dora	Oliver, 40's	Paula, 19	Ricci	Hattie Loomis	Carlotta, 53	Dan Packard	Kitty Packard, 29	Tina, 25-26	Location	Purpose of Scene
1,1	x	x	x	x	x	x					Jordan's sitting room	Planning the dinner; Oliver's insistence on inviting the Packards; establishes the high level of snobbery and class differences
1,2			x				x	x			Jordan's office	Staid Oliver vs. crass Packard; Oliver's business is failing, Packard's is booming; hints of Oliver's bad health; Carlotta broke
1,3								x	x	x	Kitty's bedroom	Self-important Packard plans to take over Oliver's shipping business; self-indulgent Kitty insists they go to the dinner; establishes Kitty's bad marriage and affair with Dr. Talbot
1,4	x	x	x	x	x	x					Jordan's sitting room	Oliver clearly in bad health; Millicent invites Larry Renault to the dinner; establishes Paula's secret affair with Renault

b

4-4 Organizing Textual Information

- a** This is one place to begin: a list of locations—in this case Act I of *Gypsy* showing the Act and scene number—the location as indicated in the script and the song in each scene. Although more information is provided in the script, this is a good overview. In any multi-locale design, it is always a good idea early on to have a listing of all the different scenic locations.
- b** This chart for Act I of the play *Dinner At Eight* is closer to a "Costume Plot" in that it is a table including the act and scene number, the characters in each scene, the specific location of the scene, and a brief description of the action of the scene—just the first step in analyzing the play.

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period styles unite to form a single production style which, whether subtle or obvious, is ultimately the overall approach to the play.

Production Style and Reality There are many kinds of reality in the theatre including the lifelike copy of nature (*naturalism*), the *fantasy* of dreams, the *make-believe* quality of storytelling, the immediacy of *documentary* or of *improvisational* style, and the performance reality of the *theatrical* style.

The interpretation of a play and the kind of audience response that is desired by the artistic team determines the specific style of a production. For example, a play such as *A Christmas Carol* can be the telling of a very dark and sad story or it can be lighter fare and filled with laughs. A different style of production is suggested if Hamlet is justified in killing Claudius than if he is seen as a petulant, selfish young man or if he is simply crazy. Whatever the style, the consistency and the integrity of the interpretation allow an audience to accept what it sees as the world of the play. This consistency is directly attributable to the collaborative work of the artistic team.

As often as not, production styles are combined. The docudrama style (documentary and literary styles), seen more often in film than in theatre, is used to capture the emotion of an actual occurrence or event. It has the factual reality of a documentary but is partially fiction. The documentary format heightens the sense of reality and holds the audience as the story unfolds.

The inherent danger in categorizing these “styles” is that ultimately it proves limiting creatively. By labeling a play, a designer runs the risk of limiting an approach to its production by making assumptions and not exploring all possibilities. One can easily fall into the trap of looking for elements that help define that particular category. It is best to use any perception of a play’s style as a guide, not an absolute. To be innovative artists, designers must remain open to working outside the “norm” of these categories and allow themselves to look at plays with a fresh eye.

Visual Style and Form The effect of style on form is more easily seen in the physical production than in the performance styles just discussed, although the two are related. Visual styles can be defined similarly, in terms of degrees of reality.

Representational style, for example, is lifelike. The design form is represented in a painting or sculpture rendered as near to its natural form and color as the technical skill of the artist allows. **Nonrepresentational** style is more suggestive of an idea and sometimes ornamental. Because its goal is sensation, the interplay of abstract form and color becomes more important. The designer does not attempt to create a form that bears a specific resemblance to actual objects. Between these two extremes lie as many possibilities as designers care to define. (See Figures 4-5 and 4-6.)

Style in Costume and Lights Costume and lighting designers use various types of *stylization* as well to help express the overall style of a play. Although style manifests itself in different ways in costumes and lights, the audience’s response in both cases is determined in part by what they see as “real.” Because costumes are closest to the actor, the farther away from what the audience recognizes as real, the more stylized it seems to them and generally the more imaginative the desired response. In lighting, the farther from natural light the more “unreal” or “theatrical” the lighting appears to be. Even the visibility of lighting fixtures (at least in a proscenium house) will seem inherently theatrical.

It is, of course, vital that all of the designers work *collaboratively* to use the same style in any given production. This may mean using the same initial imagery or metaphor or developing their designs from the same initial ideas. All aspects of the designs may well be discussed since it is rare that a decision from one designer doesn’t affect another in some way, however minor. The use, for example, of strong angular lines in the set might well need to be repeated in the costumes and reinforced by the lighting. This should be true as well in working with the sound and projection designers.

representational A form of art that directly relates to real or lifelike objects.

nonrepresentational A form of art that is abstract and ornamental, not based on real-life objects and shapes.

PHOTO COURTESY OF DONNA BARRY, UTAH STATE UNIVERSITY



a



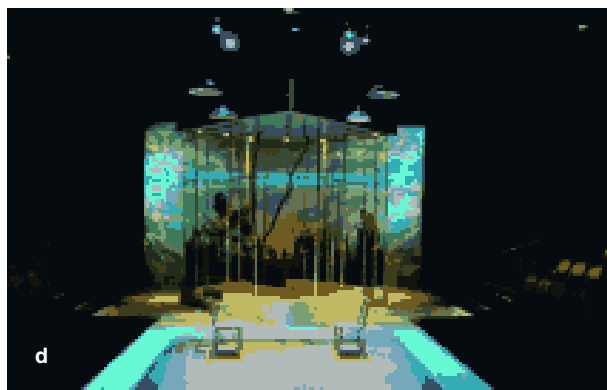
b

PHOTO BY MARK LYONS

COURTESY PETER COOK, OAM, PH.D.



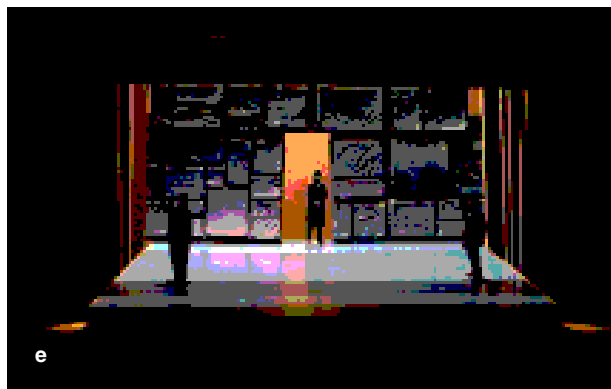
c



d

COURTESY ANNE MUNDELL

COURTESY MICHAEL OLICH



e



f

COURTESY NARELLE SISSONS

4-5 Styles of Scenery The designs shown here are various approaches to creating an environment that is appropriate for a specific production of a play showing a wide range of “styles.” Only the most obvious of categorizations are indicated here.

- a Dennis Hassan’s design for *Blithe Spirit*, a fully detailed realistic interior.
- b *The Diviners*, designed by Mark Halpin. This design is more about mood and atmosphere, created by a series of platforms that allow for multiple locations and isolation.
- c *Trojan War*, designed by Peter Cook, OAM, PhD, creates a stylized world that, in this case, is a series of almost real pieces that have been broken apart to allow more air.
- d Anne Mundell’s design for *Precious Little*, creating two distinct areas.
- e *The Chosen*, designed by Michael Olich—a very heavy, dark, and troubled world.
- f Narelle Sissons’ design for *Death of a Salesman* is a completely different look at a classic play. The Loman family is trapped in their own series of boxes.



COURTESY PAM KNAUERT LAVARWAY

4-5 Styles of Scenery (continued)

g *Lady Be Good*, an old-fashioned musical done in a style that could be described as “musical comedy realism.” Designed by Pam Knauert Lavarway.

h Chris Pickart’s fantasy design for *The Little Prince*.



COURTESY CHRIS PICKART



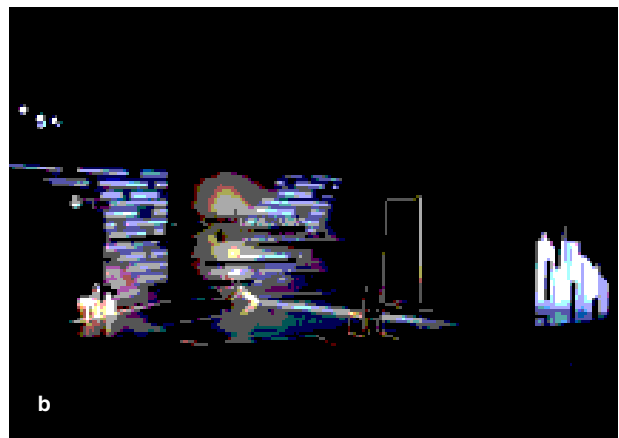
COURTESY KEVIN RIGDON

4-6 Stylization in a Production

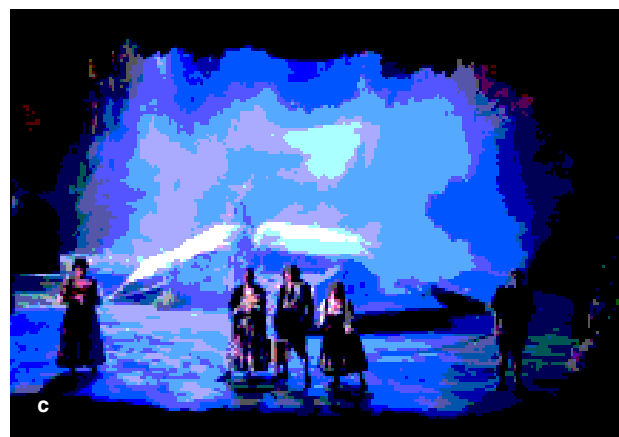
a This production of *Waiting for Godot* presents a stark, lonely and, from moment shown, despairing world which is created by the little scenery in addition to the handling of the lighting and the clothes. The director takes this even further by staging the moment to increase the audience’s awareness of how empty this world is. The focus is clearly on the seated character, who holds his head in his hands. Directed by Sir Peter Hall; scenery, Kevin Rigdon; costumes, Kevin and Trish Rigdon.

b *Live in the Wake*, designed by Gaeun Kim, showing the use of light creating the same strong horizontals as the set.

c Pam Knauert Lavarway’s design for *Into the Woods* provides a strong sense of magic through the combination of scenery, costumes, and light.



COURTESY GAEUN KIM



COURTESY PAM KNAUERT LAVARWAY

Developing the Design Approach

design approach The idea, or the visual theme, of design.

A **design approach** is the *idea*, or the *visual theme*, of design. It is the product of creative thinking, visual imagination, and collaboration with the director. As the “glue” that holds all the visual elements together, the approach provides *control* and *direction* toward a final design. The clearer and stronger the design idea, the easier every subsequent design decision becomes.

The approach to the production can begin with ideas from any member of the artistic team, although most often the director makes an initial statement. If the director is firm

in her thinking, the parameters of the approach are established immediately. There are times, however, when the director has not decided the specifics and wants to discuss the play with the artistic team. Every director is different, and designers must learn how to work with a variety of directors. In any event, the designer should approach the first discussion with ideas about the play. If they lie outside the parameters of the director's ideas, they need not be brought into the discussion.

It is also true that every designer works differently and approaches a project in his own unique way. Some designers have a particular manner of working; others work differently on every project. And because designers, like any artist, tend to grow throughout their career, most designers change their approach to work as they mature through the years.

The time spent discussing the production can and should be a very exciting and stimulating period in the development of a design. Every decision that a designer makes will have ramifications for every other member of the artistic team. If this process works, the result is an amalgam of many ideas not attributable to any one person—this is the true meaning of collaboration.

In this collaboration, many concerns arise: Is an historical style needed? How should we achieve it? How does the physical form of the stage limit or create alternatives? Once such basic ideas are addressed, the designer can begin to form the design concept, meeting often with the director and others as it develops.

Concept and Research Because research goes beyond the narrowness of finding visual information about a time period, the designer should be open-minded about where to look. Certainly, books on the period and the Internet are a good start, but one never knows where the inspiration for a design might lie. Potential outlets, such as craft magazines, sculpture, even gazing out a window at a sunset, should not be overlooked. Many designers maintain a file of images that they find exciting or that simply provide information about a topic that might be useful sometime. Such a file provides a handy and immediate resource when one is beginning a design.

Research for a design can be done in many ways. More often than not, the initial research that a designer does is based on an emotional response to the play rather than plot or ideas. If nothing else, this provides a personal approach to the work that helps keep each design unique. A smart designer will look at anything and everything from a variety of sources that might even remotely be of use. Classical artists, contemporary work, installations, craft work, and photography are all fodder for inspiration.

Although historical style used on the stage becomes part of the design approach, unless the production is a “museum piece” striving for absolute historical accuracy, it should be used to enhance the design ideas and not as the final word. For example, in Arthur Miller's *The Crucible*, it is the rigidity of the seventeenth century and how it relates to society that is of interest, not the specifics of the buildings.

Research is a critical step in the process of any design and cannot be overemphasized. Familiarity with a period “look” or historical background enables the designer to make decisions either accurate in form or as a way to suggest a period. Even a play with a contemporary setting merits research, if only for inspiration. The more fully a designer understands a period, the more easily he can draw on that information—and this is the real trick—to create an appropriate design.

Style and Theatre Forms The proscenium theatre depends to a certain extent on aesthetic distance and an objective relationship with its audience. In contrast, thrust and arena stages more regularly call on the imagination of the audience in different ways. Invisible walls and doors, different locales indicated by levels on the floor, hanging fragments overhead, and an emphasis on the floor are common theatrical conventions, establishing an abstract degree of reality the audience is asked to accept (Figures 4-7 and 4-8). Because thrust and arena audiences are physically closer to the action, furniture

4-7 Designing for an Arena Stage

Scott C. Neale's sketch for a production of *Conversations with an Executioner* in a small arena space. Note the use of the walls behind the audience to complete the environment of the room.

COURTESY SCOTT C. NEALE

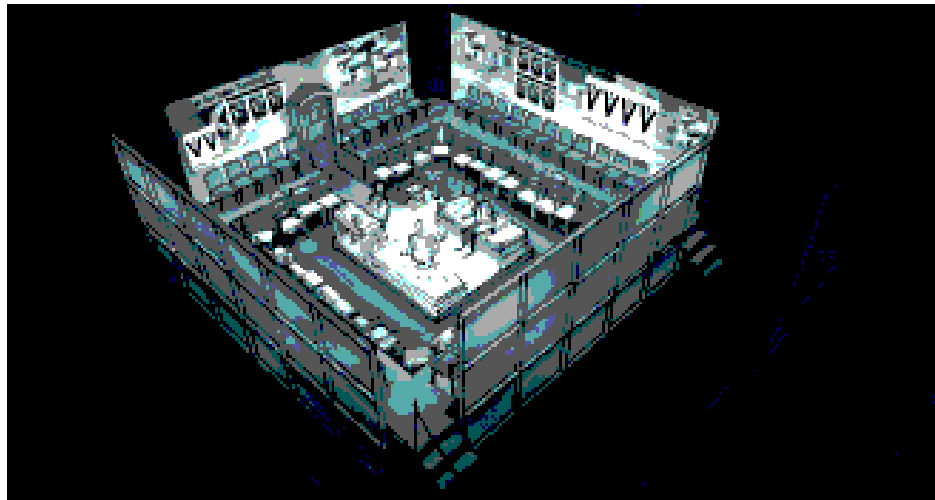
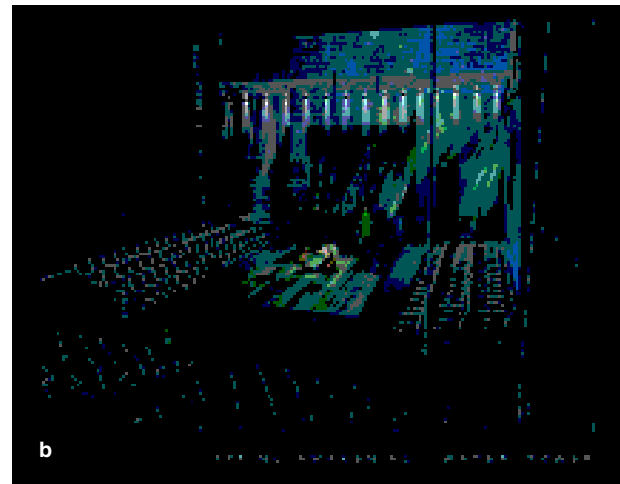


PHOTO COURTESY FRANK LUDWIG

a



COURTESY CHRIS PICKART

b

4-8 Designing for a Thrust Stage The thrust and arena stages often force the designer into the theatrical conventions or stylization inherent in the scale and sightlines of the stages' physical forms.

a *Much Ado About Nothing*, designed by Frank Ludwig.

b The musical *Spring Awakening* done on a thrust, designed by Chris Pickart.

site-specific Theatre produced using a found space that is uniquely perfect for a particular production.

and hand properties are often more real, and the actors' costumes can be more fully detailed, allowing the audience to feel they are in the scene and a part of the action. There is an increased subjective or intimate alliance of audience and performer when the proscenium wall is removed, although the reality remains theatrical.

Site-specific and Devised Pieces Not all theatre productions are presented in a formal theatre setting. More theatres are experimenting with what is referred to as **site-specific** theatre, in which the physical space in which the play takes place is determined by a found space that will support the telling of the story. Some theatres are dedicated to this. The spaces chosen can be everything from a bridge to a hill in a park to a swimming pool that is no longer used. (See Figure 4-9.)

Because the space is unique to a given production, the audience gets a sense of the fictive world that is created once they enter the space. This can prove to be both exciting and challenging for designer and audience. Often, the designer will have to create the space for the audience as part of the design for the production; it may actually stand throughout the piece. But it is always a unique experience. One of the best recent examples is the production of *Sleep No More*, produced by the British company Punchdrunk. The production has taken over an abandoned warehouse and created a



COURTESY KELLAN ANDERSON



COURTESY KELLAN ANDERSON

4-9 Site-Specific Design Kellan Anderson designed this scene design for a new play entitled *Fat Beckett*, a feminist twist of *Waiting for Godot*, for the Quantum Theatre, which does only site-specific theatre. The production required a space that could not be particularized, that was purposely vague. An abandoned, dilapidated schoolhouse seemed the perfect choice.

1930's hotel through which the audience wanders, following actors, exploring the various spaces and picking up parts of the story along the way.

Acting and Literary Styles Theatre in all its forms combines the literary and acting styles with those of the scenery, costumes, lighting, sound, and projection. All elements must together provide some degree of unity in order to create a strong dramatic form.

Scene design, strangely enough, can on occasion contrast the acting style without breaking the unity of the production. Stylized scenery does not necessarily call for stylized acting. The reverse, however, is not true. If the acting is stylized, the scenery must be, too. The important thing is that the audience will accept any degree of departure from the real in scenery as long as it is consistent, has integrity, and is in good taste.

Working with the Director/Design Meetings As stated earlier, designers need to communicate closely and frequently with the director. Some directors approach the process with a hands-off, “solve-it-yourself” attitude; others provide a “this-is-exactly-what-I-want” directive. A more equally balanced collaboration is, naturally, ideal. One-sided domination can lead to frustration and lack of creative fulfillment. The most successful and unified productions usually result from mutual respect and open-mindedness on the part of both the designer and the director.

The beginning of the design process is the most important, creative, and freeing time in the design. At no other time is it possible to explore so many completely different ideas in such a variety of ways. The longer a designer can stay in this place (without getting behind schedule), the more ideas are likely to be explored.

The collaboration, of course, begins with talking, which is done at a series of design meetings. Initial discussions should include all members of the artistic team (the director and the scenic, costume, lighting, sound, and projection designers). Each member of this team is expected to have at least a general understanding of the play for the first meeting. Most designers and many directors bring pieces of research to the table, even at the first meeting. This might include paintings to suggest a design style or color, images that the designer finds exciting in relation to the play, or anything else that might lead the team toward a production idea. It is not unusual for a designer to ask for clarification if the play is complex. Images, the nature of the play, and the general atmosphere (colors, style, staging, and directorial concept) desired for this production will probably be discussed. Some agreement may be reached, or further exploration may be needed. Because words have a way of triggering different images for each individual, the designer must put visual impressions on paper early on in order to really begin communicating.

Under the best of circumstances, the team will visit the venue for the production. Even if they are familiar with the space, walking around the empty stage and tossing around ideas about the play can be immensely helpful. Imagining the play in the space can help stir creative juices.

After reaching a mutual understanding with the director and other designers on theme, production style, and general interpretation of the play, the designer returns to the script for another reading. She must pay close attention to the physical requirements of the plot structure and any changes of locale. Then she needs to examine the action and staging requirements. The designer must determine the number of people in a scene, the types of entrances and exits, specific references in the dialogue to the scene, action hidden from one actor but visible to the audience, and so on—all in relation to the discussion with the production team and leading to the development of the basic idea and scheme of production. This often requires another reading of the script.

At this point, the designer should determine how she will organize all the information for the production. Either a series of files or a production notebook works well. By having notes from all meetings (including emails and phone calls) and all research and sketches done for the production at hand, the designer can quickly and efficiently deal with any questions that might arise about previous discussions.

At the second meeting, preliminary designs will be shown and discussed. Rough sketches, idea sketches, preliminary ground plans, and small-scale models—any of these can be shown; in part it depends on the working style of the artistic team and the individual designer. Certainly more research based on the initial discussion will have been done. If this is the first time the designer and the director have worked together, a certain amount of time discovering a “common language” or way to communicate with each other may be necessary. The director, for example, may ask for three different versions of a design or may want a particular kind of research. In any case, the designer should oblige, in the hope that this will engender discussion and lead to new ideas to develop what is already on the table.

It is through this exploration of ideas that the production style will be discovered—probably the most important part of the designer/director collaboration, and certainly the most difficult. This may happen over a short period or over several months. The number of meetings needed and the number of versions of a design vary with every production.

Each meeting should push the designer and the design a bit further; this process continues until all are satisfied with the result. This is not to say that the design process ends once the director agrees to a sketch (or a model). Throughout the build and rehearsal process, changes are likely. But once the ideas of the production are set, such changes should be relatively minor. The point is that if the ideas are clear, all the hundreds of design decisions that must be made will be easier.

During production, the director is the only one with an overall view and, therefore, must be responsible for coordinating the various styles as the show is put together. A good stage manager can be of immense assistance in keeping lines of communication open at all times. This is necessary to prevent surprises at the end of the process when it is too late to change much. An experienced designer soon learns to not take anything for granted and makes frequent checks with the director and other designers.

Rereading the Play, Again

After initial designs are prepared, the designer should look at the script again, rethinking the play with the current design in mind. Often this rereading points out specific problems with the design and perhaps suggests better answers to questions about staging or the “look” of the production. Further readings might prove necessary during the design process.



WORKING PROFESSIONALS ■ Scott Bradley: Freelance Regional Theatre Designer

Scott Bradley makes his living designing for regional theatre—not an easy task. And he has done this all over the country. He began to study set design as an undergraduate but has been involved in the arts since he was quite young. At fifteen, while studying piano, he went to an international arts conference in Switzerland, where he saw a sign for a sumi-e brush painting class, so he signed up for it. The teacher convinced him to study at the University of Illinois in Champaign–Urbana, where he began his studies in design.

After his undergraduate years, Scott moved on to Yale, which afforded him his first Broadway production, *Joe Turner's Come and Gone*. This was not his first professional design, however; that was *Private Lives* at GEVA, which Scott describes as “disastrous.” “They called me at the last minute, and I was nervous because it was my first show. I wanted it to be spectacular, innovative, and it was overdesigned. This is a play that demands doors, and we chose to have none. But there are reasons for things . . . what better place to learn about this than real life.”

Having worked constantly in most of the top regional theatres in recent years, Scott states: “The biggest challenge working in regional theatre is that they are all different. You can group them, but they are equally talented in the long run. It is really a matter of the whole group making an impression.” Of course, there is considerably less money to work with than in the past, which has affected all aspects of production.

One of the differences Scott sees between designing on Broadway and designing for regional theatre is that things are allowed to evolve a bit more in the regions. On Broadway, because of larger financial risk, everything has to be ready to go before load-in; more attention is paid to preproduction. Yet, partly because of ticket prices, some regional theatres rival Broadway quality, and it is what audiences have come to expect. One result of the financial crunch is that more regional theatres are sharing productions. “Moving a production from one space to another requires more planning ahead. You try to ask for minimal rebuilding to save time and money.” When designing a three-city tour of the play *Fences*, he kept it as efficient as possible because it was all planned in advance. His production of *The Notebooks of Leonardo da Vinci* was not meant to tour—but has done so for about ten years. “It was built out of stock flats that they were going to throw away. They were loaded on the truck and needed to be fixed when they arrived—an unexpected expense.” So you have to be ready for anything.

Scott often gets hired with plenty of advance notice, averaging, he says, about three months for the design process. The process starts, of course, with reading the play, followed by a great deal of drawing. “Sometimes even without research I start to draw, working with spatial relationships, perhaps not even having visited the theatre yet. One extreme—I was asked to design *Gem of the Ocean* at Arena Stage in D.C. and assumed it would be in the Kreeger [proscenium house] and that everything would be very real. At the first meeting,

I discovered it was to be in their arena space, so everything went out the door except for my ideas. Rather than take a literal, naturalistic bent, we investigated going into the depths of the slave ship. It was much more metaphoric, which I think is what that play needs.”

Research is important to Scott, but he prefers to do little until the first discussion with the director. In preparing for that first meeting, Scott reads the play several times, making notes of prospective issues, to make sure he knows the play inside and out. At that first meeting, “I want to hear what they have to say about the play. What I hear from the director will trigger what I look at in the library. Maybe they don’t want to do it the way I am thinking, but I won’t even let that be known at the first meeting.” The bulk of the research is done after this discussion. “I learn in the library. There is great value in looking at books. Not to disregard the Internet, but nothing can replace leafing through real pages of a book and seeing a multiplicity of images and sources overlapping.”

There is little concern about the limitations during the initial phases of the design process. “I approach a show with a smaller budget no differently at all. I can spit it out, and they tell me if they can do it or not. I try not to take that [budget restraints] into consideration at all in the beginning.”

Once an approach is determined, Scott sends a series of idea sketches to provide the director with options. He likes lots of rough sketches at the beginning of a project when ideas are still being explored. Once something is agreed on, he moves into building a model. He typically works in ¼-inch scale simply because it is more convenient when traveling. “Sometimes it’s an ⅛-inch model if I only have a day trip and want to work on it up to the last minute. I’ll take it with me and work on it on the plane. I have to encourage directors to stick their head right into the model to get a real sense of the design, so it doesn’t seem like they are looking at the design from twelve blocks away.” The end of the design process results in a ¼-inch color model. It is “the way I was trained. It’s the best way for me to confirm my proposal about something.”

Although it is more comfortable and easier to work with a familiar team, Scott welcomes working with new groups. In approaching that kind of situation, he says it is important to listen more. “I don’t know them yet and want to hear what they have to say and let them know my perspective.” He particularly likes the collaborative abilities of directors; it is what compels him to want to work with them again. In keeping with this, Scott notes that, budgetary concerns aside, “theatres realize the payoff of bringing everybody together for the first time—even if they have worked together before. There is always a big opportunity when everyone is in the same room. You have a better conversation that way.”

The way that Scott works with the shops is similar. There is a certain amount of discussion with shops that is necessary. “I don’t care if they change something, as long as it doesn’t impede the integrity of the design and as long as we have a discussion about

(continued)



WORKING PROFESSIONALS (CONT.)

the best way to go about it. If it makes a difference aesthetically, they had better call me. If I arrive and it's not my picture up there, I deal with it slowly and by the minute. As soon as I recognize it, I am on it." Because Broadway theatres don't have their own shops, the designs have to be bid out. "Sometimes these shops are used to doing industrial, so detail is not their forte. They sometimes overlook things and don't call me to tell me they need to alter something." This indicates the importance of establishing a positive relationship with the shop. "There is a tendency not to check things, simple things. I go back and say, 'Look at my drawings.'"

There are also long conversations with the scenic artist, and sometimes Scott will also paint with her or him. (This is true only for regional theatre; union rules don't allow this for Broadway productions.) But he sees the trend toward more image manipulation

being done on computer now with applications such as Photoshop. Fewer and fewer designers are able to paint. "This is a growing trend that makes me more desirable, makes me unique."

In getting jobs, Scott indicates that it is different in every case. Scott most often gets hired by the artistic director who is also directing the play. "Usually they have seen my work or have worked with me before." But, he adds: "Even after you have a foothold in the industry and enough contacts in some big cities, the important thing is to keep putting yourself out there. I still send my résumé out. Have a website."

Personal contact is critical. Today, people are less inclined to do it that way—everyone is used to instant response to email. It is hard work to get an interview, but it is necessary. Even a phone call is better than an email.

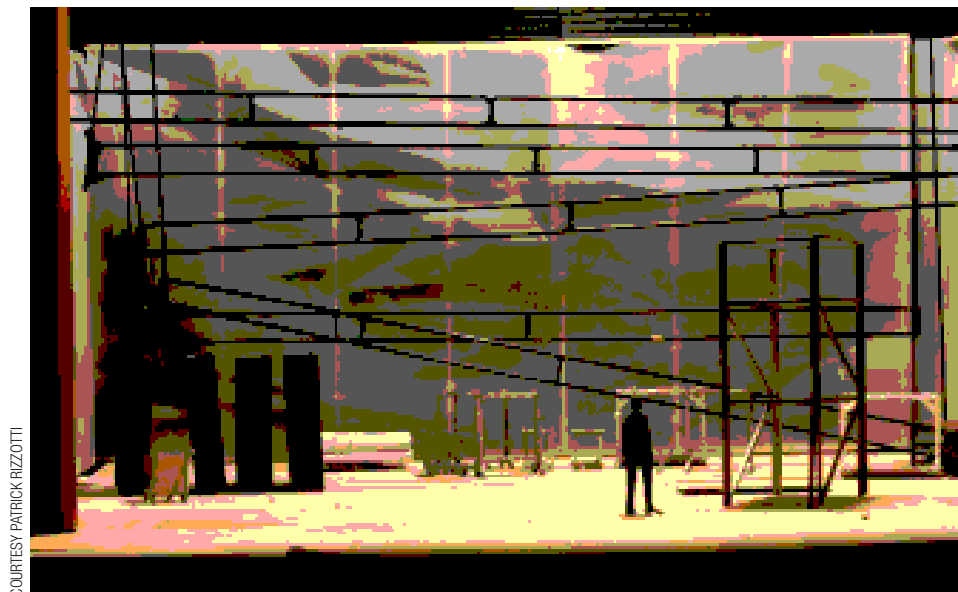
devised piece The way in which the story will be told, is discovered through the rehearsal process rather than from a written text. This process involves all members of the company—director, actors, and designers.

Devised Pieces

The above discussion about the design process is one way of creating theatre and probably the most common one. But it is by no means the only way of doing so. As with any creative discipline, there are an infinite number of ways to work through a design with a director. A **devised piece** is a form of theatre in which there is no written script at the start of the process. Although there may be a general storyline, the manner in which the story is ultimately told and the lines that the actors use are developed during the rehearsal process.

What this means for designers is a different use of their time. With devised theatre, it is important that the designers be present at rehearsals with all of the actors because they are as much a part of the creation of the script as anyone else. Rather than develop a set of designs for a specific direction, a series of potential ideas is explored, often daily, with the understanding that nothing will be set in stone until the last possible moment. Ideas are welcome from any member of the company. (See Figure 4-10.)

4-10 Devised Theatre Patrick Rizotti's design for *The Good Person of Szechwan* was created over a long period during which the designers were in constant contact with the director and actors. Numerous versions of the design were developed, changed, and then re-thought, and the company made more and more discoveries during the rehearsal process.



COURTESY PATRICK RIZOTTI

Planning the Scheme of Production

When a play calls for more than one setting, the designer needs to consider how the different sets will move. Assuming that they happen in view of the audience, the movement patterns become a major aspect of the design. Figure 4-11 shows the use of a turntable which is one way to move from scene to scene. (Chapter 10 discusses the various methods of handling scenery, the most obvious of which are wagons and turntables.) Here we are concerned with how the movement fits into the overall design scheme. Sophisticated audiences are used to all kinds of theatre magic, but they are not immune to the subtle responses that can be aroused by movement. The lateral movement of a treadmill that brings scenery onstage suggests layers; a turntable suggests connection and isolation. The planning of this movement may well be determined by the available mechanics and the amount of backstage area of the stage itself. Flying scenery is the easiest and cheapest to rig, but if there are not enough lines for what is designed, other methods of scenery delivery will have to be used. In any case, these concerns should be part of the mix early in the design process.

Unit Setting Many plays are written as a series of scenes in a wide variety of locations. Sometimes the best solution is to create an overall and perhaps more conceptual setting that will work generally for the entire play. This is called a **unit setting**. While major elements of scenery remain onstage, other pieces will be added or taken away to help establish a different locale. A unit setting can be used as a means of simplifying scene changes (Figure 4-12).

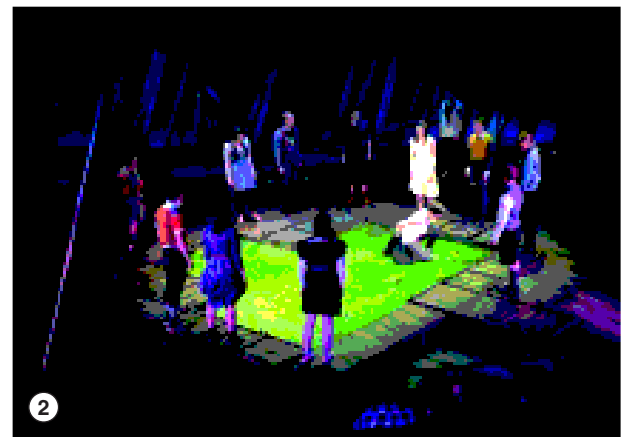
unit setting A setting based on the retention or the reuse of certain elements of scenery for more than one scene.

Projected Scenery Projections as scenery have become more and more prominent in recent years and more scenic designers are working with projection designers to create the kind of world that is needed for a production. This kind of collaborative work can prove



PHOTOS BY MARK LYONS

4-11 Using a Turntable In this design for *The Wild Party*, the designer Mark Halpin uses a turntable to move quickly from scene to scene. This method can be very tricky as often the back sides of other sets can be visible. Careful planning is a must.



4-12 The Unit Set

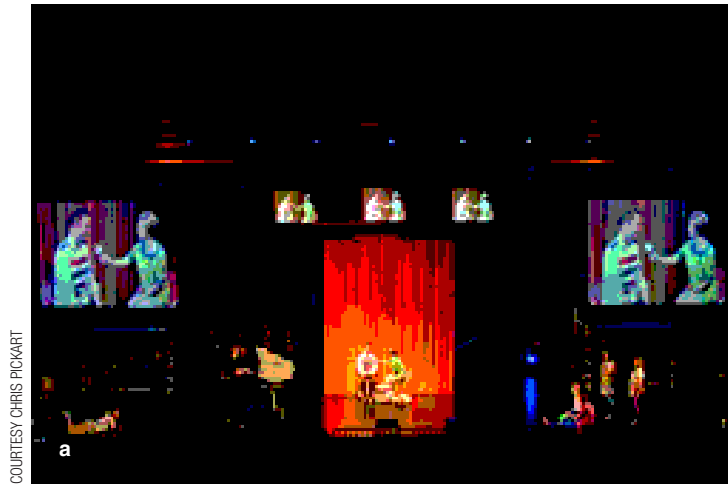
- a For *The Buddy Holly Story*, Howard Jones has designed a series of levels and a background that provides a sense of the world of the play and yet can be altered, mostly in the center to achieve specific locations.
- b For *Spring Awakening*, William Boles uses a wooden planked floor that opens up for the exterior scenes.

very exciting and requires a great deal of clever thinking on the part of both designers. In this situation, part of the job of the scenic designer is to help create appropriate surfaces on which to project the necessary images (see Figure 4-13).

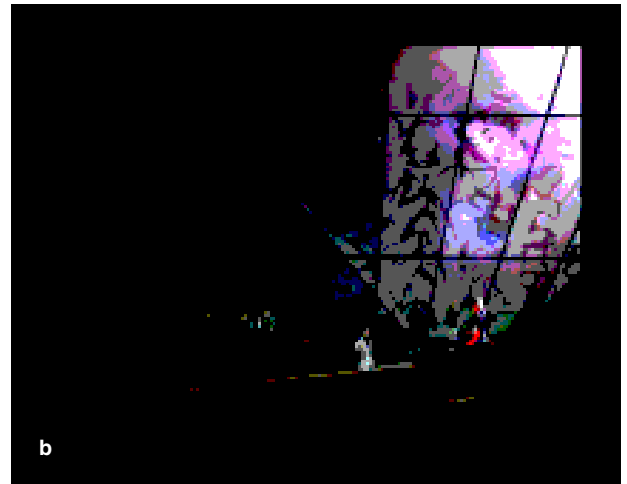
Chapter 12 discusses Projection Design in detail.

Visual Presentation of the Design Idea

It is not enough to express ideas to the members of the artistic and production teams verbally; visual communication is more specific and leaves less room for confusion. Visual presentation is the method in which designers share their ideas and is less ambiguous



COURTESY CHRIS PICKART



COURTESY HANA SOOYEON KIM



PHOTO COURTESY HELEN JUN

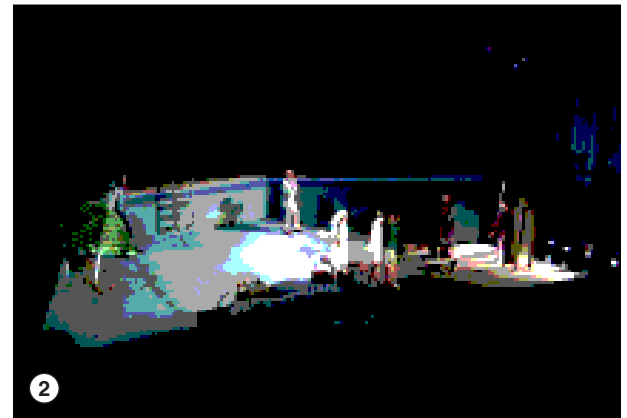


PHOTO COURTESY HELEN JUN

4-13 Scenery and Projections

- a** This production of *Tommy*, designed by Chris Pickart, uses live feed and a series of monitors, both large and small. The point was to comment on the world's obsession with fame. Directed by Casey Sams; costumes, Emily Strickland; lighting, Kenton Yeager.
- b** Hana Sooyeon Kim clearly designed *36 Views* with projections in mind to help establish the different locations of the play.
- c** For *Suddenly Last Summer*, Helen Jun created an abandoned swimming pool that had enough flat surfaces to clearly allow video to be projected on the walls (shown with and without the video).

than words. The designer will, at varying points in the production process, present some combination of color sketches, ground plans, and models. The importance placed on each form of presentation can vary with the director (some will be able to understand only models, others like to see sketches, and so on), the particular skills of the designer, and perhaps the type of theatre company or the scale of production. This is when the personality of the designer starts to show. The initial presentation of an idea might be done through a collage expressing only a feeling of the play, a small-scale model to indicate the broad shapes used in the design, or a series of rough sketches. Virtually anything the designer thinks will provide information about his ideas and artistic vision is fair game. Designers should play to their strengths but be prepared to present their work in any way or ways that best communicate the design ideas.

It is wise never to settle for the first idea. There is no way to know if it is the best one.

Roughs

The designer's first ideas of a design may be substantially revised or rejected, and young designers may find this difficult. And although the first impression may be fine, further exploration is always smart. Keep an open mind, free of preconceptions, and don't become

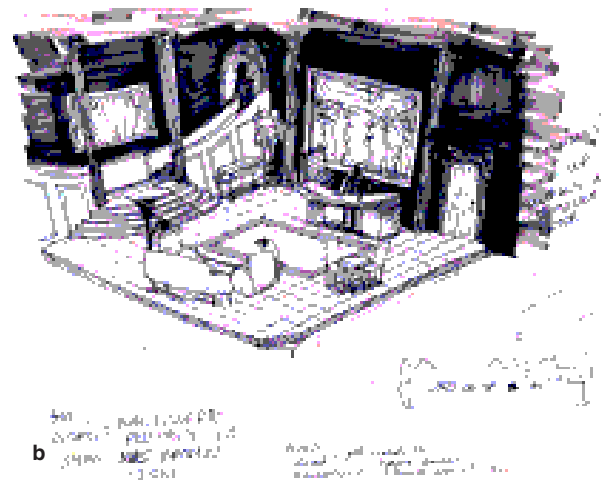
too attached to one idea. Rethinking initial ideas will at the very least improve the clarity of the visual statement and potentially lead to a more substantial and provocative design—or, perhaps, the discovery that the idea simply won't work. This is also the time to explore the extremes of ideas and make truly bold choices. It is always possible to back off an idea. A second or third reading of the script encourages different thinking about the story, especially after discussions with the director, when some parameters should have been established. It is at this stage that the designer should start to meld her ideas with those of the director.

These preliminary studies usually consist of rough, or “thumbnail,” sketches, which can be freehand, explorations with a rough model, or a SketchUp drawing on the computer and rough ground plans (Figure 4-14). After more consultation with the director, the tentative ideas of the designer are ready to be expanded into a more complete form

COURTESY JOHN BOWHERS



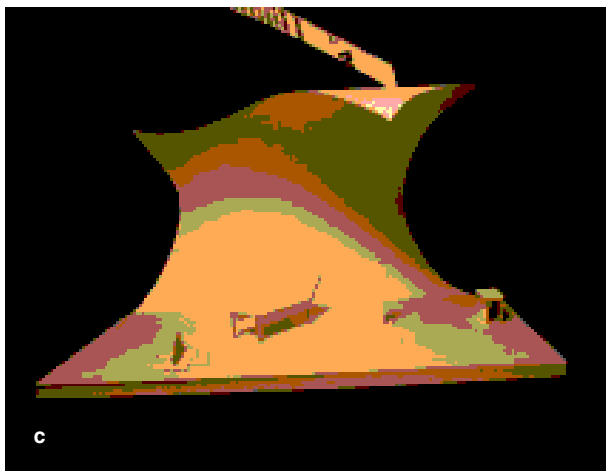
a



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COURTESY LEIGH-ANN FRIEDEL

COURTESY SARAH MARTIN



c



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COURTESY JON SAVAGE

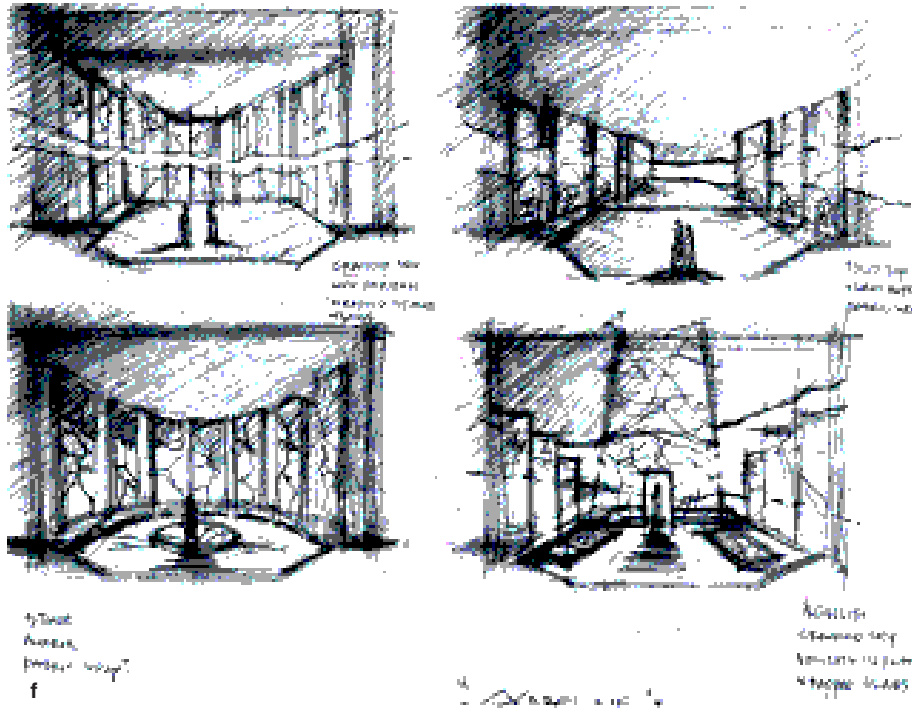
4-14 Rough Sketches Every designer does rough sketches differently and often with different goals. Some are meant to explore an idea, others to look at quality of light and space. Proportion, scale, and mood can be determined in part by rough sketches. Not all rough sketches are meant for the director's eyes—some are only for the designer's use. Shown here are a variety of styles and uses for rough sketches.

- a *Indians*, designed by John Bowhers.
- b *Hot I Baltimore*, designed by Leigh-Ann Friedel.
- c *The Seagull*, designed by Sarah Martin (albeit a model instead of a pencil sketch).
- d *The Magic Flute*, designed by Jon Savage.
- e *Cooking with Elisa*, designed by Scott C. Neale.



e

COURTESY SCOTT C. NEALE



4-14 Rough Sketches (continued)

f *Cymbeline*, designed by Michael C. Smith.

COURTESY MICHAEL C. SMITH

of presentation. These first sketches are visual ideas that will be developed in detail later and should be kept for later reference. It is not uncommon to explore a series of designs only to return to one's initial ideas. The rough sketch can be done relatively quickly, so less time and energy (and soul) are invested in a single drawing. The designer can more easily accept the rejection of a sketched design if he remembers that it represents no more than an idea still to be developed.

Some designers use a “mood sketch” to study the atmosphere of a scene. By working off a dark or black background, such as gray or black velour paper, they can easily reveal the scenic forms in an atmospheric light.

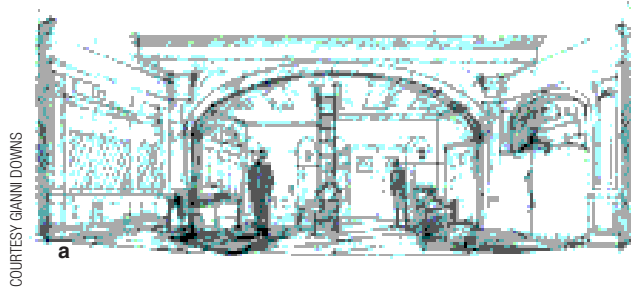
The Sketch

Once the broad sense of the design is agreed on based on the rough sketches, the designer can start to develop his ideas more fully. These sketches reveal increased detail and atmosphere. A model is also extremely effective at this point. A series of sketches can be made to show changes in lighting, scenery, and composition of the actors. Designers who are more comfortable with the computer will use applications like SketchUp, Adobe Illustrator, or Adobe Photoshop to create the sketch or a three-dimensional (3D) model.

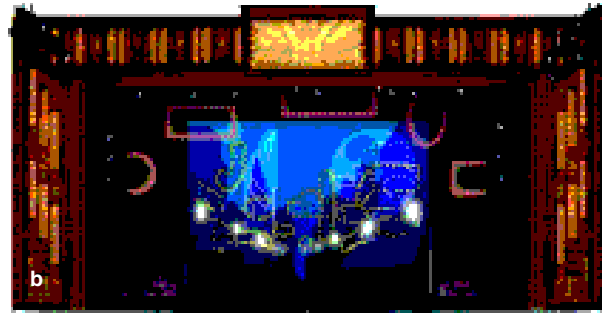
Individual designers use sketches for a variety of purposes; the particular use of the sketch will suggest how “finished” or polished it needs to be (Figure 4-15). Regardless of their purpose and style, every sketch and model should have a scale figure.

How the ideas are verbalized will clue the director how to look at the design. The more fully the designer understands the play and the clearer her ideas, the easier it is for her to explain and defend them. The director may feel free to ask about the staging for any given moment—“How do you envision this scene happening on your set?”—and the designer should be ready with an answer, if only with a broad suggestion.

The sketch should catch a significant moment in the play, preferably a moment that will best show the setting and still express the dominant mood of the play. The *sketch*



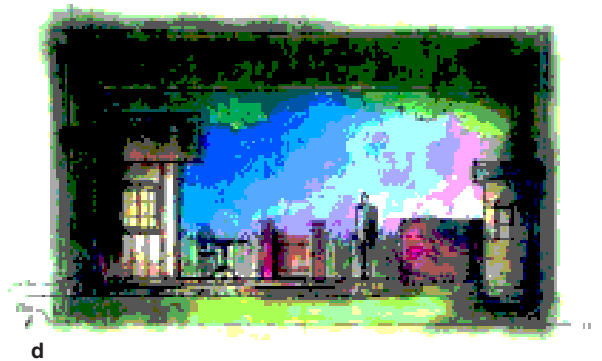
COURTESY GIANNI DOWNS



COURTESY HOWARD JONES



COURTESY MICHAEL OLICH



COURTESY MICHAEL C. SMITH



COURTESY C. MURDOCK LUCAS



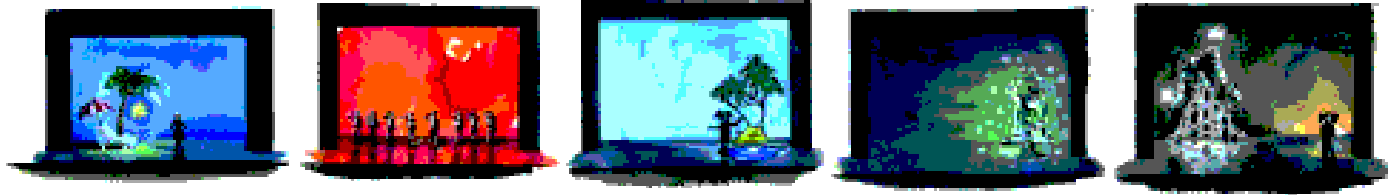
COURTESY SCOTT C. NEALE

4-15 Sketches The sketch serves as an important way for the designer to explore ideas and communicate them to the director and the rest of the artistic team, who can then contribute more ideas. This stage of the production is often the point at which decisions about scale, proportion, and style are made. (Ground plans would typically be shown with these sketches.)

- a *What the Butler Saw*, designed by Gianni Downs.
- b *42nd Street*, designed by Howard Jones.
- c *Endgame*, designed by Michael Olich.
- d *Intimate Exchanges*, designed by Michael C. Smith.
- e *The Tempest*, designed by C. Murdock Lucas.
- f *The Taming of the Shrew*, designed by Scott C. Neale.

g

COURTESY OF ANNE MUNDELL



4-15 Sketches (continued)

g These five color sketches for *Seussical* show a quick way to present a design with multiple scenes. Designed by Anne Mundell.

is an idealized drawing of the total visual picture, meaning the inclusion of costumed characters under lights, which can serve as a suggestion for the lighting designer. Supplemental sketches are used to indicate other major dramatic moments.

The sketch is always accompanied by a **ground plan** so that the director can examine the nature of the floor space that the actors can use. With a scale perspective drawing and ground plan, the director and the rest of the artistic team can form an accurate opinion as to how the actual setting will function as well as how it will look (Figure 4-16).

The designer must remember that the sketch is only a means of presenting an idea. It is not the final design and therefore should not be displayed or judged as a finished piece of art. A stage setting is not complete until it is on the stage, lighted, and viewed in the context of the action of the play. The judgment of the success or the failure of a design in the final analysis is based on how it functions under finished performance conditions rather than as a beautiful sketch.

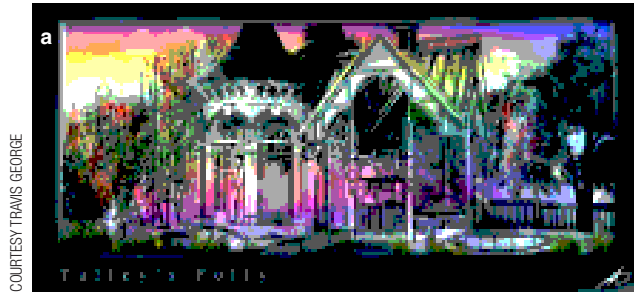
ground plan A view of a set from above, as if cut across horizontally (usually at 3 feet above the stage deck).

The Model

Although we have discussed the sketch as one of the prime means of presenting an idea, it is often superseded by a model (Figure 4-17). Most directors today expect a model, but the need for one depends on the individuals involved. Because of the three-dimensionality of scenery, some designers prefer to work with models rather than sketches, even initially. The model gives a truer indication of the spatial relationships between actor and scenery and is, therefore, helpful to the director when planning the staging. The model, whether physical or 3D on the computer, can as easily as a sketch be used to explore design ideas. Like a sketch, a model can be very rough or very heavily detailed.

Within the model, each piece of scenery is eventually constructed to an accurate scale, showing a miniature version of the set. Because the model is 3D, composition and sightlines can be checked from all angles. In addition to being a means of presentation, the model can also be used to check the appropriateness of scale, proportion, and shape. If the model is for the designer's use only, a rough version can be built, saving time and energy.

The scale of the model varies with its purpose and with the designer. Some like to work at ½-inch scale (see Chapter 6 for a discussion of scale), whereas others prefer a smaller scale. Models at ½-inch scale can be accurate, detailed, and extremely informative, but they are expensive and very time-consuming. In addition, they are awkward to transport. The ¼-inch scale model is a more convenient size for faster execution, which is sometimes important. The smaller scale allows for easier changes than does a larger scale while still providing some detail. Some designers work in scale as small as ⅛ inch because it allows for a broad assessment of the design, plus it is cheaper and faster. (The scale itself makes details impossible.) It is also easier to carry a small model to a design meeting and easier to store. What this ultimately



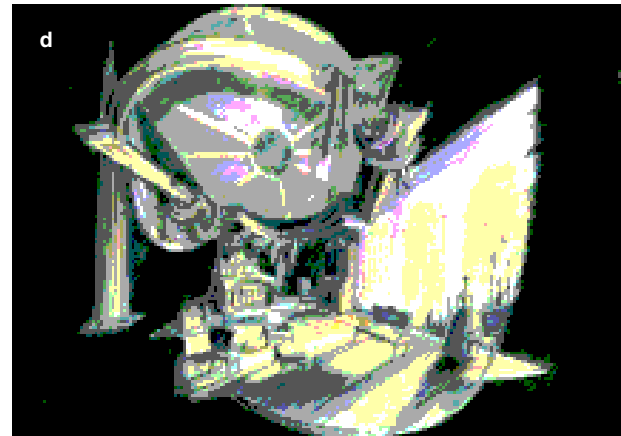
COURTESY TRAVIS GEORGE



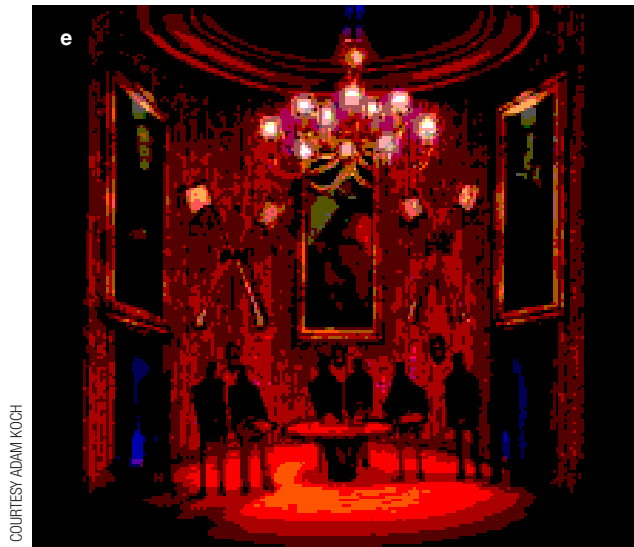
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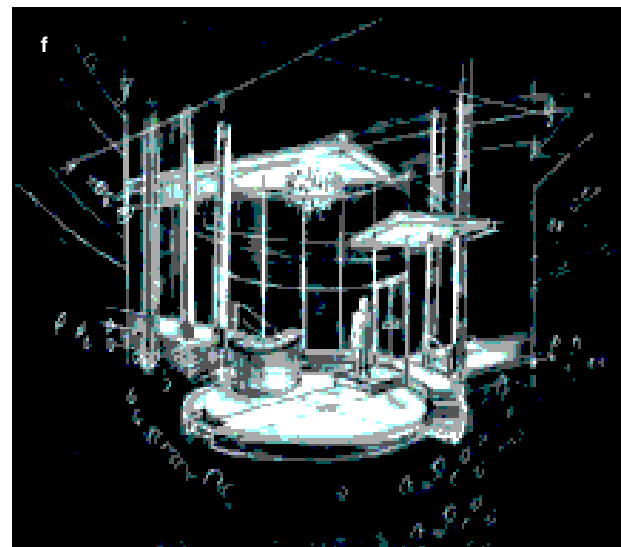
COURTESY JON SAVAGE



PHOTOS COURTESY OF DONNA BARRY, UTAH STATE UNIVERSITY



COURTESY ADAM KOCH



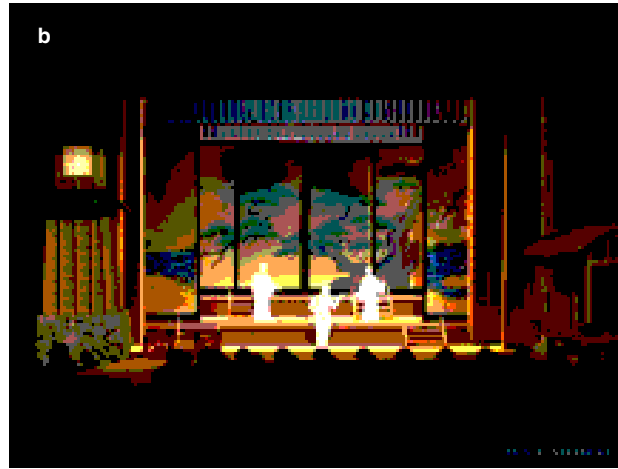
COURTESY LINDA BUCHANAN

4-16 Finished Designer's Sketches

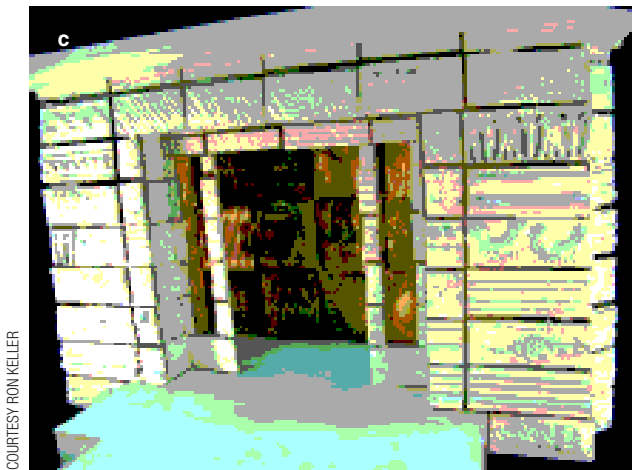
- a A very detailed color sketch for *Talley's Folly* by Travis George.
- b Sketch for *Krapp's Last Tape*, designed by C. Murdock Lucas.
- c Sketch for *Children of Eden*, designed by Jon Savage.
- d Dennis Hassan's sketch for *Dangerous Liaisons*.
- e Concept sketch for a *Corporate Event*, designed by Adam Koch.
- f Black and white sketch for *Lobby Hero*, designed by Linda Buchanan.



COURTESY LYNNE KOSCIELNIAK



COURTESY TATSUKI NAKAMURA



COURTESY RON KELLER



COURTESY C. MURDOCK LUCAS

4-17 Model

- a Model for designer Lynne Koscielniak's vision of *The Nutcracker Suite*.
- b Tatsuki Nakamura's model for *Pacific Overtures*.
- c White model for Ron Keller's *Medea*.
- d Model for the play *Trifles*, designed by C. Murdock Lucas.
- e Todd Rosenthal's model for *Roman Holiday*.

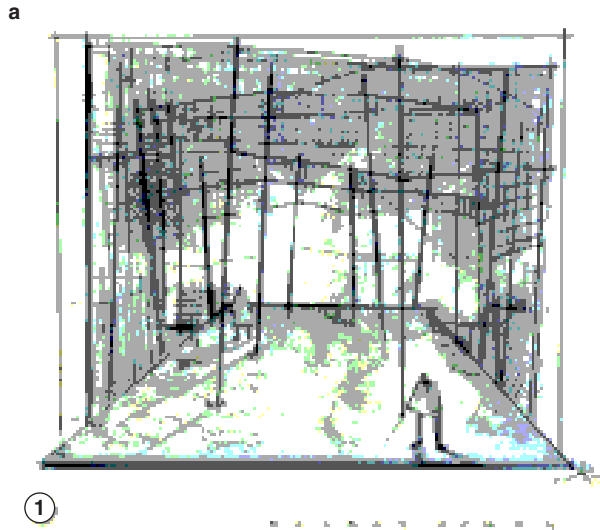


COURTESY TODD ROSENTHAL

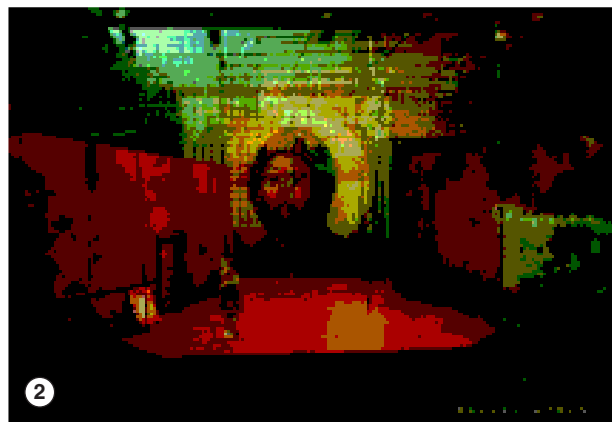
means is that the designer can explore the ideas of the design without investing huge amounts of time or money.

Sometimes called a *working model*, the *sketch model* is made of paper (Bristol board) and is used by the designer to check the 3D qualities of a setting or portions of a set. The model is usually black and white, but if heavier board is used and the paint is applied before cutting and shaping, the model can be made in full color (Figures 4-18 and 4-19).

A carefully detailed scale model is of great value to those who will be constructing the scenery. It does not, however, provide enough information for the shop to develop construction drawings. A full set of draftings (see Chapter 5) still needs to be done.



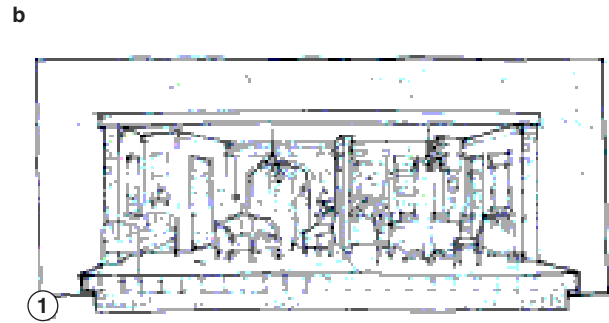
COURTESY CHRIS PICKART



COURTESY CHRIS PICKART



COURTESY CHRIS PICKART



COURTESY SCOTT C. NEALE



COURTESY SCOTT C. NEALE



COURTESY SCOTT C. NEALE

4-18 Sketch, Model, and Set

a *The Balkan Women*, designed by Chris Pickart.

- 1 Designer's sketch.
- 2 Designer's model.
- 3 Production shot.

b *Awake and Sing!*, designed by Scott C. Neale.

- 1 Designer's sketch.
- 2 Designer's model.
- 3 Production shot.

Designing with the Computer

Scanners and digital cameras allow the designer to transfer images directly into the computer so that they can then be manipulated in an infinite number of ways to develop a design. The computer makes it easy to explore a variety of ideas quickly. As they do with paper and pencil, some designers collage computer-based images together to express a design. Others scan in a pencil drawing and use the computer to adjust it. The possibilities are endless. Thanks to the computer, new directions in



COURTESY SCOTT BRADLEY



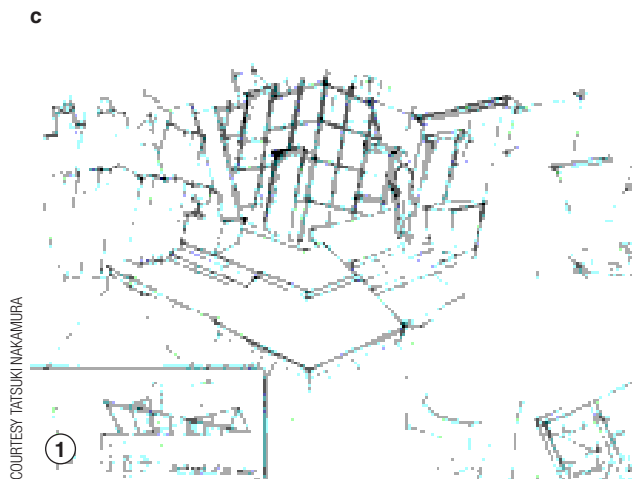
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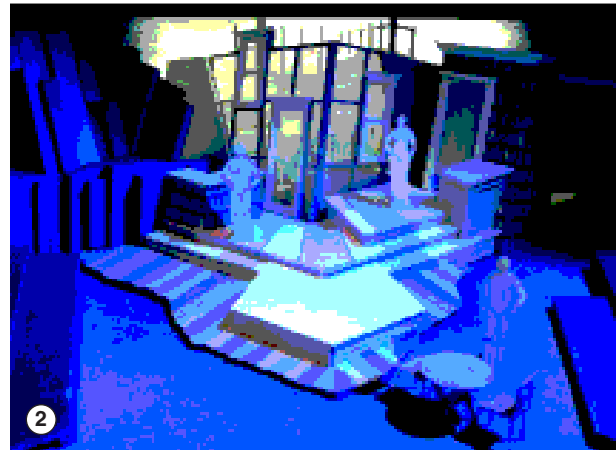
COURTESY CHRIS PICKART



COURTESY CHRIS PICKART



COURTESY TATSUKI NAKAMURA



COURTESY TATSUKI NAKAMURA

4-19 Model and Production Shot

a Design for *Clybourne Park*, designed by Scott Bradley.

- 1 Photo of the model.
- 2 Production shot.

b Design for *Fences*, designed by Chris Pickart.

- 1 Photo of the model.
- 2 Production shot.

c Design for *Rough Magic*, designed by Tatsuki Nakamura.

- 1 Sketch.
- 2 Photo of the model.
- 3 Production shot.



COURTESY TATSUKI NAKAMURA

thinking about design, in creating visual statements, and methods of exploration of an idea are being discovered.

New software applications support the creation of models in even easier ways. This technology is surely going to force us to continue to evolve our thinking and methods of working.

Designer's Preparations for the Shops

Once a design idea has been fully developed (Figure 4-20) and is ready to be translated into full-scale reality, the designer has to prepare a series of detailed drawings for the artisans who will be building and painting the set. Chapter 6 discusses these in detail but below is an overview.

Ground Plan and Section The first scaled drawings that the scenic designer must do are the *ground plan* and *section*. These two drawings show the space that the set will use both on stage and above. The ground plan is a view from (typically) 3 feet above the stage floor, indicating all walls, platforms, stairs, windows and anything else that uses physical space on stage. In some ways, this is the single most important piece of drawing or drafting that the scene designer does as it defines the acting space.

A rough ground plan is presented to the director with initial sketches. Questions about movement patterns, entrances and exits, and the specific staging of scenes will most likely be part of the conversation. Once rehearsals begin, discoveries about staging will occur that will no doubt require some rethinking and redrafting of the ground plan. Copies of the plan go to the director and stage manager (for layout in the rehearsal space).

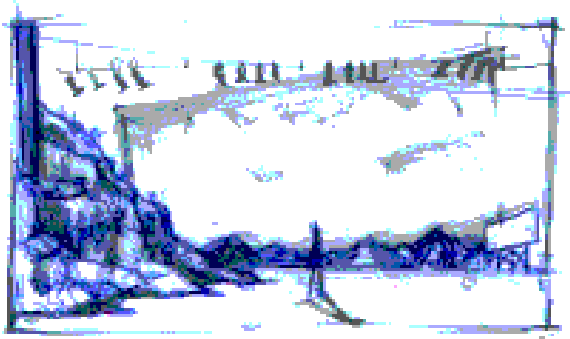
The section is a look at the entire set as if sliced vertically down the middle (like slicing an apple in half). This drafting is used to examine how the vertical space is utilized. It is done in order to determine heights and vertical position of scenic pieces, most especially masking. It is the single most important drawing for the lighting designer. It is almost inevitable that decisions made on the section will necessitate changes on the ground plan. A copy of the section goes to the lighting designer. Because the downstage space in the flies is the most desired real estate in the air above the stage, there may need to be some negotiation of how the space is used. Adjusting the position of a portal, a ceiling, or other scenic pieces may be needed to allow for a desired lighting position.

Designer's Elevations These are scaled and dimensioned drawings that provide information about the size, shape, use, and decorative detail of every unit of scenery and any built props. The designer and his staff prepare these drawings in the form of designer's elevations, from which the technical director develops construction drawings. A complete set of drafts—ground plan, section, design elevations, and any detail drawings—is provided to the scene shop and to the scenic artist.

Painter's Elevations For the artists who will be painting the scenery, the designer prepares scaled elevations that indicate the colors and painting technique of each unit of scenery. The first drawing in Figure 4-21 is the *cartoon*, or line drawing, indicating the basic layout of the composition. The cartoon is important to the painter because, as can be seen in Figure 4-21b, some of the outline is lost in the fully painted scene.

This drawing provides the scenic artist with information for the layout, open spaces, translucent and opaque areas, colors, and painting techniques. (Chapter 9 includes more details about methods of layout, proportional enlargement, and scenery-painting techniques.)

a



COURTESY MATT SAUNDERS



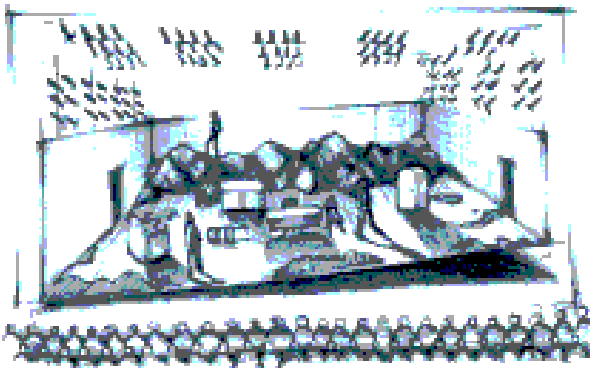
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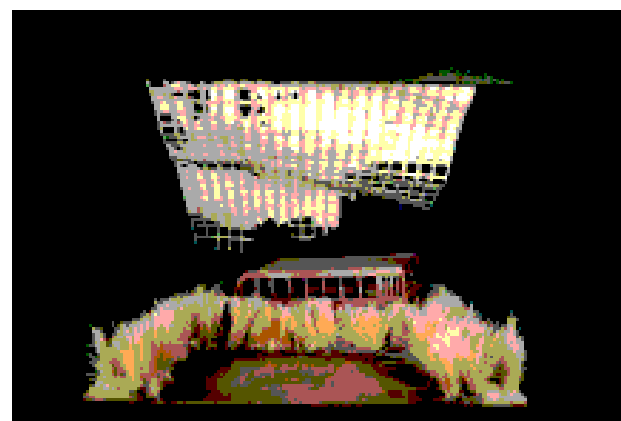
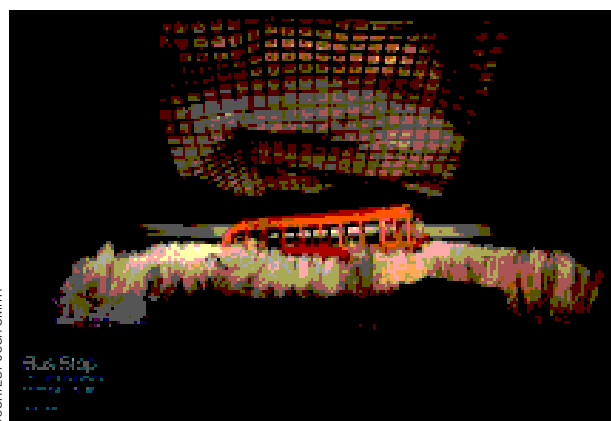
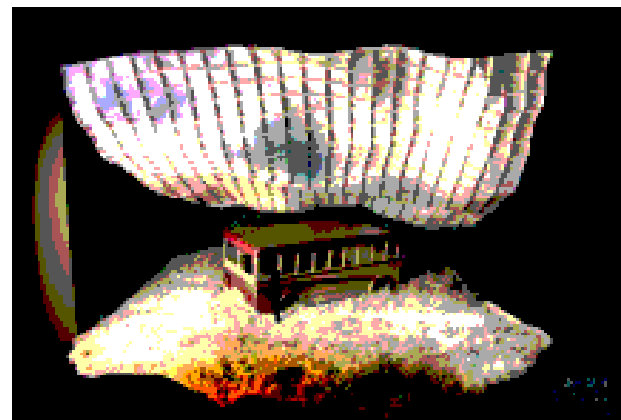
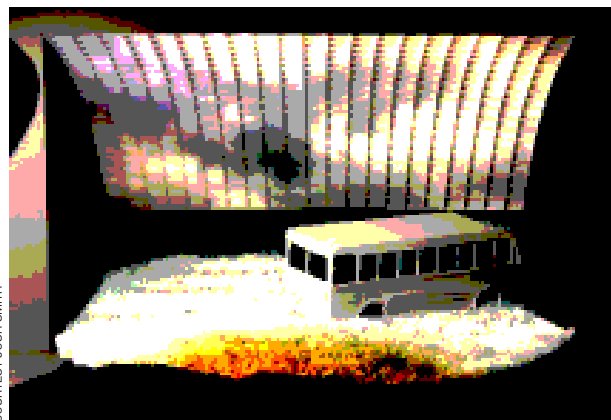
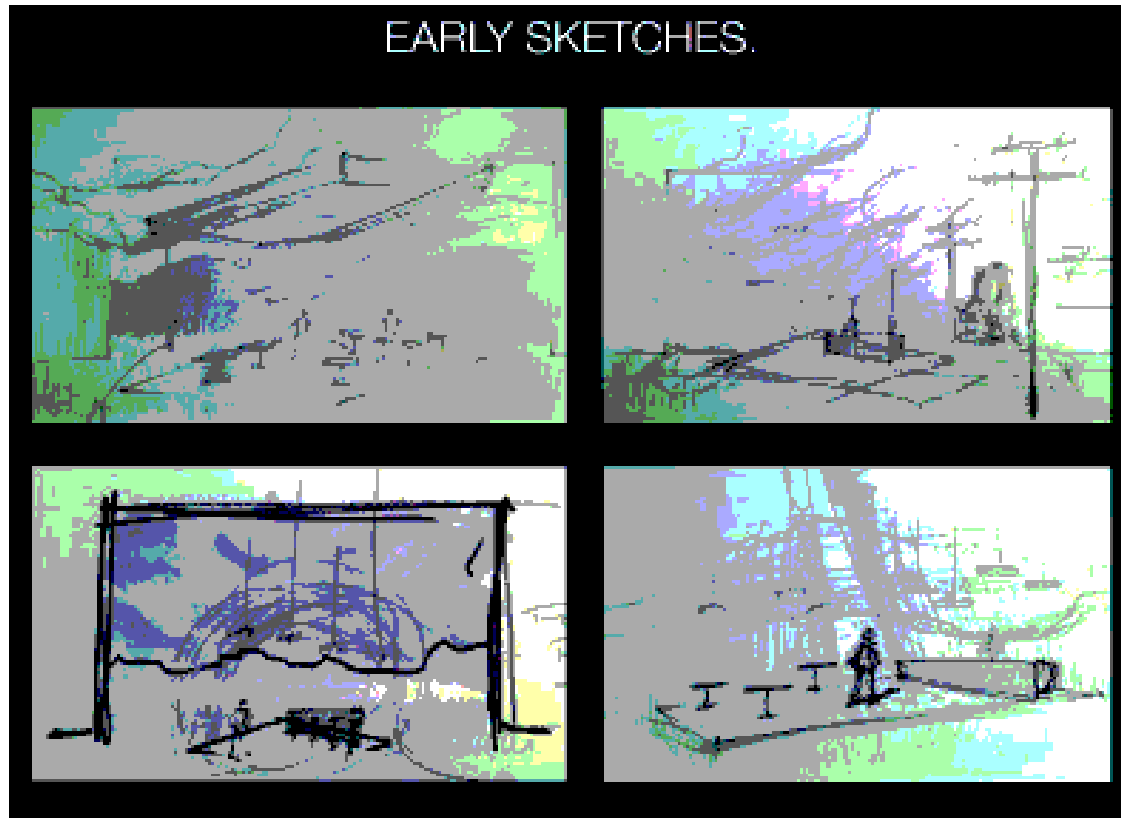


COURTESY MATT SAUNDERS

4-20 From Idea Sketch to Production Every designer discovers her own best way of developing a design. Here are two examples showing only a small portion of the work done to create a realized design. In both cases, a great deal of research (not shown) was done both for inspiration and information.

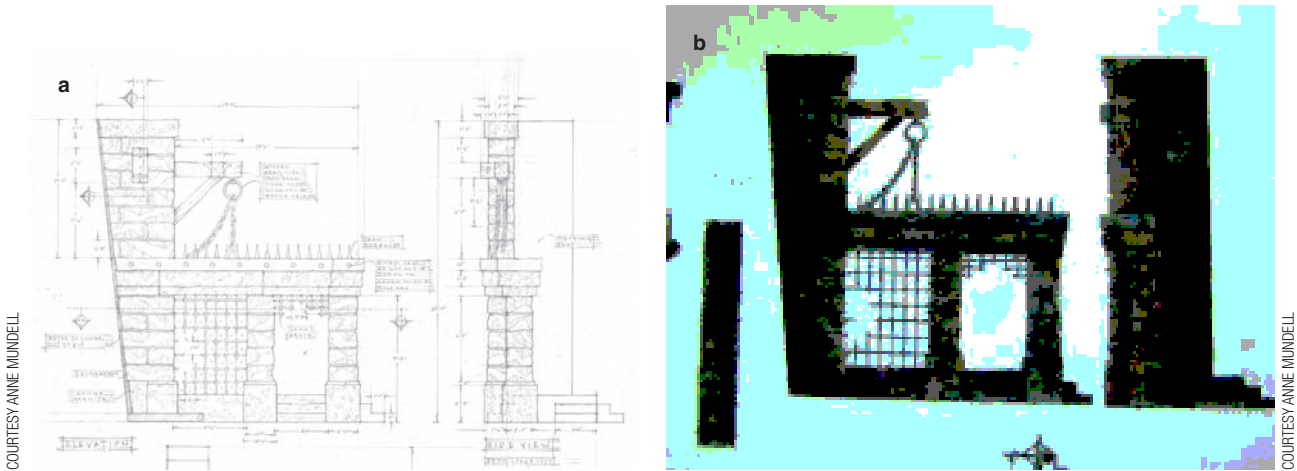
a *Curse of the Starving Class*, designed by Matt Saunders.

b



4-20 From Idea Sketch to Production (continued)

b *Bus Stop*, designed by Josh Smith.



4-21 Painter's Elevations and Line Drawing Elevations for the scenic artist are logically developed in two major steps: first the line drawing, then the paint elevation. Between the two, any and all information that is pertinent to the painting of the scenic unit will be indicated: color, techniques, opaque and translucent areas.

a Drawing—in this case it was the design elevation—used for the paint elevation for *Man of La Mancha*, designed by Anne Mundell.

b Paint elevation for *Man of La Mancha*.

Presentation from Other Designers

As members of the artistic team, the lighting, sound, costume, and projection designers should be present at the discussions of the play. Their unique points of view will provide insights to the production that may differ from the scene designer's contributions, and their ideas can be instrumental in developing the production style as well as influencing the ground plan and the setting. The entire design team needs to work hand in hand throughout the various stages of the design process.

All the designers have been influenced by the script and have formed some general ideas of atmosphere and color. Any images or ideas about the production may be displayed or discussed. An early discussion of color in light and costume is important. At later production meetings, the lighting designer (or sometimes the scene designer) will often present visual imagery suggesting color and atmosphere through the use of **value sketches** or a **storyboard**. With simple tones, a storyboard illustrates the basic forms of the setting, the changes or movement of intensity, and the direction of light within a scene or from scene to scene (Figure 4-22). The use of computer applications such as Photoshop have proven invaluable for creating storyboards.

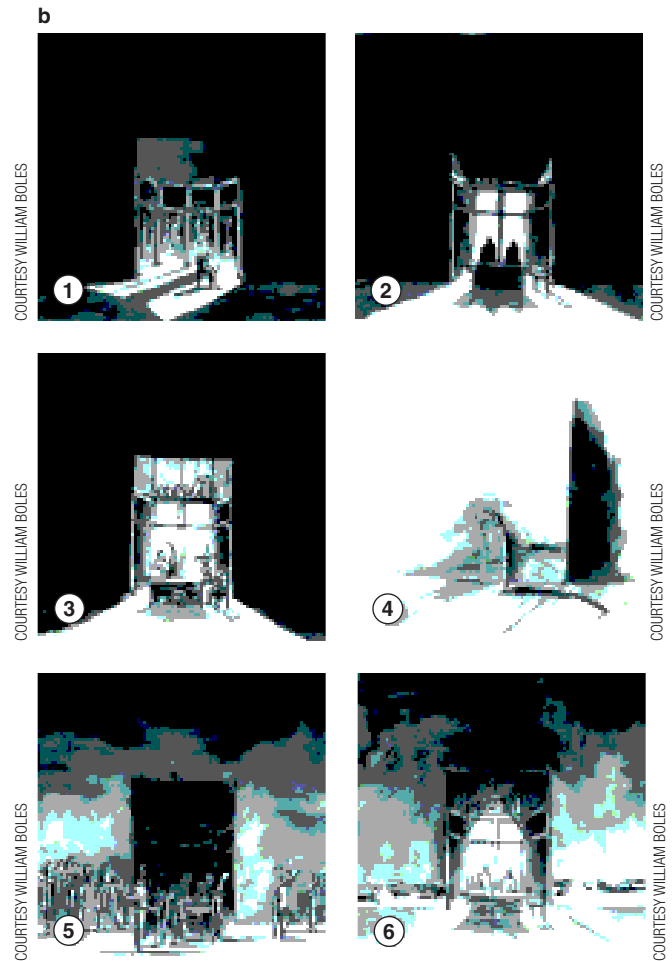
Just like the ideas of the scene designer, the costume designer's ideas are presented in sketch form in full color and with fabric swatches. The costume sketch differs from the set design sketch in that it must serve several purposes. Besides presenting a design to be viewed in correlation with the overall tonality and style of the production, the designer presents an interpretation of an individual character as well as a working drawing that the shops will use for construction information. In addition, unlike the set sketch, the costume sketch will not show the clothes under stage light. (See Figure 4-23.)

value sketch A sketch that emphasizes the light and shadow of a set.

storyboard A series of sketches that provide a moment-by-moment view of a scene, act, and so forth.

Other Venues for Theatre Design

One way to have a career in theatre is to design for regional theatres (Figure 4-24). But many theatrically trained designers design for related commercially oriented venues, using theatrical techniques. Figure 4-25 shows several examples. Such venues



4-22 Value Sketches The value sketch, often done in storyboard form, shows atmospheric changes scene by scene. This is one way for designers to communicate their ideas to the director and the rest of the artistic team.

a Shown here are three moments of *Filthy Rich*, designed and drawn by Scott Davis.

b A series of sketches by William Boles for *Far Away*.

as industrials (for example, auto and fashion shows), television and film, pageants, and themed entertainment call on the talents of the theatrical designer.

Industrials

Designing for trade shows, or “industrials,” as they are often called, has a different goal and a somewhat different process. Instead of a theatrical producer, there is a corporate client who wants to provide some form of entertainment for a sales meeting (of managers, salespeople, or another group), wants to launch a new product, or intends to present awards to a group. Ultimately, the designer creates a show that is based on a corporate idea and a corporate client with the purpose of bringing the message of the client to the audience.

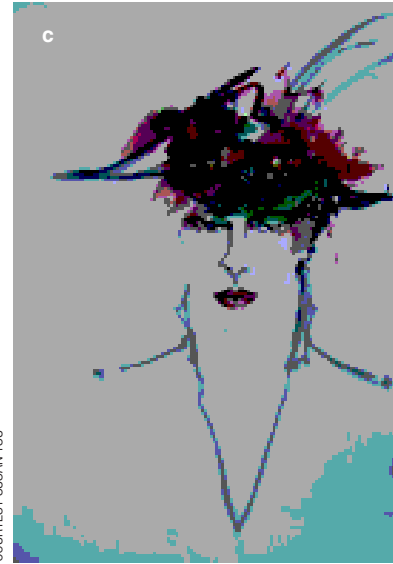
Typically, the designer works with a *creative director*, who guides the direction of the show. He provides the agenda (as for the meeting), the theme of the production, and oversees the writer—the production is this person’s vision. Overseeing the entire



COURTESY PETER COOKE, OAM, PH.D.



COURTESY SUSAN TSU



COURTESY SUSAN TSU

4-23 Costume Presentation

- a** A costume for Norina in the opera *Don Pasquale*, designed by Peter Cooke, OAM, Ph.D.
- b** Costume for the Apothecary in *Romeo and Juliet*, designed by Susan Tsu.
- c** Very loose exploration of a hat, designed by Susan Tsu.

production, the creative director provides basic parameters about the event, including the overall approach, such as its main focus and point of view as well as specifics such as whether the band, if there is one, should be seen or hidden.

There is a two-step process in designing for an industrial. The first step is getting the job by pitching an idea. When company organizers decide to hold a meeting for “x” number of people, they contact a number of production companies, businesses that create events such as this. Each production company hires a team of writers and designers to look at the needs for the particular event and determines any additional content, including entertainment. At the pitch meeting, each production company tries to sell its idea to the client, who ultimately chooses one company for the job. Part of the pitch is the design. This process usually takes about three weeks.

Once hired, the production company’s designer proceeds with getting the work done. Designs are sent out for bids, and the rest of the process is much like doing theatre. The big difference is that, as often as not, the event will take place in a ballroom or a convention center rather than a theatre. This means that the designer must create the “theatre space” within the venue, including bringing in and setting up any rigging or truss system that will be used. (Some venues will have rigging points that can be used.)

One of the standards for industrials is the use of image magnification; there is always a screen to provide content. A few decades ago, slides (from a carousel) were used, sometimes in combinations, to create a large image. Current standard practice for industrials is the use of video or other media, often requiring the expertise of a videographer as part of the design team as well as a media technician for the performance.

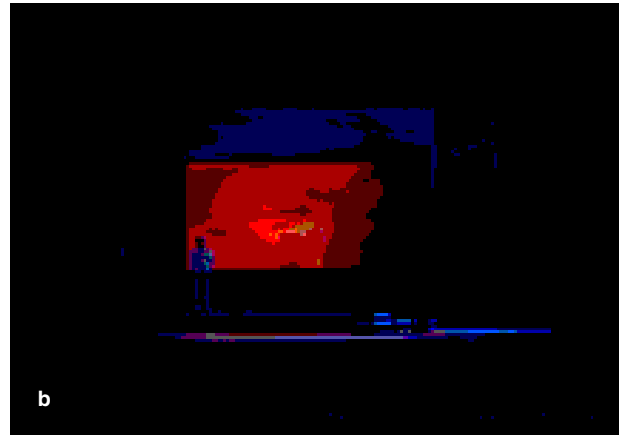
Television and Film

A major outlet for designers is the world of television and film. Although the discussion here is specifically about television work, most of the information provided applies as well to work in the film industry. Local and national broadcasting companies create original programming, ranging from full-scale movies and prime-time productions to simpler local talk shows or news programs. Recognition and consideration of the camera



COURTESY OF THE AUTHORS

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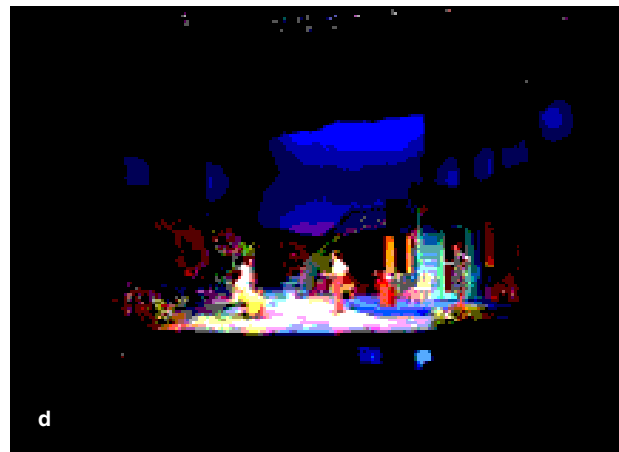
COURTESY CHRIS PICKART

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COURTESY DENNIS HASSAN

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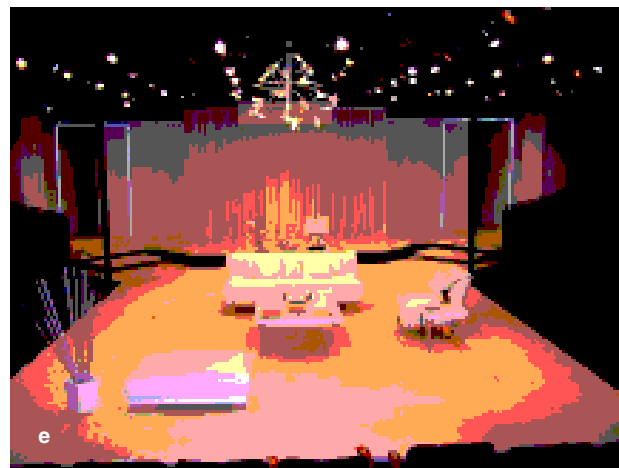


COURTESY LINDA BUCHANAN

d

4-24 Designing for Regional Theatre

- a *Twelfth Night*, designed by Dick Block for The Human Race.
- b *A Prayer for Owen Meany*, designed by Chris Pickart.
- c *August: Osage County*, designed by Dennis Hassan for Fulton Theatre.
- d *Boleros for the Disenchanted*, designed by Linda Buchanan for The Yale Repertory Theatre.
- e *The Clean House*, designed by Ron Keller for Barksdale Theatre.

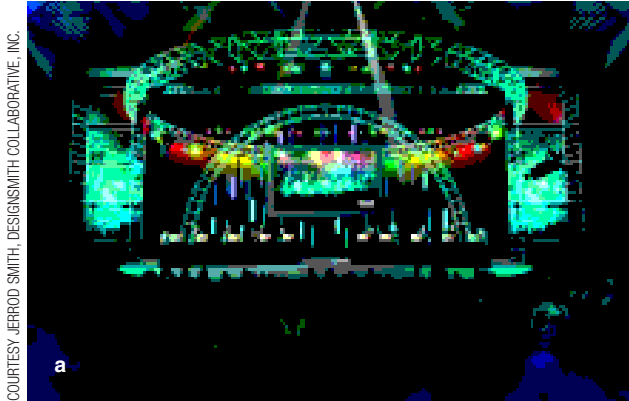


COURTESY RON KELLER

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is of utmost importance. Everything in this medium is seen through the lens, or “eyes,” of the camera. If the camera doesn’t show it, it does not exist (at least as far as the viewer is concerned).

A wide variety of programs are broadcast on television, and designers, just like actors, often get “typecast.” One-hour dramas, sit-coms, soap operas, variety and awards shows, special events, talk and news shows, and reality TV are just the major types of programming. They are all unique in some ways and are handled slightly differently, yet at the same time, they are organized similarly.



COURTESY, JERROD SMITH, DESIGNSMITH COLLABORATIVE, INC.



COURTESY, JERROD SMITH, DESIGNSMITH COLLABORATIVE, INC.

4-25 Designing Industrials

- a** A sketch for the *World Cyber Games*. Production design by Jerrod Smith, DesignsSmith Collaborative, Inc.
- b** A sketch for the *Ford* show. Production Design by Jerrod Smith, DesignsSmith Collaborative, Inc.



WORKING PROFESSIONALS ■ John Shaffner and Joe Stewart: Television Designers

Joe Stewart and John Shaffner have been mainstays of television design for a very long time, and they have literally done it all. They have an extremely long list of awards and credits that include popular sit-coms (*Friends*, *Two and a Half Men*), awards shows (*Primetime Emmy Awards*, *The American Music Awards*), and talk shows (*The Ellen Degeneres Show*, *Montel Williams*), as well as game shows and special events (1998 *Super Bowl Halftime*).

Joe graduated from Carnegie Mellon and John from University of Montana. They went to New York, where John had already contacted people at the New York Shakespeare Festival about getting a job; he lucked out and went right to work, in props. Joe got a job at Ray Diffen's studio as a shopper two weeks later.

John spent that first summer working on props for *The Taming of the Shrew* and *The Cherry Orchard*, performed in Central Park. Soon after that he became the staff painter and met designers such as John Lee Beatty and the director Wilford Leach, who subsequently hired him to design a number of productions for the Shakespeare Festival, including the Meryl Streep *Taming of the Shrew*.

Joe got hired to work on a production in Texas, a PBS production called *The Lath of Heaven*. The television work intrigued John, so he joined the team as an assistant art director, mostly doing paint work. This led to another PBS project, in Hartford, after which Joe and John returned to New York. But they had become very interested in television work. Although successful doing theatre, they reasoned that they might fare better in Los Angeles so they headed west.

Once in LA, they established a rule: each one of them had to make at least one phone call a day looking for work. "You have to be persistent. We had a few leads but nothing much." But they did have some friends in LA. John did a number of "quickie" jobs and eventually got a recommendation to the director Sam Riddle.

He got a design for a country music show followed by the 35th anniversary of the Riviera in Las Vegas, both with Riddle. "Sam stuck with me, and we did the pilot for a show called *Star Search*, produced by Bob Banner. Bob was one of the great gentlemen of television, who had just had a huge success doing *Solid Gold*." *Star Search* lasted for twelve years, starting in 1984. They shot two shows every other week. "The best advice I got was from Ed Stephenson, for whom I worked as a decorator. He taught me to negotiate getting paid by the episode, not the week, a completely foreign concept at the time.

"Joe was fortunate to have Gino Conti, who loved Carnegie Mellon people, get him a job as a replacement for *Days of Our Lives*, working with Chip Dox, who had moved into the permanent design position after his predecessor left. Joe stayed with this for four years. In between he worked as a set decorator on a game show. The studio started a new soap and asked Joe to be the assistant art director, but it was so badly organized and the studio was so unprepared for this kind of schedule, especially in the staffing, that Joe quit. He helped them find someone to step in, but this is the only time in thirty-two years that Joe has quit a job.

The big break came when, again through a friend, the magician David Copperfield wanted a new designer. John negotiated a deal to work on this project with Joe—"what we always wanted to do"—and they eventually designed a total of 12 shows. One of the producers from those shows fought to get Joe and John hired to design the pilot for a new sitcom. The producer told the studio we were the ones he wanted to work with, so then began a 14-year run on *Friends*.

For both Joe and John, the "business" is important, not just as a job but truly as a career. They are particularly interested in furthering TV design to an art form based on storytelling. "Everything

(continued)



WORKING PROFESSIONALS (CONT.)

is essentially inspired by the script, the story, the content. If you lose sight of that anywhere in the process, you are lost. It is not easy to find the ‘soul’ of a game show or an awards show, but you must. You can have all the technique in the world, but all of your choices are useless if they are not centered on telling the story of the event. In all the work we do, we succeed only when we tell a story.”

In designing a new show, they often start with the plan. Sometimes in reading the script for the first time, they pass a sketch back and forth. Concept boards are used to show ideas, especially at the beginning of the process. The producer and the director see this first, followed by the department heads, including props, costumes, special effects, and so on. For example, if the script calls for them to add a restaurant, they first need to determine what kind. “How elegant? How big? Interior is how well-monied? How classy? What works best for the storytelling? Takes about half a season before I go, ‘Here’s what’s really important.’ As long as I understand that, I’m good. Once I get off track, I find myself in trouble. I have to get into the character’s head.” The concern is that they be truthful to the world of the story and still allow the audience to enjoy watching.

They are always exploring new ways to use the camera, and they speak with great reverence about the classic tradition of multicamera use that was started by Desi Arnaz with *I Love Lucy*. Each episode is like a little play and is done in front of a live audience in order to get that instantaneous response. This is one reason that sit-coms are shot in the proper sequence for telling the story. If there is a taped sequence, that is shown in sequence as well.

The “camera as audience” is an important concept. “That is the magic of the camera: if you don’t want to see it, don’t shoot it.” With multicamera shoots, it means that “the set must be dressed everywhere at the same time for each shot. You want a little texture, pattern, some depth in each shot.” Just as the lighting must satisfy all cameras at once without refocusing for each shot, everything needs to be balanced. With a single camera, there are constant adjustments, more finesse and detail control. “You let go of some control of the picture as production designer with multicamera shoots. It is important to think ahead. You don’t have time to adjust for individual shots once shooting starts.”

Joe, who more frequently does the variety and awards shows, has some different issues. “There are lots of different surfaces that are unconventional in theatre. My big concern is how different materials read on camera.” And he seems amused that old theatrical tricks seem innovative to TV. The design process for variety shows usually involves physical modes, mostly white, although “this is old world. More current is the use of SketchUp as a white model tool.” Digital paintings are done in Photoshop. “A decent perspective drawing of the set can become a 2D rendering, but only if you can draw it first in perspective. This is where you need those basic skills and an understanding of visual basis: how architecture works, a knowledge of design. VectorWorks is no good if you don’t understand how to draft or how drawings work. This is the advantage of theatre training.” Computer skills needed include Photoshop, VectorWorks, and SketchUp.

Color is always an issue for designers, and it is certainly no different for Joe and John. “Color is always fun, but color in fashion doesn’t always work well with what is best on TV. I usually decrease the hue and the value to make it a little darker. The fashion right now is pure hue and less gray. We can make it look like that on camera, but we have to work with it [which for John usually means graying colors down]. The trick is to bring enough contrast into everything so that you don’t end up with everything too bland.” And, of course, the color should help with the storytelling.

Two issues arise when discussing the future of television. The first, not surprisingly, is technology, most especially the advent of high-definition television. HDTV is more expensive and provides higher depth of field with more focus in the background. Patterns are more noticeable, and lower contrast is more visible. This will force productions to spend more time (and money) on detail.

When it comes down to it, both John and Joe are very positive about the industry that they love. For the young designer, they suggest theatre training. “It makes you self-aware; in the end, studying stage design, in theory, you would only design onstage. Now in order to find work, you are going to go in all kinds of directions because there just isn’t that much work designing a stage play. But there are now many directions you can go, and enormous opportunities in this business.”

The biggest distinction within the world of television is that of single-camera and three-camera (or multicamera) shows. A single-camera show, typical of one-hour episodic dramas such as *Law and Order* and *CSI*, has a four-wall set with the camera inside. (See Figure 4-26.) Often one or more of the walls is a *wild wall*, meaning that it is removable to allow for a needed camera shot. Such shows are often shot in part on location, meaning someplace other than a sound stage or a studio; this is like film work. Multicamera shows, more typical of sit-coms such as *The Big Bang Theory*, are done in front of a live audience with three cameras and with sets that are more like theatrical box sets. Arranged for the most part in a line, this situation allows the audience to see



COURTESY, JESSICA KENDER, PRODUCTION DESIGNER;
ARTHUR CHADWICK, SET DESIGNER



COURTESY, JESSICA KENDER, PRODUCTION DESIGNER;
ARTHUR CHADWICK, SET DESIGNER

4-26 Designing for Television Sets from the television show *Dexter*. Jessica Kender, Production Designer; Arthur Chadwick, Set Designer.

the action, with the main location centered and the secondary sets to the sides. In part because of the audience, these shows are shot in the correct sequence for telling the story of the show; single-camera shows are shot out of sequence to accommodate needs and restrictions of the various locations. Wild walls may still be used.

Every show has an art department that includes all the staff creating the physical set. The specific organization and labor distribution depend on the individual art department, but typically it is as follows:

- *Production designer.* The person in charge of the overall look. He determines the broad strokes of the “look” of the show and hires the rest of the art department.
- *Art director.* Depending on the scale of the show, one or more Art Directors take the broad strokes provided by the production designer and make them work. This might include jobs such as fleshing out a rough idea sketch into the reality of a design.
- *Assistant art director.* She deals with detail work such as obtaining hardware, providing graphics (for example, menus and store signs), and coordinating with the props department if necessary.
- *Set designer.* This is the draftsman. She does all the measured drawings that will go to the shop.
- *Set dresser.* He is in charge of all decoration—furniture, books on shelves; all those details that help to create a life for the character.
- *Art department coordinator.* She takes care of all scheduling and makes sure that a set is ready when the shooting schedule requires it.
- *PA (production assistant).* He does whatever is left.

Many designers begin as PAs; it is a great way to learn how the television industry works, particularly for designers.

Designing an awards show such as the Emmys, the Oscars, and the American Music Awards, or any other kind of variety show, is similar in that the theatre space must be set up for cameras. Camera positions are naturally a first consideration. On the big awards shows, there will most likely be a center camera, a **jib camera**, a Vari*Lite board (used to operate moving lights), and a fixed light board (used to operate stationary lighting instruments) all in house, as well as any follow spot positions that are needed to augment the lighting. There may be projection screens in the house. There will also be secondary rooms, such as a press room and a room in which the celebrities can have a “meet and greet.” These rooms are sometimes designed by someone other than the production designer.

Sometimes the stage is created for a specific event, such as the national political conventions. In this case, then not only the stage itself but also the layout of the seating, the

jib camera A camera mounted on a tripod, usually counterweighted, that allows it to move vertically, horizontally, or in combination.

size of the chairs, the number of rows, and so on must be considered, very much as for an industrial. As always, the relationship between the audience and the speaker must be considered. For these events, the floor generally becomes very important because there are likely to be a large number of camera shots from high up.

To maintain control of the vast amounts of information needed, the designer keeps a production book that includes contacts, memos, schedules, and budget information, including all invoices. All scenery notes, such as board layouts, sketches of the various scenic elements, props details including rentals, and any other miscellaneous information, are



WORKING PROFESSIONALS ■ Thomas Walsh: Production Designer

Thomas Walsh is currently the president of the Art Director's Guild and Chairman of the Art Director's Film Society. He was the originating production designer for *Desperate Housewives* and just finished *In Plain Sight*. He got his start at Hollywood High School, where he found he was always doing theatre. Immediately after high school, he went to work in the trades as a carpenter and scenic artist, mostly at the Los Angeles Music Center. He got his degree in scene design from Cal Arts and then was hired by the Mark Taper Forum as their resident assistant designer. Eventually getting his own shows, he went on to work at Tony Walton's studios in New York, where he stayed for four years. While there, he worked on a number of productions directed by Mike Nichols, including *Hurlyburly*, *The Real Thing*, *Social Security*, and *I'm Not Rappaport*.

During this time, unique opportunities, such as designing for the American Playhouse series and independent film productions, provided him with a great deal of valuable design experience. Then both his interests and the financial limitations of working in the New York theatre led him back to Los Angeles.

Like all production designers, Tom selects his own art department staff. On *Desperate Housewives*, he had an art director, set designer, graphic designer, art department coordinator, set decorator, construction coordinator, lead painter, and property master as his core team. In addition, there are a number of set dressers, carpenters (called *propmakers* in the film trade), set painters, greensmen, props assistants, plasterers, special effects technicians, drapers, and flooring specialists, plus a number of overhire craftspeople who come and go as the show needs require. Overall, there were typically about 60 people on the team for any one episode.

Preproduction for a new season in episodic TV usually lasts about 5 to 6 weeks. "In episodic production, you have to pace yourself—everything can't be perfect; you realize that you can let some things go. . . . Your design principles always revolve around what the camera lens will see and what are the requirements of the characters and their story; you start with the details that are most important to the storytelling, and then you work your way out from there."

As this show was beginning, Tom created a series of visual concept boards, showing the various styles of houses and personal

details that the many characters might have, as a shorthand way of communicating with the writer, his design collaborators, such as the cinematographer, costume designer, and set decorator, as well as the producer and the studio. A separate style was determined for each of the main characters, yet all of them are just a bit over the top. "We had to pin the writers down initially as to 'Who is this person? What do you want to project with this character?' This was tricky, because the show as yet hadn't been cast, and writers in episodic productions like to know who their actors are so they can tailor their writing to the actors' unique personalities and strengths. We had to design on instinct knowing what the character represents to the overall direction of the show while hoping that we can still alter our conceptual course if the situation requires adjustments along the way.

"One of the greatest challenges designing for film or television is both spatial and logistical. Even the simplest of scenes, one with, let's say, two people in a room requires a small army with as many as 35 technicians on the other side of the camera in that very same room. And all those people have equipment, tools belts, workbags, etc. Bathrooms and kitchens can be particularly challenging, as you have to have room for all of those people, the camera, and lighting equipment and still maintain the intimacy that the story and reality require. The smaller the set, the more often you pull out the walls for shooting, but it's still a challenge to keep the proportions of the room believable.

"We have seven sound stages, six for sets and one as a construction mill, which are full of standing sets, plus a back lot the size of a football field that contains our residential street, 'Wisteria Lane.' Many of the houses on the lane have practical interiors, while others are only façades. The footage on a studio lot is very expensive to rent, and so we have to maximize the use of all areas, of which there never seems to be enough. . . ."

Unlike when designing a stage play, Tom first sees a treatment, eight to ten pages in length, describing the different scenes and what the characters are doing. "I start to do my breakdown based on that early treatment. The script will go through a series of as many as twelve drafts in which the staging, dialogue, and



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characters are written and rewritten. From the initial first draft I develop a concept while continuously speaking with the director about locations, staging possibilities, story tone, and logistics. We try to determine what we need to accomplish within this particular story. This approach allows us to fine-tune our selections. As the season moves along, the scripts come to us later and later. The good thing is that the stories usually get better with each generation, but it can get pretty wacky.”

A typical episode can require anywhere from between 32 to 36 sets. Four of those sets may be on location, and another four to seven may be “swing sets,” sets that are unique to one episode. It takes seven days to prep an episode and another nine days to shoot it. A five-day work week averaging twelve-hour days is typical for a one-hour episodic show, unless there is some kind of crisis. An average of six pages of script are shot each day, which results in 43 minutes of finished film for the network’s airing. On *Desperate Housewives*, few scenes run more than two pages in length at any given time, so the locales shift very quickly. “For reasons of scheduling necessity, due to actor availability, all scenes are shot out of sequence. This can get pretty crazy at times. . . .

“My presence is not usually required on the set by the time we actually start shooting. In episodic production, the designer by necessity needs to stay a couple of steps ahead of the shooting company. I leave it to my art director, set decorator, and our on-set art crew to open and manage the shooting set, so that I can prep the next set and future episode.”

Early television attracted many people from theatre because they found a familiar environment, in that early television often required proscenium-style sets and clever, as well as rapid, scene changes; designers had to do a little bit of everything. The second migration of theatre designers to the west coast really began to

increase during the 1950s, when the studios were losing revenue to television, which, at the time, was filled with hour-long dramas, very much like theatre. “Over time, designers began to carve out their own niche. . . . The current standards in the design for narrative television, by which I mean episodic, movies, and miniseries, are no different from those for feature films. The only difference at this point is one of budget, scope, and schedule, but the quality and expectations are now the same.”

“Theatre is still the best place for a student to learn about story development, visualization, and how to apply it. It is still storytelling—conceptual thinking is conceptual thinking. What is now challenging the traditional methodologies of teaching design are the new technologies, which are moving us quickly toward a whole new set of design visualization paradigms. With the current range of accessible design software, the designer’s workflow output will be as relevant to the production’s preproduction process as it will be to its postproduction completion. The same documents that a carpenter works from can now be made equally relevant to the visual effects department; early concept drawings created during the project’s previsualization phase can be quickly migrated into a digital file format, thereby remaining useful and easily adaptable throughout the workflow but in a much less linear and much more dynamic manner. This doesn’t mean that the lead designer in the future will have to be the world’s fastest computer artist, but to fully participate in the process, she will have to understand how it all works. Certainly future entry-level candidates who are competent at Photoshop and CAD type systems but who also possess a solid visual, performing, and art history background as well as classical art skills will be the ones who will be the most likely to go to the front of the line upon entry into the entertainment industry.”

kept in this book. All documentation about how the site works, including rigging and equipment, is kept as well. If the designer is hired to work on the show again, such a book can be an invaluable time saver.

The process for designing for TV is similar to that of theatre. To develop her concepts, the designer will do some combination of rough or conceptual sketches exploring ideas, followed by models, color sketches, and/or whatever else is required to present the design.

Theme Parks

Theme parks have boomed over the past decade and need good designers (Figure 4-27). Working for a theme park can include a wide range of possibilities from designing the scenery for musical entertainment to designing the rides to creating some of the buildings the vendors use. In all these venues, the designer must call into play all of his theatrical training, most particularly his humanity.



4-27 Theme Park Design Sea Lion Cannery Row Caper, designed by Steve Gilliam.

It is important to recognize that, like theatre, theme parks tell a story, one that includes the audience more directly. Just as in theatre, the story needs a point of view. Anyone attending a theme park does so to “travel” to another time period, geographical location, or fantasy world in a way that makes them feel comfortable immediately. The “story” involves everything they see, hear, and smell. The rides, the shows, the signs, the murals, the interiors, and the exteriors all must keep the story consistent. This background story is critical to the success of a park.

Theme park designers get hired by a producer, often a large corporate organization who will work for an “architect” or director, the person who oversees the entire layout of an area. Typically, there will be a lead designer and a team of several others. Often, this means working with a sponsor and probably cartoon characters (who might be connected to the sponsor or the park itself).

Lead time for theme park design will vary depending on the size of the job. If an entire section of a theme park is to be redone or added, the project could easily take a couple of years.

Other Outlets for Designers

Still other places for set designers to work that may not seem quite so obvious have recently become viable options. Many talented and well-trained theatre designers have found the following outlets for their creative work:

- Music videos
- Cruise ships
- Parades
- Interior design
- Webcasts and podcasts
- Electronic gaming

Some of these, of course, require a little more training and some specialized skills.

Looking for a Job

In explaining how to get a job in theatre, many people use the adage: “It’s not what you know but whom you know”—and there is a certain amount of truth to it. Networking in theatre is important, just as it is in any industry. Because producing a play is so difficult, everyone prefers to work with people they already know. This most often translates into working for little or no money during the early stages of one’s career.

Organizing Your Work as a Designer

No one hires a designer if they don't know her. There are essentially three parts to a "job kit" that provide basic information about who a designer is: name, occupation (that is, scenic designer, lighting designer), and contact information. These include a *résumé*, a *business card*, and a *website*. To fulfill a designer's responsibility to get her name known, these three items are a way of introducing oneself and encouraging a potential employer to look at her work.

Résumé The *résumé* is a record of a designer's work life, including education, a list of jobs (both paid and unpaid), special skills (Photoshop, VectorWorks, sewing, welding), and references. Keeping a *résumé* current is extremely important. In fact, a *résumé* should be handy at all times as job opportunities will present themselves randomly. It is best to be prepared.

It is important that all information on the *résumé* is clear and concise. First and foremost is the designer's name and specific line of work ("scene designer") followed by contact information. It is easy enough to have several *résumés*, one for each kind of job desired particularly at the beginning of a career; for example, one *résumé* might be for design work, another for scene painting. The same information can quickly be rearranged to emphasize one skill or another.

The next most important part of the *résumé* is the list of people with whom the designer has worked. This might include any designer she assisted or for whom work was provided, the scenic artist, a director for whom he designed, or any other supervisor who could vouch for her skills and attitude. List people who will remember and say good things. Potential employers always look first for names they recognize and usually contact them to get advice as to whether someone is a "good hire." At the bottom of the *résumé*, include three references with their contact information. Be sure that permission is obtained from these referents to use their names.

It is worth taking time to consider how best to organize the information that goes on the *résumé*. Most designers create a series of columns including the job (Scenic Designer), the name of the play, the director, the theatre in which the project was produced, and the date (only the year is needed). Work is listed in reverse chronological order (most recent first). Separating the lists into categories (such as Theatre Design, Assistant Work, Scenic Painting, Prop Work, etc.) makes it easier to understand a designer's work history. The use of bold print for categories, italicized titles of plays, and a logical order of information will help the reader be able to read the *résumé* quickly.

The style of the resume will indicate something about the designer. There are infinite choices in terms of kinds of paper and the use of borders, graphics, color, and so on. Take care that these choices don't make the information on the *résumé* harder to read. These decisions are important, but no one is going to hire based on the kind of pretty paper or color that is used on a *résumé*.

Business Cards Business cards have contact information and are important as a quick reference to potential employers after they meet a designer. The business card should match the style of the *résumé*—same font, same color, same overall style. The use of electronic business cards is becoming more common. There are several applications for smart phones that will keep the information of a business card. There are also applications that will allow two people to "bump" phones to transfer that information easily and quickly.

If a "hard copy" business card is used, there is a wide range of card stock that is standard. Colored background, colored print, use of graphics can all make the card unique, just as on a *résumé*. They can be designed and printed easily using a computer which, of course, allows for immediate or frequent changes if necessary. Any printing company can be used also.

After the initial contact, it is not a bad idea to send a reminder of the meeting. A résumé should be included. Some designers prefer to use a postcard with a good image of a design as a follow-up.

Website Any designer starting out today must have a website. As society has become electronically connected, this is the easiest way to keep current. As with the résumé, it is important that a designer's website be simple and quick to navigate. It is not useful if the information is difficult to find. Moreover, it need not be fancy although it should be tasteful. The site should be individualized, as it is a reflection of the designer's aesthetic style. The style should match the résumé and business cards.

Many websites will have the designer's contact information on the first page. Others will lead with a design. What is important is that links to the résumé and portfolio are easy to find. Careful thought and organization is critical for a website design. A website may well get a potential employer interested.

It is not necessary to be fluent on web design as there are applications with templates to help with the electronic aspect of a site. In addition, there are companies who design websites (although this can be very expensive). The website, again like the résumé, will be in constant flux as a designer continues to work so a site that is easy to change should be considered. Many designers will use the website as a way of communicating with a director. Any and all work can be placed on the website for a director to peruse and then comment on. For some, the website becomes the repository of all of their work. However, it is not really necessary to show every image of a production. The best practice here is to only show the most impressive work.

Getting Known as a Designer

There are any number of ways in which a novice set designer can begin a career. Some work as assistants, others begin as scenic artists or props artisans, and still others begin by designing a series of small, low-budget productions. By playing to their strengths, working to capacity on every project, and getting to know as many directors, producers, and other designers as possible, designers can increase their chances of getting work. Because of the competitive nature of theatre work, it is incumbent on the designers to be aggressive in "advertising" themselves. There is a certain amount of hustling that must be done to get work, particularly if living in a large city such as New York, Los Angeles, or Chicago. Being readily available (often at a moment's notice), being willing to introduce one's self, and being able to have a conversation with a designer, a director, or a producer who is a stranger are all good strategies.

Working as an Assistant For many young designers, working as an assistant is the most obvious way to begin a career. Historically, this was the case, as theatre was—and to a large extent still is—based on an apprentice-type system. The advantage of working as an assistant is that a novice can observe up close how a more seasoned theatre artist works and potentially meet other designers, directors, producers, and especially assistant directors. Some designers will, after establishing a trusting relationship with an assistant, hand off projects that they either don't want or are unable to schedule. Many young designers get their start this way. Typically, a scene design assistant drafts, builds models, or does research. Some designers will use assistants during tech rehearsals. This varies with the designer and, in part, depends on the particular skills that the assistant demonstrates.

It is not unusual to work for little or no money at first, as is true of many internships (discussed below). If the experience and contacts are worthwhile, this can be valid. But if his skills are good, an assistant should expect to be paid. Certainly, the more experienced assistants will be able to demand higher pay.

Research the basic information about a designer before making contact. Find out what productions a particular designer or director has done and look at those designs; then make direct contact. This approach will ensure a much more gratifying conversation and increase the chances of landing a job.

Internships Almost every regional theatre and most summer theatres in the country have internships. These jobs may be in the scene shop, paint shop, or prop shop. The advantage of working as an intern is steady employment, typically for a year (or a few months if it is a summer theatre). This is a great opportunity to meet several designers as most theatres hire on a show-by-show basis. Since the designers' paperwork is readily available to anyone in the shops, it is a good chance to look at all drafts, sketches, and models as well as to observe their design process and behavior with the various shops. Interns often will ask those visiting designers to take a look at their portfolio, which can lead to assistant work (see above). Many theatres hire staff from the intern pool, so this is a good way to get a more permanent job which may eventually lead to design.

Theatres looking for interns will expect at least a beginning level of skill but this will vary greatly depending on the theatre and the specific internship. A portfolio and/or interview may or may not be required. Many theatres interview candidates at national conferences, such as USITT (United States Institute of Theatre Technology) and SETC (Southeast Theatre Conference), as well as at their home theatres.

When looking for an internship, it is wise to research any theatre that is of interest as they are all unique. The more information a potential employee has about what kind of plays a theatre generally produces, the better prepared he or she is for an interview. It is not a bad idea to ask around and learn where colleagues had a positive experience.

Working as a Scenic Artist or Props Person A skilled scenic artist or props artist will always be able to get work. Regional theatres, as mentioned above, hire in both areas often as interns, as discussed above, as well as staff. Some job in people for individual productions (particularly true for scenic artists) and some have full-time staff. This is another way to get to know both designers and directors. As with interns, many staff people work their way up to design or parlay this work into an assistant position with a designer. In either of these shops, close involvement with the designer will help form a strong working relationship.

One advantage to working in a regional theatre, especially as staff, is that there will be time to design during down time. Most regional theatres are in medium to large cities in which there are a number of small theatres looking for designers. Although some of these jobs may not pay, the experience might be worth it both in terms of filling out the resume and getting to know directors. Of course, every design experience is a lesson if a designer is paying attention.

The potential disadvantage is that staff will sometimes get "type-cast"—for example, as a scenic artist who occasionally designs. This can make it more difficult to get design work.

Working Freelance This is probably the most difficult way to get started, but it is the right way for many young designers. It is likely that the only designs on the résumé at first will be work that has been done at school. Most working professionals view that with some skepticism. With this approach, being aggressive about getting work is critical to convince a producer or director that it is worth taking a chance on a relatively untested designer.

It is probably easier to approach the business this way if living in a major city as there are more small theatres hiring designers. This provides more opportunities for work although it requires taking initiative. For at least a year, a novice designer should take every job that is offered. This is a good way to expand a network; working one job often leads to another. The sooner the resume fills with professional work, the better. Get as much information about every theatre that is nearby and find a way to meet the artistic director.

This may mean balancing design work with assisting, prop work, scene painting work, and anything else that comes along. Small theatres often have small budgets and little or no staff so more creativity than usual is needed. But by being tenacious, one can develop a solid reputation as a designer. This can lead to better jobs at larger theatres with more support.

The Portfolio

A designer's portfolio is a visual record of his or her work as an artist. Because every designer is unique, every portfolio will be different. A designer should use the portfolio to tell whatever story he or she wants to tell. Assuming a designer is working, there is always new work to show; therefore the portfolio, like the résumé, should be a living, ever-changing document. There is no one way to put together this kind of documentation. There are, however, guidelines to help the novice designer.

Designers should choose the method that is most comfortable for them to show their work. Images can be pasted on a page or be loose, pages bound in a spiral-type book, or grouped in a loose pile. It is easier to control pages in a book but easier to move back and forth between images if pages are loose. If images are mounted on paper, that paper should be neutral in color in order to keep the focus on the work. It is not a good idea to splash color throughout the portfolio for this reason. Simplicity is key. Employers are interested in the work and in the designer, not in scrapbooking potential.

The images themselves should be of the highest quality, easy to see, and on the best paper that is affordable. Someone looking at a portfolio will skip over excellent work if the images are unclear, too dark, or otherwise hard to see. All images should be labeled with at least the name of the production or, if there are several images from one production on a page, a single label on the page will work. Identify the job if not as scenic designer (that is, scene artist, assistant).

The portfolio should show the range of the designer's work, his ability to get a show through a shop, and his process in developing an idea culminating in a successful design. As with actors, producers and directors make decisions about their interest almost immediately. The first design in the portfolio should be the strongest work to get them intrigued from the start. Moving around from one kind of production to another—large tragedy to small musical to a classic and so on—helps maintain interest and shows a range of work.

Keep in mind that directors, producers, and other designers look at portfolios with a different eye. A producer is most likely to want to see only finished work (as in production shots) whereas a director will want to see the process. This might mean including a page of research, rough drawings, and an initial model to indicate how ideas were communicated. A designer will likely want to see all of that plus an indication of an ability to draft and build models. Review a portfolio just before showing it to reorganize for a particular audience.

It is common not to get an immediate response after the initial contact. A follow-up note or a phone call after a week or so is an appropriate response.

The Interview

It is generally not difficult to get an interview with a designer or with a regional theatre. Most directors and some producers are happy to see who is new to the field or maybe just new to them. A simple email or telephone call will usually suffice. If a director or designer is particularly busy, scheduling might be an issue so flexibility is an advantage.

Get as much information about the theatre and the interviewer as possible. A regional theatre might have a designer interview with the artistic director or the production

manager. Find out what they have done as it might be a discussion topic, particularly if it was something that was inspiring.

Honesty about skills and qualifications is important. It is never a good idea to “fake” an answer to a question. A smart designer will be ready to respond to any question about any work that is shown. The assumption is that anyone getting an interview is capable of designing. The real question is whether the interviewer wants to work with the candidate. If there is something in common, bring it up. Mention any acquaintances who have already worked at that theatre. Don't bad-mouth previous colleagues even if asked and even if the experience with them was difficult.

Every interview is different. Some interviewers will do all of the talking; some will do none. Others will ask questions about the work. It is possible that an interviewer will grab a portfolio, flip through it quickly, and be done. The next time, someone might dwell on the first design and not get halfway through the portfolio.

Dress appropriately. A professional and a designer must look the part. Better to be overdressed than underdressed. Different venues will suggest different clothing choices.

A thank-you note after an interview is always a good idea. Not only is it common courtesy, it will remind the interviewer of the conversation.

When Not Employed

When not working, take the time to improve skills. Take a drawing class or a painting class or volunteer at a theatre working backstage (almost no theatre turns down volunteer labor). Most museums offer art classes of various kinds, usually very affordable and even small cities have theatre of some kind. Or learn a new computer program or skill that will help with design work. During unemployment is the best time to work on skills that need development.

5

Color in the Design

Any discussion of color must begin with a definition of the word. This is not as easy a task as it might seem. To a physicist, color is light, referring to the small visible portion of the electromagnetic spectrum. An artist will refer to paint, and a psychologist will suggest that color is individual perception because no two people see color in exactly the same way. Any experience of color involves all these attributes. The theatre artist must consider all of them when using color as part of the critical analysis of and emotional response to a play.

Although scenery, costume, and lighting designers all learn about the properties of color, they apply this knowledge in different ways. All designers are interested in color and light, but lighting designers are more involved with the physics of color; scenic and costume designers are more involved in painting and dyeing; and all three deal with the manipulation of colored materials. Whatever the specific use of color may be, it is the melding of ideas onstage to form a cohesive visual statement that is ultimately important. The designer in the theatre must be aware of the separate uses of color and be able to explain the effects of color both as light and as paint. Thus, any explanation of color in the theatre must involve not only the separate study of color in light and color in pigment but, more specifically, the integration of the two.

Clearly, then, any theatre artist, designer, director, or actor should understand at least the basic “language” of color in order to communicate clearly. Everyone should be aware that not only do no two people *see* color in exactly the same way, but no two *respond* to color the same way. Color inevitably elicits an emotional response. It is one of the strongest elements of design and the most difficult (if not the most important) element to understand.

The Language of Color

The three most basic terms used to discuss color are **hue**, **value**, and **chroma**. (See Chapter 3 for a brief discussion of color as an element of design.) One can describe a color by *hue* identification or, simply put, the name of the color (red, yellow, and so on); *value* level, or the amount of black or white present in a color or how light or dark it is; and the degree of *chroma*, or freedom from adulteration by mixture with another hue. Any color can adequately be described in simple semiscientific terms by referring to its hue, value level, and degree of chroma. In normal communication, emotionally charged phrases such as “blushing pink” or “passionate purple” are common but open to interpretation. But, because descriptive labels are so firmly a part of the advertising and merchandising of color in fabric, paint, and the light-color medium, a designer soon learns to translate them into more communicative terms. A “chocolate” shade, for example, might be described more precisely as a spectrum orange neutralized to

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hue The name of the color (red, yellow, and so on).

value The amount of black or white present in a color or how light or dark it is.

chroma Purity of color; freedom from adulteration by mixture with another hue. Also referred to as *saturation* or *intensity*.

one-half chroma but retaining its normal low-light value position. (We discuss and illustrate these concepts in more detail later in this chapter.)

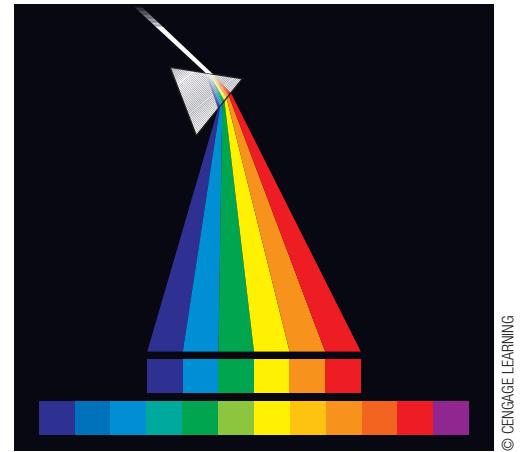
Because there is no color without the presence of light, a general understanding of these principles is necessary. Chapter 16 covers this information thoroughly; however, this chapter deals more specifically with color and pigment, with but a few brief words about the science of light. Only a small portion of the electromagnetic waves that are called *light* are visible to the human eye. When these visible wavelengths are mixed together, we see white light. Conversely (and probably more useful to us), if we break white light into its components, as through a prism (a process called *refraction*), we see a separation of colors into the visible spectrum, from ultraviolet to infrared (Figure 5-1).

Hue

The position of a color in the spectrum determines its hue. The number of hues that can be separated or identified as principal hues in the spectrum is arbitrary, but six are commonly and easily identified: *red, orange, yellow, green, blue, and violet* (Figure 5-1). Different color theories distinguish more or fewer discernible hues, depending on the purpose. In application, the painter may wish to begin with a larger number of “hues” when mixing colors, especially since his mixing will not be as accurate as mixing done by a professional but will be much more subjective.

Primary hues fall within the six basic hues of the spectrum and form the basis for the mixing of color in both light and pigment. In other words, theoretically, all other hues can be created by mixing the primaries. In pigment, the primaries are red, yellow, and blue; in light, red, green, and blue are the primaries. Mixing any two primary hues produces the three **secondary hues** (orange, green, and violet in pigment; in lighting, cyan, magenta, and yellow (CMY)).

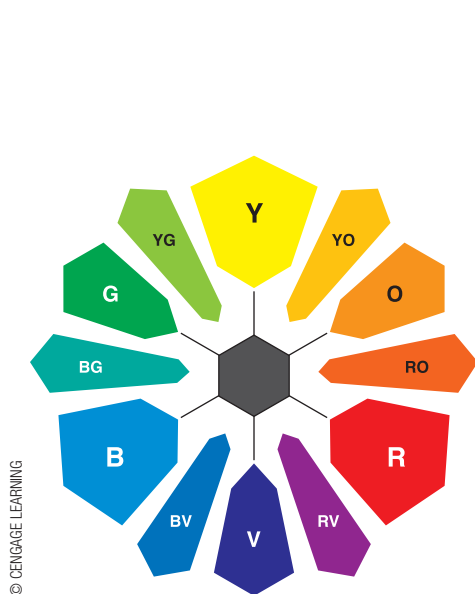
The Color Wheel To show the physical relationship of spectrum hues, most color notation systems use a color wheel (Figures 5-2 and 5-3). The circular arrangement of



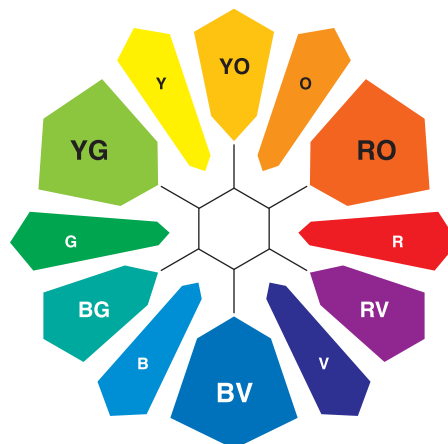
5-1 Spectrum Hues The breakdown of sunlight through a prism refracts light into first six, then twelve spectrum hues.

primary hue One of three hues that are used to mix all other hues. In pigment, the primary hues are red, yellow, and blue; in light, they are red, green, and blue.

secondary hue One of three hues produced by mixing any two primaries. In pigment, they are violet, orange, and green; in lighting, they are cyan, magenta, and yellow (CMY).



5-2 Pigment Color Wheel Twelve principal hues of the spectrum arranged in a circle. Diagonals are color opposites; their subtractive mixing would produce a neutral shade similar to the gray in the center.



5-3 Light Color Wheel The light color wheel is centered on the light primaries. The large lozenges are the light primaries YG, BV, and RO. Two adjacent primaries mix to form intermediate, or secondaries, that become complementary hues. The secondaries are lighter in value because of the additive mixing of the primaries. The additive mixing of all primaries is shown by the white in the center.

tertiary hue Any hue that is the result of mixing a primary hue with a secondary hue. In pigment, there are six possibilities: blue-green, yellow-green, yellow-orange, red-orange, red-violet, and blue-violet.

complementary hue One of any two hues directly opposite each other on the color wheel.

tint Lighter value of a hue.

shade Darker value of a hue.

colors brings into view the diametric and adjacent correlation of the twelve spectral hues and thus provides designers a schematic view of primary and secondary hue relationships. For example, both the primary and secondary hues form triangles. Using the color wheel, we can easily see how, by mixing two primaries together, we produce a secondary hue. Taking this one step further, mixing a primary color and a secondary color (such as green and blue) results in a **tertiary hue**, such as yellow-green, blue-violet, and so on.

Complementary Hues Hues that appear directly opposite each other on the color wheel are **complements**. When any two complementary hues are placed side by side, the color contrast is so high that it produces an apparent vibration. Mixing two complementary colors results in a “neutralizing” of the hue (see the following discussion on chroma).

A knowledge of complementary hues is not only necessary for mixing pigment but is also important in the composition of any production color scheme for both the costume and scenic designers. If the scenery and costumes are too close to one another in hue, the actors may well “disappear” into the background. Conversely, if the actors and the scenery are in complementary colors, the lighting designer will have a difficult time avoiding graying out color. Color in light and pigment must be compatible or have the same complementary colors.

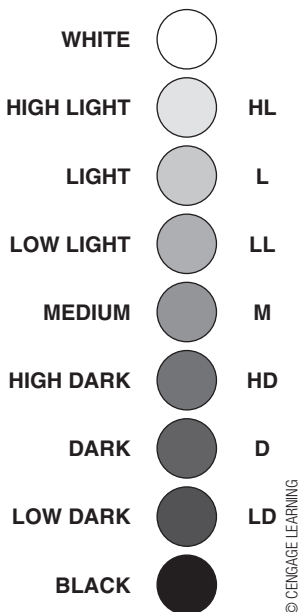
Value

The light-to-dark relationship of a hue or mixed color is its *value*. The lighter values, nearer white, are known as **tints**; the darker values, approaching black, are referred to as **shades**. Both represent variations of the true hue (Figure 5-4).

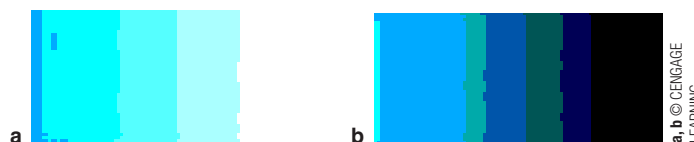
The use of value as a color variant or a control is more obviously the tool of the painter than of the lighting designer because of the necessarily greater range in pigment mixing. Subtle value differences are easier to accomplish in paint, particularly in the darker ranges, because in the use of colored light there is no black. However, the lighting designer does have control of the *amount* of light, which directly affects the value of every object onstage. Using less light lowers the value of what the audience sees.

Although the number of steps in a value scale (or gray scale) is arbitrary, the standard is nine (Figure 5-5). This is due to the eye’s limited ability to distinguish smaller differences. The value in the center of the scale is referred to as *medium* (*M*). The steps above *M* toward white are *low light* (*LL*), *light* (*L*), and *high light* (*HL*). Below *M* toward black are *high dark* (*HD*), *dark* (*D*), and *low dark* (*LD*). Within this range the artist can create form without the use of color.

Value and Hue Every hue in its purest form has an inherent value on the gray scale. The light-to-dark difference between yellow and violet is the most extreme example. Other hues have less value difference and some, of course, are about equal (Figure 5-6). Red and blue, for example, both place at high-dark.



5-5 The Value Steps



5-4 Tints and Shades

a The range of tints from primary blue to white.

b The range of shades from primary blue to black.

The Value Sketch The worth of the value sketch cannot be overemphasized. Using black and white tones to suggest light, an artist can model the forms in a design. This expressive method allows the designer to suggest the tone of the piece without worrying about the specifics of color. Many old masters applied monochromatic underpainting, using the values of a single hue to express form and light before overprinting in full color. Value sketches can be expressed in any medium, although marker, pencil, and pen and ink are the most common (Figure 5-7).

Chroma

The instant the purity of a principal hue is modified, the change is referred to as a difference in its *chroma* (*saturation* and *intensity* are also common terms for this). Even the addition of a small amount of white or black changes the purity of a hue, and therefore its chroma. Most changes move the hue toward a neutral gray (as on the value scale). Like value, chroma has a scale in which the degree of pureness, or freedom from neutrality, is measured in steps. Although there are an infinite number of steps possible from a pure hue to neutral gray, most color theories use only four for

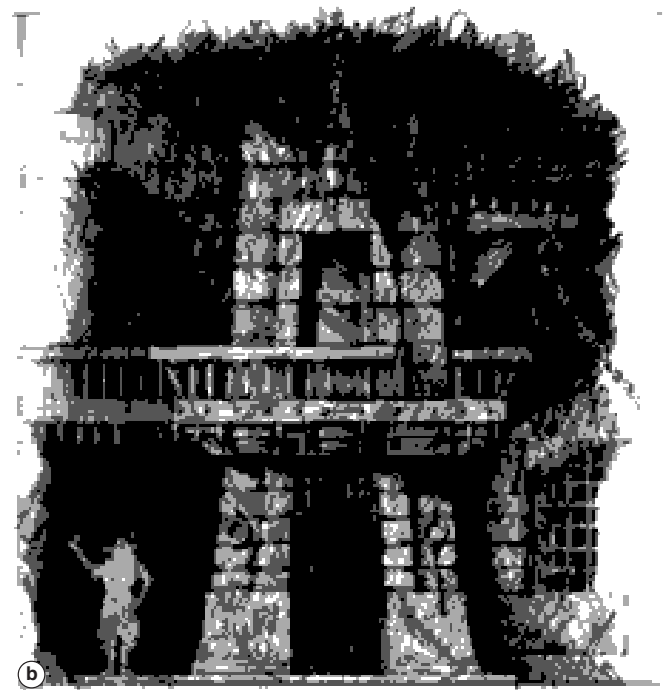


5-6 Hue-Value Relationship The twelve principal spectrum hues are arranged next to the value scale in their natural light-to-dark relationship. The middle value of the seven steps between black and white is referred to as medium in value; the three steps above are known as low light, light, and high light. The lower value steps are high dark, dark, and low dark.

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a COURTESY TIM SATERNOW
b COURTESY ANNE MUNDEL



5-7 Value Sketch Three black-and-white sketches showing light and dark.

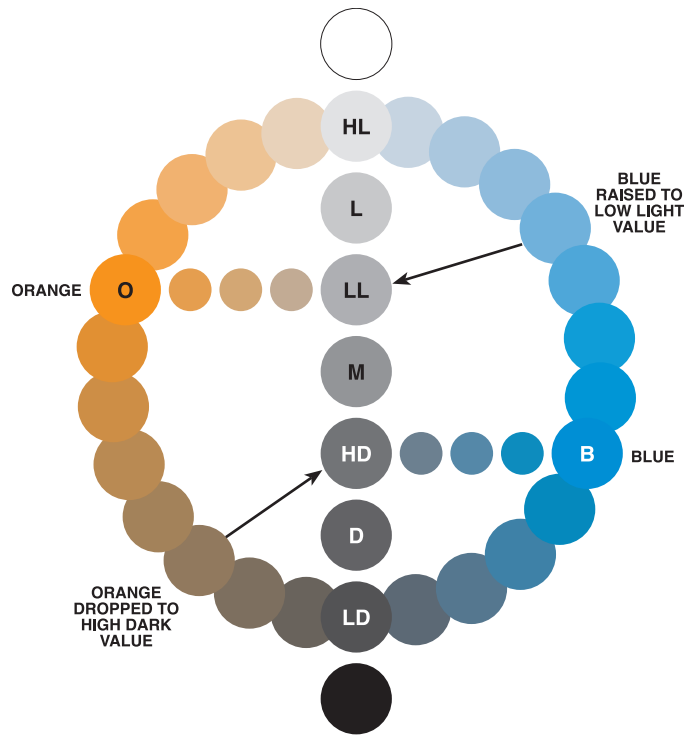
- a *Buried Child*, designed by Tim Saternow.
- b *Man of La Mancha*, designed by Anne Mundell.
- c *Beauty and the Beast*, sketch and design by Scott Davis.



COURTESY SCOTT DAVIS

5-8 Value and Chroma The complementary hues blue and orange are subjected to value and chroma changes first by alternately mixing each color with white and black in the outside ring to effect a value change. Chroma changes at fixed value are accomplished horizontally by mixing a color with its complementary hue after it has been raised or lowered to the same value (arrows). Note that changing the value of a hue automatically alters its chroma.

It is possible to alter chroma at each value step and completely fill the circle with a variety of tints and shades. This mixing procedure (impossible to reproduce accurately), applied to any set of complementary colors, serves the stage designer as a method of creating new and unusual colors as well as matching existing shades.



practical reasons, working in quarter portions from a fully saturated hue to three-quarter saturation, through one-half, then one-quarter to complete neutrality. These steps are particularly useful in describing a color. Intermediate steps are as subtle as can be perceived.

Mixing complementary hues such as red (high dark) and green (low light) in equal parts results in medium gray on the value scale. This is very useful because designers rarely want a pure hue onstage. The amount of the complementary color can be controlled to achieve exactly the saturation of color that is desired. Although complementary hues in paint result in neutral tones, when mixed in light, they produce white.

Using the complement is the easiest and usually best way to control chroma through pigment, even though neutralization can be accomplished to a certain extent by the use of black or white. As a tint or shade moves a hue toward black, it is moving as well toward the gray (or value) scale. However, the use of a complementary color to neutralize a hue gives the painter a chromatic neutral that has more life under the stage lights. Black especially tends to “deaden” a color.

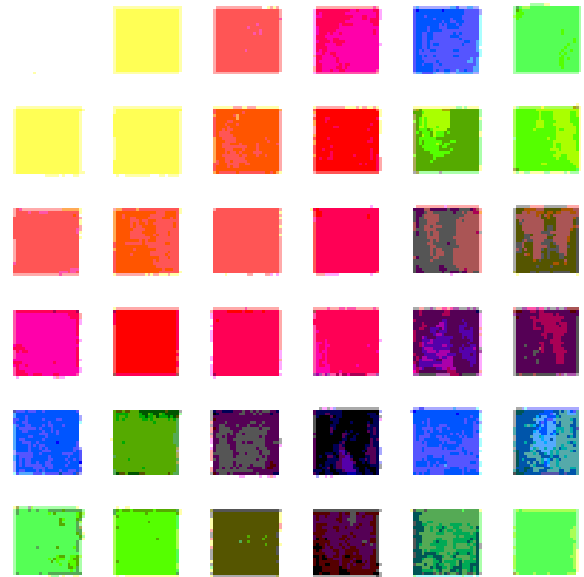
Figure 5-8 shows the value and chroma changes produced by mixing orange and blue hues. When the value of either orange or blue is raised or lowered, its chroma is also changed as the tint or shade becomes more neutral. However, each quarter step on the direct horizontal line to the value scale represents a chroma change without a value drop. This change is accomplished on the orange side by the proportional mixing of blue (the hue complement of orange) after it has been raised to the matching value of orange. In other words, it is possible to change the chroma of a hue without affecting its value, but it is impossible to change the value of a hue without modifying its chroma.

Color in Pigment

Pigment refers to the coloring agents in paints, dyes, and nature. It can be best explained as the chemical properties of color that create hue. At first, pigments came from natural sources; the indigo and madder plants are familiar examples. Minerals and semiprecious stones were also pulverized and made into pigments. The practices of the past established many of the names of colors still used today, such as madder lake and indigo blue.

In the mid-nineteenth century, chemical breakthroughs produced colors that had never been seen before. These dyes were made from natural materials, mostly minerals and their compounds. Although present-day pigments are often created from compounds not found in nature, many still bear the name of their earlier source, such as chrome green, alizarin crimson, and calcium red.

Theoretically, one could make any hue by using only the three primaries in pigment (Figure 5-9). However, attempting to create pure secondary hues by mixing pigment primaries is impractical because of the color impurities of manufactured paint. It is worth noting as well that every manufacturer of pigment creates slightly different paint in terms of impurities. One company’s “ultramarine blue” might be more green than that of another company. Hence, a painter should begin with a larger palette that might include all the principal hues of the spectrum. This palette includes the primaries and secondaries as well as intermediate hues in the color wheel.



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5-9 Mixing Color in Pigment: Using the five colors in the example shown (watercolor pigments closest to primary and secondary colors), one can see how they change when layered on top of one another. In this case, the color at the top is painted on top of the color in each row. Note that pigment varies by the manufacturer. Somewhat different results would be seen in other media.

Color Modification Through Light

Chapter 16 provides a detailed discussion of the use of color modification, or the use of colored light on colored surfaces. Here we look at the more general aspects of color in light, especially as it relates to pigment. The arrangement of the twelve principal colors on the light color wheel (Figure 5-3) is the same as with pigment. The secondary and intermediate colors are developed from the mixing of the light primaries.

The team of designers can have complete control over how objects are perceived. Colored light can modify surface color. The intentional use of colored light on a colored surface is a useful tool for achieving a variety of visual effects. (See Figure 5-10.) Designers in the theatre have to consider not only the colors of a painted background, costumes, and other materials of a set, but also the colors of the lights that will reveal them.

A colored surface reflects its own color and absorbs all others. A white surface lit with white light reflects rather than absorbs all the wavelengths, allowing us to see the object as white. Likewise, unfiltered light on a black surface is mostly absorbed, revealing the object as black, or without color. Under white light, a colored surface such as green reflects only green wavelengths and absorbs all others. Adding a colored filter to the white light changes our perception of the colored surface. A red filter allows only red light to transmit, which mixed with a green surface appears black. (See Figures 16-6 and 16-7.)

Understanding the basic principles of reflection and absorption, as well as color perception, is critical to set, costume, and lighting designers for obvious reasons. Once again, clear communication throughout the production process is essential. If from the start everyone is aware of how color is to be used in production, great success can result, and the designers can use one another to enhance the statement each is trying to make. Without it, a color disaster may result.

Color Vision and Perception

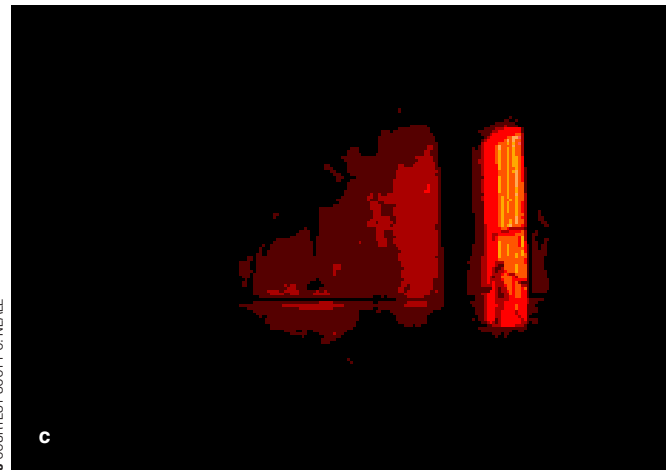
Scientific explanations aside, what the eye sees and the brain interprets is subjective. Everyone interprets color uniquely. The eye functions like a camera, receiving light through its lens, but we process the information based on social norms and our personal background, history, and experience.

a COURTESY SCOTT C. NEALE
b COURTESY SCOTT C. NEALE



5-10 Color Modification The use of light changes the feeling of this set for *Medea*. Designer, Scott C. Neale.

c COURTESY SCOTT C. NEALE



Intensity and Color Overload

The retina of the eye assimilates light energy. Hence, after any sudden change of intensity or color, the retina has to regenerate itself. This process takes place over a noticeable period. It takes the eye about one to one and a half minutes to adjust in a blackout, for example (rod regeneration); a color change (cone regeneration) may take as long as five minutes.

The time lag the eye experiences after a sudden change of color explains *afterimage*, a phenomenon of color vision. Until the eye has recovered, it retains an image of the object and a color impression long after the object has been removed or changed. The afterimage, however, is in the complementary hue of the original image color.

The phenomenon of afterimage, or the color-balancing tendency of the eye, also affects how a color appears in the context of another color. In 1839, M. E. Chevreul, an early color theorist, first referred to this effect as the *simultaneous contrast of color*. In 1960, Josef Albers called the same effect *interaction of color*.

Whether subtle or obvious, the degree of color interplay is a critical element in the use of color by stage designers. Aside from the designer's mixing and creating of colors, his arrangement of colors plays a vital role in stimulating an emotional or intellectual response from the audience.

The relative quality of color is significant. The interaction of any two colors affects all variants. The value of a color seems higher when it is adjacent to a dark hue (e.g., a neutral violet can be seem more blue if surrounded by a more reddish tone) and the chroma of a color can be sharpened or deadened by its background. Figures 5-11 through 5-17 show a few classic examples of obvious color interactions that influence the designer's use of color.

Color Sensation and Subjective Response

The experience of color includes elements of sensation or emotion as well. When they choose colors, in both pigment and light, to establish a mood or specific atmosphere on the stage, designers in the theatre must be aware of the scope of the audience’s often subconscious emotional response. The psychological effect of color on an audience, however, is difficult to measure because each individual has different associations with color. To some extent, the designer must depend on a measurable individual response and hope it will multiply.

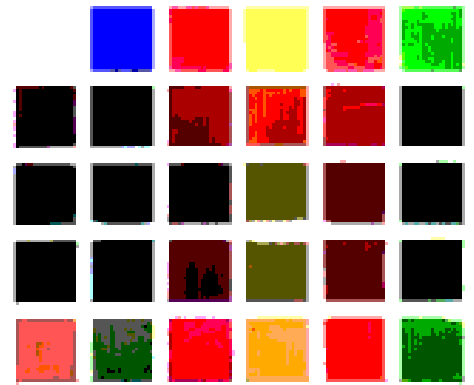
Most emotional response to color is conditioned by a lifetime of reaction to colors in nature and under natural light. We are repulsed, for example, by strong colors in light that produce unnatural flesh tones or discolor our food—one reason green is difficult to use onstage. We are also influenced by centuries of social and religious conventions buried deeply in the subconscious. Finally, we react to symbolism in color, some primal and others more contemporary (such as traffic lights and color-coded road signs) (Figure 5-18). We hear constant references to things like “fall colors” (meaning shades of orange, red, and brown, as in Figure 5-11); we associate color combinations of pink and white, green and red, orange and black with various holidays. A person driving a red car is more likely to get stopped for speeding because the color stands out against the earth, and red suggests speed.

The psychological description of a hue is, at best, general. It is generally accepted that cool colors—blue, green, and blue-violet—recede, and the warm colors—yellow, orange, and red—move forward. Such perceptions can be useful to a designer trying to suggest more depth onstage, but it does not mean that she cannot use these colors in any other way. There is nothing to stop a designer from using color in an unusual way; in fact, exploring different ways to use color may lead to deeper meaning. If it helps to create the atmosphere necessary to tell that story, the audience will accept it.

As we have seen, adjacent colors can counter or modify an emotional response to a particular hue (Figures 5-12, 5-13, and 5-14). The intercolor experience, which involves both the psychological response and the physiological limitation of the eye, can also be tricked by an optical illusion. This phenomenon of “fooling” both the eye and the mind through careful control is dependable enough to be considered an important part of the effects of color on a theatre audience.



5-14 Hues and Neutrals A small neutral surface is influenced by the color of the ground that surrounds it. The neutral in each of the six blocks appears to vary slightly, depending on the background color.



5-11 Using Earth Tones Earth tones are extremely common in use, and an amazing variety can be achieved. This chart shows how four of the most common earth tones in pigment—burnt sienna, burnt umber, raw umber, and yellow ochre—mix with five acrylic pigments that are closest to primary and secondary colors. As with watercolor, pigment varies with each manufacturer. Somewhat different results would be achieved with other media.

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5-12 Hue and Value Relationship Color is seen in relationship to its surroundings. Proximity can greatly affect our perception of color. In this example, the center stripe of violet does not change. As our eye moves from the lighter value of the orange to the darker value of the blue, the violet stripe appears to also change—darker in relationship to the orange, lighter in relationship to the blue.

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5-13 Warm and Cool Relationship In this example of color relationships, our perception of the light violet stripe in the center is once again affected by its surroundings. The closer to the cool blue hue, the warmer the violet appears; the closer to the warm red hue, the cooler the violet stripe appears.

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5-15 Hue to Complement The range of the hue red to its complement of green. Note the grayish tones in the middle of this bar.

Color Manipulation

Some designers have an intuitive sense of color. The colors they put together seem right for the specific dramatic moment or atmospheric scene. A designer in the theatre, however, frequently has to suppress personal preferences in order to maintain color control (harmony or contrast) within the production. To ensure a unified color solution, all designers—scenery, costume, and lighting—rely on color schemes that are determined well in advance in order to coordinate the final color impression.

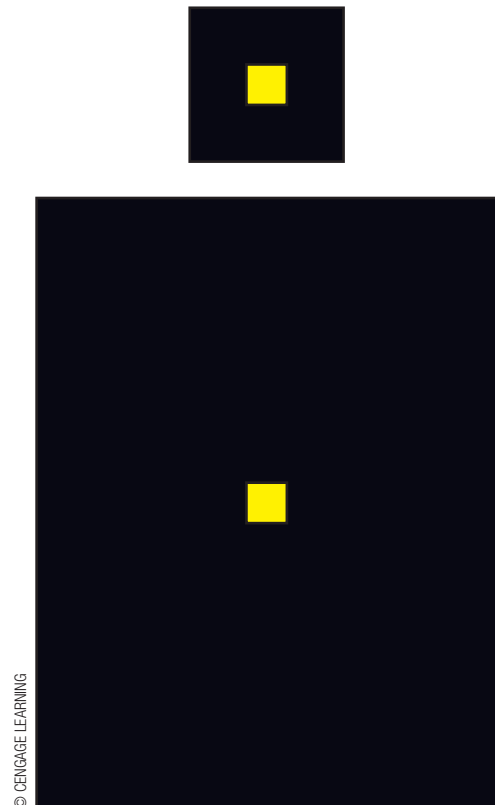
The Color Scheme

The development of a production color scheme may be as simple as deciding on the overall tonality of a single hue, or it may involve selecting several related or contrasting colors. The *harmony* or the *contrast* of hues becomes the basic control of a production color scheme. The mood of the production is often expressed in the interrelationship of the colors in the scheme. All the variants of color (hue, value, and chroma) may be called on to provide interest and flexibility to the final colors in the composition or to enhance our understanding of the play. One obvious example is a musical number with a lead singer or dancer who is dressed in white surrounded by an ensemble in black (see Figure 5-17). A designer can use chroma to achieve focus more subtly: if the majority of the stage is bathed in colors of similar saturation, the one object that is brighter becomes the focus.

One way to develop a color scheme is to examine the relationships of the hues on the color wheel. The closer the hues are on the color wheel, the more harmonious they appear together. Increasing the distance of two hues on the color wheel increases the contrast, the limit being complementary colors (see Figures 5-15 and 5-16).



5-16 Complementary Colors Note how the blue hue appears to change when placed next to variations of the complement orange. Top to bottom: blue with orange, a tint, a shade, a lower chroma.



5-17 Hue and Field The larger field of black makes the small amount of yellow appear brighter than it does in the smaller field of black.



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5-18 Color Associations We make all kinds of assumptions about color. The blue stop sign and the green caution sign simply look wrong. Red is used because it signifies potential danger; therefore, one must “Stop.” Yellow is a color we use typically to suggest caution.

Typical color schemes include these:

- **Monochromatic.** A **monochromatic** scheme uses one hue and its variations in value (with the addition of black or white) and chroma. A monochromatic scheme means that the complement to the hue is used only to neutralize or gray down the color. It does not mean the use of a hue and its complement in equal amounts. (A monochrome of green uses red only to neutralize the green to a gray.)
- **Analogous.** An **analogous** color scheme has little contrast because it uses three hues that are adjacent on the color wheel (yellow, yellow-orange, and orange, for example). This is one way to maintain a very tight palette.
- **Complementary.** The perception of vibration when placing complementary colors next to each other has already been discussed. This problem can be alleviated if the saturation of the two complementary colors is at variance.
- **Black and white.** Although this color scheme can be severely limiting, it can also be extremely elegant. It suggests high contrast, but it could just as easily mean the use of many grays. The use of warm and cool grays can enable the designer to create interest and contrast quite subtly. One variation is to use one hue sparingly in addition to black and white. The Edward Gorey design for *Dracula* is a good example. The set was entirely black and white—no grays—with a single element of red in each set (such as a single red rose in a bud vase or a glass of red wine).

monochromatic Using only one hue, black and white, and the complement to reduce the chroma.

analogous Using any three adjacent hues on the color wheel.

The color scheme serves as a guide to color composition within a design or throughout a production. Besides providing a means of color communication among collaborating designers, the color scheme is also a device for explaining color relationships and analyzing the dramatic use of color. There are, of course, innumerable color schemes; every production calls for a unique way of looking at color, and every designer has a unique way of exploring it.

The Color Plot

The control of color within a composition is only a portion of the color planning that occurs in designing for the theatre. The color scheme for each setting of a multiscene play must also be considered in the context of the entire production.

Some scene designers and many costume designers use a *color plot* to make preliminary studies of the entire production. Although it is a view of the show the audience will never see, it does serve as a color guide for the design team. Through the color plot, the overall development of color can be studied. The functional relationship of colors is clearly visible. The progressive unfolding of changing color within a scene or throughout a production, as well as moments of high contrast or subdued uniformity, can be demonstrated in the color plot. The color plot also establishes the progression of colors from scene to scene and act to act.

6

Drafting the Design

Drafting, or measured drawing, is the visual language and fundamental means of communication among the designer, stage technicians, and, to lesser extent, the director. The planning of a production throughout all its phases relies on the common language of conventions that communicates technical and artistic information. In order to provide simple, clear, and accurate information in such a way that all ideas can be carried out efficiently and accurately, the designer must have knowledge of these conventions and the skills to use them.

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For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

Drafting Equipment

Drafting for the theatre is similar to architectural drafting and engineering drawing in that it is *measured line* (as opposed to free-hand). Whether done with a pencil or on the computer, care, specificity, and the proper use of conventions in drafting are critical in order to provide clear and useful information. This enables the designer to communicate to the shops, the director, and fellow designers exactly what scenery she has designed. Although it is probably easier to learn these conventions by pencil, it can certainly be done on the computer as well. Regardless of which method of drawing is used, it is critical that a designer know what he is drafting as well as why and how he is drafting it.

Both pencil and computer draftings are acceptable. While no shop requires designers to use the computer, any young designer needs to know how to use a CAD—or computer-aided drawing—program such as AutoCAD or VectorWorks, now the standard in theatre.

As with any task, the proper equipment must be used. For CAD drafting, all that is necessary is a computer and the appropriate software. The list for hand drafting is a bit lengthier because there are various tools for different tasks. Figure 6-1 shows the basic hand drafting tools that are needed. It should be noted that numerous other pieces of specialized equipment for unique tasks can also be used.

Because most scenery is too large to be represented in a drawing at actual size, it is necessary to draw “in scale,” that is, reduce the size in regular proportions. Most theatre drafting is done in ½-inch scale, meaning that each ½ inch line represents 1 foot in actual size.

Drawing pencils, mechanical pencils, and leads for lead holders have varying degrees of hardness and softness. Soft lead produces a blacker line than hard lead because under pressure it releases more graphite. The leads are graded by letter—from 6B (very soft) through HB (medium soft to firm) to 6H (hard). The combination of H, 2H, and 4H leads are typically the most useful, but every designer drafts a bit differently. Other leads might be needed to give the variety in line quality necessary for a good print. The choice of lead and drafting tool is determined by the personal taste of the draftsman.

6-1 Hand-Drafting Instruments

	<p>Drafting table with T-square (top) with parallel rule (bottom)</p>	<p>Typically clear white pine to prevent warpage. Typical sizes are 32 x 41 inches and 36 x 42. Should be covered with vinyl plastic such as BORCO or VYCO.</p>
	<p>45° triangle</p>	<p>Plastic or metal, used to draw verticals and 45° lines.</p>
	<p>30-60-90° Triangle</p>	<p>Plastic or metal, used to draw verticals and 30°, 60° or vertical lines.</p>
	<p>Adjustable Triangle</p>	<p>Plastic or metal, with one right angle and one adjustable arm, used to draw any angle and its perpendicular.</p>
	<p>Bow Compass</p>	<p>Used for drawing circles or arcs; can be used with an extension bar for larger radius.</p>
	<p>Beam Compass</p>	<p>Metal arm with 2 adjustable holders—one for metal center point, the other for small piece of lead to draw</p>
	<p>Architect's Scale Rule</p>	<p>Plastic or metal device use for measuring "in scale." Divisions are in feet and inches. (Engineer's scale uses the metric system).</p>
	<p>French Curves</p>	<p>Plastic or metal, used for drawing irregular or non-geometrical curves; wide variety of shapes and sizes</p>

DRAWINGS COURTESY OF MICHELLE CARELLO AND THE AUTHORS



TOOLS OF THE TRADE ■ Drafting Equipment

In summary, basic drafting equipment includes the following:

1. Drawing board or drafting table
2. Drawing board cover
3. T-square or parallel rule
4. Two triangles: 30-60-90 degree and 45-degree
5. Adjustable triangle
6. 6-inch bow compass
7. Architect's scale rule
8. Tracing paper and good drafting paper
9. Lead holder, mechanical pencil (and lead), or drafting pencils
10. Lead-sharpening device: pencil sharpener or lead pointer (for use with lead holder)
11. Series of templates, but at least circles
12. Erasers and erasing shield
13. Drawing cleaning powder or art gum eraser
14. Drafting tape or dots

Hand drafting requires some kind of translucent paper. Vellum, an excellent but expensive tracing paper, is durable, 100 percent rag stock with a nonglare surface to reduce eyestrain and will produce an excellent print. To save money, inexpensive rolls of thin canary yellow or white tracing paper (often called “bumwad”) can be used for preliminary drawings, saving the good drafting paper for the finished drawing.

In addition, the hand-draftsperson should have the following: a sharpener, such as a *lead pointer* for use with a lead holder, or an electric or battery-powered pencil sharpener for use with drafting pencils; an *eraser* and *erasing shield* for erasing pencil-line mistakes; *drawing cleaning powder* to help keep the drawing paper clean; and *drafting tape* or dots, which are used to fasten the tracing paper to the drawing board.

The Graphics of Design

There are as many ways to draft a production as there are designers. Although each designer differs in the amount of information given and in the specific way the material is organized, there is one principle that is the basis for all drafting—the **orthographic projection** (Figure 6-2).

In spite of its academic sound, the orthographic projection is a simple drawing. Orthographic means “straight line.” A straight-line projection (meaning, in this case, an extension of a line) is a method of representing the exact shape of an object in a two-dimensional drawing. Almost all drafting begins with this.

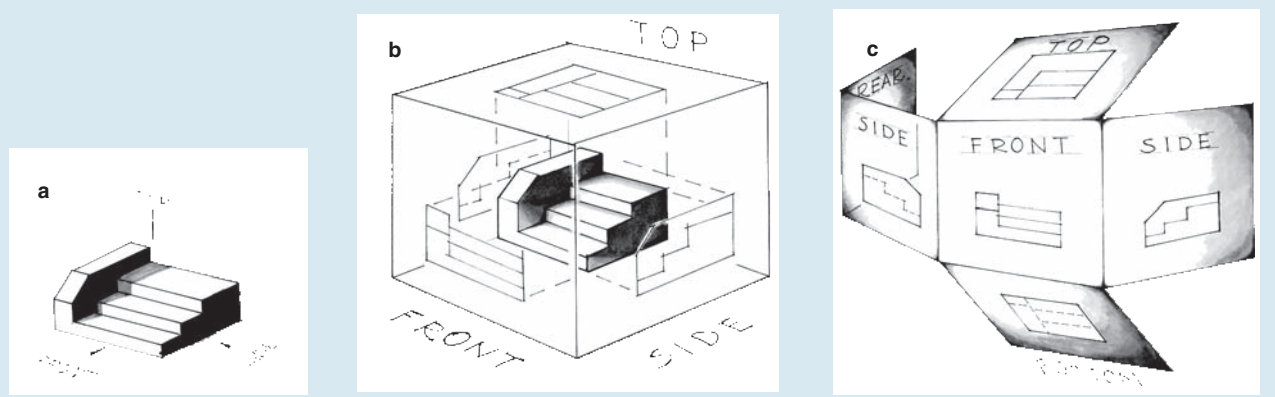
For example, while it is easy to recognize an object from a perspective drawing (Figure 6-2a), it is not possible to measure height, width, and depth. An orthographic projection reveals the object one view at a time—typically top, front, and side—in a measurable line. These views of an object must be aligned correctly in order for them to have any value to the designer (Figures 6-2 and 6-3). Additional views are drawn as needed. Each view is seen in true dimension by straight-line projection so it can be measured.

To understand the method of transposing the views of the object in space onto the drawing board, imagine that this object is in the center of a transparent cube (Figure 6-2b). Projected perpendicular to each face of the cube is a line drawing of the object as it appears in each view, ignoring perspective. With one plane of the cube containing the front view as the center, the other faces are unfolded to both of the sides, the top, and the bottom (Figures 6-2c and d).

These are the three principal views of the object: the *top* view, the *front* view or **elevation**, and the *side* view. The front view is generally the most recognizable one, or the view most likely or most often facing the audience. It is these three views together that give the carpenter a bearing on visualizing the unit in three dimensions. The top

orthographic projection A straight-line projection drawing of an object showing three views, typically the top, the front, and the side.

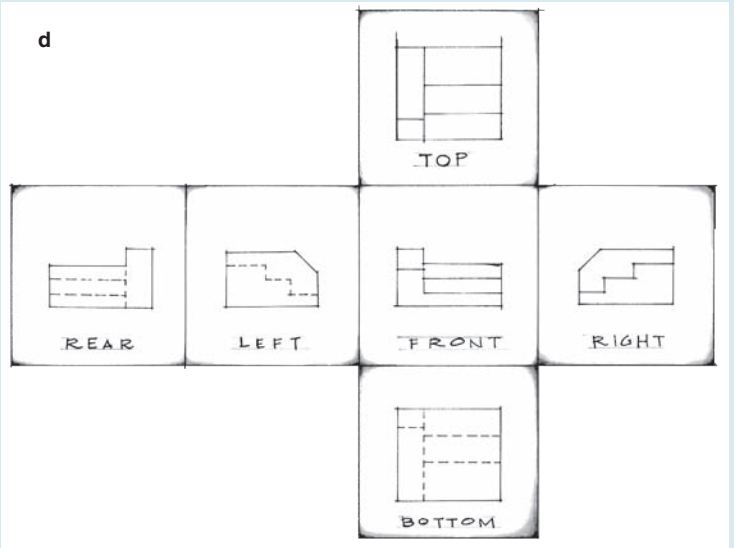
elevation A view of an object in which the line of sight of the viewer is perpendicular to the object, sometimes referred to as a projection.



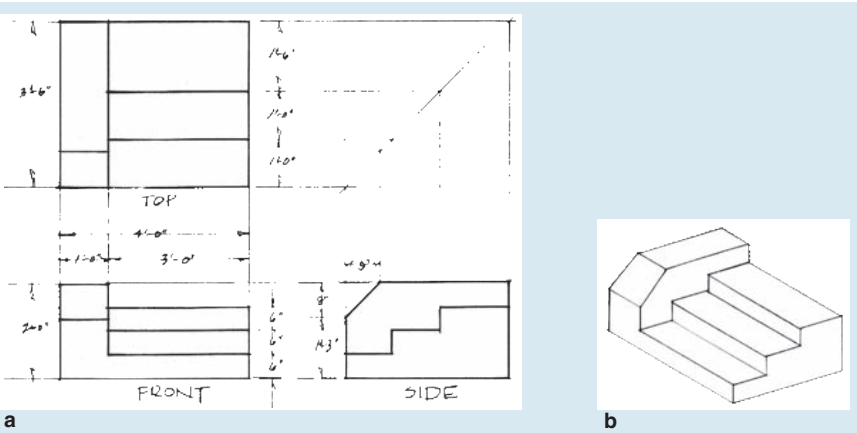
DRAWINGS BY MICHELLE CARELLO

6-2 Orthographic Projection

- a Pictorial view of a three-step unit.
- b Three-step unit surrounded by transparent cube with projection of each side.
- c Transparent cube unfolded.
- d View alignment.



DRAWINGS BY MICHELLE CARELLO



6-3 Scaled and Dimensioned Drawings

Designer's drawings: Three views of an object (top, front, and side) are usually shown, depending on the complexity of the subject. One view may be omitted or an additional view (such as a section) included, if it makes the drawing clearer. Note that the edges of the object in the top and front views are lined up, as are the top and bottom of the object in the front and side views. This alignment is critical in an orthographic projection.

and side views are shown above and to the sides of the front view. Proper alignment of these three views is critical and is done as if rotating the object 90 degrees in a given direction (depending on the view). On paper, this means projecting lines on the vertical or horizontal as shown in Figure 6-3. This saves time and work once the front view (showing height and width) has been drawn, for example, projecting the ends of the object vertically establishes the width for the top view. No re-measuring is needed. In the same way, by extending the height lines of the object, you establish the heights for the side view.

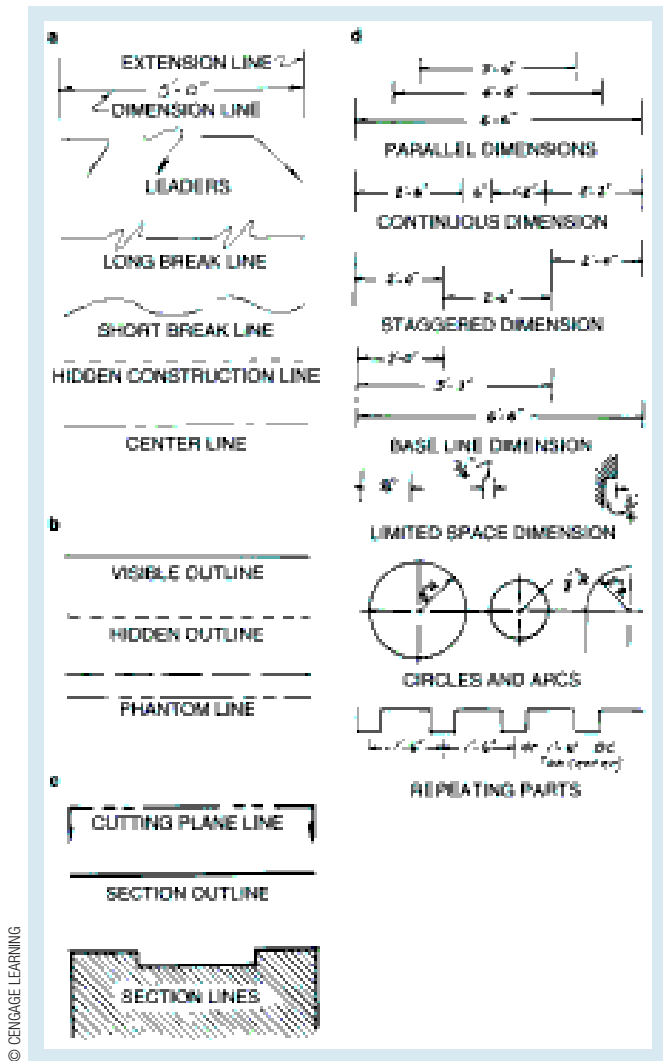
Drafting Conventions

The most fundamental aspect of understanding the graphic language of drafting is learning the standard conventions or symbols, just as one needs to know the conventions of English in order to read a book. The “vocabulary” of drafting includes lines of all types. There are thick lines, thin lines, dotted lines, straight lines, and curved lines—each with a different meaning and function. To correctly draw and read a set of working drawings, one needs a thorough knowledge of these symbols and how they are used. The goal is clarity of presentation and accuracy of representation.

Line Weight and Types

The first and simplest convention is the drawing of lines in different weights, or thicknesses. Most scene designers draft with three weights of line: lightweight, mediumweight, and heavyweight (Figure 6-4).

Different line types and weights are used for different and quite specific purposes. The specific choice of a line weight is determined by its function and tells the reader how to look at the drawing. It also gives the print a feeling of depth, making it easier to read. Although every designer has her own style, consistency of line weight within a set of drawings ensures clarity and can be achieved absolutely with computer drafting. Line weight can be achieved with various leads for the novice draftsman or expert control of the pencil for someone more experienced when hand drafting; on the computer, line weight can be achieved through the use of different colors or in an initial set-up.



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6-4 Line Symbols

- a Lightweight lines.
- b Mediumweight lines.
- c Heavyweight lines.
- d Types of dimensions.

hidden outline The outline of an object that is hidden from view, drawn in dotted line.

Mediumweight Lines Mediumweight lines are used most frequently. They are the *outline* or *object lines* that represent the shape of the object, showing visible edges of all surfaces as they appear at the angle of view. The visible outline is a solid, mediumweight line.

Dotted Lines Dotted lines are used under three circumstances: (1) **hidden outline**, when a view covers or hides a surface outline (see Figure 6-2d); (2) alternate position, or any secondary position when an object appears in more than one place on stage; and (3) any object that is above or, in the case of a section, behind the cutting plane.

Lightweight Lines Lightweight lines are used for reference or imaginary lines. Their function is to give additional information about the object without confusing the overall picture created by the outlines.

Dimension lines, with arrowheads at the ends, mark the extent of the surface that is being measured. The dimension itself, set into the line, shows the exact distance or length and is mediumweight. If dimension lines are set too close to the drawing or within the drawing, they may become difficult to read. To keep the dimension line away from the object, *extension lines* are used. These solid lightweight lines are drawn perpendicular to the surface of the object. As the name implies, they extend the surface to the dimension line. The arrowheads of the dimension line touch the extension line. The extension line itself can touch or be held clear of the object, about 1/16 inch depending on the designer’s preference. (See Figure 6-13 for an example.)

Leaders are free-hand lines with one-sided arrowheads that touch the surface where a note or dimension applies. If the leader is always drawn slanted or curved, there is less chance for anyone to confuse it with the dimension line.

Break lines are space savers that denote an object whose entire length or height is not drawn. When it is necessary to draw a unit of scenery that is too large to fit on the paper, a piece out of the center is removed from the drawing using a set of break lines to show that the scenic unit is not represented in full length. The break line can also be used to indicate that the outer surface of an object has been cut away to show inner structure.

The *center line* is unique in that, as a reference line, it should be lightweight, but given its importance in locating scenery on the stage, it is often drafted in medium-weight. Moreover, it is represented by a special dotted line: an alternating long dash and dot. This particular dotted line should not be used for any other purpose. The center line is a familiar symbol in the plan of a stage setting, where it marks the center of the stage or proscenium opening.

The **plaster line**, an imaginary (therefore dotted) line on the upstage edge of the proscenium arch, is similar to the center line in that it is of such great importance that it is typically drafted in mediumweight line.

plaster line Imaginary line on the upstage edge of the proscenium arch.

Heavyweight Lines Heavyweight lines indicate an object that intersects a cutting plane. Often a side view does not provide enough information about an object, in which case a *section*, or cutaway view, is used. The *section line*, which consists of an alternating long line and double short line, is used to indicate where on the object the cutaway view exists. Arrowheads point in the direction seen in the section view. The outline of an object at this cutting point is drawn in solid, heavyweight line.

Scaled Drawings

Designers communicate information about their design through scale drawings, providing the carpenters and other viewers an accurate basis for studying the proportional relationship of various elements of the set. Many misunderstandings that occur between the designer and the technicians are over drawings that are not clear or that do not provide complete specifications.

Most drawings are done in ½-inch scale (written as 1/2" = 1'-0"), which means that every ½ inch on the drawing is equal to 1 foot at full-scale or actual size. Decorative details that might not be clear at a small scale are frequently increased to 1-inch scale (1 inch equals 1 foot) or larger. Molding or other details that the designer wants accurately reproduced can be presented at full scale. Rough plans are often drafted at ¼-inch scale.

The Ground Plan

The **ground plan** is analogous to the top view in an orthographic projection. Because an actual top view would not provide much information, a **cutting plane** typically 3'-0" above the stage floor is used, leaving a horizontal view from above with the upper portion of the set removed. This height cuts across almost all openings, allowing us to see where doors, arches, and windows exist.

It is impossible to overstate the importance of the ground plan. Because the staging of the production depends on the use of the floor space, the designer must continually think about the plan while the ideas of the set are being developed. The plan grows with the design, pushed one way for aesthetic reasons, altered another way for practical ones, modified for staging purposes, and finally solidified into the key working drawing and information center. The director cannot stage the play without studying

ground plan A cutaway view of a set from a horizontal cutting plane 3'-0" above the stage floor; essentially the top view of the set in an orthographic projection.

cutting plane An imaginary line along which an object is sliced, allowing the viewer to see inside; typically used in reference to a plan or a section view of an object.

and understanding it. The stage manager tapes it out in the rehearsal hall. The lighting designer relates the light plot to the plan, and the production staff depends on information in the ground plan to set up the scenery appropriately.

The ground plan locates the set onstage, labeling the units that make up the complete setting. This includes any walls, furniture, and **masking** or any piece of scenery—walls, black drapes, and so forth—that are used both to complete the stage picture beyond openings such as doors or windows and to hide the workings of the backstage area. The ground plan also includes the position of any furniture, although some designers draft a separate plan to provide that information. In addition, any piece of scenery that will be used in more than one position should be shown (**alternate position**).

masking Any piece of scenery that is used to complete the stage picture and prevent the audience from seeing the backstage area.

alternate position Any secondary position of a piece of scenery, drafted in dotted line.

The sightline points (see Chapter 2) are used to help determine the best arrangement of scenery that allows all audience members to see the action of the play. The extreme house right and house left seats in the front row are marked on the ground plan with a cross overlapping a circle. These “sightline points” also enable the designer to place masking appropriately beyond an open door, a window, or any other opening in order to control what any audience member can and cannot see.

hanging chart A chart included on the ground plan and section that indicates the placement of each piece of scenery that hangs or flies from a batten, including line set number, distance from the plaster line, and trim.

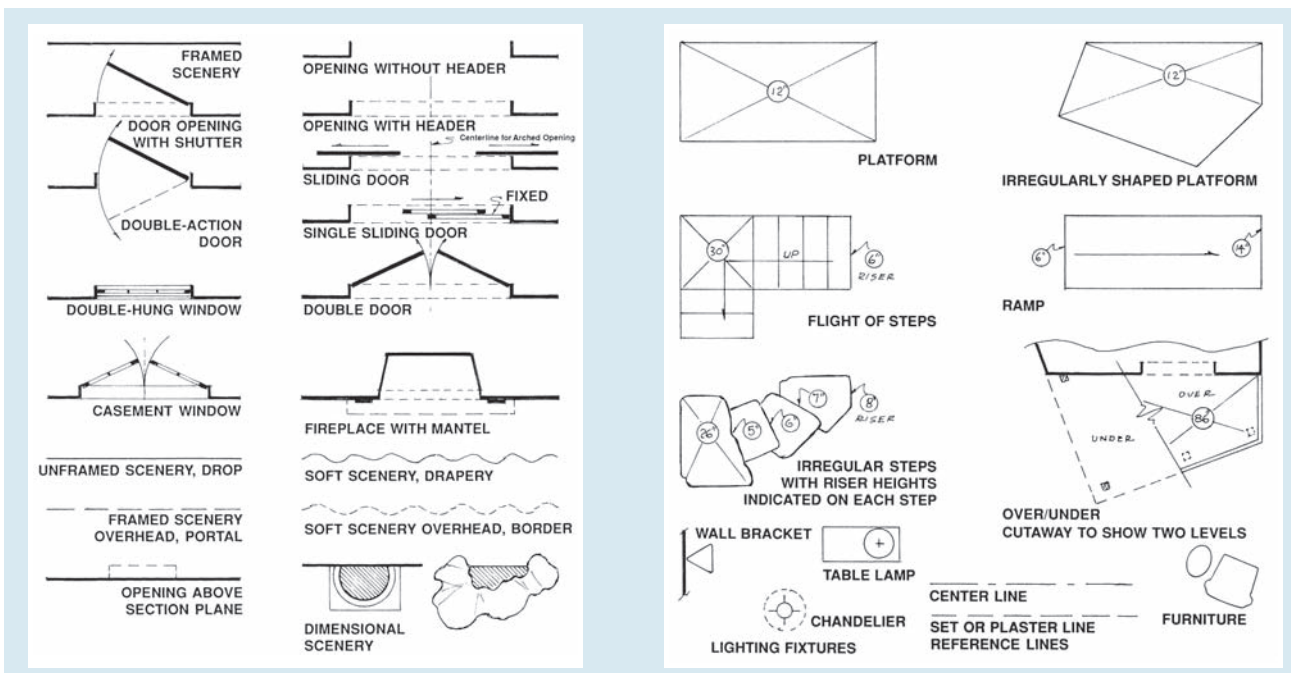
On one side of the drafted ground plan, the designer usually includes a **hanging chart**. This contains the line set number for any piece of scenery that flies or hangs from a batten, as well as the name of the scenic unit, its distance from the plaster line, and its **trim**, or height above the stage floor. A set that has no hanging scenery does not need to include this chart on the ground plan.

trim Height of something above the stage floor.

All walls should be labeled clearly. A simple number or letter system is best. It is also not a bad idea to label any drops, scrim, or masking on the ground plan. Anything out of the ordinary requires a label for easy understanding of the drawing.

Symbols

The ground plan is usually drawn at the scale of $\frac{1}{2}'' = 1'-0''$. In any scale, designers must use appropriate symbols and conventions to communicate the set. Most of the symbols shown in Figure 6-5 are standard; their use and meanings are logical enough if one keeps in mind that a plan is a horizontal section view.



6-5 Drafting Symbols

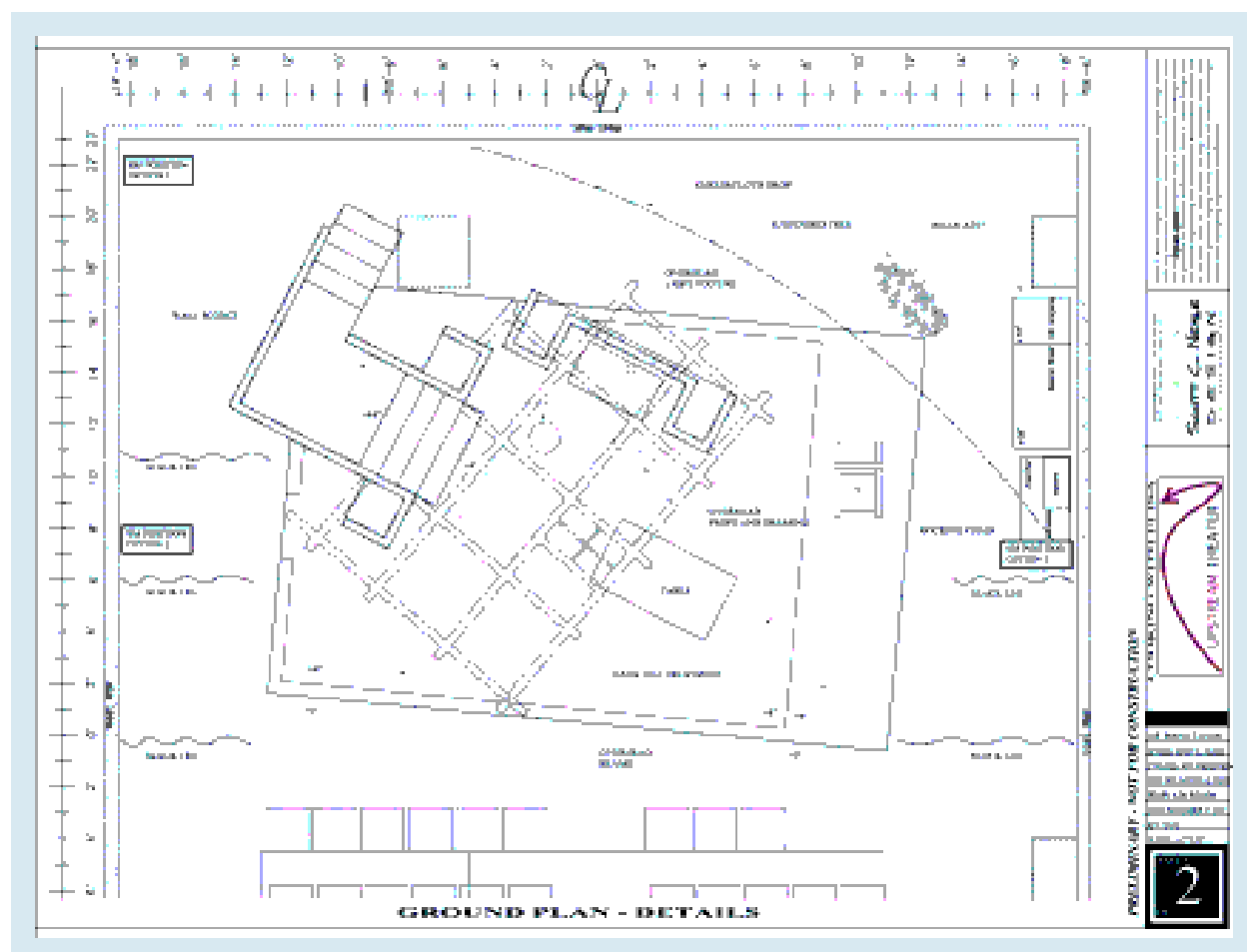
Dimensioning the Ground Plan

Any point on the stage is located by its distance right or left of the center line and its distance upstage or downstage from the plaster line. If a production will tour, the designer might substitute the **set line**, a dotted line or lightweight solid line, indicating the edge of the set farthest downstage. Only major turning points of a set are dimensioned. With few exceptions, no other dimensions should appear in the ground plan.

The technical director uses the dimensions to place the scenic pieces on the stage properly; the stage manager uses them to tape the set on the floor in the rehearsal space. It is not necessary to dimension the plan in great detail because all the scenery will appear elsewhere in separate elevations with complete dimensions. Two ground plans are shown in Figures 6-6 and 6-7.

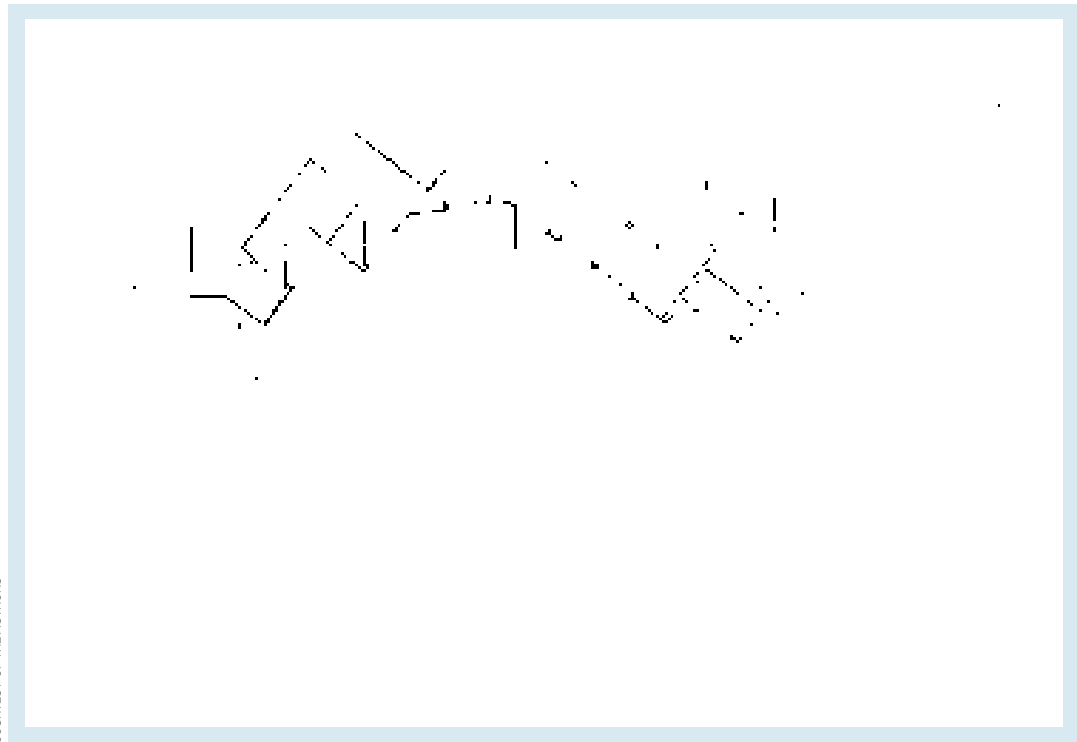
After all major turning points, a few additional dimensions may be needed, such as the radius of any circle or arc. More complex, multileveled, or unusual unit sets might require additional information if the plan is to be useful. Many designers dispense with dimensions altogether in the plan as it is expected that the stage manager in taping out the plan in rehearsal and the technical director in loading in the set will carefully measure using a scale rule.

set line The edge of the set farthest downstage, usually parallel to the plaster line.



6-6 The Ground Plan The ground plan is a horizontal section with a cutting plane usually at 3 feet above the stage floor. This height most often provides the most information, although it can be adjusted higher or lower if necessary. (Use the symbols from Figure 6-5 to understand the plan.) The darkest lines represent places where the walls of the set intersect the cutting plane. Mediumweight lines outline steps and platforms as seen from above. The dotted lines indicate openings (and anything else that exists above the cutting plane). Lightweight dimensions locate the set on the stage as it relates to two reference lines—the plaster line and the center line. Ground plan for *Cooking with Elisa*, designed by Scott C. Neale.

GROUND PLAN BY SCOTT C. NEALE FOR COOKING WITH ELISA



6-7 Ground Plan with Levels This is a ground plan for *The Nerd* that, typical of a box set, is a combination of platforms, steps, and walls. Designed by Dick Block.

section A view of a set from one side, as if cut across vertically at the center line.

Sections

The **section**, sometimes referred to as a *hanging section*, is a view of the set with a vertical cutting plane at the center line looking either stage right or stage left. To envision this, we can imagine that a large knife has sliced the set in half vertically at the center line, and we are standing on one side looking toward the cut surface (Figures 6-8 and 6-9). Just as the ground plan provides information about the amount of *horizontal* stage space taken up by the set, the section offers information about the *vertical* space, the heights of the set and masking. This view, which in orthographic terms takes the place of the side view, is crucial. Without a section drawing of a set, it is impossible to determine the necessary heights of masking walls or the placement, trim height, and size of borders. In addition, the section is the most important piece of drafting for the lighting designer because it enables her to figure out possible lighting positions and angles.

Given the rules about line weight and orthographic projections, any place at which a scenic piece intersects the cutting plane (almost always the center line) will be in heavy-weight line. The remaining parts of the set that can be seen from the center line will be in mediumweight solid line. If they are behind another piece of scenery, they are hidden outline and should be in mediumweight dotted line. Any scenic pieces behind the cutting plane (for example, a stage-right window if we are looking toward the left side of the stage) will also be in dotted mediumweight line. Although rarely done, if this proves too confusing, two sections can be drawn.

The only dimensions needed on the section are the vertical openings of any portals, including the false proscenium if there is one, and the trim height of any borders (and even that is optional). In addition, there should be a hanging chart aligned to the set above the section drawing including the same information that appears in the hanging chart of the ground plan. Any piece of scenery that flies should be shown in both its “in”

COURTESY OF THE AUTHORS

a

COURTESY OF ADAM KOCH

b

6-8 Drawing the Section from the Ground Plan

- a** If the set is small enough, both ground plan and section can be drafted on one sheet, although the section will be rotated 90 degrees, as seen in this drafting for the play *Wilson*. It is the alignment of one view with the other that is critical, allowing any line to be projected from plan to the section and vice versa. Designed and drafted by Dick Block.
- b** The easiest method of aligning the section with the ground plan. Because the drafting is done on translucent paper, it is easy to trace from one drawing to another. Typically, the ground plan is taped down to the drafting board perpendicular to the section. If the plaster line of both drawings is lined up, it is easy to get the correct placement upstage/downstage of the scenic pieces on the section by projecting the lines from the plan onto the section drawing. This is much easier and faster than remeasuring every piece of scenery. Heights of platforms and stairs are noted on the plan; those will have to be measured on the section. As with the ground plan, the points at which any piece of scenery intersects the cutting plane—in this case **NOT** the center line—are drawn with heavyweight lines. Objects behind the center line (in this case, stage right) are indicated with a dotted line. The drawing for the play *Loaded*, designed and drafted by Adam Koch, is a bit different in that more information is conveyed by using a different line as the section line cutting plane. This is clearly stated in the title block of the section drawing; the cutting plane is clearly indicated on the plan (not shown here). The process is exactly the same but with a slightly different view.

position and its “out” position. The predominant position should be in solid medium-weight line; the alternate position should be in dotted line as in the ground plan.

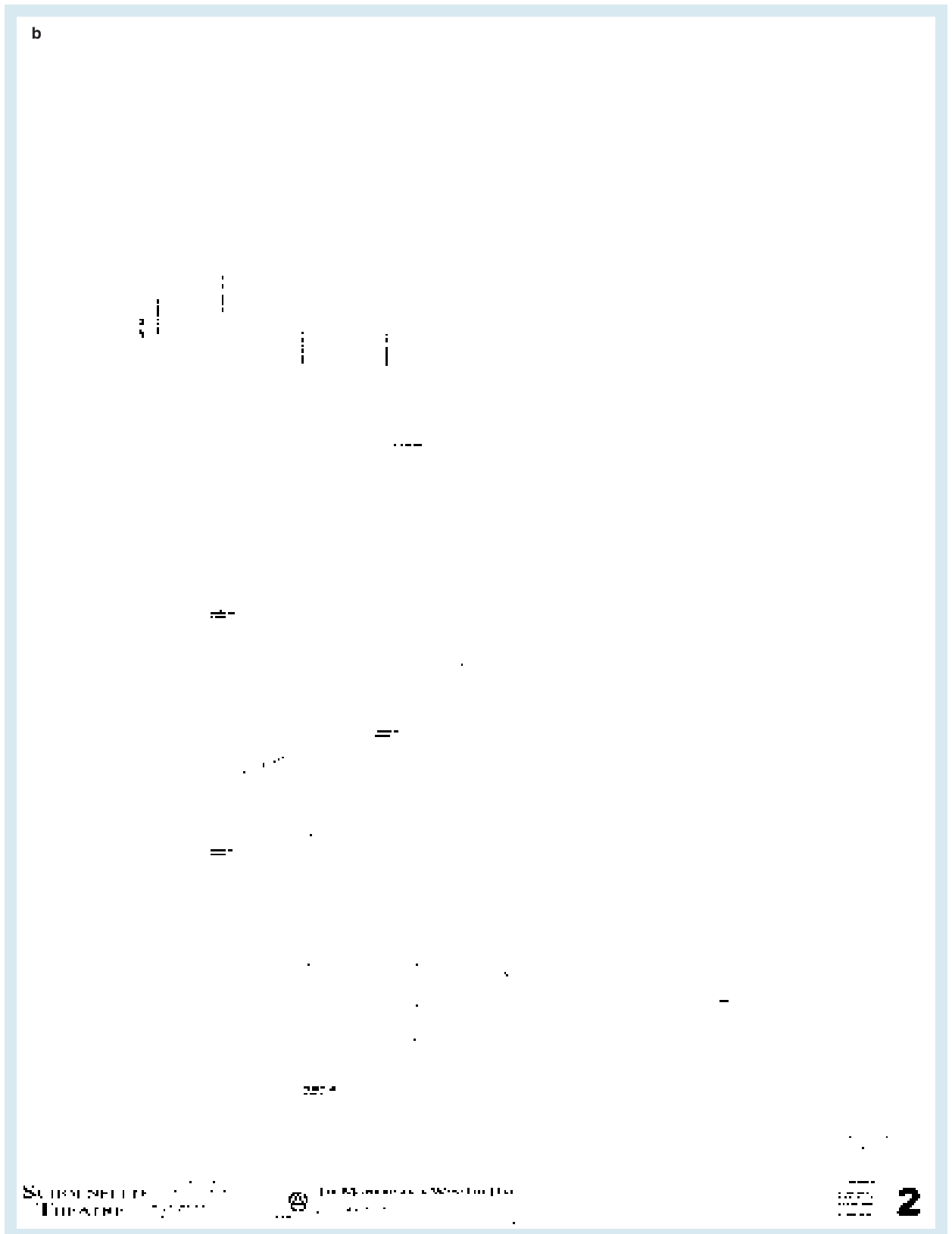
The decision to draw a stage-right or a stage-left section is determined by which will be more informative, a choice which is often obvious. If one view shows clearer information about windows, arches, and doors, then that is the view that should be drawn. Keep in mind that the lighting designer will need to be able to see any openings (such as arches, doors, or windows) in the set that allow for light.

As in the ground plan, sightlines figure prominently. In a section, the designer can check the verticals, again making sure that the audience can see all that is necessary and nothing that they should not see. The sightline point also allows the designer to make



6-9 Ground Plan (facing page) and Section To get a sense of the space needed for this set, both ground plan and section views are needed. (For a complete idea of the design, a front elevation [perspective drawing] is necessary.) The section view will include enough detail of the set that one can get a sense of the design. The set designed by Todd Rosenthal for *The Motherf**ker with the Hat* is complicated because it shows the spaces for multiple locations, changed in part by a turntable. Much more information is needed to fully understand the design so photographs of the model in various scenes are included at the bottom of the page.

a Ground plan for *The Motherf**ker with the Hat*.



COURTESY OF TODD ROSENTHAL

6-9 Ground Plan (facing page) and Section (continued)

b Section for *The Motherf**ker with the Hat*.

fly space The space above the set.

sure that any flying scenery is completely out of sight when it is in the “out” position. If the theatre has a balcony, those sightlines need to be checked as well.

Fly space, or the space above the set, is quickly filled with lighting equipment, traveler tracks, masking curtains, and the like. A certain amount of juggling may be necessary to get all the pieces to fit and work easily. Once the lighting designer has seen the section, there may be some negotiation about the optimal use of the fly space to allow for needed lighting positions.

Designer’s Elevation

The ground plan is an assembled view showing the relationship of many parts; the design elevations are drawings that show each individual piece of scenery (Figure 6-10). The setting is drafted in 1/2-inch scale showing each individual piece of scenery in orthographic projection and laid out most often from stage right to stage left.

Each piece of scenery—whether it is a flat, a platform, or a three-dimensional piece—is drafted with as many views as needed to explain its size, shape, and function. The front view is always needed, but most scenic pieces should have a plan view as well. This may seem excessive, but even a simple wall will be better understood when drawn from more than one view. Any wall that has an arch, a door, or a window should include a section view intersecting the opening, allowing the designer to explain the relationship of the wall, reveals, attendant molding, and any other added elements.

The main purpose of the design elevations is to explain each piece of scenery so that the shop can determine the best method of construction. Clarity and precision are critical. Anyone reading the drawings can know only the information that is provided (Figure 6-11).

Information about material use and any other information that might affect the construction should be provided. For example, a wall that gets rough treatment (an actor running into it or throwing something at it), a door that gets slammed, or a window through which an actor crawls needs extra bracing. An indication of surface treatment for a piece of scenery informs the shop and the scenic artist how to “finish” the piece and might determine its construction. The more thorough the information provided in the drawings, the better the technicians can plan for the final product.

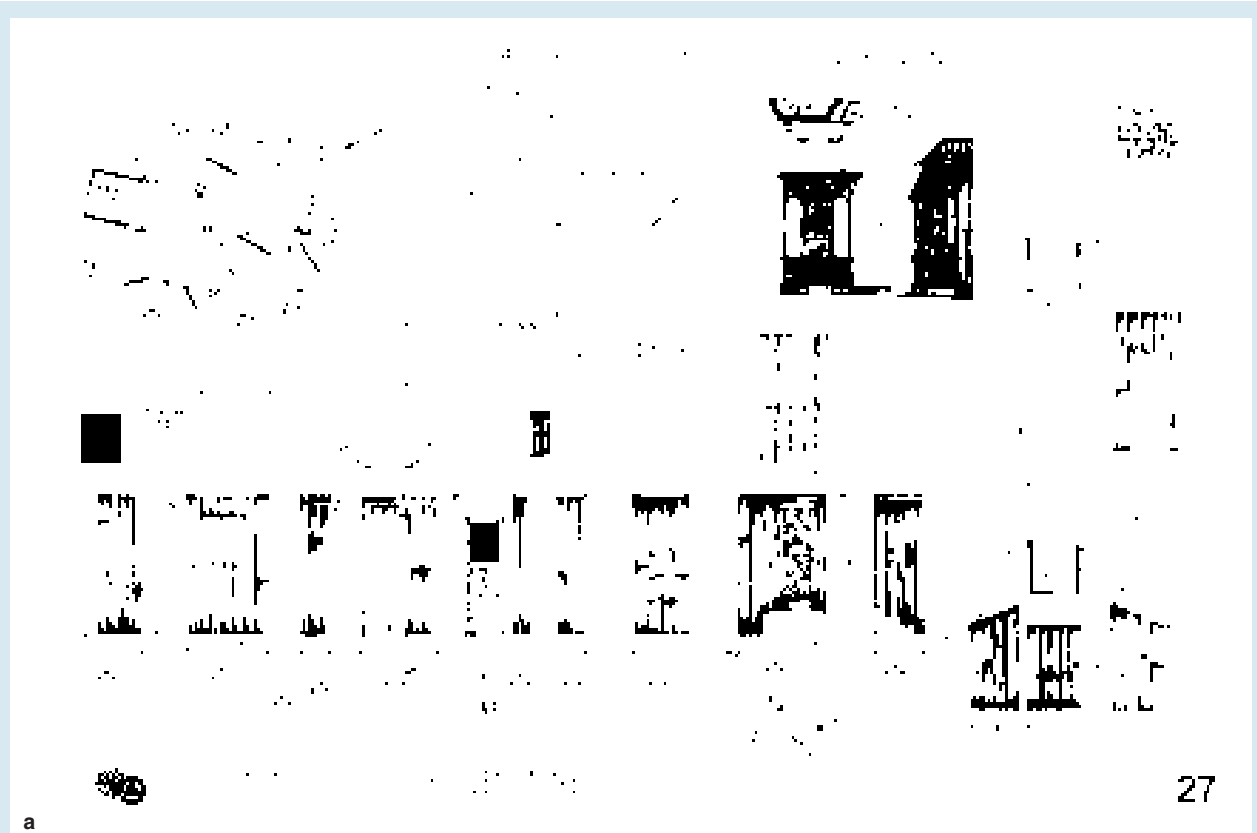
Most shops have a standard method of building flats and platforms, but some indication of how the scenery should be built can be useful. For more unusual pieces, the shop will often make suggestions for a better method of construction or have ideas about cheaper materials. A wise designer pays attention to these ideas as long as they will achieve the desired result.

Each individual piece of scenery should be labeled as indicated in the ground plan. The accuracy of cross-referencing is especially important when stock scenery is being used because such labeling is the carpenter’s only guide to how the pieces are assembled. For clarification, the design elevation of a scenic unit may include the adjacent pieces.

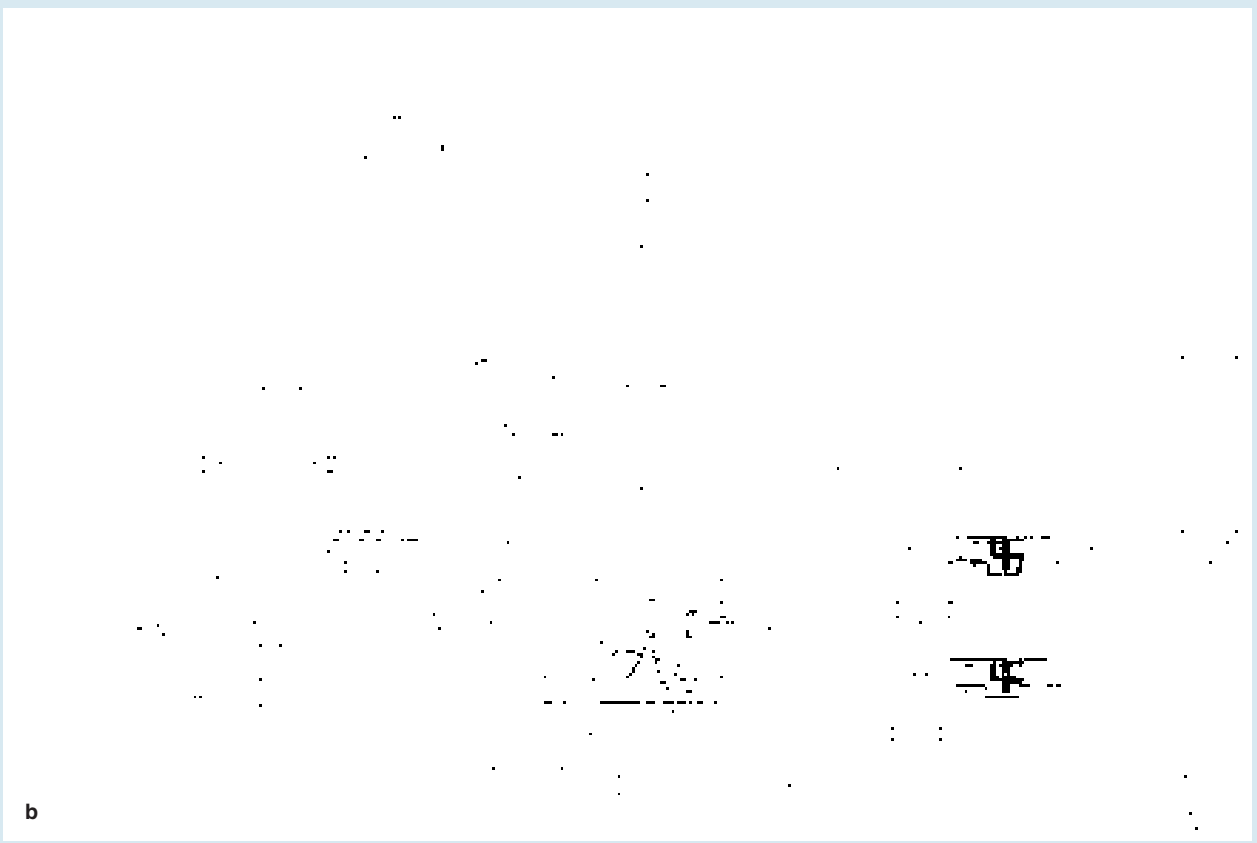
The designer should thoroughly discuss the final draftings with the shop before building begins. Questions always arise and should be addressed before the shop can provide estimates of time and money. This is a critical step in the design process as redesigning might be necessary to remain within the production’s budgets. Further explanations of the overall approach to the design may also help the shop understand what the designer is trying to achieve with the design. A complete set of draftings should be made available to the shop, the scenic artist, and the lighting designer; the plan should be available to the stage manager.

Designers vary in the amount of detail they show in the elevation. Although the decorative trim and other details are best shown at a larger scale, including some of this detail on the elevations is wise (Figure 6-12). Any detail shown in the design elevation

COURTESY STEVE GILLIAM



COURTESY ANNE MUNDELL



6-10 Designer's Elevations The front of every element of scenery is shown in a flattened-out view. The basic outside dimensions and interior openings are indicated. Side notes give specific directions to the scene shop.

a Design elevation for *Fiddler on the Roof*, designed by Steve Gilliam.

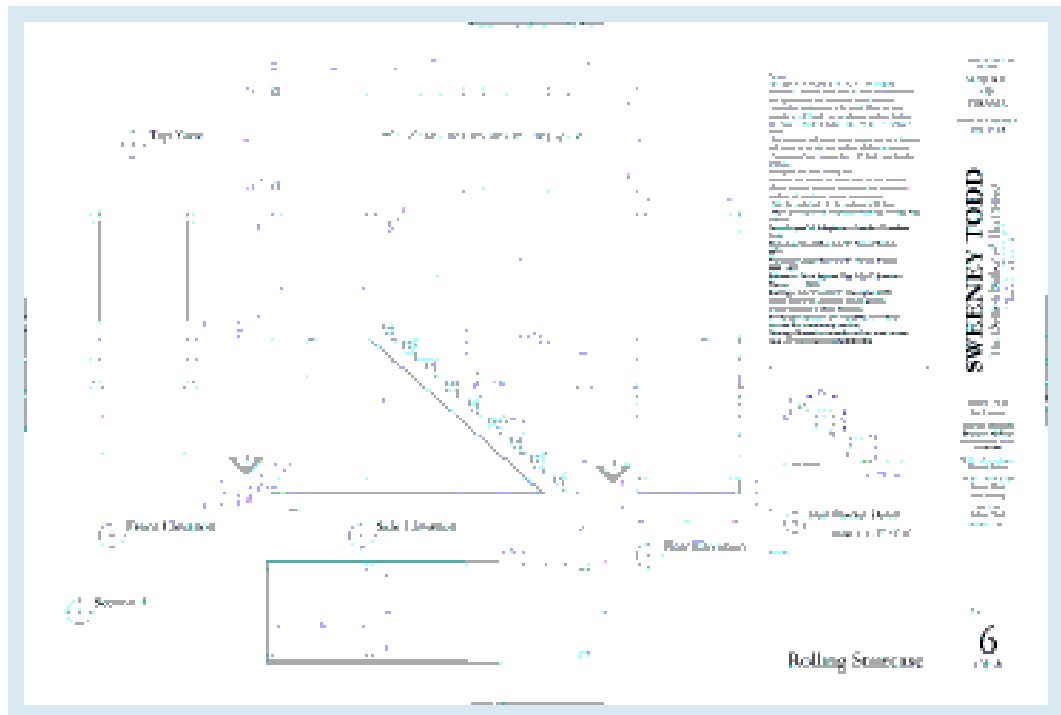
b Design elevation for *Moby Dick*, designed and drafted by Anne Mundell.



COURTESY TATSUKI NAKAMURA

6-10 Designer's Elevations (continued)

c Portion of the drafting for *Pacific Overtures*, designed and drafted by Tatsuki Nakamura.



COURTESY BRANDON MCNEEL

6-11 Design Elevation of Platforming In terms of drafting, platforms, ramps, and stairs are treated the same as walls. The drawing shown here is for a production of *Sweeney Todd*. The drawing is set up as an orthographic project for ease of moving from one view to another. In addition, decorative details and clear, concise notes are included on the page. Designed and drafted by Brandon McNeel.



COURTESY HELEN JUN

6-12 Design Elevation Design elevation for *Suddenly Last Summer*, designed and drafted by Helen Jun. The design is an abandoned swimming pool. This drawing shows the details of the ship's ladder allowing access to the platform above the pool.

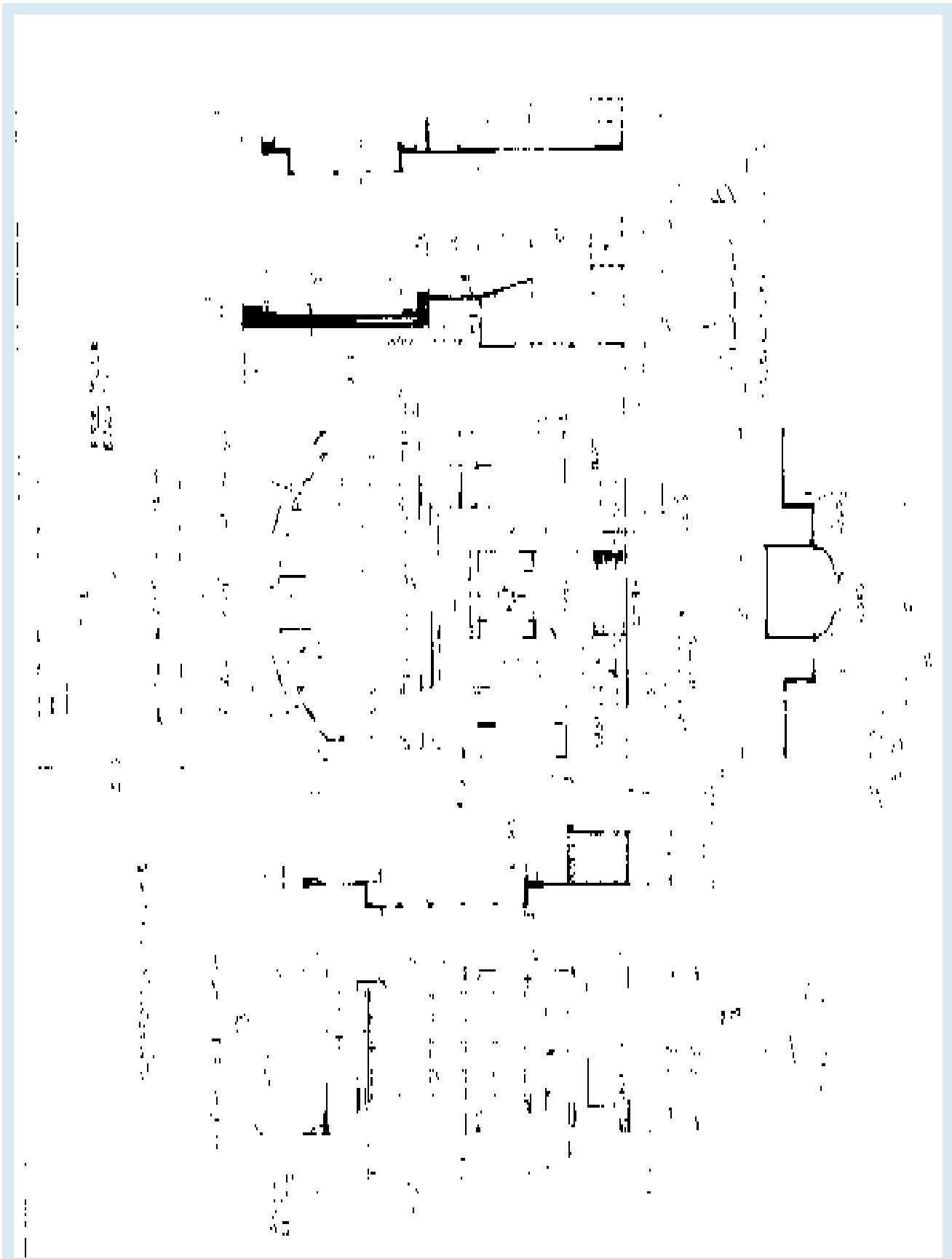
gives the carpenter some idea of special construction that may be needed. Placement of shelves, pictures, and lighting fixtures—in short, anything that is attached to the wall—should be indicated so the shop can plan for appropriate support.

Dimensions

The designer places dimensions in order to show limits and measure for clear communication with the shop. A properly given dimension includes the dimension line, measurement, and extension lines. There is no set rule for the amount of dimensioning on a drawing. Every designer does it a little differently, some providing only the outside dimensions of a piece of scenery, others providing the dimensions of almost every detail.

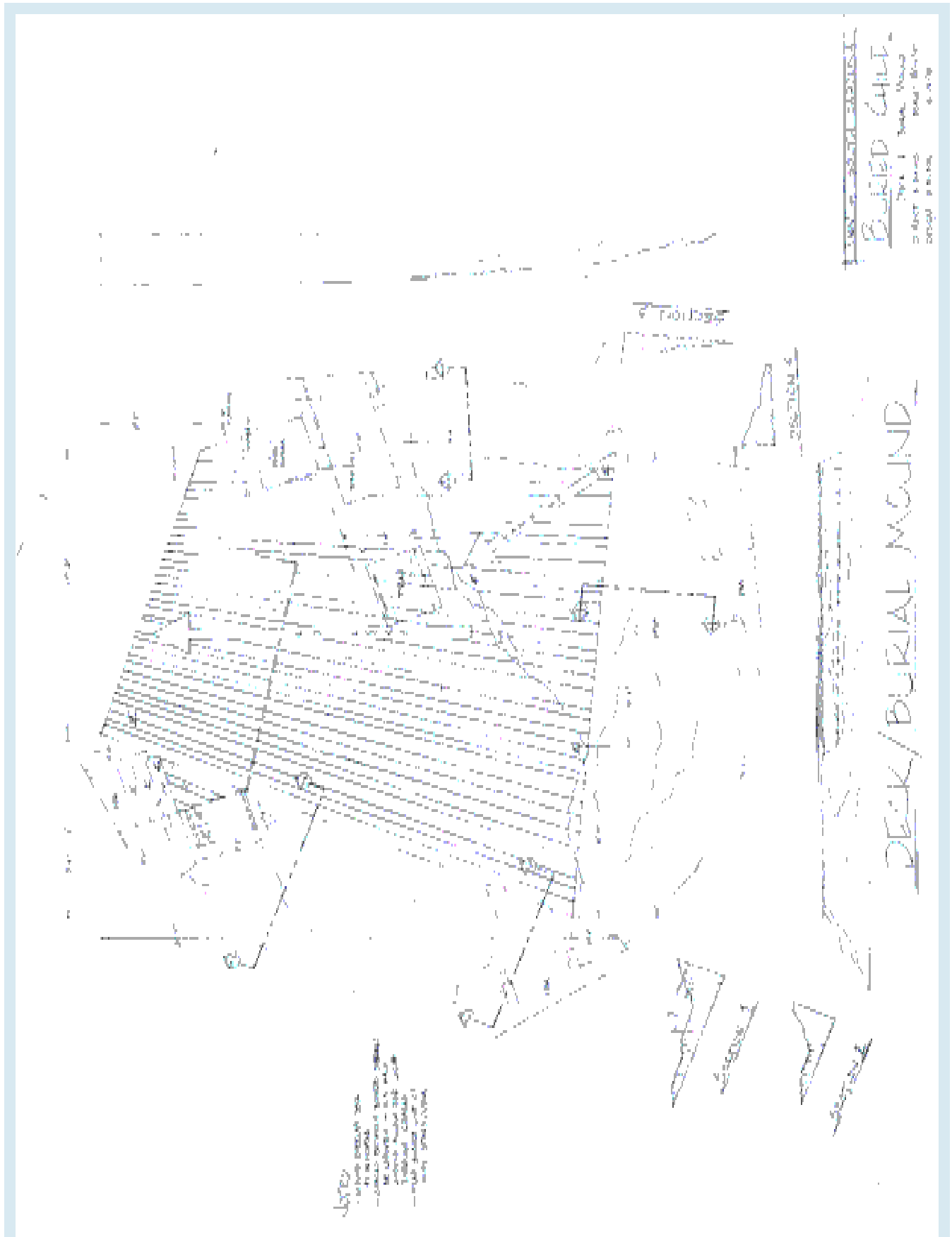
Drafting Three-Dimensional Scenery

An irregular three-dimensional object can be more difficult to draft (Figure 6-13) than architectural forms, such as columns and step units. More than the typical three views of the object (top, front, and side) are likely required. But if the designer has a firm grasp on the principles of orthographic projection and the secondary types of views, it should be fairly easy to determine how best to draft any object. Segmenting the form into a series of contour pieces is one method, as in Figure 6-14, but there are an infinite number of others. A scaled model sculptured in modeling clay can be a big help to the shop but is not absolutely required. If using CAD, there are several 3-D programs that easily create models that are useful to the shop. Whatever the method used, it should provide enough information for the shop to replicate the piece for stage.



COURTESY OF THE AUTHORS

6-13 Three-Dimensional Scenery This drafting, part of a sheet for a production of Steve Martin's *The Underpants*, shows a fireplace framed by panels and windows. The sections show details of the fireplace as well as the windows above. Careful dimensioning allows the shop to build the unit to specifications. Designed and drafted by Dick Block.



6-14 Drafting an Irregular Three-Dimensional Form The acting area for this set of *Buried Child* was placed on top of a mound of earth, as if on a gravesite. To clarify the shapes of the earth mound, a series of section views were drawn. Designed by Dick Block.

6-15 Auxiliary View In this design elevation of the house unit for *South Pacific*, an auxiliary view was needed to show the true length size and shape of the roof of the main unit. Note that a standard orthographic projection of the entire unit was drafted first; the auxiliary view of the roof piece was achieved by rotating from the top view in order to get a true length line of the roof curve. Designed by Dick Block.



COURTESY OF THE AUTHORS

auxiliary view A drawing done in addition to the standard top, front, and side of the orthographic projection, in which an angled surface is rotated to reveal true length measurement.

true length line A line in a drafting in which the measurement on paper is the actual length of the line of the object.

Auxiliary Views

When an object is angled in such a way that one or more surfaces will not be clear or measurable with the top, front, and side views of the orthographic projection, an extra drawing, or **auxiliary view**, may be necessary.

If an object has an angled surface, the top, front, and side views may not be **true length line** or measurable. A pyramid, for example, has four diagonal corners that cannot be measured easily without an extra drawing. A ramp with a slope line angled to the center or plaster line (other than at 90 degrees) cannot be drawn in section view without extra information. By “rotating” the object on paper about the slope line, one can find the true-lengths. Figure 6-15 shows how this is done.

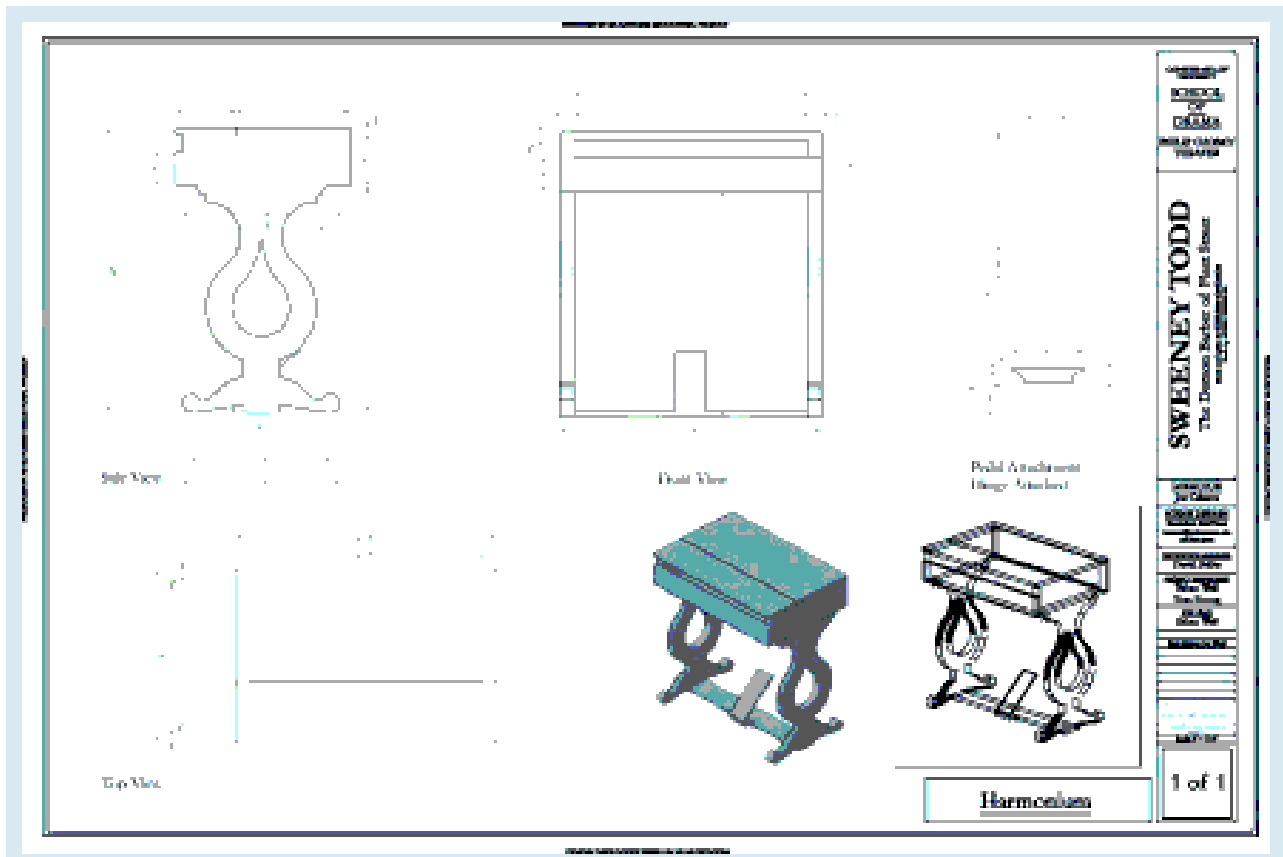
Planning Properties

The designer is responsible for the selection of properties, for the design of specially built pieces of furniture, and for the general arrangement of properties in the setting.

In planning the properties, the designer’s chief concern is to coordinate design needs with those of the director. A meeting of minds can be achieved easily if the designer shows his ideas through sketches, clippings, or photographs and provides a plan to indicate the size and position of set properties as they appear in the setting.

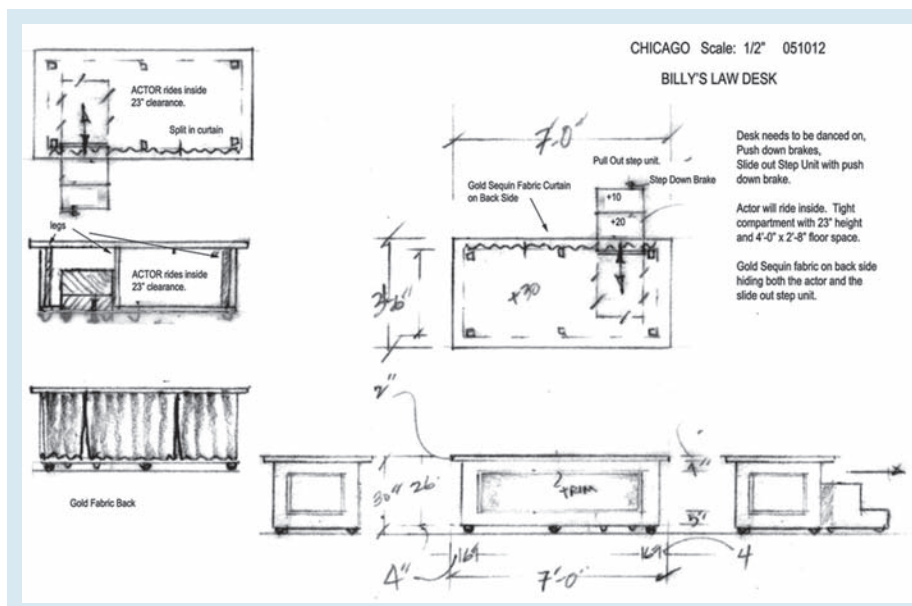
The construction of a special prop, like any three-dimensional piece of scenery, requires a working drawing. The usual orthographic showing three views will suffice; or, if the piece is not too complicated, a dimensioned pictorial drawing will serve (Figures 6-16 and 6-17). Again, the designer will find it wise to present all the important details at full scale.

Designers must become quite skilled at drafting in order to communicate their design to the rest of the production team. Knowing the tools, conventions, and approaches of drafting is essential to theatre design.



COURTESY BRANDON MCNEEL

6-16 Property Drawing This drawing for the harmonium in *Sweeney Todd* shows all the detail needed to build this prop. Particularly helpful are the two isometric views in the lower right. Designed and drafted by Brandon McNeel.



6-17 Freehand Pictorial Drawings For a relatively simple object, usually furniture, a freehand drawing suffices in lieu of a formal drafting. There is enough information on a drawing such as this for the carpenters to begin building this desk for the character Billy Law in *Chicago*. Designed and drawn by Steve Gilliam.

COURTESY STEVE GILLIAM



The Scene Shop, Tools, and Equipment

Before the ideas of the designer can reach the stage, the designs, in the form of working drawings, have to go through a construction period. The scaled model is transformed into full-scale scenery, the graded wash in the sketch becomes a carefully painted backdrop, and what appears to be an insignificant spot on the elevation is fashioned into a particular bit of detail. Step by step, all the scenery is fitted together on the stage in final form.

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For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

Although the study of technical production is placed here in the logical order of the development of a stage setting, it presents knowledge a scene designer should possess *before* beginning a design. For this reason, keeping current with new trends in production, understanding methods of constructing and handling scenery, and knowing the uses of theatrical materials and techniques should be part of a designer's training. A logical place to begin is with a survey of the tools and materials that are used to make scenery and an examination of the working procedures of a scenery shop.

The Scene Shop

No scene shop is perfect, and no two designers or technicians would agree on what makes one ideal. A designer should have some knowledge of the space requirements and layout of a good scene shop. This understanding will enable a designer to take advantage of the strengths of a shop when possible and compensate for the weaknesses when necessary. And, as some designers get work as consultants, this knowledge will prove invaluable.

Space Requirements

The overall area of a scenery shop depends on four things: the size of the stage the shop is to serve; the location of the shop in relation to the stage and storage areas; the number and kinds of productions to be produced in an average season; and the nature of the shop's working procedure and personnel.

The size of the stage, or in some cases stages, that the shop will serve should determine the size of the shop itself. Because a large stage requires large elements of scenery, its shop would need a more expansive space in which to make them. Similarly, a shop serving more than one stage needs to have enough space to accommodate large quantities of scenery.

The location of the scene shop may also affect its size. A shop near the stage can sometimes use stage space to construct scenery, assuming, of course, that the stage is not occupied by rehearsals during the build period. This shop, therefore, could be relatively small. Factors such as soundproofing and careful scheduling need to be considered to

avoid problems. Further, traffic in and out of the shop from users of adjacent spaces may present difficulties depending on the building layout. Conflicts with rehearsals and performances may be unavoidable, rendering the shop inoperative some of the time. A shop in a remote location, however, might need additional space to store scenery and properties as well as supply areas for construction and painting. Although a distant shop requires the handling of scenery from the shop to the stage and back again, it does allow workers to operate free of preperformance uses of the stage.

The specific uses intended for a shop also factor into size. A shop serving only small productions will have different requirements than one serving large-scale productions or a road house for big tours, and still different from one that functions as a maintenance shop for a larger facility. A theatre that is rented out has unique issues as well. Producing operas and musicals are likely to require more space than a theatre producing only intimate straight plays.

The final factors influencing the overall size of the shop are the shop procedures and the personnel. The nature of the shop's personnel and working hours may vary from a staff of full-time professionals to scattered groups of part-time student apprentices or volunteers. A small, highly skilled staff working steadily is more efficient than large sporadic groups requiring sufficient space to do many separate jobs simultaneously. A further evaluation of the space requirements resulting from shop procedure includes an analysis of the areas of work, tools and equipment, and materials of the average scenery shop. And, of course, the budget allowed for the shop, in both building and operating costs, must be considered.

Work Areas

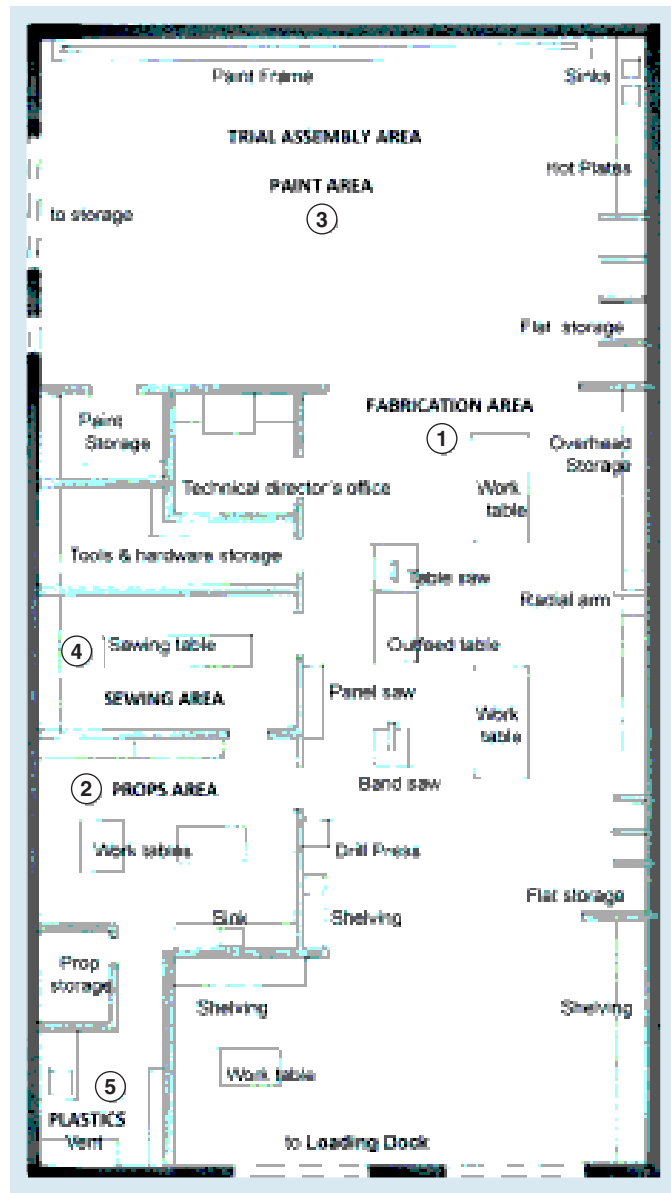
The shop is divided into areas related to the various steps in the process of building and painting. These areas, although usually multipurpose, correspond to the following functions: (1) receiving materials, (2) storing materials and tools, (3) layout, (4) fabrication area—cutting, framing, covering basic units of scenery, (5) the trial, assembly of basic units into portions or all of the complete setting, (6) property preparation, and (7) scene painting. (See Figure 7-1 on the following page for a sample shop plan.)

1. *Receiving.* The first area to be used in the shop is the receiving area, into which all major materials arrive from a loading dock. Receiving should be large enough to hold a pallet, enabling easy movement into the shop.
2. *Storage.* All shops need space for storing materials and small tools, thus the need for lumber racks, pipe and structural steel racks, paint bins, and hardware cabinets. There should also be consideration for the storage of brushes near the painting area and of small tools near the woodworking area. Efficient work partially depends on adequate storage areas.
3. *Layout.* Large pieces of scenery are often drawn out full size in the shop for planning purposes.
4. *Fabrication area.* In this area, the lumber is worked (bored, planed, cut, and so on), framed, and covered. There should be space for the large power tools, such as table saw, band saw, drill press, and panel saw, as well as workbenches. An air compressor, which can also serve the paints and props areas, and a storage tank for pneumatic tools are needed as well.

The location of power outlets convenient to the working positions of power tools in all areas is essential. Also, each power tool should ideally have its own dust-collection system to contain waste as the work is done. Careful consideration of adequate lighting and ventilation for all areas is critical for safe working conditions.

7-1 Scenery Shop No two people would agree about the “ideal” shop. Here is a one plan of a scenery shop for a modest theatre. Notice that the layout is based on the various functions of the shop.

- 1 The shop needs areas for fabricating, or cutting and framing, scenic units as well as tool and lumber storage. The major power tools normally include a radial arm saw, table saw, band saw, drill press, sander, miter saw, and panel saw. Two work tables are essential, as well as a dust-collection system. There must also be storage space for short and long pieces of lumber (and metal) and an office for the technical director or project manager.
- 2 The prop construction and maintenance area contains a spray-painting booth, wood lathe, work bench, and furniture work table. This area should have forced ventilation. The plastics area is nearby but separate, as is the sewing area. There is a storage room dedicated to props work and supplies.
- 3 The paint and trial assembly area must have enough space and height for a trial assembly of all or a portion of a set (ideally the same size as the full stage). There is enough floor space to stretch the largest drop used onstage, and enough height to accommodate a vertical paint frame. Paint storage is adjacent. There is a large entrance directly to the stage from here.
- 4 A sewing room for draperies and drops has a storage room as well, which is connected to the prop area.
- 5 The area for working plastic is well-ventilated. Vacuum forming, printing, and an area for constructing small properties are located here.



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The framing and covering of scenery can often take place on template benches or waist-high work tables on casters so they can be moved easily out of the way. A base size of 5 feet by 10 feet allows for the easy construction of a 4 × 8 platform. Add-on tables of 5 feet by 5 feet and 2½ feet by 10 feet are ideal. A larger area is needed for the joining or hinging of units of scenery.

Most shops are no longer organized with material-specific areas, so there is often no dedicated metals areas. Welding can be separated with a welding screen, but working with plastics does require a properly ventilated space (often the prop shop).

5. *The assembly area.* This space ideally should be as large as the stage area and high enough to stand the scenery upright. Besides serving as a trial assembly area, it can offer enough floor space to paint flats and to lay out full-scale patterns of irregularly shaped scenery.
6. *The property area.* The altering, repairing, upholstering, and finishing of furniture and other props is a specialized operation that often requires different tools, materials, and paints from those found in the scenery shop. It should be in an area protected from the dust, spattering paint, and general confusion of the scenery shop.

7. *The painting area.* This area should be near a sink, gas or electric burners, and the paint bins. Vertical painting, which occupies the least amount of floor space, requires enough overhead clearance to stand the scenery upright. The simplest vertical painting method is to mount the scenery on a fixed frame against a wall and paint from a rolling platform (see Chapter 9).

Certain painting techniques require horizontal painting, and, in fact, many scenic artists prefer this method. It requires a large floor on which to lay the scenic pieces. A wooden paint deck allows for easy attachment of drops to the floor.

The lighting in this area must be bright and, if fluorescent, color corrected. Ideally, this space should be protected from dust.

Scenery Materials and Tools

An ideal scenery shop is well-stocked with appropriate materials and tools. Here we consider briefly the categories of materials that are used for making scenery. To compile a comprehensive list is, of course, next to impossible because designers and technicians are constantly bringing new materials into the theatre as well as discovering new uses for old materials.

Materials can be divided and classified as follows:

1. Structural (lumber and metal)
2. Cover stock (fabrics and sheet goods)
3. Hardware (joining and stage hardware)
4. Rigging (rope, cable, wire, and chain)
5. Paints and related supplies (to be discussed in Chapter 9)

Note that the number and kinds of tools and materials used in the theatre are truly limitless. Because of the special needs of theatre scenery, designers and technicians often “borrow” materials and techniques from other industries and frequently use them in ways not originally intended. Often, the scene shop includes inexpensive tools and materials developed for reasons completely unrelated to theatre construction but nonetheless have proven to be quite helpful in the scene shop.

Building Scenery with Wood

Types of Wood

Lumber is one of two principal structural materials used in the theatre (the other is metal, to be discussed in the next section). Because of wide variation in the availability and cost of lumber, shops use the best quality lumber that is most convenient and affordable at the time. Because of cost, some have turned to lightweight structural steel in addition to, or instead of, wood for framing (discussed later).

To fill the general needs of scenic construction, lumber must be lightweight, strong, straight, and inexpensive. White pine offers the best combination of weight and strength, but it is not readily available in all areas. Although woods such as spruce are lighter, they are not strong enough, and they tend to splinter and split. Lumber selection and quality, as well as construction techniques, vary from region to region, so a wide range of types of lumber is found in scene shops. The hardwoods are rarely used; for most scenic purposes, their weight, cost, and difficulty in use negate the advantage of strength.

The type of materials and construction used must fit the specific needs of the production. The approach to a one-night-only production and the materials used are likely to be quite different from those of a tour or a show that is expected to have a long run.

Grades and Sizes of Lumber

At the lumberyard, wood is classified by quality determined by the straightness of the grain and freedom from knots. Hence, clear white pine is the highest quality of pine. Wood is further classified according to its expected use. A board used for trim or a finished surface is of a higher quality than one to be used as a structural member hidden from view. Prices vary regionally. The grade of lumber used should be appropriate for its specific application and will depend on your specific area of the country.

The *select grades* of lumber are designated by A, B, C, and D. Hence B-select or better is a high-grade pine. C-select is used in the construction of paneled doors, window sashes, turned work, and architectural moldings.

The *common grades* are numbered 1 to 5. They are not intended for a finished surface, although many times 1- and 2-common are used as knotty pine paneling. In general, 2-common is the usual framing material for scenery unless better grades of pine are available at reasonable prices. Assuming a long run, a higher quality might be used, but at considerable expense. As always, one must balance costs versus need. Construction grade and pressure-treated lumber (for outdoor use) are also available but very expensive.

The *stock sizes* of lumber refer to its rough-cut size, referred to as **nominal size**—not to the finished dimension after the wood has been dressed (planed or smooth on all sides).

Thus, a 1×3 is really $\frac{3}{4}$ inch by $2\frac{1}{2}$ inches. Stock lengths vary, but the most common are 8, 10, 12, 14, and 16 feet (the longest stocked length). Longer lengths can be obtained on special order.

Because 2×4 s are so commonly used in home building, a “precut stud” used in housing construction is often 93 inches (as opposed to 96 inches or 8 feet). This is because the common height for a room in a modern home is 8 feet. In framing a home, there is a top and a bottom 2×4 plate, each at a thickness of $1\frac{1}{2}$ inches. Subtracting this 3 inches from a total height of 8 feet leaves us with 93 inches. When ordering 8-foot lengths of 2×4 , be specific. The loss of those 3 inches could be critical.

Most often, lumber is sold by the linear foot, as just described. The common unit of measurement for lumber used to be the **board foot**, particularly for finer types of wood such as cherry, walnut, and maple, although the term is less commonly used now.

A board foot is the equivalent of a 1-inch-thick board that is 1 foot square. A 16-foot length of 1×3 , for example, contains 4 board feet. A piece of lumber of any size can be reduced from its linear dimensions into board feet.

Special shapes such as “rounds” are stocked in diameters from $\frac{3}{4}$ inches to $1\frac{1}{2}$ inches and sometimes as large as 3 inches in diameter. Dowel is available in $\frac{1}{8}$ - to 1-inch diameters and 3-foot lengths made of maple and birch.

Other special shapes are stock moldings, which are made in a great variety of sizes and contours. Before specifying moldings, the designer should check local suppliers because names and shapes vary throughout the country. See Figure 7-2 for examples of stock lumber and molding shapes.

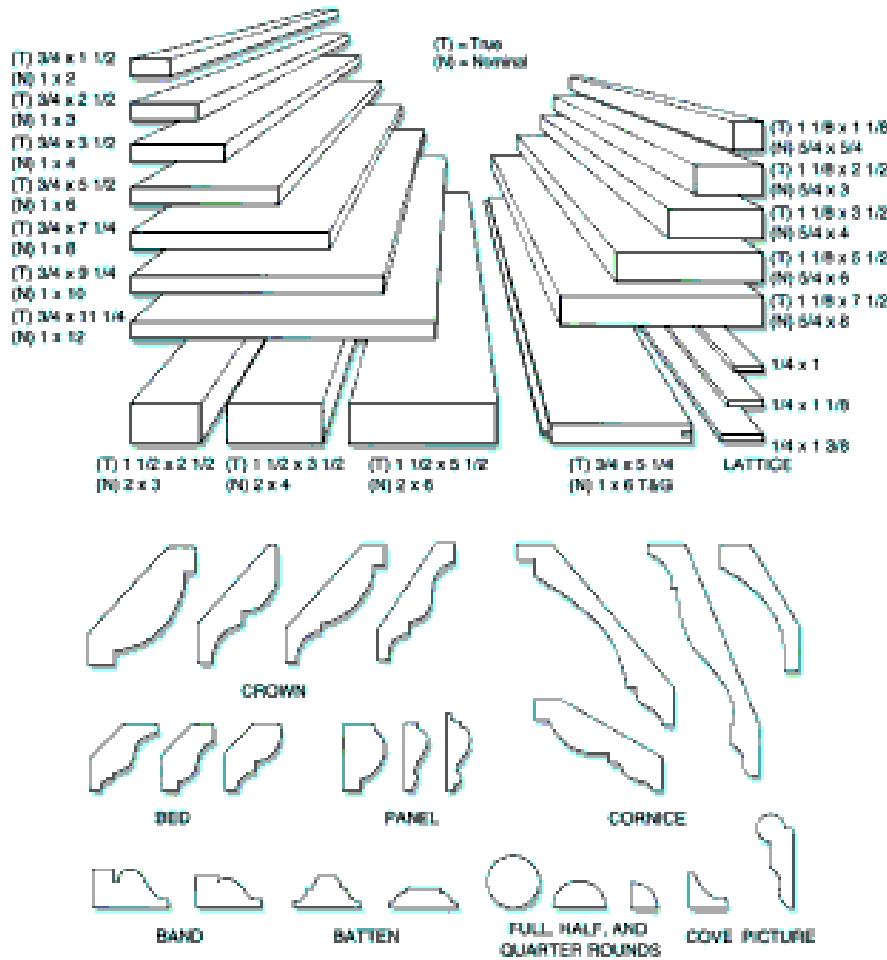
It is worth considering the use of *recycled wood* in construction because it is more readily available than ever. Most recycled wood products are a composite of waste-wood fiber and plastic garbage or grocery bags. Although more expensive than regular wood, recycled products resist decay, moisture, and warping, negate the problem of splinters, and obviously help reduce the use of natural resources. Several companies manufacture a wide range of wood products, although generally not for load-bearing use. Microlam and Parallam are manufactured to form boards the same length and width as a 2×4 , which are useful as structural framing members.

Reclaimed wood, or wood obtained from demolition projects after its initial use or from unproductive orchards, is another option that is somewhat cheaper (but perhaps less available) and also cuts back on the use of natural resources.

nominal The rough-cut size of a piece of lumber as milled before being planed to working size.

board foot A measurement of lumber equivalent to a board 1 inch thick and 1 foot square.

7-2 Stock Lumber and Molding Shapes



Measuring and Marking Tools

To build scenery it is necessary to cut, shape, bore, and join the wood. The tools for working wood are either hand tools for limited and special work or power tools for mass production and precision work. The working and joining of wood, however, is always preceded by careful measuring and marking in every step in the construction and assembly of the completed setting (see Figure 7-3).

The importance of accurate measurements cannot be overstressed. Almost all mistakes in building are directly traceable to incorrect measurements or a misinterpreted mark. Mistakes are often made, particularly by inexperienced carpenters, from ignoring the **kerf**, or thickness of the cut (groove or notch) made by a saw. Wood is cut, not sheered, so any cut board will lose an amount equal to the blade width. Typically, a board is marked to the specific length needed. If a cut is made on the inside of the mark, or within the needed length, the board will be too short by the amount of the blade width.

kerf Thickness of the cut made from a saw blade.

Wood-Cutting Tools

The chief cutting tool is the saw. Some are hand saws, some are power saws that are handheld, and the remaining are fixed power saws. Figure 7-4 illustrates the various types of saws to be discussed here.

Basic Hand Saws The shape of the tooth (pointed or chisel), the set of the tooth (flare of every other tooth in the opposite direction), and the tooth count (number of teeth per inch) determine the specific work a saw can perform.

7-3 Woodworking Measuring Tools

	Framing square	Calibrated; establishes right angle for framing and marking the angle cut of stair and carriage.
	Tri-square	Marking guide for 90° angle cuts; calibrated.
	Combination square	Calibrated; has adjustable sliding bar for measuring and establishing marking guide for 90° and 45° angles.
	Bevel gauge	Transfers or saves predetermined angle of bevel.
	Chalk line (snap line)	Snapping a long, straight line to be used as a framing guide, reference line for full-scale layout, or painting guide. (Snapping = marking a straight line by stretching a length of chalk- or graphite-covered string between two points, pulling the middle up, and letting it go.)
	Trammel points	Mechanical device for marking the radius of a circle or an arc; the bar (if calibrated, used to measure) holds the trammel points.
	Spirit level	Instrument designed to establish true vertical or horizontal.

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miter Any cut across the grain of the wood.

bevel Any cut in the same direction as the grain of the wood.

scroll work Curved, detailed design resembling a rolled piece of paper.

dado Notch cut into a board, allowing a second piece to fit into it.

rabbet Wide groove cut into the face of a board, allowing another board to fit into it.

tenon A projecting member in a piece of wood or other material for insertion into a mortise to make a joint.



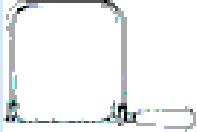


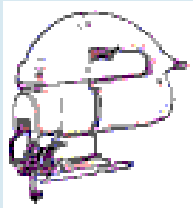



The *set* of a saw is the degree of bend every other tooth has away from the saw blade. The set of the saw teeth keeps the saw from binding (getting stuck in the board) because the width of the cut is wider than the blade. When a saw has lost its set, it begins to bind in the cut (see the box on page 127 on woodshop safety).

There are a basically three types of cuts that can be made on wood: a cut angled across the grain, or **miter**; a **bevel** cut in the same direction as the grain; and various kinds of curves, most often used for profiles or cutouts but including **scroll work**.

Wood-Shaping Tools

There are innumerable ways of shaping wood, and many of the tools used to do it are limited to very specific cuts (Figure 7-5). For example, the simplest hand tool for shaping, the chisel, is excellent for cleaning up **dado**, **rabbet**, and routed areas; routers are used for **tenons**. At the same time, many power tools can be adapted to replicate the work of specialty tools. For example, the table saw can be equipped with a dado head, a set of special blades that cuts a groove. Molding cutters can also be attached to the table saw for simple molding cutting. The radial arm saw can also be rigged to dado, shape, and rout.




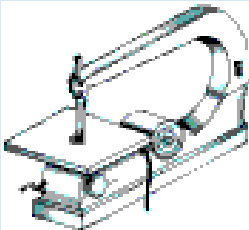

7-4 Wood-Cutting Tools

HAND-POWERED SAWS		
	Hand saw	Used for ripping along the grain; hence the teeth are angled and flat-edged like a chisel with sharp and straight teeth to cut across the grain as opposed to those of a crosscut saw.
	Keyhole saw	Used to cut irregular lines; for heavy, coarse work; has high tooth count.
	Coping saw	For irregular cuts; high tooth count for a smoothly cut edge; removable blade makes it good for inside cuts.
	Japanese Dozuki saw	Stiff blade with a back for accurate cuts such as miters.
HANDHELD POWER SAWS		
	Circular saw	Used as rip or crosscut saw; lightweight and small blade make it portable; depth of cut is limited.
	Jig saw	Used to cut irregular lines, as in scroll work; portable; does not limit the size of the work; versatile tool for scroll cutting at any stage of assembly.
	Cut-awl	Designed for light, detailed cutting; requires padded bench or table.
	Reciprocating saw	Handheld saw that makes rough cuts (often referred to by brand name: Sawzall®). Good for making controlled cuts in a wide variety of materials.
	Radial arm saw (pullover saw)	Has pullover action for accurate crosscuts, limited miters; mounted on long table to hold wood.

(continued)

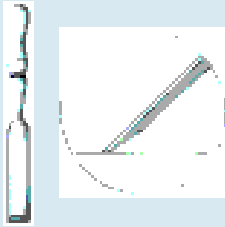

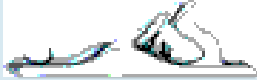






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7-4 Wood-Cutting Tools (continued)

FIXED POWER SAWS		
	<p>Table saw</p>	<p>For easy and accurate rip cuts; heavy enough for precision work in quantity.</p>
	<p>Band saw</p>	<p>For scroll work, but limited to outside cutting and to work no larger than the depth of its throat (20" throat should serve the average shop).</p>
	<p>Panel saw</p>	<p>For cutting large panels such as cover stock (e.g., plywood).</p>
	<p>Scrollsaw</p>	<p>For scroll work, but limited to outside cutting and to work no larger than the depth of its throat. Can do very tight curves with a coping saw blade.</p>
	<p>Compound miter saw</p>	<p>Specialized tool for cutting wood that changes plane as well as angle (such as a corner of an angled roof); the blade must be tilted and angled.</p>

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7-5 Wood-Shaping Tools

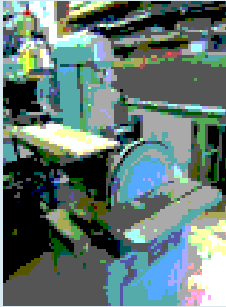
HAND-PARING TOOLS		
	Chisel	Simplest hand tool for shaping; excellent for cleaning up dado, rabbet, and routed areas.
	Surform	Designed to work across the grain; replaceable blade; faster than block plane but leaves rough finish.
	Smoothing plane	Pares a surface to accurate dimension with the grain of the wood.
	Block plane	Smooths or shapes end of a board; can be used to correct a bad cut or to shorten board for delicate fit.
	Rasp	Designed to work across the grain; rough finish.
	Drawknife	For shaping large, wide surfaces.
HANDHELD POWER SHAPING TOOLS		
	Router	Versatile tool with many differently shaped bits; can be used on wide variety of jobs, including dado, rabbet, flush cuts, and tenons.
	Random Orbital sander/Air-powered	Best for smoothing end cut; can reshape or round a with coarse sandpaper; less effective with flat surface because it leaves sanding marks.
	Biscuit joiner	Used to attach two boards with almond-shaped crescent; joiner cuts series of half-biscuit-shaped grooves into which biscuit is glued.

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(continued)

7-5 Wood-Shaping Tools (continued)

FIXED POWER SHAPING TOOLS

**Belt and disk sander**

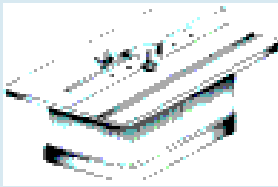
Removes great deal of wood quickly but leaves rough surface; often first tool used in sanding process.

**Lathe**

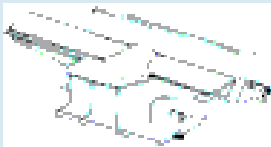
Used to turn or shape cylinders; shaped with chisel that can be moved along work; for spindles, stair railings, and so on.

**Bench grinder**

Used to remove wood and smooth small pieces; more often used to grind down rough edge of metal or sharpen tools; has one fine and one coarse wheel.

**Shaper**

Used to cut variety of moldings by using different combinations of blades.

**Jointer**

Smooths or sizes a board by changing the depth of cut, beveling an edge, or cutting rabbet on one side of the board.

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pegging Method of attaching two pieces of wood by inserting a small wooden dowel (peg) into a hole drilled into both pieces.

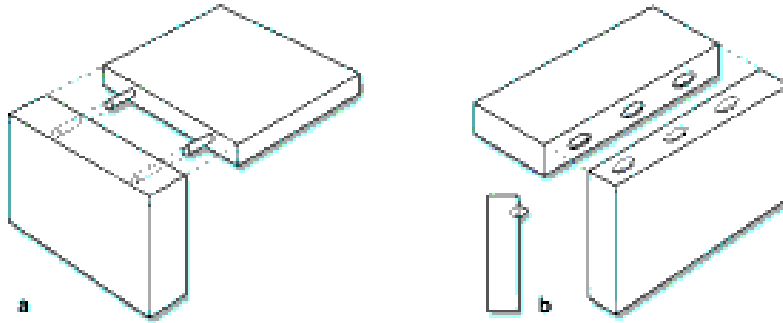
However, these adjustments must be made by an experienced carpenter because they can be extremely dangerous. It is far better to use a tool that is created for the job.

The *biscuit joiner* is used to ease the process of attaching two boards. It is a variation of **pegging** but uses an almond-shaped piece of compressed beechwood called a *biscuit*. The biscuit joiner cuts a series of half-biscuit-shaped grooves in each of the two pieces of wood to be joined (Figure 7-6). Glue is added to the wood and the biscuit, then the two pieces are clamped together and left to dry. The moisture in the glue causes the biscuit to swell, tightening the joint.

Numerous other shaping tools are useful in the shop, such as the *orbital sander* and the *random orbital sander*. These are used for finish smoothing, such as a stained table top. With its round base, the entire plate of the random orbital sander orbits as the disk spins, providing the advantages of faster sanding and reducing swirl marks.

The *power plane* does the same job as a handheld smoothing plane, but faster and more efficiently. Its rotating drum has two or three knives that do the smoothing. It deals with the end grain of a board (such as the corner top of a door) better than does a plane with nonrotating blades.

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7-6 Pegging and Biscuit Joinery

- a** Here is a simple pegged joint, with two dowels inserted into appropriately sized holes.
- b** The more common method now is to use a biscuit joint. The glue causes the biscuit to swell and tighten in the hole.


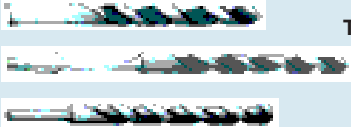



Boring Tools

Tools with a cutting edge that revolves about a central axis to cut a circular hole are called *boring tools* (Figure 7-7). The tool consists of two basic parts: the bit, which is the cutting part of the tool, and the mechanism to rotate the bit.

The types of bits vary greatly depending on the size and the depth of the hole, the kind of hole (clean bore, taper, ream), and the nature of the material (hardness, thickness). Likewise, the power-providing part of the tool varies with the type of bit used and the speed of rotation necessary to do the work.

Having first come into wide use about 20 years ago, the *cordless drill* has revolutionized scenic construction owing to ease of use, greater efficiency, and the speed with which batteries can be recharged. Although nails used to be the structural fastener in wood construction, this is no longer true because it is easier to undo screws than to remove nails. Because theatre work is essentially temporary, this drill has literally changed the way that people do theatre construction.

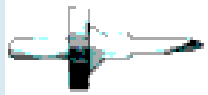
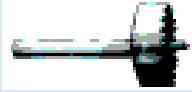

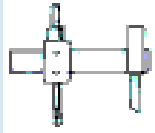





7-7 Wood-Boring Tools

	Auger bit	When rotated, pulls the cutting edges of the bit into contact with the wood; no need for high speed; bits are manufactured in increments of 1/16" (1/2" auger is No. 8 bit).
	Twist drill bit	Depends on speed or rotation and pressure to advance. Special bits of hardened steel are used for drilling into wood or metal.
	Paddle bit	For wood cutting; high rotation provides accuracy; chisel-like edges of bit; paddle varies in size from 3/8" to 1 3/4".
	Countersink bit—wood	Used after hole is drilled; enlarges top of opening with bevel cut deep enough to set a flathead screw or bolt flush with outer surface of work; note that for Plexiglas it is better to drill the countersink first in order to lessen the chance of splitting.
	Countersink bit—metal	Same as the countersink for wood but used for metal.

(continued)

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7-7 Wood-Boring Tools (continued)

	<p>Woodscrew tap and countersink</p>	<p>Drills hole and countersinks simultaneously.</p>
	<p>Hole saw</p>	<p>Used to cut oversized holes (1½" and wider) in wood or metal (dependent on manual's statement of use) at high speed; depth is limited to size of shank.</p>
	<p>Forstner bit</p>	<p>Smooth blade, similar to hole saw but can be used at angle; not used for metal.</p>
	<p>Hole cutter</p>	<p>Used to cut holes in wood and metal.</p>
	<p>Extension shank</p>	<p>Lengthens the depth of cut of paddle bit by extending the shank.</p>
	<p>Expansion bit</p>	<p>Type of auger bit; adjustable to cut holes 1¼"-2½" in diameter.</p>
	<p>Hand power drill</p>	<p>Includes multiple bits for multiple purposes.</p>
	<p>Cordless drill</p>	<p>Cordless version of power drill; workhorse of the shop.</p>
	<p>Drill press</p>	<p>Stationary power drill, used to control depth of bore; spindle speed can vary for precision work.</p>

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SAFETY PRACTICE ■ Woodshop Safety

When working with power tools such as table saws, radial arm saws, drill presses, and handheld power tools, follow these guidelines:

1. Dress appropriately. Avoid loose clothing; pull long hair back. Wear goggles. For protection from high-level noise, wear earplugs or ear protectors.
2. Always use the guard rails or fences on power tools; accidents happen even to the most careful carpenter. However annoying such rails may seem, they are for your protection.
3. Get appropriate training on the proper use of every power tool.
4. Keep all blades and drills sharp to prevent chances of the wood kicking back. A dull blade can bind or skip and cause an accident. If the blade binds in the middle of a cut, do not force the wood. Shut off the power while holding the wood or the tool firmly until the blade stops completely, then back the work out.
5. When using the sander, be aware of the dust hazard; sawdust fumes of certain woods may be toxic. The sawdust should be gathered or handled with caution. Wear a dust mask and avoid inhaling fumes. Use a respirator whenever there is a danger of any toxic substance in the air, keeping in mind the importance of using the appropriate type of respirator and filter for the material being worked. Follow manufacturer's instructions for proper use as well.
6. Make sure the space under work is clear. Do not cut the sawhorse.
7. If you use an unusual setting on the saw or the drill press, return it to a standard setting after work is finished.
8. Ask for help whenever ripping a long board, and use a push stick, which is a simple shop-built jig that allows the user to push a board through the saw and keep his hands well away from the turning blade.
9. When using a power tool, concentrate on what you are doing and pay attention to where your hands are.
10. After the work is finished, clean up and return tools to their places.
11. Above all, follow the work procedures of the shop in which you are working.
12. Use the appropriate tool for each job.

Wood Construction Tools and Hardware

Fastening wood to wood is a basic construction technique. Tools are designed to drive or set hardware such as *nails*, *staples*, *screws*, or *bolts*, to fasten wood together in a variety of combinations (Figures 7-8 and 7-9). Wood can be attached with glue as a primary fastener, with nails, staples, or screws used to hold pieces together until the glue dries. (Chapter 8 provides specific information about construction techniques.)

Pneumatic Tools

These are tools driven by air pressure to save time and energy (Figure 7-10). No well-equipped scenery shop should lack a pneumatic nailer and staple gun, which offer great speed and efficiency. With the slightest pressure of the finger, a nail or staple is set in one stroke.
















The pneumatic staple gun can drive, and clinch if needed, staples from $\frac{5}{8}$ inch to 2 inches long. The 1-inch staple is used to fasten corner and keystone blocks in the construction of flat scenery (see Chapter 8). Staples vary in (crown) width and wire gauge as well as length.

Because pneumatic tools require about 90 pounds per square inch of pressure to operate, the shop must have either a portable heavy-duty compressor or a built-in compressed-air service with connections positioned conveniently throughout the shop. The same system with a pressure regulator can provide compressed air to the painting and property construction areas to operate paint spray guns. There is a pneumatic version of almost every power tool that a shop might need.




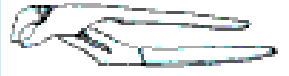

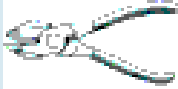


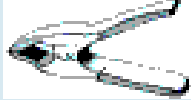

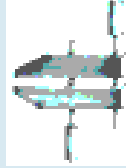


Building Scenery with Metal

Metal has been used in the theatre as a structural material for some time and is increasingly being used as a design feature. Metal, like any other material, has its limitations but

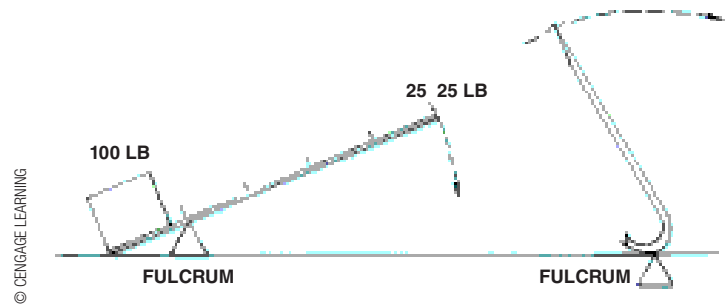
7-8 Wood Construction Tools

	Claw hammer	Used to drive nails; rounded claw end used to pull out misdirected nails.
	Straight claw hammer (ripper)	Straight claw used to pry apart joined members.
	Mallet	Wooden, rubber, or plastic head used to tap member into place without damaging edge or surface of wood; also used with chisel.
	Tack hammer	Used primarily for upholstery; has magnetic head.
	Ball-peen hammer	Used for working metal.
	Screwdriver	Slotted head used to drive in screws.
	Phillips head screwdriver	“+” head used to drive screws.
	Nutdriver	Hex-head or Robertson or square head; driver does not slip and destroy screw heads.
	Socket wrench	Ratchet action and interchangeable wrench heads; efficient for tightening and loosening nuts.
	Pry bar (wonder bar)	Long handle provides excellent leverage (see lever action, Figure 7-9).
	Nail puller	Used to pull out nails; same leverage as pry bar.
	Crowbar	Also used to pull out nails and to pry apart two joined members; same leverage as pry bar.
	Grommet set die	Used to cut holes and set grommets into fabric, such as a drop.
	Staple gun	Drives staple when trigger is pulled.
	Staple hammer	Drives staple when hammerlike action is provided.

7-8 Wood Construction Tools (continued)

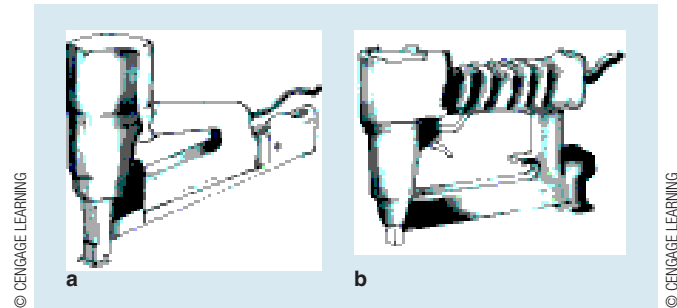
	Crescent wrench	Has adjustable jaws to fit sides of nut and apply even pressure.
	Utility pliers (slip-joint pliers)	Gripping tool with wide range of uses; adjustable to two sizes.
	Vise grips	Allows carpenter to clamp down work and then let go.
	Channel pliers	Similar to slip-joint pliers but adjusts to larger sizes.
	Needle nose pliers	Used for more delicate work or when work area is small.
	Lineman's pliers	Often used by electricians; has a large, fat nose used for pulling wires; usually has blade to cut wire.
	Diagonal cutters (dykes)	Standard electrician's tool for cutting soft wire.
	C-clamp	Holds boards face-to-face, allowing glue to dry while work is in place.
	Spring clamp	Heavy-duty and with strong jaws; extra strong spring action holds the work while plastic coating protects wood; easy-on, easy-off clamp.
	Band clamp ("ratchet strap")	Woven strap with ratcheting apparatus to tighten band around irregular or curved surface.
	Hand-screwed clamp (jorgensen clamp)	Similar use as c-clamp, but wood of clamp does less damage to work; best in face-to-face joints.
	"Quick-grip" clamp	Adjustable jaws can be attached to any length of standard pipe; has more flexibility than standard bar clamp.
	Bar clamp	Designed to hold boards edge to edge.

7-9 The Lever A long bar placed over a fulcrum or pivot point close to the work (a rock to be moved or a nail to be pulled) requires less energy at the long end of a bar than at the short end.



7-10 Pneumatic Tools

- a Pneumatic nailer for structural nails.
- b Stapler for $\frac{3}{8}$ -inch to 2-inch staples. A 1-inch staple is suitable for attaching corner blocks (used in connecting the stile and the rail of a soft-covered flat; see Chapter 8).



when utilized effectively can greatly enhance a production. Designers and technicians need to be familiar with the most common metals used and the basic techniques of working with them. There are many different tools and skills that are unique to metalworking, and adequate training in their use is always necessary.

Types of Metal

Mild steel is the most commonly used metal in theatre productions. It is easily cut, drilled, and welded. It is also the least expensive and most readily available metal.

Aluminum is also gaining popularity as a strong, lightweight alternative to steel in many situations. It comes in many variations of hardness and ductility (the ease with which something bends). Although cutting and bending aluminum is easier than cutting and bending steel, aluminum requires more sophisticated tools and techniques to weld. Its light weight and high strength-to-weight ratio make it popular for touring shows.

Stainless steel, which is high in chromium or nickel, is used less often but fills a crucial role when needed. The corrosion-resistant quality of stainless steel makes it ideal when the scenic unit is exposed to the elements or is used underwater for a long time. However, its hardness and higher cost can make it difficult to work with, often requiring special tooling.

All metals are manufactured and treated according to certain parameters in order to fulfill a specified range of needs. The best suited type of metal should be chosen for any specific application. (More information is available from the American Welding Society (AWS) and The American Society of Mechanical Engineers (ASME).)

Forming and Fabricating Metal

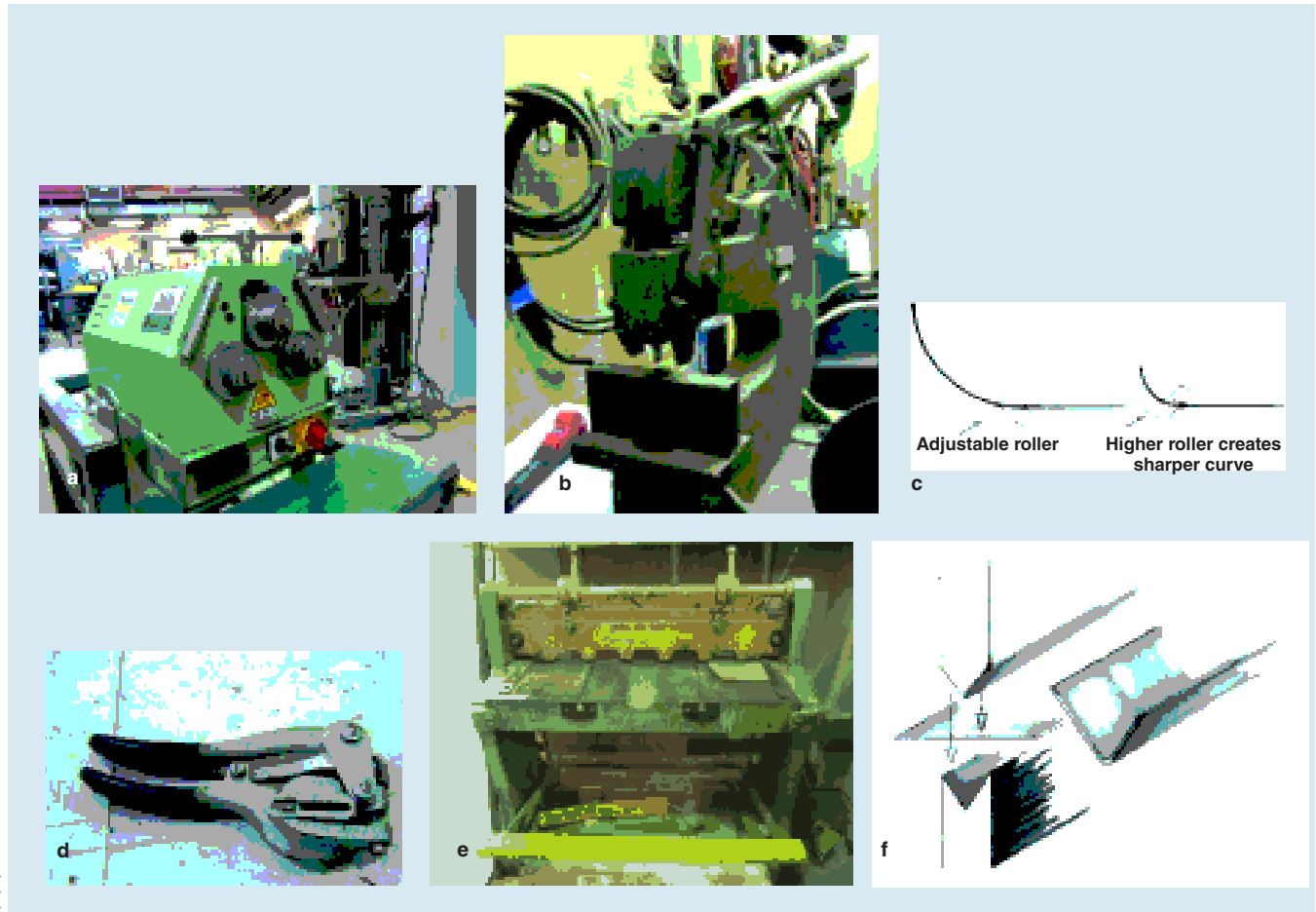
In the factory, when metal is still molten, it can be *formed* in many ways: *rolling* to produce *plate* and **sheet metal**; **extruding** by squeezing the molten metal through a shaped aperture to form rods, tubes, and so on; *casting* liquid metal into molds; *drawing* the softened metal through a small aperture to make *wire*; and **forging** or stamping the metal into a prescribed shape (see Figure 7-11).

Forming generally produces the following shapes: *plate*—rolled steel no thinner than $\frac{1}{8}$ inch; *sheet*—rolled steel no thicker than $\frac{1}{8}$ inch; *strap*—rolled steel narrower

sheet metal Piece of metal that has been rolled into a flat sheet, thinner than plate.

extruding Squeezing molten metal through a shaped aperture to form a shape such as a rod or a tube.

forging Stamping metal into a shape.



a, b, d, e COURTESY OF THE AUTHORS

c, f © CENGAGE LEARNING

7-11 Fabricating Metal

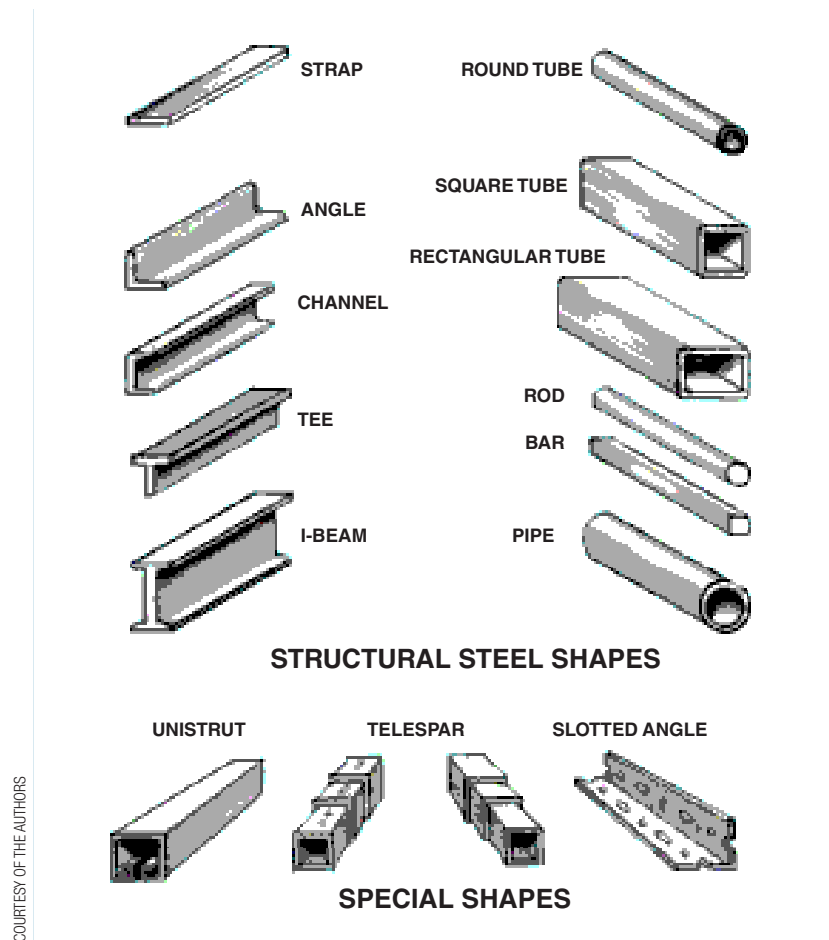
- a Rolling machine.
- b Bench punch.
- c Switching roller position changes the curve.
- d Hand punch.
- e Brake forming.
- f Foot shear.

than plate; *rod*—solid round, square, and polygonal shapes; *structural* shapes such as channel, angle, and I-beam; *tube*—extruded or welded round, square, and rectangular; *pipe*—round malleable iron; and *wire*—drawn carbon steel, aluminum, or copper. Sometimes these terms appear to be interchangeable.

The *fabricating* of metal involves special techniques and tools, many of which are common in other trades as well. The table saw, for example, can be used on wood and plastic as well as on nonferrous metal (although with the use of a specific blade for the material to be cut). The following terms are often used in the fabrication of metal: *brake forming*—the linear folding of plate or sheet metal; *shearing*—cutting sheet metal in a scissors-like tool; *rolling*—cold-rolling sheet metal between large hardened steel cylinders into curved or cylindrical shapes; *twisting*—twisting a square bar into a decorative shape or a wire into cable; *punching*—making holes or a pattern through plate or sheet metal; *mechanical fastening*—bolting or riveting together structural steel or sheet metal; *welding*—joining metal to metal by fusing them together at a high temperature; *brazing* and *braze welding*—joining metals at a lower temperature whereby only the filler metal (usually a bronze alloy) is made molten; and *soldering*—joining sheet metal, tubing, or electrical parts with solder (usually a tin or lead alloy).

Structural Steel Shapes Here we discuss the typical shapes of structural metal used in the theatre; cross-sections of these shapes are shown in Figure 7-12. All shapes come in a variety of thickness and lengths; choosing the right combination of size and thickness depends on the work the structural member must do. In the beginning, the designer and the technician are wise to understand all the size and weight variations of any one shape.

7-12 Structural Steel Shapes



- *Strap.* Very thin strap is commonly used as a *sill-iron*, a horizontal strip holding the bottom of a door frame in position.
- *Angle.* A good reinforcing shape for stiffening or bracing scenery, this useful cross-section comes in many sizes. It is often used in stage machinery construction.
- *Channel.* Its U-shaped cross-section makes it stronger though not as adaptable as an angle.
- *Tee.* The tee is useful for stiffening. When it is used horizontally in a framework, it is stronger than angle. The tee also serves as a guide for the arbor in a counterweight system.
- *I-beam.* As the name suggests, the I-beam is best used as a beam in which the top of the “I” carries the main thrust or weight.
- *Rod.* A round solid, the rod is sometimes used as the internal member of a steel truss or is easily bent into decorative shapes for scenery or props.
- *Bar.* A square solid, sometimes used as a spindle in a metal railing; bars can be bent and twisted into ornamental shapes found in wrought iron work.

Although the terms *tube* and *pipe* are occasionally used interchangeably, this is a mistake. Tube, which is extremely efficient as a structural material, is usually extruded and is much more precisely made than pipe is. It is manufactured in a variety of shapes, listed here. Pipe is either rolled and welded or cast.

- *Round tube.* Tube can be extruded or welded. The larger tubes can become vertical support members, whereas smaller diameter tubes can be bent into decorative shapes (see the discussion of EMT in the subsection that follows).

- **Rectangular and Square tube.** This popular shape can be cut and welded into structural or decorative forms. It is the most commonly used shape overall. Square and rectangular tube begins as round tube and is roll-formed into its new shape.
- **Pipe.** With heavier side walls than tube has, malleable iron pipe can be threaded and joined with fittings (Figure 7-13). Although the outside dimension (OD) remains the same, pipe is available in a variety of side-wall thicknesses.

Special Shapes Frequently, a manufacturer's name is used so often to refer to a specific type of material or tool that it becomes the "generic" reference to the material or tool. Some of these special items are shown in Figure 7-12 and described here.

Unistrut, a specially formed channel-shaped steel, is used to create knockdown framing that is adaptable to platforming and trussing in the theatre. It reduces the necessity of welding and cutting and is available in different forms.

Thin-wall conduit (EMT), a type of galvanized-steel pipe, has become a very popular structural and decorative material in the theatre. With walls too thin to thread but quite easy to bend, it has many uses in scenery construction. It comes in many diameters ($\frac{1}{2}$ ", $\frac{3}{4}$ ", and $1\frac{1}{4}$ "), and in 10-foot lengths. Because of zinc oxide fumes, take extra caution when welding or brazing EMT. Optimally, the zinc oxide coating would be removed before welding.

Telescoping square tube, commonly referred to as *Telspar*, comes in three varieties: (1) with solid sides; (2) punched with round holes; and (3) punched with square holes.

Slotted angle iron, designed to bolt together in a variety of ways, is also made in strap and channel shapes.

Flat Steel *Sheet metal* is rolled metal less than $\frac{1}{8}$ -inch thick. Thickness is indicated by *gauge*. As the number of the gauge increases, the thickness decreases in steps of 1.5 hundredths of an inch (0.015)—hence, the larger the gauge, the thinner the sheet. Sixteen-gauge thickness is approximately $\frac{1}{16}$ inch. Twelve-gauge thickness is approximately $\frac{1}{8}$ -inch thick. Many forms of sheet metal besides regular steel exist.

Plate is rigid and comes as thin as $\frac{1}{8}$ inch. It can be cut to order in sizes for various needs, such as a motor's base plate or a pipe-stand base to add weight to the bottom.

Expanded metal is a steel plate or sheet that is punched with a pattern of slits and then stretched from opposite edges to expand the plate into a grille surface. Some expanded metal is weight bearing and has been used as platform flooring, allowing light to pass through in interesting patterns.

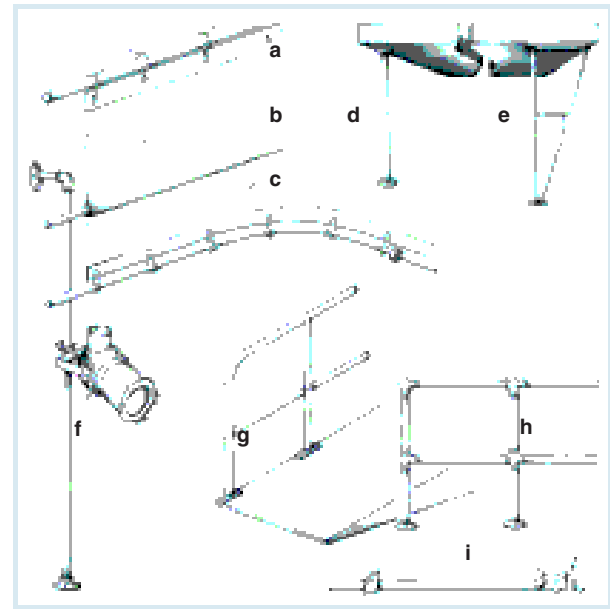
Perforated sheet metal has holes punched through it in certain patterns and is used for many different things.

Galvanized steel, aluminum sheet, zinc, and copper sheet have been used as scenic materials. Shadow boxes and thunder sheets are two common uses of sheet metal in scenery construction.

Metal screening, such as hardware cloth ($\frac{1}{4}$ -inch mesh), galvanized screen ($\frac{1}{16}$ -inch mesh), and chicken wire (1-inch mesh), is primarily used as an armature typically covered with papier-mâché or fiberglass. Galvanized screening is often used to simulate window glass.

Metalworking Tools and Equipment

The use of metal requires special tools to cut, shape, and join it. (See Figures 7-14 through 7-17.) It also requires equipment that supports various methods of fabrication. Although



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7-13 Various Uses of Pipe

- a Top batten for drop, cyc, or stage drapery.
- b Bottom batten for drop pipe sleeve.
- c Curved bottom batten using tie lines.
- d Freestanding platform legs.
- e Special bracing.
- f Lighting booms and battens.
- g Bent pipe and welded railing.
- h Cut pipe and fitted railing.
- i Bar clamp.



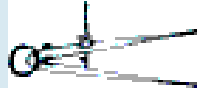




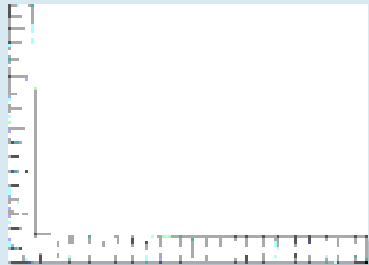
some woodworking tools can be used on metal, most metalworking tools are designed to work only with metals and plastics.

Basic Metal-Joining Tools and Materials

The various forms of metal can be joined with bolts, screws, rivets, or threading or by fusing the metals together with heat. Threaded pipes used to be the norm; however, there are now better methods for connecting nonthreaded pipe. Some, but not all, of these metal fittings are fine for structural purposes. Kee Klamp and Speed Rail, for example, should be used only for railings. None are useful for plumbing. Threading makes pipes less convenient to use and less efficient as stock pieces.







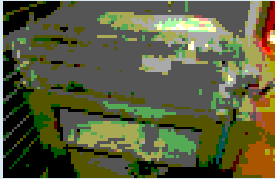
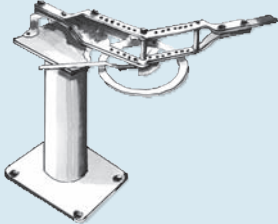
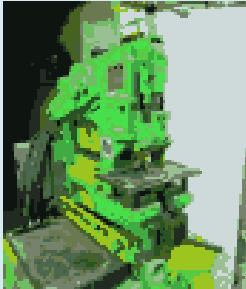
Sheet metal can be firmly joined with *rivets* (Figure 7-19). A hole is drilled through overlapping sheets; the rivet is inserted through the hole from the front; a washer is placed over the back of the rivet; and to finish the joining, the shaft is *peened*, or flattened. Rivet nuts are used to put a threaded insert into any piece of metal and allow for easy assembly and disassembly.

7-14 Metalworking Tools

MEASURING AND MARKING TOOLS		
	Scribe	Used for marking on metal; sharp point scratches line on surface.
	China marker (grease pencil)	Makes marks on metal or any other hard surface.
	Compass	Used for marking circles and arcs on metal.
	Inside caliper	Used to measure and transfer interior dimensions.
	Calipers-Dial (top) and Digital (bottom)	Highly accurate (up to .001 inch); can be metric or English measure.
	Centering punch	Marks center of circle and provides a start hole for drilling in metal.
	Metal straightedge	Calibrated for measurements as well as for drawing a straight line.
	Framing square	Calibrated, but used mostly for layout work.

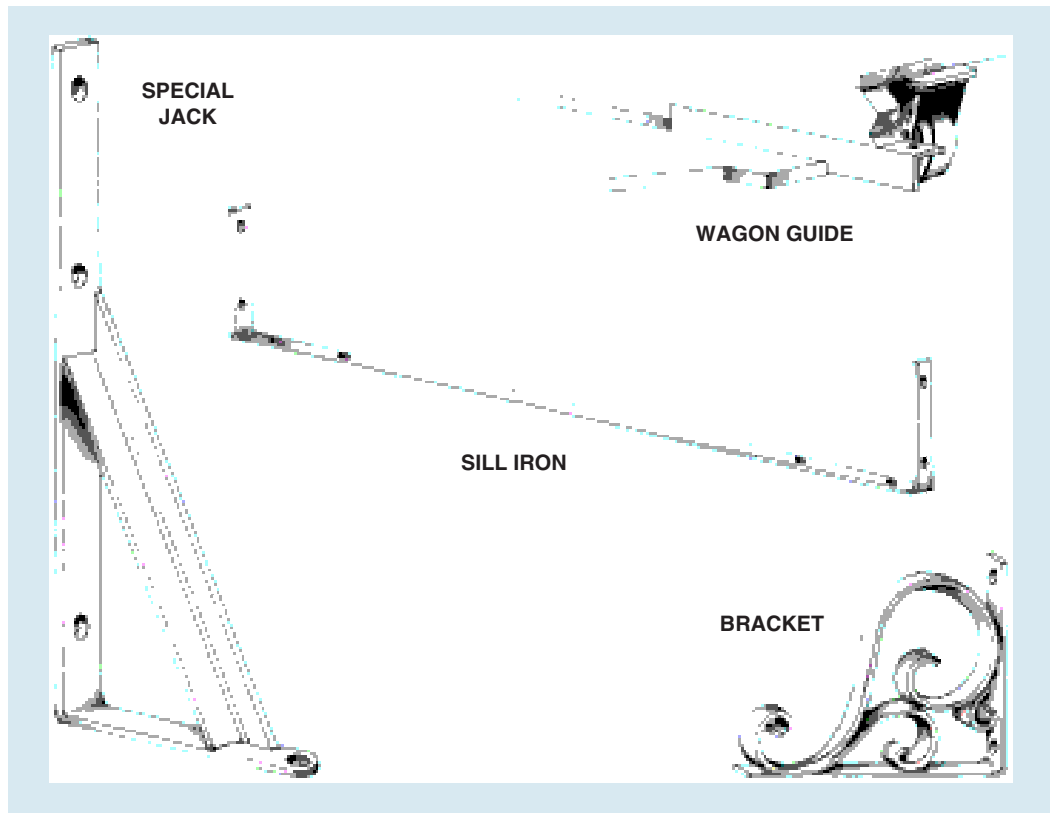
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7-14 Metalworking Tools (continued)

SHAPING TOOLS		
	Anvil	Old-fashioned but still extremely useful tool for shaping metal on both curved and flat sides.
	Machinist's vise	Steel jaws hold metal for filing or for bending strap iron.
	Blacksmith's hammer	For shaping metal by hammering over surfaces of an anvil.
	Ball-peen hammer	For shaping metal over an anvil.
	Files	Can be flat, round, or triangular and can smooth a rough cut or round edge of metal.
	Sheet-metal roll (also called "rolling machine" or "slip roll")	Sheet metal fed between three adjustable rollers to determine degree of curve.
	Lightweight break	Hand- or foot-operated to cleanly bend sheet to prescribed angle.
	Hossfeld bender	Used to bend many shapes of metal: pipe, tube, rod, bar, and angle.
	Ironworker	Multifunction tool includes punch press, shear, and brake.

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7-15 Decorative and Structural Uses of Rod and Strap


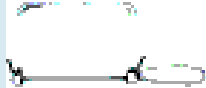
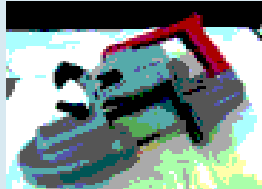





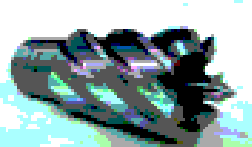
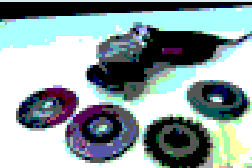
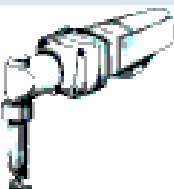


7-16 Pipe-Cutting, Threading, and Bending Tools

	<p>Pipe cutter</p>	<p>Used to cut lengths of pipe to specific dimensions; cutter rotates around pipe for a clean cut.</p>
	<p>Pipe threader and die heads</p>	<p>Used to thread pipe; various dies for different sizes of pipe.</p>
	<p>Pipe vise</p>	<p>Holds pipe to allow for cutting or threading.</p>
	<p>Stillson wrench</p>	<p>Used to grab and hold pipe for work purposes.</p>
	<p>Pipe bender</p>	<p>Used to create curves in a pipe.</p>

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7-17 Metal-Cutting Tools

	<p>Hacksaw</p>	<p>Used to cut metal bolts or bars; has fine-toothed blade.</p>
	<p>Metal cutting blade in scroll saw</p>	<p>Used for small curves; removable blade allows for interior cuts.</p>
	<p>Porta-band</p>	<p>Handheld unit used in situations where lack of space doesn't allow any other power saw.</p>
	<p>Reciprocating saw (Sawzall®)</p>	<p>Handheld saw that makes rough cuts.</p>
	<p>Bolt cutters</p>	<p>Used for rough cutting of rod or strip stock.</p>
	<p>Tin snips</p>	<p>Used for cutting sheet metal.</p>
	<p>End-cutting nipper</p>	<p>Used most commonly for pulling staples and small nails.</p>
	<p>Side cutter</p>	<p>Wire cutter; also a good tool for removing plastic components from sprues (the passages through which metal is poured into a mold) or trimming tabs and vents from metal figures.</p>
	<p>Annular cutter</p>	<p>Used for cutting accurate holes in thick material; note hollow center.</p>
	<p>Cutting disk</p>	<p>Similar use to grinding wheel (see Figure 7-5) but much thinner disk (1/16").</p>
	<p>Power nibbler</p>	<p>Used for inside cutting of metal.</p>

(continued)

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7-17 Metal-Cutting Tools (continued)



Power shears

Handheld power saw for cutting straight or curved lines.



Abrasive wheel cutoff saw

Used for crosscutting pipe, tube, or any structural steel form.



Oxyfuel cutting torch

Rough cuts but useful when cutting work can't be brought to the tool; can also be used for welding.



Horizontal band saw

Used for crosscutting pipe, tube, or any structural steel form; more effective than abrasive cutoff saw for longer lengths of metal.



Cold saw

Stationary saw with an extremely hard blade, low rotational speed, and fluid coolant/lubricant; used for extremely accurate miter cuts (including 90°).



Plasma cutter

Used to cut all sizes of metal; similar to arc welder; with jet of air, it melts the metal and blows the resulting puddle through the work.

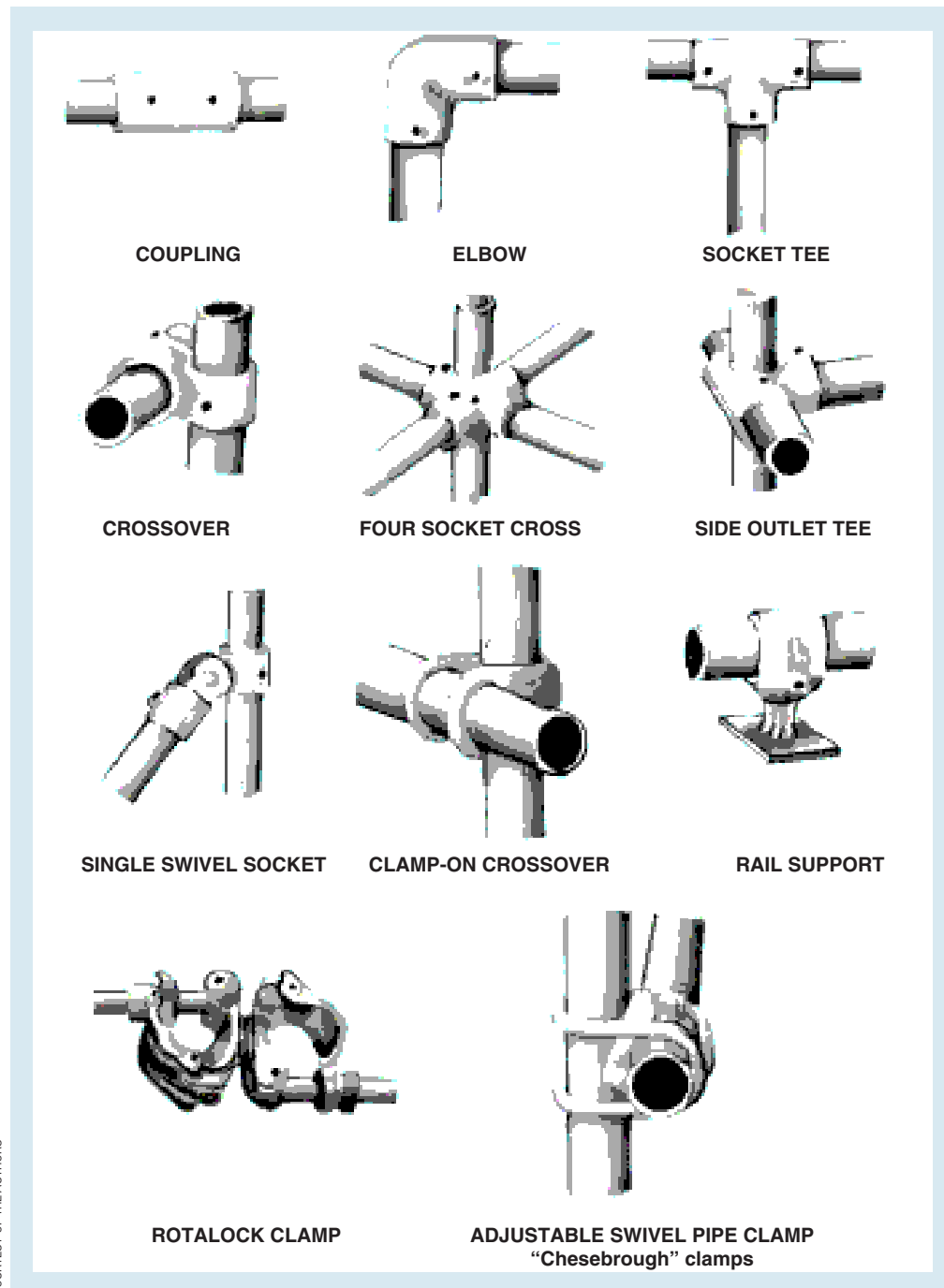
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Soldering and Brazing Processes

As a method of joining metal, solder functions as a *bond*. The strength of the bond depends on the preparation of the surfaces to be joined and an even application of solder. The surfaces should be free of oil, paint, and oxidation (rust). A flux, borax, or rosin is applied to further clean the metal and prevent oxidation.



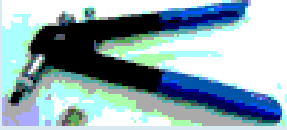


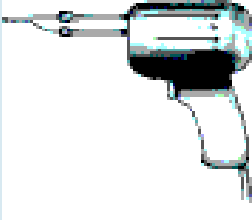
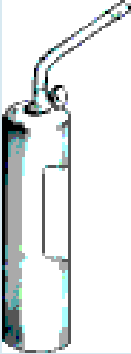
Sufficient heat must be supplied at the tip to melt the solder along the joint. The soldering of pipe to a fitting requires a torch. The joint surfaces are cleaned and polished with emery cloth and coated with flux before the heat and solder are applied. For the soldering of electrical connections, an internal rosin flux is used to prevent corrosion and prepare the surface.

7-18 Iron Pipe System



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7-19 Metal Joining Tools

	<p>Sheet metal screws</p>	<p>Used to join two metal pieces, wood to metal and plexiglass to metal; some are self-threading. Commonly used brand name is TEK screw.</p>
	<p>Blind riveter and pop riveter</p>	<p>Used for joining two pieces of sheet metal when back of work is inaccessible; this tool compresses the rivet with a squeeze or two of the handle.</p>
	<p>Rivet nut setter</p>	<p>Rivet nut is inserted from front through hole drilled through one piece. Rivet will expand inside material when handle is squeezed to allow for use of bolt in the material.</p>
	<p>Rivets</p>	<p>Metal bolt or pin having a head on one end, inserted through aligned holes in the pieces to be joined and then hammered on the plain end so as to form a second head.</p>
	<p>Soldering iron</p>	<p>Rod-shaped metal implement with a pointed or wedge-shaped tip; provides sufficient heat at tip to melt the solder along the joint for delicate work.</p>
	<p>Soldering gun</p>	<p>Same as above but useful for larger pieces.</p>
	<p>Propane torch</p>	<p>Supplies heat to large area of fitting.</p>


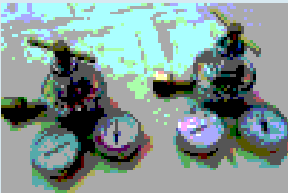


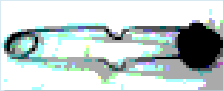
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Welding

Welding is the joining of metal with extreme heat, in which one piece coalesces with another. It provides a more permanent joint than soldering does; it requires specialized equipment and training. Metalworking in general and welding in particular are dangerous. Proper training and extreme caution are essential. In fact, on structural elements such as platforms and on large scenic units such as stairways, welding should be done by a certified welder. Certification, standards, and services are provided by the AWS (American Welding Society) and the ASME (American Society of Mechanical Engineers).

Gas welding Equipment Oxyfuel welding uses oxygen as a catalyst to intensify the burning of gas (Figure 7-20). *Oxyacetylene welding* (OAW), the only kind of *oxyfuel*



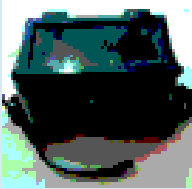
7-20 Gas Welding Equipment

	<p>Oxygen and acetylene tanks</p>	<p>Fuel tanks; shown on tank truck with chain to keep them upright and for ease of moving.</p>
	<p>Regulators</p>	<p>Oxygen (green, on the right) and acetylene (red, on the left) regulators to control the gas flow.</p>
	<p>Welding/brazing torch and tips</p>	<p>Guides the gas flow exactly to the work; tip has single opening for welding and brazing (below, on left). Cutting tip (below, on right) has ring of holes around a center hole.</p>
	<p>Rosebud tip</p>	<p>Used for heating and bending.</p>
	<p>Flint striker</p>	<p>Creates a spark to start torch.</p>

(continued)

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7-20 Gas Welding Equipment (continued)

	Welding gloves	Safety precaution to protect the hands.
	Tank wrench	Used to open and close valves on the gas tanks.
	Goggles	Safety precaution to protect the eyes.

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welding that is used in the theatre, ignites an oxygen and acetylene mixture to produce a flame hot enough to weld steel. Welding is possible with or without a filler metal. In addition, oxyfuel equipment can cut metal with a cutting attachment.

Arc Welding Equipment The heat of arc welding comes, as the name implies, from the arc of a high-amperage short circuit between the metal and the rod or electrode. The work has to be grounded to complete the circuit from the rod to the holder, through the electrode cable and to the power source. *Shielded metal arc welding* (SMAW), often referred to as *stick welding*, used to be the standard in the entertainment industry but has been replaced by GMAW (gas metal arc welding), commonly known as MIG welding.


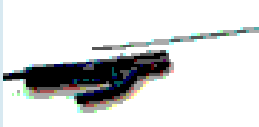



In stick welding, a rod serves as both the filler metal and as the conductor that allows electricity to go from the source to the work (Figure 7-21). The weld is continuous through the length of the rod, which is consumed during the process. The metal rod has a shield, referred to as *flux coating*, which melts as the welding is done. This leaves a residue called *slag*, which must be chipped off after the metalwork cools and becomes solid.

MIG Welding MIG welding has become the standard for scenery construction (Figures 7-22 through 7-24). Its low equipment cost, easy learning curve, and speed have made it preferable to other processes. MIG uses a wire filler fed through a multifunction cable and gun. The arc is surrounded with an inert gas shield, via the cable from an external tank. The trigger of the gun nozzle simultaneously turns on the shielding gas flow, starts the power to melt the wire, and starts the pinch roller that feeds the wire. When the trigger is released, all three processes stop. Because the shielding gas protects the wire from impurities in the air, there is no slag.

MIG welding is a relatively simple one-handed operation that is easy to learn. The heat of the arc and gauge of the wire can be altered to weld various thicknesses of metal. In addition, a special form of MIG wire is available with a core that negates the need for gas. Called flux core arc welding (FCAW), this is considered a separate welding process.

TIG Welding Gas tungsten arc welding (GTAW), or TIG welding, is essentially an electric version of oxyacetylene welding, using an electric arc instead of a flame. This type

7-21 Stick Welding Equipment

	Stick welder	Used for shielded metal arc welding, commonly referred to as SMAW.
	Welding rod	Actually electrodes; rods are numbered in reference to material of electrode and tensile strength.
	Helmet	Safety precaution for eyes and head; the arc from stick welding can literally be blinding.
	Chipping hammer	Used to chip off slag, the residue left after the metalwork cools.
	Ground clamp	Allows work to be grounded; common to all kinds of electric welding.

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SAFETY PRACTICE ■ Welding Safety

Proper training is critical.

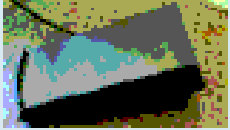
Gas welding operators should wear goggles, ear protection, protective clothing, and gloves, more for protection from flying sparks than from the intensity of the flame. Because there are no ultraviolet rays generated in the flame by gas welding, it does not have to be isolated or shielded from other shop activity. Precautions should be taken, however, to guard flammable materials from the sparks by using sheetrock pads under and around the work. An appropriate respiratory mask should also be worn when working in confined spaces. Long sleeves are also recommended.

Arc welding operators require the same protection, plus shielding from the ultraviolet rays of the arc. A welder's helmet with

a ray-absorbing window should be worn to protect the eyes. If other workers are nearby, a portable shield should be used to protect their eyes as well. A protective hat must be worn whenever any welding produces sparks.

Prolonged welding in a closed room requires forced ventilation. Flammable materials should be avoided anywhere near a welding area for obvious reasons. By law, a proper fire extinguisher must also be present. In many situations, a *fire watch* (person assigned to fire watch duty) must be present during all welding time and for 30 minutes after in order to ensure that there is no danger of fire.

7-22 TIG and MIG Welding Equipment

	<p>TIG welder</p>	<p>Used for gas-tungsten arc welding (GTAW).</p>
	<p>Torch</p>	<p>Delivers arc to weld area.</p>
	<p>Foot pedal</p>	<p>Used to control amperage when both hands are needed elsewhere.</p>
	<p>MIG welder</p>	<p>Used for metal inert gas welding (MIG welding).</p>
	<p>Spool gun</p>	<p>Feeds the wire electrode.</p>
	<p>Torch</p>	<p>Portable apparatus that produces a very hot flame by the combustion of gases; used in welding and construction.</p>
	<p>Gas flow meter</p>	<p>Provides the rate of the shielding gas being delivered to the MIG welding nozzle.</p>

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of welding uses a nonconsumable electrode (tungsten). The arc created between the tungsten electrode and the work melts the metal, forming a puddle, some of which vaporizes. A filler is required to replace that metal and strengthen the joint; therefore, this type of welding is a two-step process of alternating the melting and adding filler. TIG welding provides an unobstructed view of the welding process and thus is preferred for applications that demand precision, such as trusses. It is most commonly used on aluminum and stainless steel.

Cover Stock

The material used to cover the structural frame of scenery, thereby providing a surface for painting, is known as *cover stock*. The frame can be covered with a fabric or a hard surface, depending on the use and handling of the particular piece of scenery. A scenic unit that must take abuse (an actor pounding against a wall, for example) or that must be weight bearing (a wall that must hold up a shelf or a wall with a window that is climbed on) will be covered differently than a wall that must be translucent.

Soft Surfaces

A “soft-covered flat” uses fabric for its skin, most commonly unbleached muslin. Muslin is also frequently used for drops (an unframed piece of painted fabric used as a background; see Chapter 8 for more information). As with other scenic materials, the use of muslin depends on location, price, and availability. There are areas where canvas is cheaper. Almost any fabric can become a covering material to serve as a special effect or as an unusual painting surface. Burlap, velour, scrim, terry cloth, and even string rugs have been used as covering fabrics.

Although inexpensive, the surface of soft-covered flats tends to vibrate whenever anyone walks by it, negating the sense that it is a solid wall. Unless the production is a very low-budget one, these flats tend to be used where they are not prominently seen (such as offstage masking walls).

Hard Surfaces

The use of hard-covered flats has become the norm. They are more efficient and, given the increase in fabrics costs, only slightly more expensive than soft surfaces. The most frequently used hard-surface material is $\frac{1}{8}$ -inch or $\frac{1}{4}$ -inch lauan. (*Lauan* is a generic term referring to tropical plywood.) It is lightweight but still strong enough to supply a hard surface with a minimum of framing.

Typical materials used for cover stock include plywood, MDF (medium density fiberboard, a composite wood product) and OSB (oriented strand board, or layers of strands of wood compressed and bonded with resin). All these products have advantages and disadvantages—cost, weight, and paintability are all factors to be considered.

Other commonly used hard-surface materials include $\frac{1}{8}$ -inch and $\frac{3}{16}$ -inch Upson board, an inexpensive board made of laminated paper; $\frac{1}{4}$ -inch A-C plywood, a very sturdy but heavy board (also used for keystones and corner blocks); $\frac{1}{2}$ -inch Homesote[®], a paper-pulp board with little strength but thick enough to be carved or textured (as for



7-23 Welded Joints

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7-24 Steel Staircase View of a welded steel spiral staircase for a production of *A Midsummer Night's Dream* for the Shakespeare Theatre of New Jersey, designed by Dick Block.

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stone); and Masonite®, a very heavy hard surface of compressed wood pulp. Tempered Masonite is an extremely hard surface that is often used as a floor covering. Typically, shops also use ¾-inch plywood for platform tops. Most of these materials are available at the local lumber yard in stock 4-by-8-foot sheets. Occasionally, oversized sheets—such as 5 feet by 9 feet, 4 feet by 10 feet, and 4 feet by 12 feet—are stocked.

Plastic offers another type of hard-surface cover stock. Because the use of plastic as a scenery surface is usually related to a textured or relief-sculptured surface (such as brick or stone), it is reserved for discussion in Chapter 8, in which the techniques of working plastics such as Styrofoam, urethane foam, and thermoplastics are discussed.

Every project has unique requirements. Other materials less usual than those discussed here might be used for various purposes. If the designer and the technicians are open to what is available, they will find a great variety of materials to use.

Scenery Hardware

In the scenery shop, hardware is divided into two categories: fastening hardware used in the construction and basic assembly of scenery; and stage hardware for the bracing, stiffening, rigging, and onstage assembly of scenery.

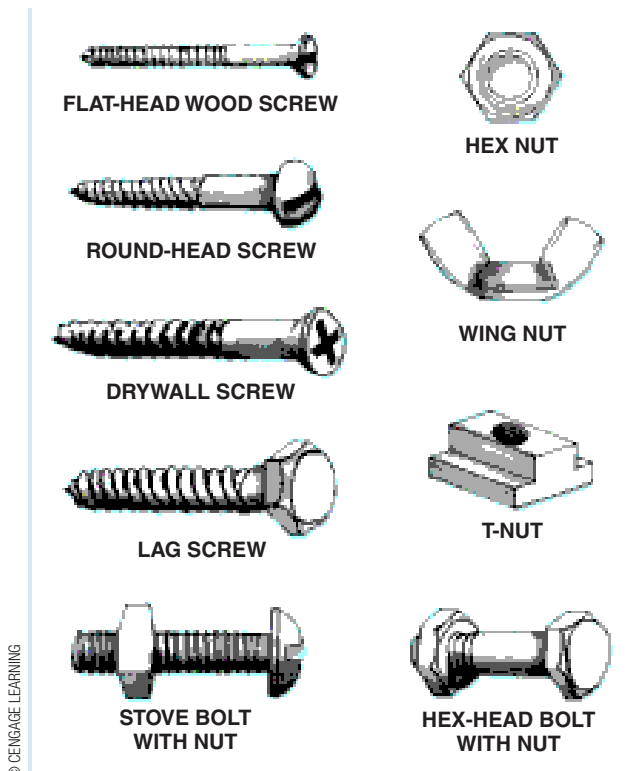
Fastening Hardware

Fastening hardware is an important part of normal scenery construction. It includes all the necessary nails, screws, and bolts to fasten wood to wood or metal to wood.

Nails Driven with a hammer or pneumatic nailer, a nail is used for a relatively permanent fastening of wood to wood, although as mentioned earlier, it is fast falling out of use. Nails are stamped out of steel wire to a particular thickness, length, and shape of head. The weight is known as *penny* and is represented by the letter *d*—a 10d nail is longer and thicker than an 8d nail.

A *common nail* has a flat head for easy driving and extracting. The wide flat head also adds strength to the joint. Useful common nails for theatre might include 8d (2½"), 10d (3"), and 16d (3½"). A *box nail* is a lightweight (smaller wire) common nail, 4d (1½") or 6d (2"). A *finish nail* is a small-wire, small-headed nail for finish work such as attaching molding or trim. A finish nail's head is set below the surface of the wood so it can be covered with wood putty or paste, thereby concealing the nail. Finish nails in stock would begin with 1-inch wire brads (very fine wire) and include 4d (1½"), 6d (2"), and 8d (2½"). The double-headed *duplex nail* is used for temporary assembly and comes in sizes 6d, 8d, and 10d.

Screws The screw acts as an internal clamp in that it pulls the material into itself as it tightens. The tapered advancing threads of the screw are drawn into the wood as the screwdriver turns, providing a very firm fastening of wood to wood. The diameter of a screw is indicated by number; the length is indicated in inches. The types of heads are numerous—the *flat head* with tapered sides to countersink into the wood; the *round head* to set on the wood surface; and the *hex head* of the *lag screw*. The types of recesses in the screw head for the driving tool include the *slot*, *Phillips*, and *Robertson square*. (See Figure 7-25 and refer again to Figure 7-8.) The most common sizes to stock might be No. 8 screws: ¾, 1, 1¼, 1½, 2, 2½, and 3 inch.



7-25 Hardware: Screws, Nuts, Bolts

With its deeper and steeper threads, a *wood screw* not only can hold better but can be driven faster. The industrial-quality wood screw is made of tempered high-grade carbon steel and is lubricated for easy installation. It has extruded threads, meaning the threads extend beyond the diameter of the shank (most screws are turned from shank stock). The extruded threads give the screw greater holding power. Most often, screws are now made with Phillips heads rather than slotted heads to help ease installation.

The *alloy wood screw* (square drive), often sold as deck screws, is a better alternative to the commonly used drywall screw as it is more reliable in quality.

A *lag screw* has wood screw threads. It is used in heavy assembly when a bolt is not feasible, and it is driven with a socket wrench. Sizes $\frac{5}{16}$ to $\frac{1}{2}$ inch in diameter and $1\frac{1}{2}$ to 4 inches long are suitable for most needs.

Tacks and Staples A No. 6 or No. 10 *carpet tack* will secure a carpet, padding, or ground cloth. *Upholstering tacks* in various colors and patterns aid in the construction or remodeling of furniture for properties; usual size will be $\frac{1}{2}$ inch or $\frac{3}{8}$ inch.

The size and shape of a *staple* vary with the type and make of the stapler as well as with the nature of the work. Hand-powered staplers, hammer staplers, electric staplers, and pneumatic staplers each require a slightly different type of staple. Staples for hand or electric staplers (for attaching fabric or metal screening to wood) vary from $\frac{1}{4}$ inch to $\frac{1}{2}$ inch in size. Staples for pneumatic staplers (for fastening wood to wood) are most commonly $\frac{3}{4}$ inch or 1 inch but can be as large as 2 inches in size.

Bolts, Nuts, and Washers As fastening hardware, the bolt and nut are stronger than the nail or the screw. The nut and bolt are also easy to disassemble, allowing scenery knockdown. Bolts commonly used in theatre are the stove bolt, the machine screw, the carriage bolt, and the machine bolt.

Both the *stove bolt* and the *machine screw* have a flat head and a slotted recess and are threaded their full length. They are among the most commonly used pieces of hardware in the theatre. In short lengths and small diameters ($\frac{3}{16}$ inch), they are used to reinforce the screws in a backflap hinge or hanger iron. The flat head of the machine screw fits into a countersink, whereas the slotted round head of the stove bolt sets on the face rather than being countersunk. Both bolts are tightened using a socket wrench.

The *carriage bolt* is engineered specifically for fastening wood. The rounded head with the square shank is expected to be drawn into the wood surface and thereby resist turning as the nut is tightened. Because the bolt is not threaded its full length, care needs to be taken to select the right length bolt for each joint. Normal sizes to stock are $\frac{3}{8}$ -inch diameter—3, $3\frac{1}{2}$, 4, and 6 inches in length.

The *machine bolt*, also commonly used in the theatre, has a finer thread than the other bolts discussed. It also has a square or hex head. Although it can be used for wood, it is manufactured for metal assembly such as slotted-angle and structural steel framing. The size of bolt depends on the forms of the steel and the nature of the structure. Frequently used sizes are $\frac{3}{8}$ -inch diameter—1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, and 4 inches in length; and 2-inch diameter—6 and 8 inches in length (Figure 7-26).

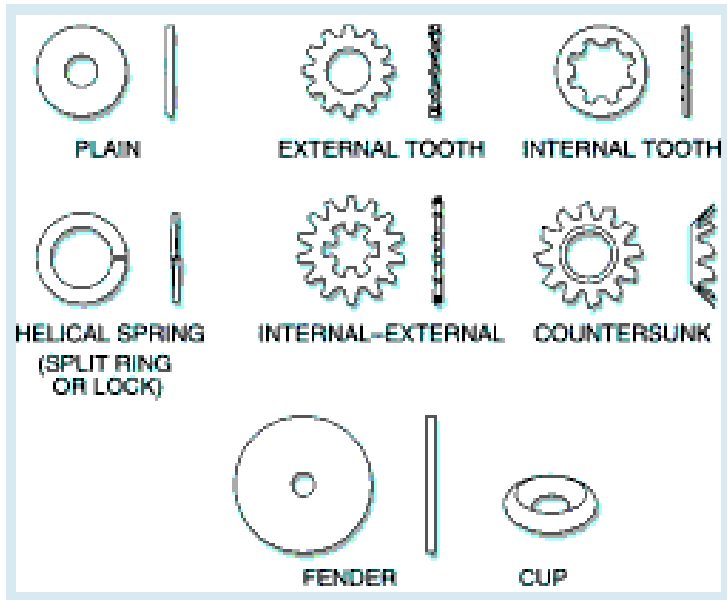
Bolt length is determined by the amount of bolt that will be recessed into the work, not by the total length of the bolt.

Nuts are usually hexagonal with inside threading that matches the bolt. Their function is to tighten the bolt in place. Although the *hex nut* has to be tightened with a wrench, the *wing nut* is designed to be tightened by hand for easy and quick assembly. A *T-nut* has sharp prongs to anchor the nut in the wood surface around a predrilled hole, thus permitting rapid fastening.



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7-26 Bolt Length



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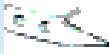
7-27 Types of Washers

The *washer* is a flat disk of steel with a center hole slightly larger than the diameter of the bolt (Figure 7-27). It spreads the pressure of the tightened nut for a stronger fastening. The *lock washer* is a cut disk with offset ends that provide enough pressure to keep the nut locked in place. Lock washers also come in other shapes, including “star” and “wave.” Washers are used under the nut—never under the head of the bolt.

Stage Hardware















Because scenery must be portable, many pieces of hardware have been developed especially for the stage (Figure 7-28). Most of them are designed to brace, stiffen, and temporarily join units of scenery as well as to work with rigging for the flying of scenery.

7-28 Stage Hardware

	Loose pin back-hinge	Used to connect two pieces of scenery temporarily (as for a scene change).
	Strap hinge	Commonly used to hold door frame in place.
	Hinged foot iron	Used with a stage screw to secure the bottom of a unit of scenery to the floor.
	Bent foot iron	As above, used to secure scenery to the floor for bracing.
	Straight foot iron	Used on the bottom of a jack brace, a triangular structure, usually of wood, used to support or brace a vertical flat.
	Stage screw and plug	Plug is set in hole drilled into stage floor; stage screw is then screwed into it through a foot iron to secure unit of scenery.
	Stage screw	Used as above, but no plug is needed; screw is driven directly into stage floor.
	Lash cleat	Holds lash line in place against edge of flat.

DRAWINGS BY MICHELLE CARELLO

7-28 Stage Hardware (continued)

	Lash eye	Used to secure lash line to top of flat.
	Lash hook	Used when there is not enough room for a lash cleat.
	Stop cleat	Holds flats together at a corner joint when lashed.
	Picture hanger	Used to fasten lightweight scenery to toggle.
	Batten hook (keeper hook)	Used over a toggle to hold a horizontal stiffener.
	Hook and eye	Quick way to hold a joint but not very strong.
	Turnbuckle	Used to make adjustments in the level of a rigged scenic unit.
	Straight hanger iron	Used at the top of a framed scenic unit when it is to be flown.
	Hooked hanger iron	Used at the bottom of a framed scenic unit when it is to be flown.
	Square plate and ring	Attached to scenic unit when it is to be flown.
	Plate and D-ring	Used to hang vertical and horizontal units; also used to guide lines.
	Ceiling plate	Used for flying scenery, such as ceiling.
	Swivel eye snap hook	Used to attach scenic units, but not very strong.
	Casket lock (coffin lock)	Recessed into the edge of a wagon platform; a hidden lock that can be unlocked with an Allen wrench through a small hole in the platform top (see Figure 10-13e).









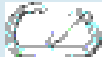
DRAWINGS BY MICHELLE CARELLO

Rigging Hardware

There are three categories of rigging hardware (see Figure 7-29):

1. Hardware that attaches directly to the unit to be flown.
2. Hardware that creates a usable termination in the cable or rope.
3. Hardware that connects the two types just discussed, allowing for adjustment and removability.

7-29 Rigging Hardware

	Forged eyebolt	Used as lifting point or to guide a liftline; to be safe, an eyebolt must be forged (as opposed to bent) so that the circle is continuous.
	Snap hook	Forged hook with spring-loaded latch; used most often to attach sandbags.
	Cable clamp (Crosby)	Holds cable loop in place to form a permanent termination.
	Cable thimble	Used in making a loop or an eye in cable.
	Swaging sleeve	Slips around and, with the use of a swaging tool, is crimped (or compressed) around cable to form a permanent termination.
	Cable thimble used with crimped sleeve	Cable termination shown with crimped swaging sleeve.
	Quick link	Similar to link in chain but with one end that is threaded to open and close.
	Shacklebolt	Two-part fastener consisting of inverted U that slips through ring of attachment hardware.
	Carabiner	Rock-climbing hardware with spring-loaded latch, sometimes lockable.

DRAWINGS BY MICHELLE CARELLO

Rigging

Rigging is defined as the use of rope, chains, pulleys, or other equipment to support scenic pieces. This can include anything from something as simple as connecting a drop to a batten to flying an actor with sophisticated machinery. Anything beyond the simplest connection requires careful, skilled, and trained personnel to maintain safety.

Rope

Constructed of spun *fibers* that are first twisted (normally to the left) into a *strand*, *rope* is formed by twisting three or four strands in the opposite direction (that is, to the right). This twisting is known as the *lay* of the rope. The opposing tensions of the lay of the rope and the lay of the strand hold the rope together.

The fibers of a rope can be from *natural* or *synthetic* sources. The most common natural fiber is manila. Relatively inexpensive, it has many uses in the theatre. Synthetic fibers such as nylon, polypropylene, polyethylene, and polyester have been incorporated into rope construction. The continuous length of synthetic fibers adds strength and flexibility to a rope. Although the cost of a synthetic fiber rope is considerably higher than one of natural fiber, its life span can be much longer.

Sizes of rope most frequently used in the theatre include the following (see Chapter 10 for information about rope knots used for rigging):

- $\frac{5}{8}$ -, $\frac{3}{4}$ -, $\frac{7}{8}$ -inch *three-strand*. Used for purchase lines of a counterweight flying system and the lift or hoist line.
- $\frac{1}{4}$ -, $\frac{3}{8}$ -, $\frac{5}{8}$ -inch *three-strand*. A lightweight rigging good for breasting and bridling (see Chapter 10).

Another kind of rope is *braided rope*, which is quite flexible. Cotton is the most common natural fiber used in braided rope. However, the same synthetic fibers found in stranded rope are used in braided rope. When strands of synthetic fiber are braided around a central braided core, the resulting rope carries amazing strength. It is not, however, recommended for use as hoisting rope because it tends to stretch and lose trim. It is also very expensive. An excellent combination of fibers for theatre use is cotton strands braided around a central core or strand of polyester or polyethylene. Many other combinations are available.

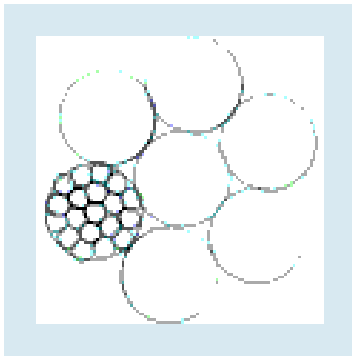


SAFETY PRACTICE ■ Rope Safety and Care

Those who work in the theatre should observe the following guidelines for safe use and maintenance of rope:

1. Do not overload. The rope manufacturer's listed BP (breaking point) is for new rope and under a fixed load. Rope in the theatre is run over sheaves and pulleys, tied and untied, and subjected to variable loads—all of which eventually weaken it. To avoid overloading, it is a good practice to use a safety factor of 10, or $\frac{1}{10}$ of BP. A normal hoist line of manila rope, for example, is $\frac{3}{4}$ -inch three-strand with a BP of 5,400 pounds. With a safety factor of 10, 540 pounds would be a safe load.
2. Keep a file of the installation date of all hoist and purchase lines.
3. Establish a schedule of inspection, rotation, and replacement of hoist lines, especially those of natural fiber.
4. In each inspection, check for fraying or chaffing where a rope runs over the gridiron or through a sheave. Look for damage from clewing several lines together and other stress points of stage rigging.
5. Store natural fiber rope in a clean, dry area away from excessive heat.
6. Protect ends of rope from fraying or unwinding by binding or whipping the strands together.
7. When rope has reached the end of its useful life, cut it up into small lengths of 3 to 4 feet before throwing it away. This prevents scavengers from using an unsafe piece of rope.

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7-30 Aircraft Cable Structure The most common configuration of aircraft cable that is used for theatrical purpose is the 7 x 19 construction which has a good combination of strength and flexibility. This means that the cable has 7 strands of 19 wires each.

Sizes and uses of braided rope include these:

- $\frac{1}{2}$ inch (No. 10). Drawline for heavy traveler curtain.
- $\frac{5}{16}$ inch (No. 8). Lash line and lightweight rigging.
- $\frac{1}{8}$ -inch awning cord. Lightweight window-curtain rigging, trick line, and tie-lines.

Aircraft Cable

Sometimes referred to as *wire rope*, *aircraft cable* is made of flexible, high-grade steel wire twisted into strands like fiber rope. Six or more strands are twisted into one cable.

Its flexibility and strength allow it to pass through small pulleys and make it useful for special rigging and winch work.

Sizes and uses of cable are as follows:

- $\frac{1}{4}$ -, $\frac{3}{8}$ -inch 6 x 19. Hoist line in counterweight system.
- $\frac{1}{4}$ -inch 7 x 19 aircraft cable. Winch, turntable, and wagon drives.
- $\frac{1}{16}$ -, $\frac{3}{16}$ -, $\frac{1}{8}$ -inch 7 x 19 aircraft cable. Most flown scenery, some winch drives, and actor-flying rigging. The smallest diameter cable in common use is $\frac{1}{16}$ inch, which is not typically load bearing but works for light-duty rigging. The smallest diameter typically used for “load bearing” applications is $\frac{1}{8}$ inch, which has a break-strength of at least 1,800 pounds. This size cable is very good for rigging flats and other scenic elements. (Note: A “break-strength” of 1,800 pounds does not mean the cable is safe at that weight. Always read manufacturer’s information for specifics.) A $\frac{1}{4}$ -inch cable (minimum strength of 7,000 pounds) is common for heavier loads and to drive moving scenery. Both of the above cables are available with a black matte finish.

Considerably more information can be found in the *Wire Rope User’s Manual* published by the Wire Rope Technical Board, which is a certifying agency for the manufacture of wire rope. They can be contacted at:

Wire Rope Technical Board
801 North Fairfax Street, Suite 211
Alexandria, VA 22314-1757
(703) 299-8550
e-mail: wrtb@usa.net
<http://www.wireropetechnicalboard.org/>

Chain

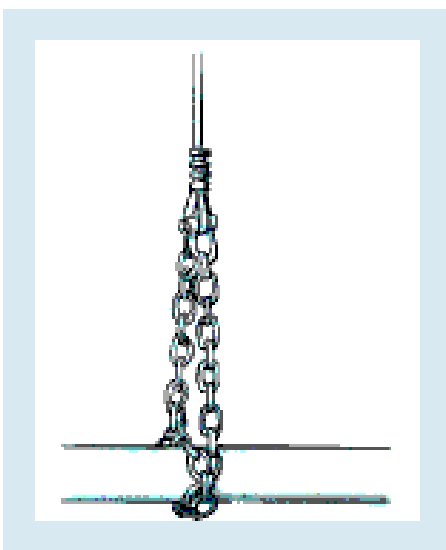
Chain is used for weight at the bottom of a drape that must remain flexible (for example, drapes with fullness) and is often used in a cable termination as a transition between a cable and the object being rigged (such as a batten) (Figure 7-31). When chain is used for rigging, it must be *welded link* chain. *Bent link* chain (such as jack chain, the kind used typically for swing sets) is inappropriate for rigging applications. Consult the chain manufacturer’s specifications for acceptable working loads.

Sizes and uses are as follows:

- $\frac{1}{2}$ - and $\frac{3}{4}$ -inch jack chain (single or double). Curtain weight.
- $\frac{1}{4}$ - and $\frac{3}{8}$ -inch proof coil chain. For cable termination.

Although designers do not usually work directly with the rigging or the other materials described in this chapter, a thorough knowledge of stage materials and tools can help them envision creative possibilities and avoid problems in actualizing their designs.

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7-31 Chain Used for Cable Termination Welded link chain wrapped twice around batten and connected to a screw pin shackle, looped around a cable thimble. The cable itself winds around the thimble and is crimped with a swaging sleeve.

Building the Scenery

Scene designers and technicians are interested in the construction of scenery not only to become familiar with building techniques but also to become aware of the uses and limitations of various materials. The more they know about present-day theatrical materials and techniques, the better they can introduce new materials and original methods into designs.

The building of scenery is under the charge of the *technical director* or *project manager*, the person responsible for translating the designer's idea into reality. The better an understanding the technical director has of the designer's ideas and interpretation of the production, the more profound an effect he can have on the design.

Compared with standard building construction, scenery construction may, seem at first glance, to be unduly flimsy and unnecessarily complicated. These characteristics are due chiefly to the unique demands the theatre places on scenery. First, it must be portable and lightweight, so as to move easily from the shops, on the stage, and sometimes from theatre to theatre. Second, because theatre is larger than life, scenery has to be able to assume large-scale proportions for conceptual, storytelling, decorative, or masking purposes. Therefore, large expanses of scenery must be furnished with a minimum of structure and a maximum of portability. And finally, because scenery exists for only a short time—the run of the production—its construction must be cost-effective. This does not necessarily mean made from the cheapest materials; rather, it means balancing costs against the weight and structural demands of a material. It also implies the economical use of scenery onstage (the responsibility of the designer). Higher material costs can be made affordable if a scenic element has more than one use or can be reused at a later date.

For the purpose of discussion, we have separated the various types of scenery into two-dimensional and three-dimensional groups. Each is similar in method of construction, function, and handling requirements.

Two-dimensional scenery includes all flat scenery such as walls and **profile pieces** and is categorized by its basic shape rather than by the way it is used on the stage. The individual units of flat scenery that are assembled to make a three-dimensional form on the stage are still classified as two-dimensional scenery. Two-dimensional scenery is further subdivided into two groups: framed scenery and unframed (or soft) scenery. Within these two groups falls the bulk of the scenery that is used on the stage.

Three-dimensional scenery refers to the scenic units that are built in three dimensions to be handled and used as solid forms. Three-dimensional scenery is separated into two basic groups: weight-bearing, meaning the weight of the actor and other scenic units, and non-weight-bearing.

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profile piece A flat piece of scenery that follows the outline of an object, such as a tree, hill, or fence.

Soft Scenery

Large unframed pieces such as stage draperies, drops, and the cyclorama, or “cyc,” are considered soft scenery. They all serve the same function—providing a large area of scenery with a minimum of construction and a maximum of portability. Because they are soft, they must hang from a batten or pipe for support and can be easily folded or rolled for transportation or storage.

Stage Draperies

Construction The large panels of stage draperies are made by sewing widths of materials together. Vertical seams are most often used for three reasons. First, they are less likely to catch the light because a vertical direction is typically used for a drop. Second, a vertical seam is less conspicuous because it is lost in the folds of the drapery. Third, there is less strain on a vertical seam than on a horizontal one, which carries the cumulative weight of each width of material from the bottom seam to the top.

The seams are sewn face to face to present a smooth front surface. The top is reinforced with 3- to 4-inch jute webbing through which grommet rings are set at 1-foot intervals for the tie-lines. The bottom has a generous hem containing a chain or pipe that functions as a weight for the curtain. Occasionally, the chain is encased in a separate sound-deadening pocket, called a **pipe pocket**, that is sewn on the back side of the drapery.

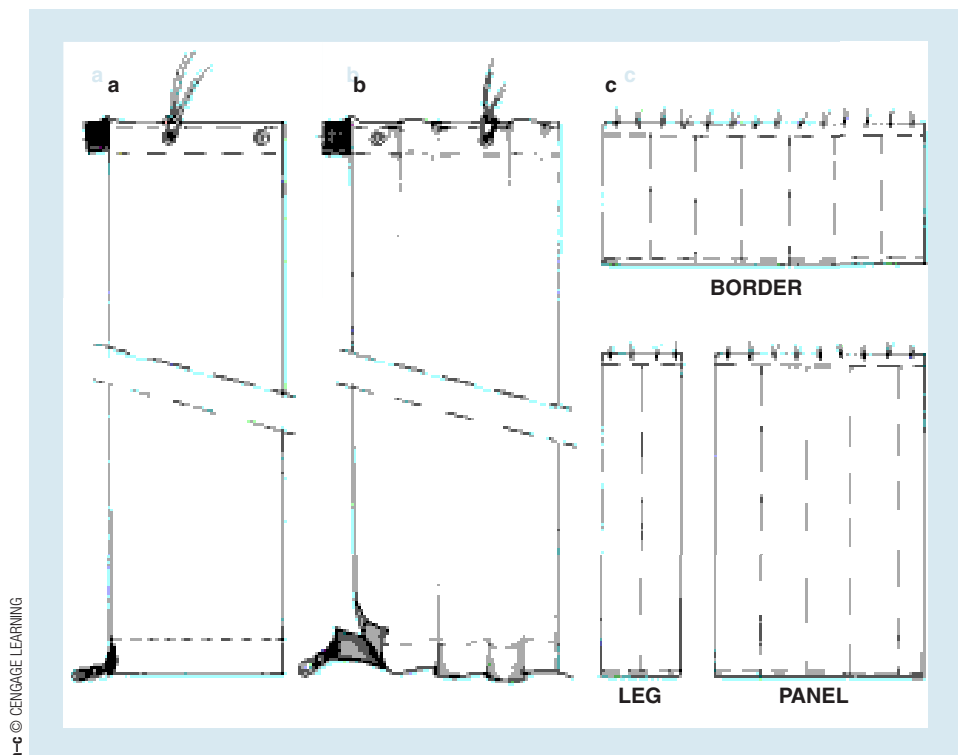
Drapery fabrics may be sewn flat to the top webbing or gathered or pleated onto the webbing to give a fixed **fullness** to the curtain. For a front curtain or traveler curtain, fixed fullness is an advantage because it has a softer look. If used as masking, it absorbs more light than does a flat curtain panel. However, it is not as flexible because the latter can be hung either flat or with varying degrees of fullness for a greater variety of uses (Figure 8-1).

pipe pocket A casing sometimes stitched to the back at the bottom of a drop into which a chain or pipe can be inserted for weight.

fullness The effect achieved by gathering or pleating a given width of fabric into a narrower width. For example, a 10'-0" wide drape at 100 percent fullness would need 20'-0" fabric width.

8-1 Stage Draperies

- a Flat drapery construction. Webbing with grommets and tie-lines at top; hem enclosing chain weight at bottom.
- b Gathered drapery. Fullness gathered on top webbing; chain pocket attached above hem at bottom.
- c Types of stage draperies: border, leg, panel.



Materials Any fabric can serve as a stage drapery. Determining which kind will work best depends on the budget, how the drapes will be used, and the effect that is needed. Are the draperies to be opaque, translucent, or transparent? Are they to be pictorial, decorative, or simple masking? Are they to be stock draperies or used for a one-time special effect? Answering such questions helps determine the kind of material to choose and its relationship to cost and use.

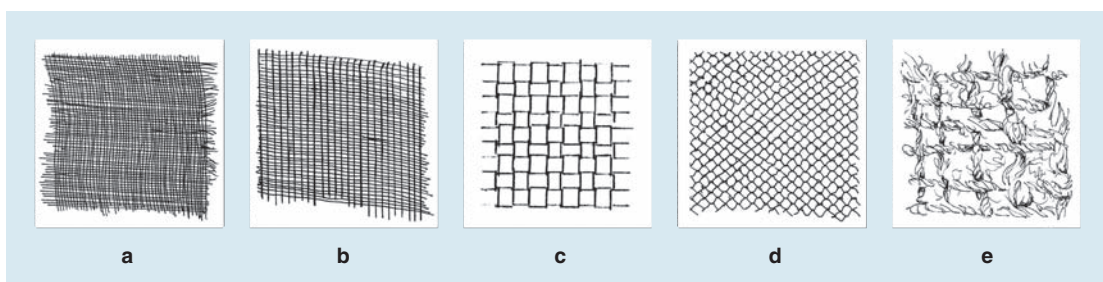
Velour, although expensive, is a commonly used drapery material, especially for masking. Its pile weave has a rich texture under the stage lights that cannot be duplicated with cheaper substitutes. It hangs and drapes beautifully, is opaque, and is easy to maintain, handle, and store.

Among the more economical fabric choices are duvetyn, commando cloth, and flannel. Commando cloth and duvetyn are almost as opaque as velour but drape poorly and lack as rich a surface quality. Flannel drapes a little better than duvetyn, and it has almost the same opacity. Its napped surface has a fair texture under stage lights. Used for masking, these fabrics absorb considerably less light and do not appear as dark as velour.

Stage draperies are made of other materials as well. Monk's cloth and many cottons have enough texture to make an interesting and inexpensive curtain when hung in fullness. Corduroy has a different texture, which, although semi-opaque, drapes and hangs well.

Sometimes draperies are expected to be translucent or even transparent. Muslin is the least expensive translucent fabric. It has a further advantage of coming in wider widths than many other translucent materials, such as satin or nylon crepe, and is easily dyed or painted.

Gauze, the general term applied to all transparent materials, is available in a variety of fabrics, such as cotton or nylon net, chiffon, and organdy. Although these fabrics are available at the local fabric store, their chief disadvantage is their narrow width, which increases the number of seams in a curtain. The seams become visible when the transparent curtain is back-lighted. Some gauzes, as well as muslins, are woven on wide looms especially for theatre use. *Shark's-tooth scrim* is a transparent material that has a rectangular or ladder pattern and is made in 30-foot widths. *Bobbinet* is a hexagonal net that has a much more open weave than shark's-tooth scrim does (Figure 8-2). The shark's-tooth, in addition to draping well, is dense enough to provide a dye-painting surface but still becomes transparent when light is removed from its face. *Filled scrim* or *leno scrim* can be used as a cyc, or painted drop, for a softer look.



8-2 Gauzes A variety of gauzes are illustrated to show their different weaves.

- a** Theatrical gauze: this fabric, which looks like surgical gauze, has very little strength.
- b** Shark's-tooth scrim: horizontal, ladder-weave; strong, not as sheer as bobbinet, best for dye painting.
- c** Burlap: one of many weaves, this one is more open than some and is very flexible; easily stretches out of shape.
- d** Bobbinet: hexagonal weave; very transparent and strong but stretches out of shape easily.
- e** Erosion cloth: designed for landscapers, this gauze has a very open weave; can be painted and drapes easily.

drop A large piece of fabric that is dyed, painted, or otherwise treated to create a background.

Drops

Another large-area piece of scenery is the **drop**, taking its name from the fact that it hangs on a batten and is dropped in. For ease of transportation, drops are made to fold. Special theatrical paints are flexible enough to withstand folding *only* if the paint application is thin and kept to one layer. Even then, with age and use, the paint will eventually crack or otherwise show wear and tear.

Drops are commonly made of muslin because it is available in wide widths and is an excellent, inexpensive translucent material. Other materials such as burlap and theatrical gauzes are sometimes used to achieve a specific desired effect. Theatrical gauzes are particularly useful because they come in wider widths than most fabrics.

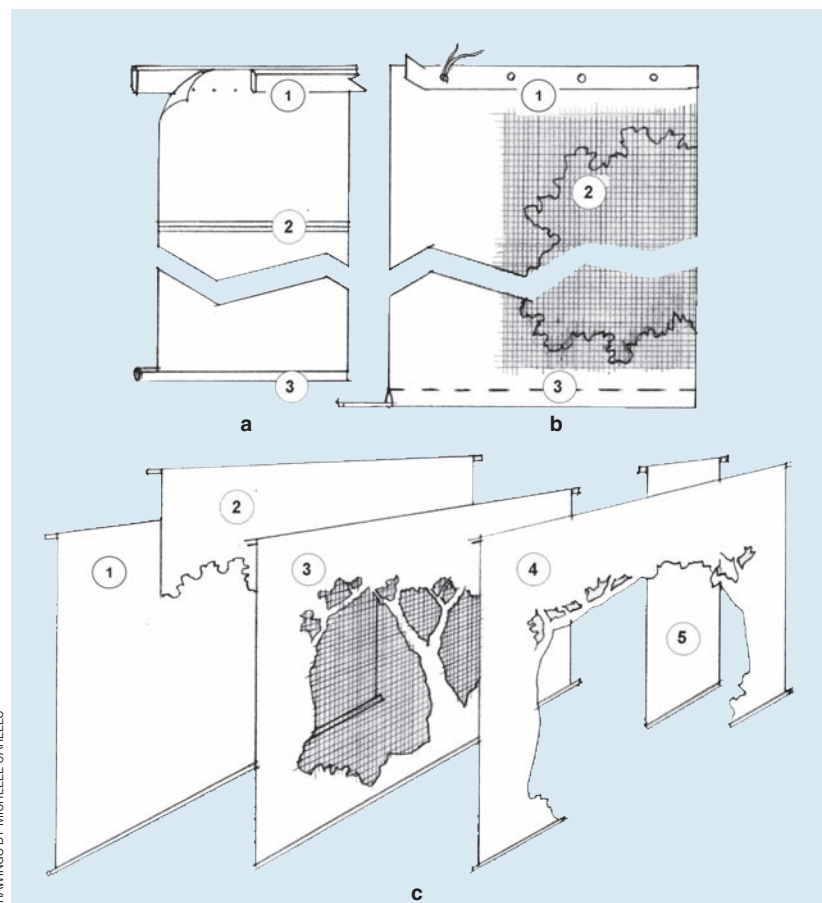
A translucent drop is painted with dye or transparent paint and is equipped with tie-lines at the top and a pipe pocket (Figure 8-3). Ideally, a translucent drop is made by using 30-foot-wide muslin, although this may not be affordable. If seams in a translucent drop are necessary, their position must be part of the design. If not carefully hidden in the design, they produce a distracting shadow line. For this reason, translucent drops are sometimes made with vertical (or sometimes even irregularly placed) seams. Because the drop will almost certainly be lit from above, vertical seams are less obvious.

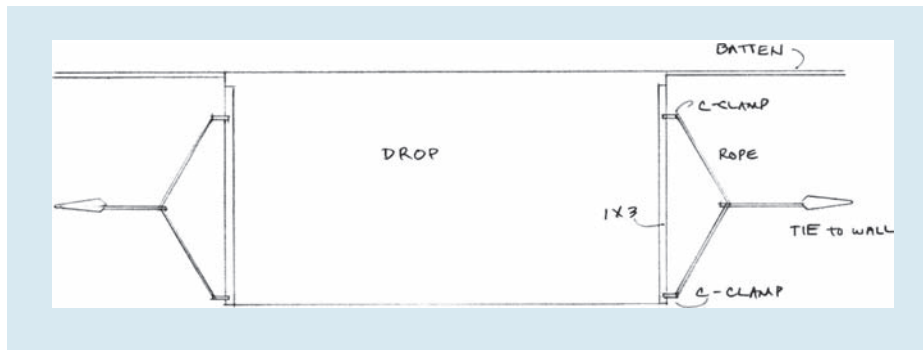
The drop is typically made with horizontal face-to-face seams. The weight of a pipe in a pipe pocket at the bottom provides enough tension to pull the horizontal seams taut, stretching the drop into a smooth surface. To assure this smooth surface, a drop should also be stretched horizontally. One method is shown in Figure 8-4.

Ideally, the bottom pipe used should be ½-inch Schedule 40 pipe (Schedule 40 is standard pipe weight and refers to pipe wall thickness) in 10-foot threaded lengths. Any

8-3 Drop Construction

- a** Rear view of a drop:
- 1 Top batten, with drop sandwiched between two 1 × 4s.
 - 2 Face-to-face horizontal seam.
 - 3 Bottom batten, double 2-inch half round.
- b** Rear view of a cut drop:
- 1 Top webbing with grommets and tie-lines.
 - 2 Netting glued over openings or cut edges to support loose ends.
 - 3 Drop bottom with pipe sleeve for the removal of bottom batten.
- c** Types of soft goods:
- 1 Plain backdrop.
 - 2 Cut border.
 - 3 Cut drop, netted.
 - 4 Leg drop or portal.
 - 5 Leg.





8-4 Stretching a Drop

pipe larger is too heavy; any pipe longer is likely to get bent. Prethreaded pipes allow you to screw lengths together as you insert the pipe into the pocket.

A cut drop, such as in Figure 8-3b, must be backed, most often with bobbinet, opera net, or scenery net. The cut edges of a drop must be supported with a lighter material, often with a 1-inch square mesh.

The Cyclorama

The largest single piece of scenery in the theatre is typically the **cyclorama**, or “cyc.” The cyclorama’s most familiar use is as a sky or void, backing a setting or elements of scenery placed in the foreground. Most commonly, the cyc is hung flat across the back of the setting, although it can also extend downstage in a gentle arc on either one or both sides of the set. The terms *drop* and *cyc* are often used interchangeably, although technically a drop is painted. A bought cyc is often dyed but can be a solid color and unadorned.

The challenge in making a cyclorama is to create a large, uninterrupted, smooth surface. A seamless cyc, although ideal, can be prohibitively expensive. With a seamed cyc, the direction of the sewn seams becomes important. Because the cyc material is hung flat, the tension from horizontal seams helps pull the surface smooth. As with a drop, unless the cyc is curved, it should be stretched. This allows for the best lighting surface.

Vertical seams round the corners better than do horizontal seams, but the former do not present as smooth a finished surface. In both cases, the seams are sure to show under a high level of illumination. This can be corrected by hanging a large flat panel of shark’s-tooth scrim directly in front of the canvas cyclorama. The scrim becomes the reflecting surface, and the canvas acts as a backing. An added benefit is that a scrim causes the background to appear more distant. If the scrim and the cyc can be several feet apart and lit separately, designers can achieve great flexibility in what the audience sees.

cyclorama Historically, a curved hard background. Today, the abbreviation “cyc” is used for any sky drop.

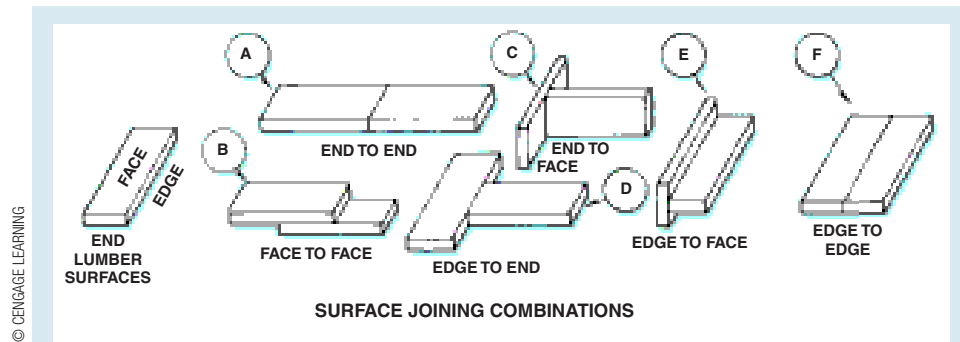
Framed Scenery

Framed scenery is structured to support itself in a standing position, although it may be aided by hanging support or be flown altogether. Most framed scenery deals with relatively small modules. If too large, it has to be hinged to fold into a smaller size or be dismantled into smaller parts to move in and out of the theatre.

Wood Scenic Construction

The traditional material for scenic construction is wood. The various wood joints are derived from the many ways of combining lumber surfaces. The surfaces of lumber are

8-5 Typical Wood Joints Used in Scenery Construction



described as its *face* (flat surface), *edge*, and *end*. The surface-joining combinations are classified as *end to end*, *face to face*, *end to face*, *edge to end*, *edge to face*, and *edge to edge*, as illustrated in Figure 8-5.

Joining lumber has two steps: first, the cutting and fitting of the joint; second, the securing of the joint. Fixed joints are secured with glue and nails, staples, or screws. Temporary joints are held with bolts, loose-pin hinges, or keeper hooks.

There are two basic techniques for framing a traditional theatrical flat, or wall, applied to any size or shape, seen in Figure 8-6. The soft-covered flat uses an end-to-edge joint, which is joined most commonly with a ¼-inch-thick plywood plate called a *corner block* or *keystone*. The plywood is attached with its grain perpendicular to the joint, inset from the edge of the flat by ¾ inch.

The top and bottom horizontal framing members are called **rails**, which extend the full width of the flat; the vertical framing members, interior to the rails, are **stiles**. Internal horizontals or verticals are referred to as **toggles** and are generally spaced at 4- to 5-foot intervals.

To strengthen and hold the flat square (at 90 degrees), diagonal braces are used to create triangles, an inherently stronger shape than a rectangle. Two diagonal braces are typically used. For this to be effective they need to be on one side of the rectangle, as shown in Figure 8-6.

Any openings in a flat, such as an arch, window, or door, are generally framed on the back of the flat with 1 × stock (such as 1 × 3) on edge to suggest the thickness of a wall. This frame is referred to as a **reveal**. To create the reveal for a curved opening, ¼-inch lauan is used, held in place by a series of 1 × supports.

To cover a flat with muslin, cut the piece of fabric slightly larger than the frame. Keeping the weave of the fabric vertical, place the muslin on top of the frame without pulling it tight; this allows for shrinkage, which occurs when the muslin is painted. The standard is to allow about 1 inch of fabric to fall onto the table for a 3-foot-wide flat. Staple each corner to hold the fabric in place. Starting with the middle of one stile, staple the muslin to the inside edge of each, placing a staple approximately every 8 to 9 inches. Work toward each corner in this fashion. Staple the fabric to the rails in the same way. If necessary, adjust the staples in the corners so the fabric lays flat. Then glue the loose edges of fabric to the frame on all sides. After this has dried, carefully trim the excess fabric with a mat knife.

The framing technique for hard-covered flats is similar to that of a soft-covered flat, but the joints in this method are end-to-face so that the framing members are perpendicular to the face of the flat. This is called a **Hollywood flat**. The hard cover, most often lauan, negates the need for diagonals, corner blocks, and keystones. The advantages of hard-covered flats are greater structural integrity and the ability to accept a wide range of textural surfaces. As well, the frame of the flat doubles as the reveals around openings. It is preferable for the hard-covered flats to be covered

rails Top and bottom horizontal framing members of a flat.

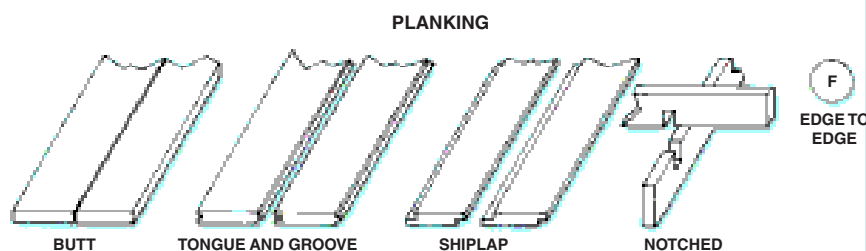
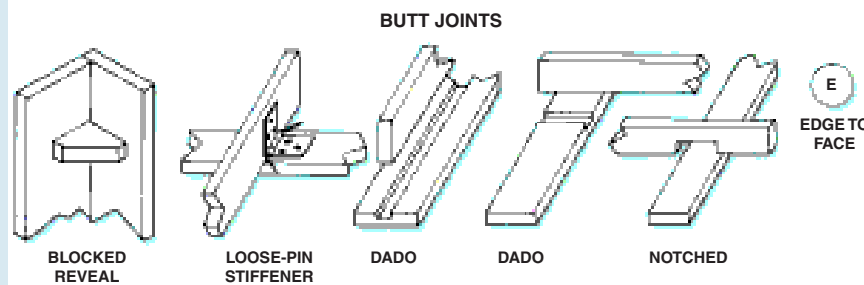
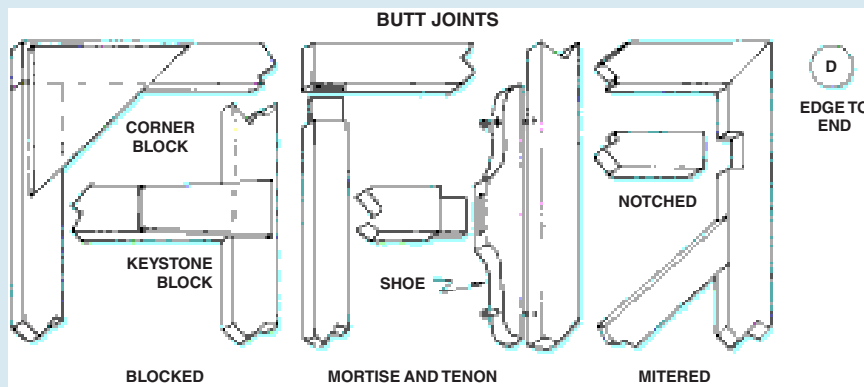
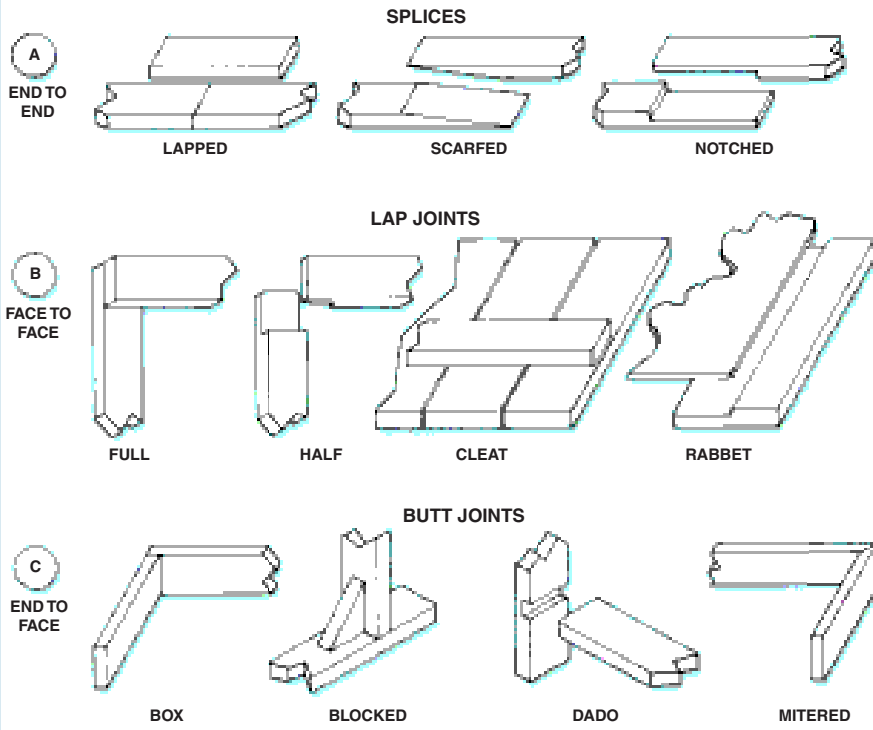
stiles Vertical framing members of a flat.

toggles Internal framing members of a flat, usually horizontal but sometimes vertical.

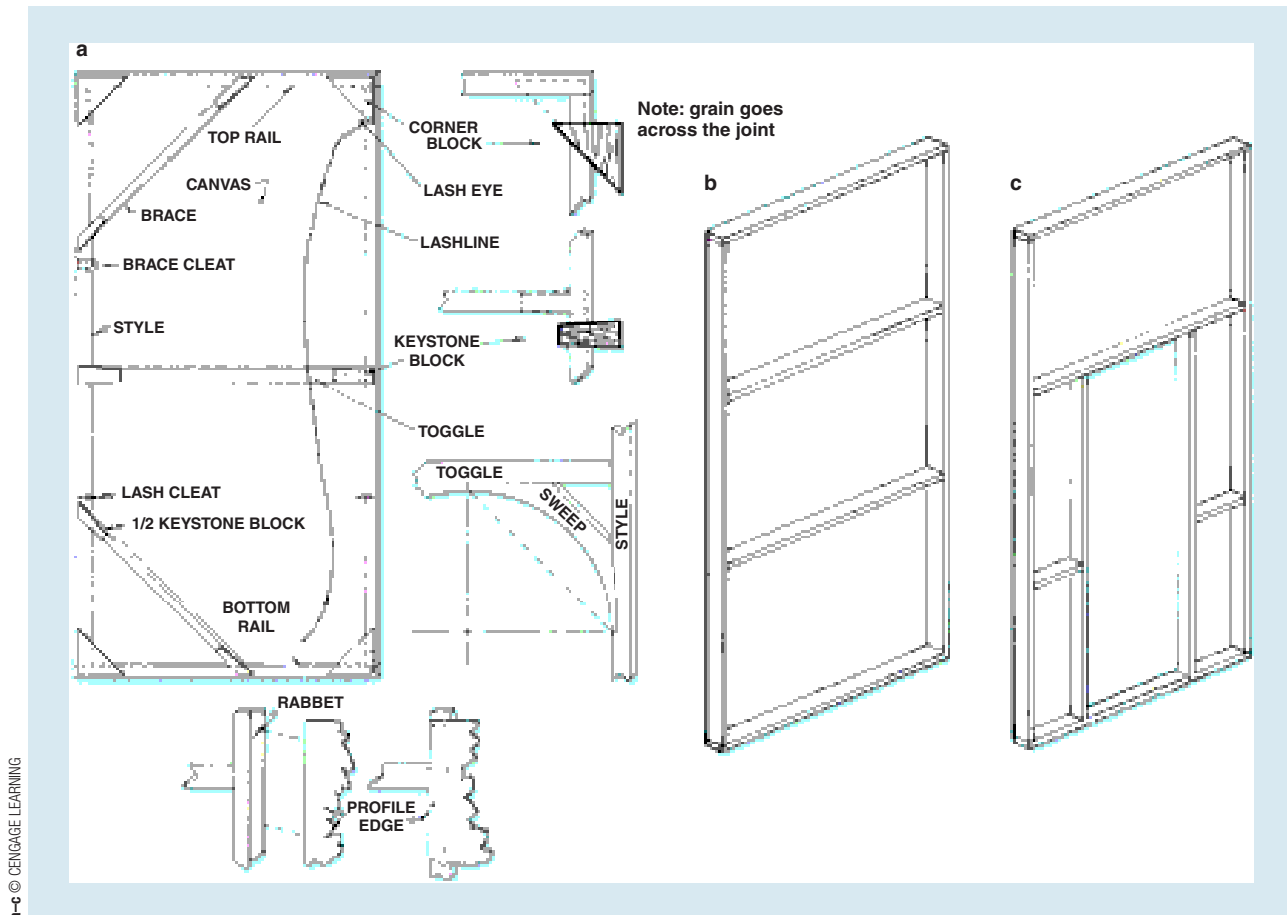
reveal The frames of an opening in a flat to indicate the thickness of the wall, usually 1 × stock.

Hollywood flat A flat in which the framing members are on edge; the corners of the flat are end to face (as opposed to end to edge).

8-5 (continued)



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8-6 Framed Scenery

- a Flat construction.
- b Hollywood flat construction.
- c Construction of Hollywood flat with door opening. Note beveled threshold.

with muslin to provide a good paint surface. The basic framing techniques for soft- and hard-covered flats can be used for door, window, wall, or profile flats, as shown in Figure 8-7.

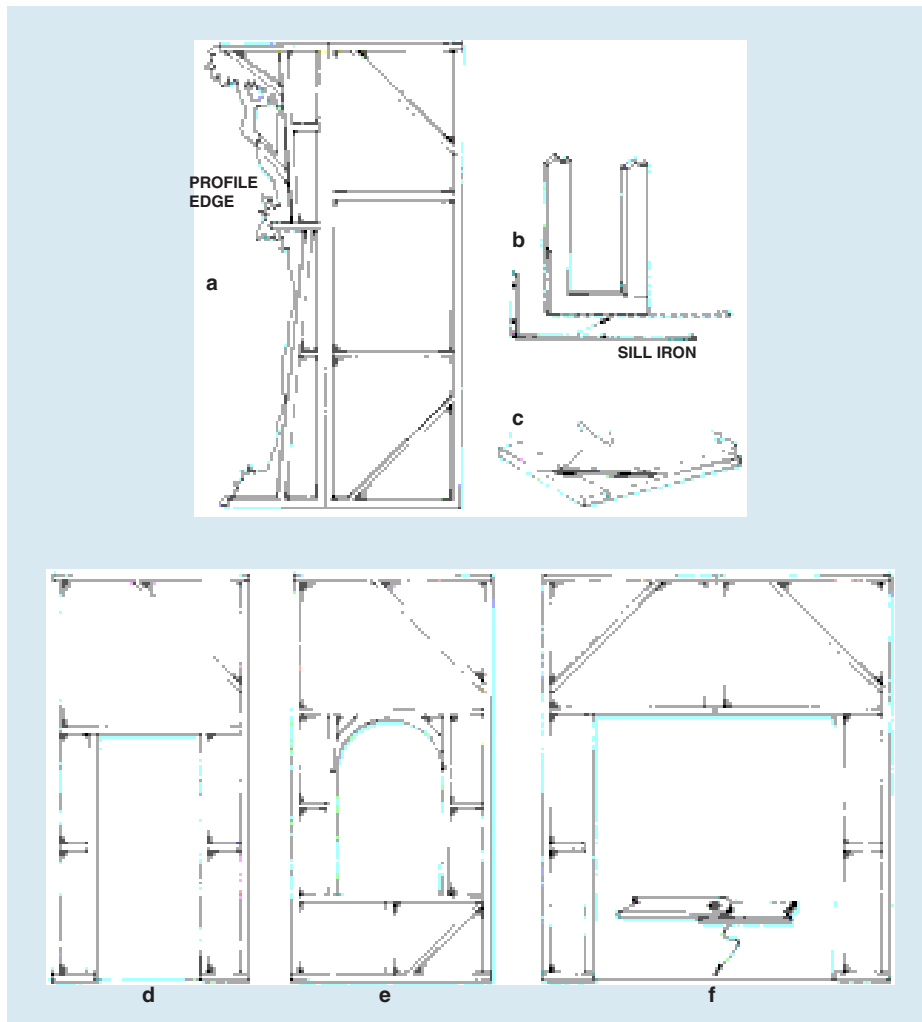
Framing Curved Scenery

The framing of a curved surface requires a technique similar to the one used for a Hollywood flat. All framing members are on edge rather than on the face. The toggles are sweeps, most often of $\frac{3}{4}$ -inch plywood, cut to the desired curve of the surface. Because the covering must be firm yet able to bend, lauan or $\frac{1}{8}$ -inch ply are commonly used. Canvas or muslin is glued to the finished form to provide a surface matching the rest of the scenery (Figure 8-8).

Metal-Framed Scenery

Because of the recent accessibility of MIG welding to more scene shops (see Chapter 7), the use of metal-framed scenery is becoming more common and is comparable in cost.

The structure is essentially the same as with wood-framed flattage—an outside frame with interior toggles—but in this case welded together. The advantages of metal-framed



8-7 Uses of Framed Scenery

- a** The framing of a profile flat, or a flat with profile edges of ¼-inch plywood.
- b** Detail of sill iron used across the bottom of an arch or a door opening in a flat.
- c** Detail of canvas covering technique. Staples are set on the inside edge of the external framework.
- d** Door flat.
- e** Window flat.
- f** Two-fold flat with double-door opening. Note hinged sill iron.

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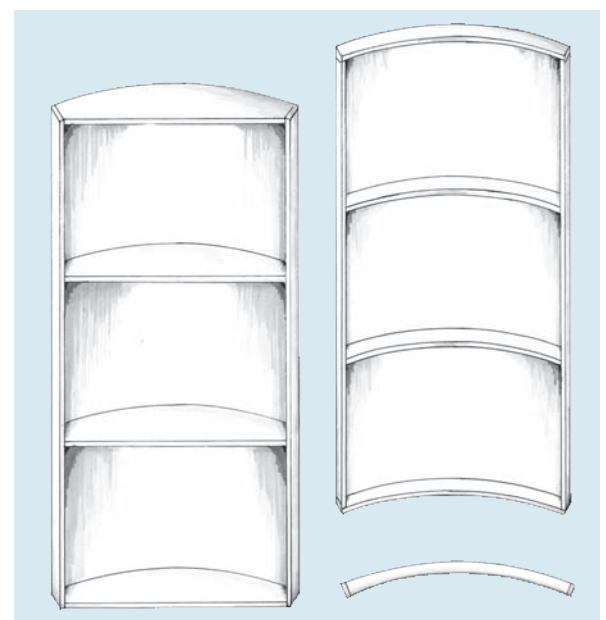
flats are strength, stability, and durability. They can be hard- or soft-covered (Figure 8-9). Because metal frames need fewer interior supports, a transparent wall can easily be created using scrim as a cover.

Light-gauge steel tubing is used for the frame. This can be rectangular, but square is more common, the most widely used being 1 × 1-inch (outside dimension of the tubing) 18 gauge (thickness of the tube wall) square tubing. A T-nailer shoots varying lengths of staples to penetrate up to 14 gauge steel. For lighter gauge metal (16–18), a lauan cover can be stapled. A rivet nut setter can be used as well.

Unlike wood-framed flats, metal-framed units can be hung from the top of the flat because they cannot come apart (see Figure 10-6). If they are hung this way, the flat will hang flat like a curtain.

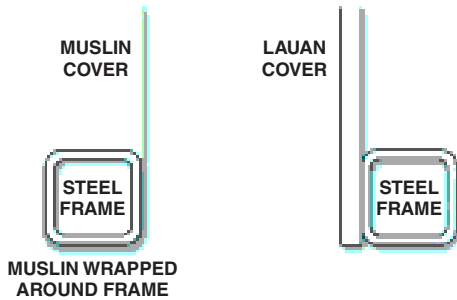
Doors

A door, in a sense, is a moving piece of scenery used by the actor and is an important element that requires both skill and time in the preparation of a set. Even hanging a door must be handled carefully. For these reasons, many theatre groups stock a set of good doors and casings that can be used in a variety of ways. A door's malfunction



DRAWINGS BY MICHELLE CARELLO

8-8 Curved Scenery Stiles and toggles are framed on edge to stiffen a 1/8-inch lauan cover, which is most often used with curved surfaces.



8-9 Covering Metal-Framed Flats For soft-covered metal-framed flats, the muslin cover is wrapped around the metal frame and glued in back. Hard-covered metal-framed flats have the lauan cover attached to the face of the metal frame.

can destroy not only the scenic illusion but also the carefully developed mood of a scene.

A door unit is made up of three basic parts: (1) the actual door, called a **shutter**; (2) the frame, comprising the jambs (vertical members), header or top (that together make up the reveal), and sill (bottom); and (3) the trim, which forms the decorative frame around the door opening. The door is always hinged to the reveal. Most often the reveal is built as part of the flat structure, as this is the easiest method of construction. The shutter is built separately and hung in the opening. The trim around the door is attached to the flat. One can also build the shutter, reveal, and trim as a complete but separate unit from the flat; this unit is referred to as an **independent door** (Figure 8-10a). The third method is to build a **dependent door** in which the reveal structure, containing the shutter, butts up against the back side of the flat (Figure 8-10b). The trim can be completely painted or attached and set away from the opening to increase the apparent size of the doorway.

The action of a door affects its construction. For example, a door that swings onstage requires facing on both sides; a swinging door takes special hinging, as does a Dutch door; sliding doors involve tracking; and additional rigging becomes necessary for the trick door that, as if by magic, opens and closes by itself. Home centers stock a wide variety of hollow-core doors that are affordable and easily adaptable for use onstage.

Windows

Windows, like doors, require skilled carpentry but are more difficult to build. A window has a reveal and trim, but the **window sash** takes the place of the shutter. The arrangement of panes within the sash varies with the style of the window. As with a door, the carpenter needs to consider the design of the window and its practical use. A window that must open is considerably more difficult to build than one that is simply decorative.

The pattern of the thin **mullions**, or interior framing pieces, can be used to support the structure of the window as well as hold in place any glass facsimile being used. Although complicated mullion patterns can be cut in profile out of $\frac{3}{4}$ -inch plywood, this works well only if the windows are far enough upstage that the audience cannot see much detail. Delicate tracery, which can be created using caulk-like materials and a caulking gun, needs to be supported by one of several materials that can pass for glass and strengthen the mullions at the same time.

Real glass is too fragile and far too dangerous to use onstage. Plexiglas, the most obvious substitute, has certain drawbacks. When the window background is darker than the onstage lights, the window reflects the lights as a mirror does. Also, to avoid a Plexiglas “shimmy,” it has to be at least $\frac{1}{4}$ inch thick and is therefore expensive. (The use of Plexiglas windows in TV and film, however, is common practice. Reflection problems are minimal because there is only the one eye of the camera, which is more easily controllable than a live audience.)

Windows are sometimes left clear or backed with netting or screening. The net, although nearly invisible, has enough density to give the feeling of glass and will catch light coming through the window.

Like a door, a practical window involves sliding or swinging on hinges. A window may have the vertical sliding action of a double-hung window, or it may slide horizontally. It may have the vertical hinging of a casement window or the horizontal hinging of the awning-type window (Figure 8-11).

Because of the great variation in sash styles, it is a little more difficult to plan a set of stock windows than doors. Conventional windows that are often used can be standardized and put into stock. Also the casing (reveal and trim) may be kept in stock to be used with different sashes for each show. As with doors, manufactured windows can be used where practical.

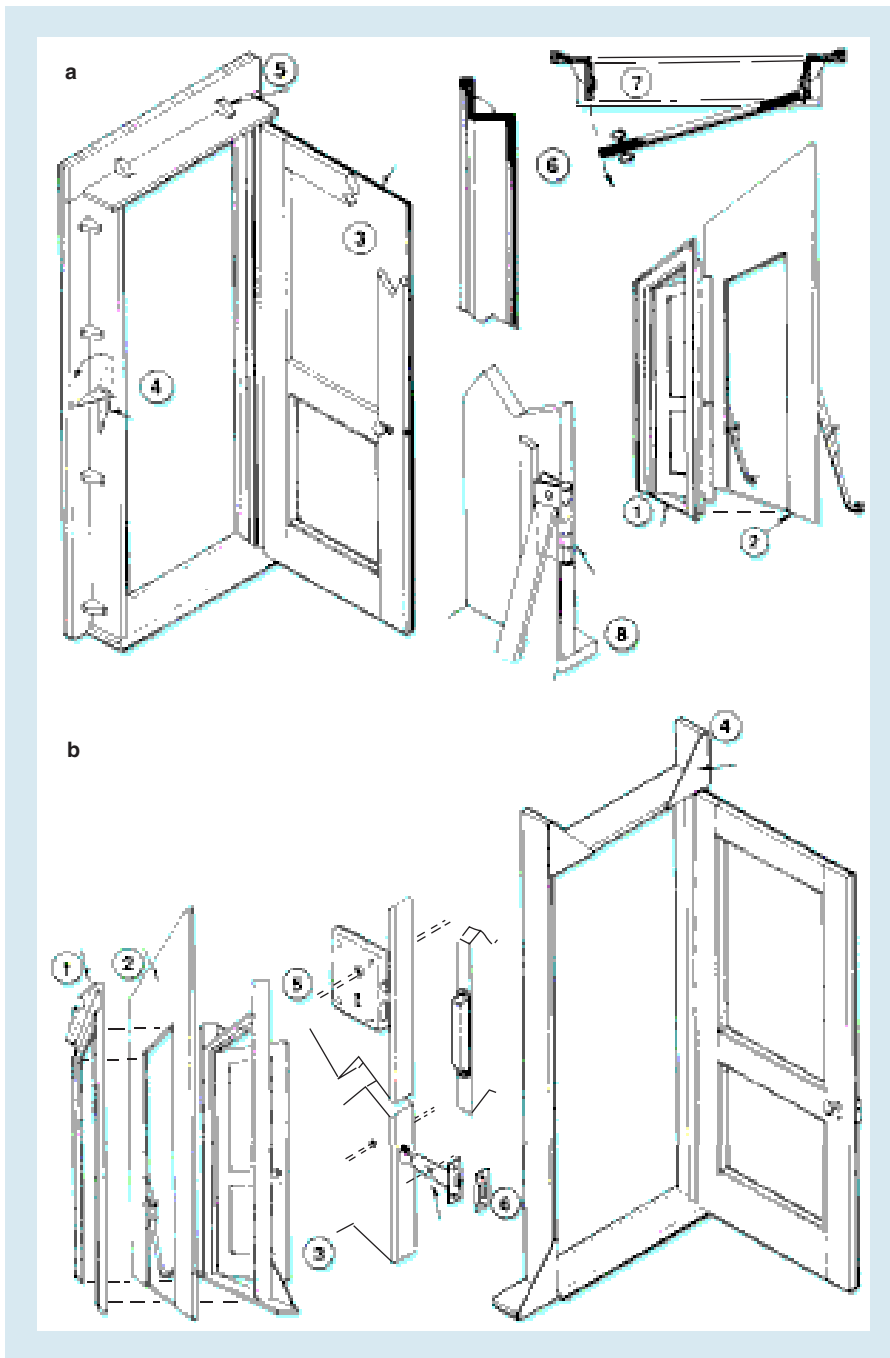
shutter The part of a door that opens and closes.

independent door A door that is a completely separate unit from the flat or wall into which it will be fit.

dependent door A door in which the reveal structure is a part of the flat or wall that frames it.

window sash Frame that contains the panes of a window.

mullions Interior window-framing pieces.



a & b © CENGAGE LEARNING

8-10 Door Construction

a Independent door:

- 1 Door reveal and trim built as one unit.
- 2 Flat with standard door opening.
- 3 Detail of door construction.
- 4 Angled strap hinge on jamb to hold door unit in the opening (the wall flat is jammed between the door trim and the strap hinge).
- 5 Blocks to hold trim in place.
- 6 Cross section of door unit through header.
- 7 Plan of the independent unit showing the hinging.
- 8 Butt hinge on door.

b Dependent door:

- 1 Separate trim.
- 2 Flat with a standard door opening.
- 3 Door and reveal.
- 4 Corner blocks to hold reveal square.
- 5 Rim lock. Attached on back side of door.
- 6 Tubular latch. Sets into edge of door.

baseboard Piece of molding at the bottom of a wall that protects the wall from chair legs slid against it; also used as a device to move our eye from the horizontal surface of the floor to the vertical surface of the wall.

chair rail Piece of molding, usually about 3'-0" above the floor to protect the wall (both plaster and wallpaper) from the back of a chair sliding against it.

wainscoting Any wood lining on a wall, usually seen in the form of paneling.

picture rail Piece of molding that is used to hang pictures.

cornice Piece of molding at the top of a wall, most often the largest in scale, used to move our eye from the vertical surface of the wall to the horizontal surface of the ceiling.

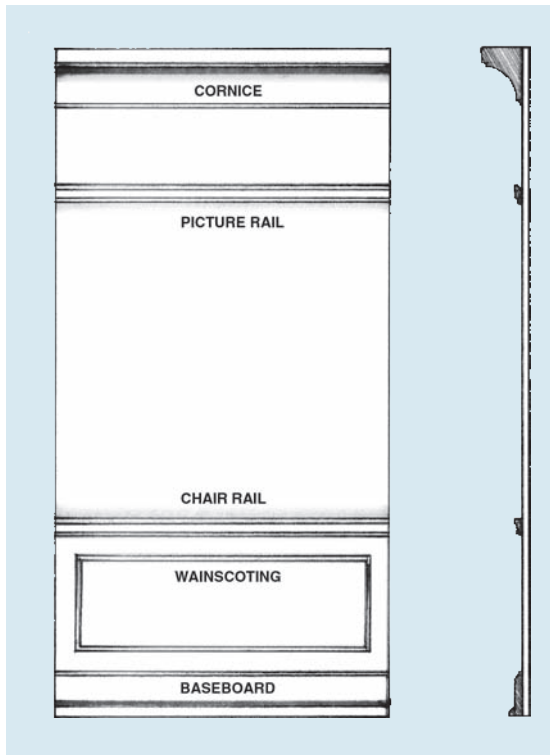
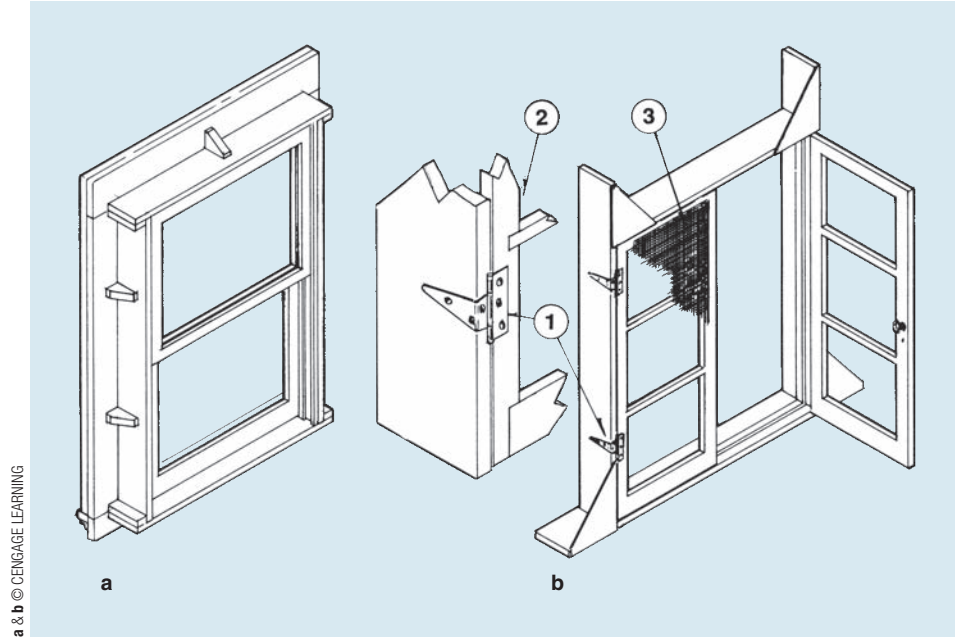
Trim

Decorative trim appears on a set in places other than around doors, windows, and other openings. Depending on the time period of the design, **baseboards**, **chair rails**, **wainscoting**, **picture rails**, **cornices**, over-the-mantel decoration, and other kinds of trim may all contribute to scenic illusion (Figure 8-12).

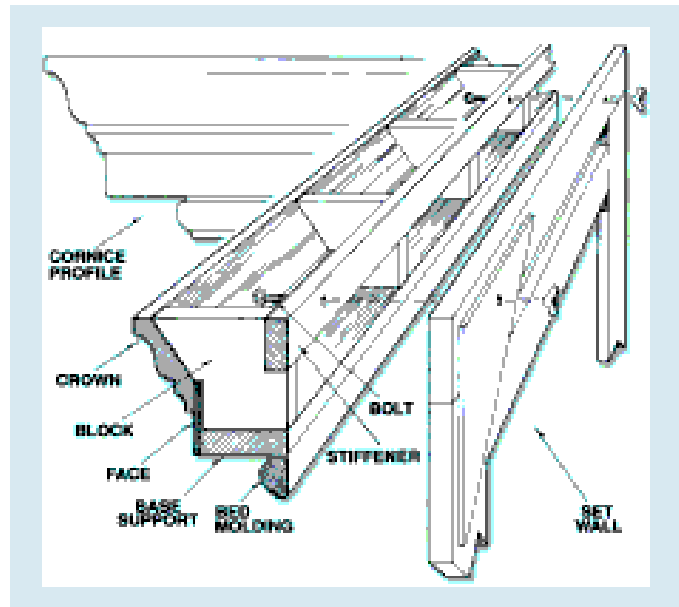
The attached trim may require additional framing within the flat for support. Chair rails and baseboards are easy to attach, but the construction and hanging of a cornice is more complicated. The average cornice and other trim pieces can be made of stock moldings, even when the trim is oversized for theatrical purposes. To keep the framing lightweight, the molding is nailed to sweeps set at about 2-foot intervals

8-11 Window Construction

- a Double-hung window. Trim is attached to reveal in the same manner as the independent door's trim (or can be attached to the flat).
- b Casement window. The reveal is constructed in the same way as the dependent door with hinged sashes.
 - 1 A bent T-strap hinge in place of the butt hinge.
 - 2 Notched mullions.
 - 3 Galvanized screening to strengthen the sash and simulate glass.



8-12 Standard Wall Trim Seen in Various Period Styles



8-13 Cornice Construction A cornice is a lightly framed three-dimensional element of trim that usually runs along the top edge of a wall. The perspective view shows the block-framing technique and a method of attaching the cornice to the scenery.

and backed with 3 ply or longitudinal framing strips. The whole assembly is attached to the wall flats with bolts or turnbuttons (Figure 8-13).

Architectural and decorative trim, of course, can be duplicated in lightweight materials such as carved Styrofoam or vacuum-formed shapes (discussed later in this chapter). Flexible plastic molding, although expensive, is also available and is useful when molding must follow a curved surface.

Weight-Bearing Structures

Certain elements of scenery cannot be reduced to flat planes. Others, because they are so small, are more practically built as three-dimensional forms. This is especially important if the form is to bear the weight of an actor or other pieces of scenery. Weight-bearing structures take many forms: architectural shapes such as steps, ramps, and platforms; irregular forms of rocks; and free forms of abstract designs. Raising a large portion of the stage floor and the use of steps and ramps bring excitement to a design composition, variation to the staging, and potential challenges to the stage technician. The technician must create a platform at a specific height above the stage floor that is structurally sound enough to support actors and furniture with a minimum of deflection and, at the same time, be portable and economical. A large expanse of platforming is subdivided into smaller units for ease of handling. A single unit is made to knock down into even smaller parts.

Platforms

Construction Any surface platforming technique can be broken down into the three structural members that are always present in some form or other: the top, rail, and post. In the simplest terms the perimeter shape of the platform is framed and then supported up to the desired height.

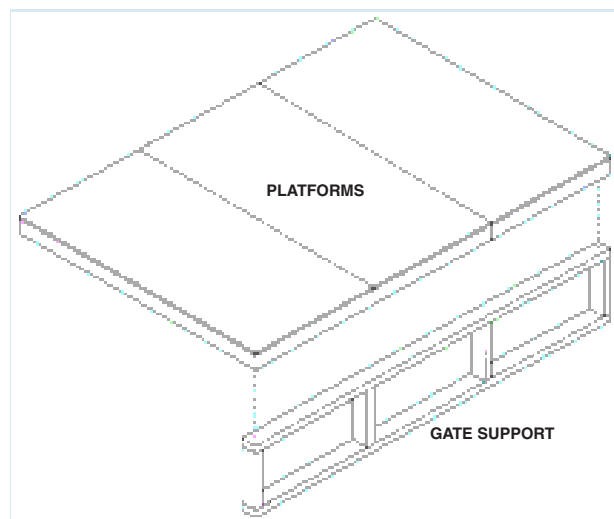
Most frequently, the lid structure and the frame structure of a platform are permanently attached to each other, sometimes referred to as a “rigid platform” and built in stock lid modular sizes (4×8 , 2×8 , 4×4 , 3×3 , 3×6). This typically consists of a perimeter frame of 2×4 s or 1×6 s or a tubular steel frame that is then covered with a $\frac{3}{4}$ -inch plywood lid. The platform is elevated to its specified height using simple lumber legs, typically 2×4 s bolted to the frame. Each leg is independent of the others. This style of construction is applicable to platforms of any shape.

A more efficient type of platform support is stud wall construction, referred to as *gating*. Similar to house construction, this is an all 2×4 frame consisting of two horizontal members joined by a series of vertical members. The advantages of this method are quick installation, very rigid support, and the ability to create raked or angled decks easily. In this method, support members are often shared by a series or group of platforms. The framed platform is attached to the gated support (Figure 8-14). Because they are separate, components can be made of different materials. For example, one could use a steel tubular-framed platform with a wood-framed gate (and vice versa).

The frequency of the leg support depends on the size and the material of the frame. For 2×4 s, the standard interval for legs is 24 to 30 inches. Obviously, the thicker and wider the lumber, the fewer supports are needed.

Joining Platforms Joining two or more stock platforms together is standard practice. The cheapest and fastest way to do this is to use large C-clamps to pull together the frames of two separate platforms. The C-clamps must be thoroughly tightened and checked periodically during the run of the production because activity on the platforms can loosen the grip of a clamp, allowing it to fall to the floor.

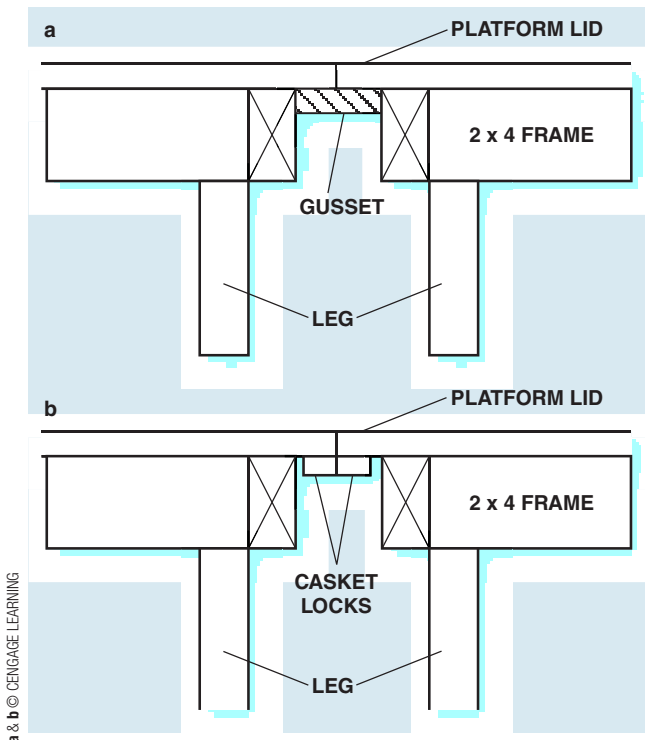
Another inexpensive and easy method is bolting two platform frames together. For this, **casket locks** are commonly used in one of two ways. One can place each casket lock in a notch cut out of the frame of the platform. The disadvantage of this method is that this weakens the structure of the frame. An easier method is to employ what is called *hold-back framing*, in which the frame of a platform lid is inset $1\frac{1}{2}$ to 2 inches from the edge of the platform. This then allows space for the casket lock to be



8-14 Gated Platform Support Three 4×8 platforms with gate support.

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casket lock A two-piece locking device incorporating a rotating wedge that pulls both pieces together and locks them with one turn of an Allen T-wrench. Also called *coffin lock*.



8-15 Connecting Two Platforms

- a** The simplest way to connect two platforms is to use a plywood gusset underneath two platform lids that overhang the support.
- b** A better method is to use casket locks, which work most effectively with an overhanging platform lid.

truss A framework of wood or metal that uses triangles and is therefore considerably stronger than a simple beam.

and will safely support much more weight than a beam of the same size and length. This works because of the previously mentioned strength of the triangle. Without changing the size of one of its sides, a triangle, unlike a rectangle, cannot be changed in shape.

The stress forces on a beam or beam-type structure can be illustrated by placing the beam in an unstable condition (Figure 8-16). As the beam sags, the top face is under compression while the bottom face is in tension. The stress forces within a truss are similar. When the top member is compressed in a horizontal direction, the bottom member is in tension. The vertical members are compressed, and the diagonals are also in tension.

A long single truss has a tendency to torque or twist. As a result, a long span has to be stiffened with a second, third, or even fourth truss, forming a *box truss*. This structure can withstand a great deal of force.

Stress Skin Panels The stress skin construction technique produces a panel of great rigidity and structural strength. Typical stress skin construction consists of two plywood sheets that sandwich an internal structure, often a wood or honeycomb core (Figure 8-17). In essence, the “skins” resist the forces of compression and tension in the same manner as the top and bottom of a truss do. The extra rigidity of a stress skin panel generally reduces the amount of substructural support required.

Ramps Ramps can be constructed in the same manner as any of the platforms just discussed.

Free Forms

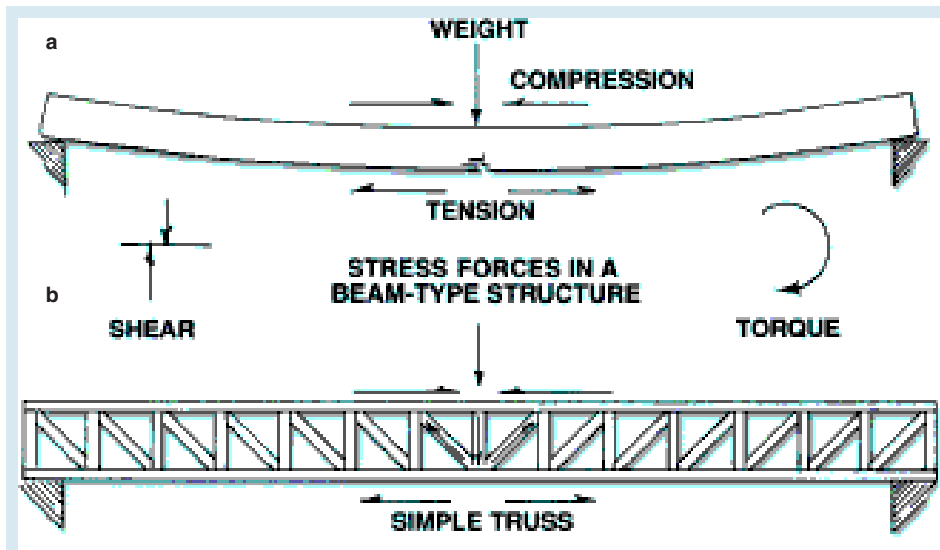
Irregular surfaces that cannot be reduced to a series of flat planes must be constructed as a three-dimensional unit. Examples include rocks and abstract forms that may have to bear weight.

bolted directly to the underside of the lid rather than to the support. This method, standard in commercial scenery, leaves the frame structure completely intact. In either method, casket locks must be the same size and placed exactly the same way in relation to the platforms. Casket locks work particularly well when frequent installation and deinstallation of platforms are needed, such as for touring productions.

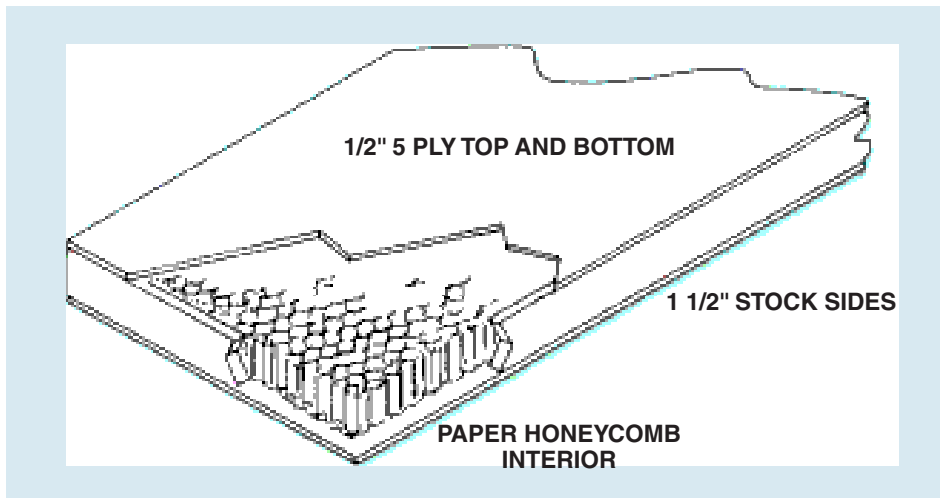
In the second method, carpenters use hold-back framing and a $\frac{3}{4}$ -inch plywood gusset plate 3 to 4 inches wide screwed to the bottom side of the lid to connect two platforms (see Figure 8-15). It is easier and cheaper than using casket locks, and there is no need to crawl under the platforms. However, it makes striking the set more difficult and is generally less desirable than using casket locks.

Truss versus Beam A *beam* is a horizontal structural member that bridges a long span between vertical supports. In the theatre, beams and cross beams support the stage floor to provide a pattern of trap openings. Because of its necessarily heavy weight, a beam is not suitable for scenery construction. By framing a beamlike structure with a network of cross bracing, the resulting lightweight structure, called a **truss**, can function as a beam.

Truss framing involves two long horizontal members—one on top and one on the bottom—and a series of vertical posts spotted at intervals to hold the members apart. Carpenters complete the framing by inserting a diagonal at each interval. Just as the diagonal brace strengthens the frame of a flat, the diagonals greatly strengthen a truss. A simple truss is considerably stronger

**8-16 Truss**

- a A beam in an unstable condition illustrates the direction of stress forces.
- b Simple truss showing the direction of each stress force.

**8-17 Stress Skin Panel** Construction of panel.

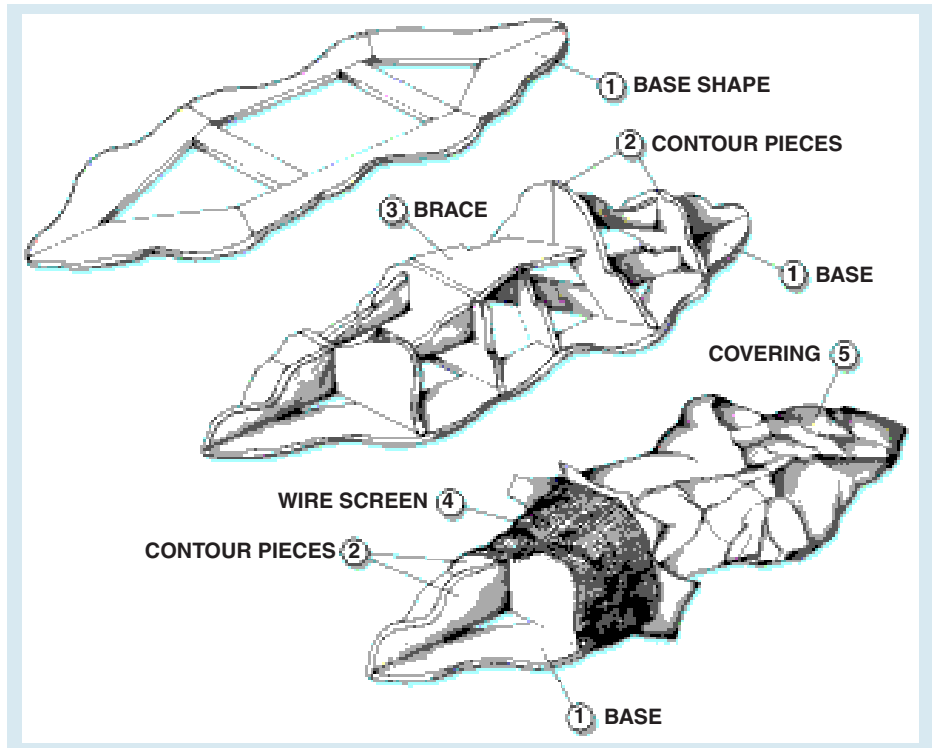
Framing an irregular surface is, of course, more or less extemporaneous (at least within the parameters of the design) and depends on the sculptural artistry of the carpenter or scenic artist. Some designers provide a model to clarify the drawings. The form usually suggests the specific manner of construction; nevertheless, there is a basic method that can be adapted to most irregular shapes.

One method of construction of a rock piece, demonstrated in Figure 8-18, involves the following steps: (1) The exact shape of the base of the rock is framed as a piece of flat scenery; (2) Across the shortest dimension of the base is set a series of shaped pieces that follow the contour of a section taken at that point (see Chapter 5); (3) The contour pieces are stiffened with cross bracing, and all weight-bearing surfaces are reinforced; (4) Over the contour pieces is placed chicken wire or some other structural mesh, which is manipulated into the desired shape; (5) The final surface is applied. The kind of covering material depends on the desired texture. The best results are usually obtained with fabric soaked in a glue and pigment (preferably the base color) mixture. The fabric is then draped over and tacked to the framework and allowed to harden. A form made in this manner is lightweight, inexpensive, and surprisingly sturdy. (We discuss textured and sculptured surfaces later in this chapter.)

8-18 Construction of Rock Forms

Steps in construction:

- 1 Shape of form on floor; conventional framing.
- 2 Contour pieces.
- 3 Cross bracing.
- 4 Wire screening.
- 5 Burlap.



DRAWINGS BY MICHELLE CARELLO



a & b COURTESY OF THE AUTHORS

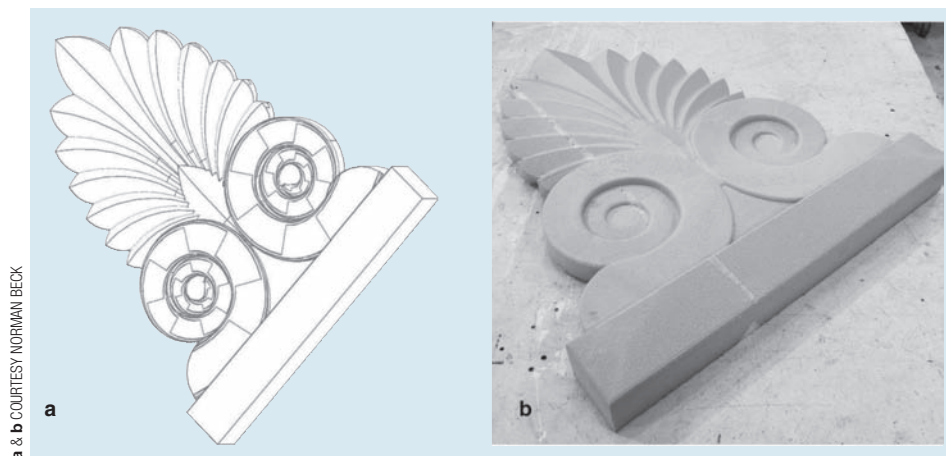
8-19 CNC Router

- a CNC Router Computer.
- b CNC Router.

CNC Fabrication Technology

Technology continues to change the way that scenery is built. Computers can now be utilized to control machinery, the best example of which is Computer Numeric Control (Figure 8-19a). CNC machines include routers, lathes, drills, various kinds of welders, and much more.

One of the most commonly found CNC machines is the router which, in simplistic terms, can create shapes from softer sheet material such as plywood, MDF, plastics, and nonferrous metals (Figure 8-19b). The system uses an XY table, meaning the



8-20 CNC Router Constructed Scenic Piece

- a CAD drawing of scenic piece.
b Finished palmette carved by CNC router.

computer-generated drawing uses X and Y coordinates. These coordinates are uploaded to the router, which uses both linear and rotary motion. The resulting cutting follows the pattern precisely as can be done only using a computer with linear accuracy up to .0001 inches or .001 mm and rotary accuracy to .001 degrees. The sizes of the tables available vary from 18×24 inches to as large as 10×40 feet (a typical shop will have a table up to 5×10 feet).

Although the initial expense of a CNC router is high and training is involved, the advantages are great. There is no other way in which this level of precision and duplication is attainable. Building time compared with any other method of fabrication is reduced, thereby lessening the cost, and the potential for human error (assuming an accurate drawing) is removed (Figure 8-20).

Steps

A flight of steps is made up of risers and treads. The **tread** is the horizontal weight-bearing surface, and the **riser** is the vertical interval of change in level. The rule of thumb guiding the size ratio of the tread to the riser is based on the ease of movement up and down the steps. Referred to as “the 18-inch rule,” it is this: the sum of the riser and the tread should equal 18 inches. For example, a 6-inch riser would require a 12-inch tread, an 8-inch riser a 10-inch tread, and so on. Any rise lower than 4 inches or higher than 9 inches is an “actor trap,” meaning it is likely to cause an actor to trip. The low-riser and wide-tread combination is more desirable for the onstage steps, permitting more graceful movement up and down.

A flight of steps can be built for the stage in many ways. One method is a modified platform trestle construction with each tread supported by a complicated post-and-rail framework (Figure 8-21a). This way, however, makes a bulky three-dimensional platform that is difficult to store and move.

Steps can be made to knock down into more easily handled parts by the use of the cut-carriage method of construction (Figure 8-21b). The pattern of the riser and tread is cut from a wide board running parallel to a line drawn through the nosing of each step. The **nosings** is the intersection of the top of the riser and the outside edge of the tread. A **carriage** is cut from a board wide enough to retain at least 3 inches of uncut board along the bottom edge. The thickness of a carriage depends somewhat on its unsupported length. Often 1-inch pine stock is used for lightweight construction, whereas 2-inch stock is required for a heavier structure. The use of a *metal carriage* can be seen in Figure 7-24.

The choice of carriage stock is also affected by the nature of the riser material. A riser can be made of 1-inch pine or $\frac{3}{4}$ -inch 3 ply—or left open. As the riser material becomes lighter, the carriage stock should increase in thickness.

tread Horizontal surface of a step.

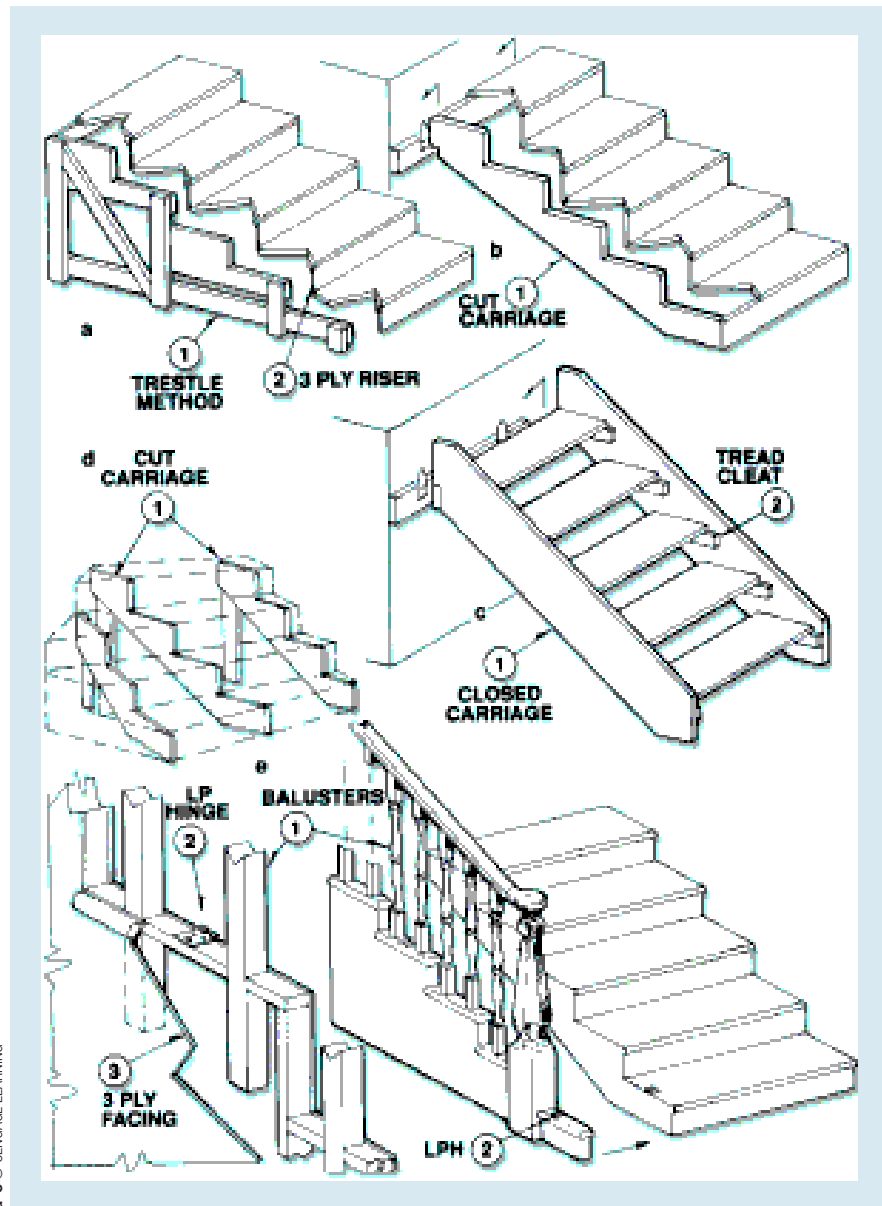
riser Vertical surface of a step, often referred to as *facing*.

nosings The projecting edge of a stair tread and top of stair riser; often refers to any molding hiding the intersection of tread and riser, particularly if the tread itself does not project.

carriage The supporting structure of a staircase tread.

8-21 Stair Construction Techniques

- a** Trestle method, similar to gate:
- 1 Trestle with the top edge framed to riser-tread pattern.
 - 2 For riser stock, 3 ply is used.
- b** Cut-carriage method:
- 1 Carriage is cut to riser tread pattern. Step unit leans on platform for support.
- c** Closed-carriage method:
- 1 Because the closed carriage can be used only on the outside of the stair unit, this type of construction limits the width of the stairs.
 - 2 Cleat to hold tread. Note that no riser is used.
- d** Cut-carriage method used on an irregular-shaped flight of steps:
- 1 Carriages with same riser height but varying tread dimensions.
- e** Stair facing:
- 1 Framed out of 1 $\frac{1}{8}$ -inch baluster stock.
 - 2 Facing pin-hinged to steps.
 - 3 If both faces are covered with 3 ply, the facing unit becomes reversible with minimum alterations.



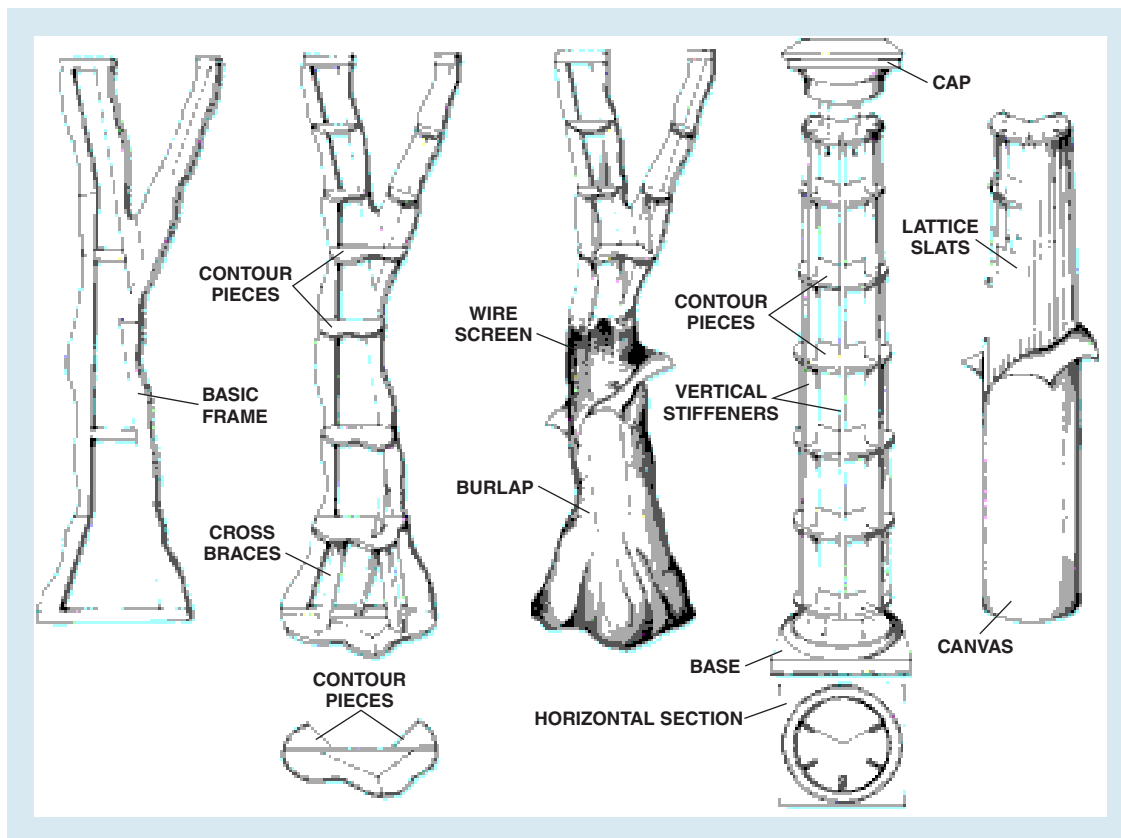
A flight of steps has at least two carriages. The need for additional carriages depends on the thickness of the tread and the width of the steps. For example, a $\frac{3}{4}$ -inch-thick tread needs a carriage at least every 30 inches along its width. The lower step of the carriage sits on the floor, and the top is either attached to the front of a platform or is supported by legs.

The understructure of a stair unit (or platform) is often hidden by a **facing**. One method of doing this is seen in Figure 8-21e. In this method, the stair railing, stringer, and newel post are incorporated into the facing. The carriage supports the bottom ends of the balusters. It can be an “open carriage,” revealing the profile of the tread and risers, or it may be a “closed carriage,” masking the ends of the steps.

facing The edge of a platform or stair tread, used to hide the structure decoratively.

Non-Weight-Bearing Structures

Columns, tree trunks, and any other objects that have dimension but do not bear weight need only be strong enough to hold their shape, with lightweight framing in comparison to weight-bearing structures.



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8-22 Construction of Columns and Tree Trunks

An irregular shape may be built in three dimensions by the use of two structural elements: the basic silhouette of the object and numerous contour pieces. In a tree trunk, for example, the basic silhouette is the vertical outline of the trunk and branches. The contour pieces are spaced at intervals perpendicular to the silhouette frame (Figure 8-22). After sufficient bracing and stiffening, the form of the trunk is rounded into shape by attaching any of a variety of screening materials over the contour pieces. This is, in turn, covered with burlap or canvas for the finished surface.

Columns have regular shapes and lend themselves to slightly different construction methods, including the use of Sonotubes, if the column is not tapered. If it is tapered, the circular or semicircular contour pieces can be attached to a central core or be held at intervals by slats on the outer surface (Figure 8-22). The exterior surface of the column can be handled in two different ways: (1) The surface can be made up of thin vertical slats (best for a column with a taper) that are covered with canvas after all the slats have been rounded with a plane or rasp, or (2) The column can be covered with flexible $\frac{1}{8}$ -inch lauan or other thin sheeting material.

Textured and Sculptured Surfaces

Closeness to the audience, increased amount of handling, and change of design focus from scenic background to set properties (partially caused by the increase in the number of thrust stages) have led to the need for easier methods of simulating sculptural forms. Moreover, deeply textured surfaces read well under stage lights and give the scenery a feeling of authenticity and stability. A surface such as stone can be accomplished in any number of ways. While the tried-and-true, if somewhat laborious, technique of papier-mâché works, the availability of many foam products and techniques has made it easier



8-23 Carved Rigid Foam This carving of a horse's head for *Billy the Kid*, designed by Young Jaung, is an excellent example of the kind of rigid foam carving that can be done.

- a Blocks of foam glued together.
- b The general shape roughed out.
- c Details added to complete the sculpting.
- d Paint added to finish the piece before installation.
- e View of the finished horse head with all details.

to texture a surface or to create sculptural relief, architectural details, and many three-dimensional forms. Figure 8-23 provides an example. The choice of material is determined by its specific use onstage.

Premanufactured Foams *Styrofoam*, the trade name of Dow Chemical's low-density, rigid polystyrene foam (RPF), has been used successfully as a lightweight material that is easy to carve into three-dimensional details or textured surfaces. Using a water-based foam adhesive, blocks of Styrofoam can be glued together or to a scenic surface for convenient carving. Styrofoam can also be turned on a lathe, as for a balustrade. As with any foam product, any form of heat applied to it results in a chemical release of toxic gas fumes. (See the box on safety practices.)

Regular Styrofoam is low-density and therefore very porous. This limits detailed carving and reduces its strength. *Urethane* is a high-density, rigid foam (RUF) that is easier to carve in detail or turn on a lathe. It also has greater strength than a low-density foam does.

Sections of rigid or flexible foam can be glued to reinforcing wood or to an adjacent surface with a variety of adhesives. The manufacturer's recommendations for the use of adhesives must be followed carefully; doing otherwise could bring disastrous results.

Sculpted foam surfaces need to be sealed or primed to provide a surface that will accept paint. There are several possible methods for sealing the surface. A flexible glue alone will work if the surface is not touched by actors. Likewise, if there is little contact with actors, a layer of cheesecloth adhered with glue seals and strengthens the foam,



SAFETY PRACTICE ■ Foam Safety

- Because the chemical action in all foam systems is highly toxic, precaution must be taken to ensure proper ventilation and protection of the hands. Any method of shaping foams—whether hot-wire cutting, sawing, or sanding—can release toxic gases. The use of an appropriate respirator and a well-ventilated space are critical. The use of disposable surgical gloves is strongly recommended and often necessary.
- Any area of contact of the foam chemicals with skin should be washed with soap and water immediately.
- The use of a respirator is effective *only* if it creates a tight seal (a custom fit is ideal) and the cartridge used is manufactured specifically for the type of fumes being released. The use of goggles for eye protection is also recommended.
- There is no way to make some two-part foams completely safe. A self-contained breathing apparatus, such as a respirator, can be expensive and may provide no more than a false sense of security.

but at the price of losing detail. If the foam surface will get abuse (for example, it must bear the weight of actors), the best method for sealing it is to use Jaxsan, a latex roofing product that can be mixed with paint.

Foams, of course, are quite lightweight and many times have to be counterweighted or attached to heavier units of scenery to maintain stability and the illusion of reality. Nothing is more disconcerting than a supposedly quarter-ton Greek statue bouncing like a Ping-Pong ball if it is knocked over.

Ethafoam Rod Ethafoam rod (*backer rod* is the industry term) is a commercial insulation material. It is a flexible, closed-cell foam extruded in various diameters of ½ inch to 2 inches. It can be easily cut with a band saw or knife into half-rounds or quarter-rounds and glued to a surface as a decorative relief or curved molding. Similar forms in sheets and other shapes are available. It does not, however, accept paint very well as the paint cracks as soon as it is touched.

Two-Part Foams and Latex Some foams are manufactured and sold as a two-part kit. Proper mixing of the two components yields either a rigid or a flexible foam, depending on the particular ingredients. This is useful, for instance, in cases in which a mold can be prepared for a sculptural element or decorative detail that recurs several times on a set. Figure 8-24 illustrates foam casting.

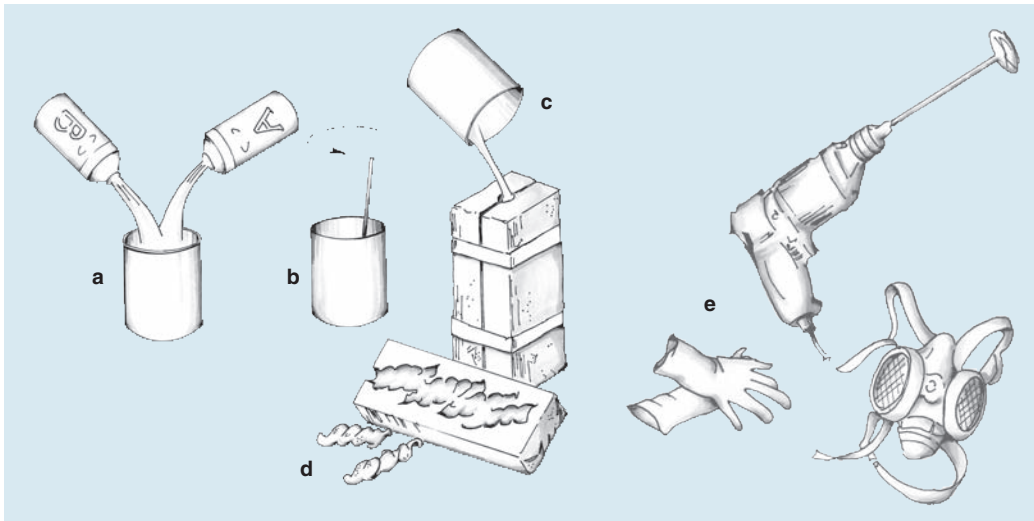
There are innumerable types of two-part foams, each one manufactured for a specific purpose. The stage technician should choose a particular type of foam according to both the specific properties of the final product and the expense.

It is critical to follow the manufacturer's instructions and recommendations when working with foams, both for ease of use and especially for safety. As mentioned before, all foams give off fumes, and many of them behave differently if impurities are introduced. Ammonia, for example, will make some foams collapse. Those who are especially sensitive need to take extreme care.

Hot-Wire Cutter The hot-wire cutter is a handy tool for cutting and shaping rigid foam. Both the table hot-wire cutter and the hand cutter with the flexible wire loop are useful to cut large blocks and to carve small forms (Figure 8-25). The wire loop is made of a high-resistance wire conductor (Chromel or Nichrome resistor wire). The wire's resistance generates enough heat to melt the rigid foam, thus enabling it to cut the block cleanly and quickly.

Thermoplastics

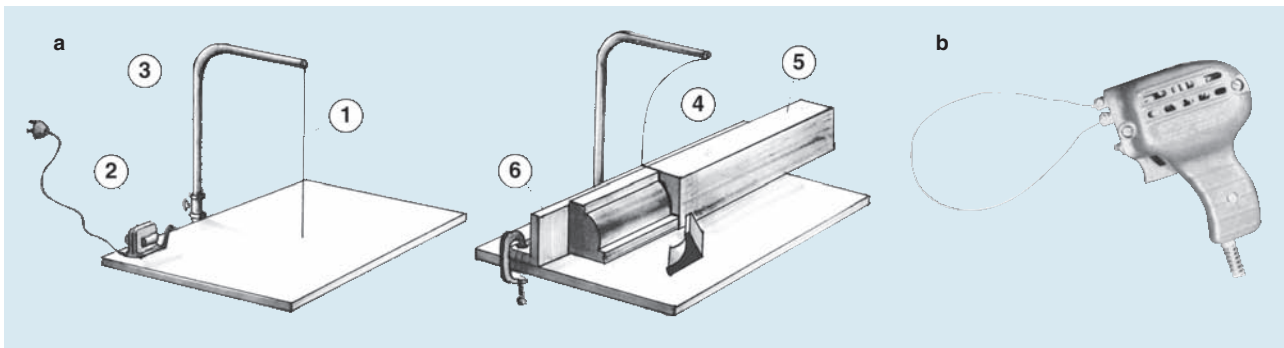
Another method for shaping three-dimensional details such as arabesques, props, masks, and armor plates or for duplicating real objects is the vacuum forming of sheet plastic.



DRAWINGS BY MICHELLE CARELLO

8-24 Foam Casting Demonstrating one of the many forms plastic foam casting can take, these drawings show the steps in duplicating various forms. Note that the actual process is more complicated than indicated here.

- a Mix equal parts “A” and “B” (catalyst).
- b Stir mixture vigorously for about 30 seconds.
- c Pour mixture into a hollow mold prepared with parting agent.
- d After liquid foam expands into the mold (about 20 minutes) remove the casting from the mold. With the excess foam cut away, the foam is ready for painting.
- e Take great care in mixing by following all instructions and using the proper equipment, such as a mixing tool, disposable surgical gloves, and a respirator.



a & b © CENGAGE LEARNING

8-25 Hot-Wire Cutters

- a Table hot-wire cutters for sculpting rigid foams:
 - 1 Nichrome resistance wire.
 - 2 Low-voltage, high-amperage transformer (about 16 amperes).
 - 3 Adjustable arm to facilitate the cutting of large blocks of foam.
 - 4 Nichrome wire bent into the shape of the molding.
 - 5 Strip of styrene foam or rigid urethane foam.
 - 6 Fence guide clamped to table top.
- b Handheld hot-wire cutter.

When a thermoplastic is heated, it loses its rigid state and becomes ductile. While heated and pliant, it can be reshaped or stretched over a mold, then allowed to cool and return to a hardened state. A true thermoplastic can be reheated and reshaped without a discernible change in its physical properties, making it economically feasible for theatre use.

Of the many thermoplastics available, there are three that are best suited for use in the theatre: high-impact polystyrene, low-density polyethylene, and cellulose acetate. They can be opaque, translucent, or transparent; come in a selection of colors or take

paint and dyes; be noncombustible; and be strong enough to withstand normal handling onstage and the mechanics of fastening (nailing, stapling, and so on). The working thickness depends on how rigid or flexible the final form must be but needs to not be more than .004 inches.

- *High-impact polystyrene*, as the name implies, resists high-impact damage. It also has great flexibility for intricate forming, comes in a wide range of colors, and is obtainable in opaque or translucent sheets.
- *Low-density polyethylene* is also tough and flexible. It is normally milky white (no colors) and opaque, but it turns translucent when heated and formed.
- *Cellulose acetate* is a well-known plastic with excellent forming characteristics. It is also quite sturdy and completely transparent.

Vacuum Forming To take an accurate impression of the mold, the heated thermoplastic sheet must be tightly drawn by a vacuum around or into the form, a process called *vacuum forming*. The basic steps of vacuum forming are as follows: (1) heat the plastic sheet uniformly to the temperature that renders it flexible (750–1,000°F); (2) transfer it quickly to a forming table, then stretch it over the mold and clamp its edges to the table to form an airtight seal; (3) remove the air through the forming table by turning on the vacuum tank and pump, thereby sucking the heated plastic sheet over or into the mold; (4) allow the plastic to cool and harden into its new shape; (5) break the seal and remove the plastic form for trimming, painting, and attaching to scenery, costume, or any other formed unit.

The best material for constructing the mold is wood because it can withstand the heat needed. Most other materials will deform under the process.

Heat Gun Useful accessories to the thermoplastic-forming process include the heat gun, which can deliver a blast of hot air (750–1,000°F) from an enclosed heating element and turbo fan. This tool is used at close range to soften portions of the plastic sheet that may not have taken to the mold accurately. The heat gun can be used on any surface and should be used with caution as heat applied to many plastics will release harmful vapors.

Welding Gun Similar to the heat gun, the hot-air welding gun produces a fine jet of hot air (400–700°F) that, when directed at a seam or thermoplastic welding rod, can weld plastic sheets or plastic forms together. Because the welding gun needs a jet flow of air, it has to operate from an air compressor.

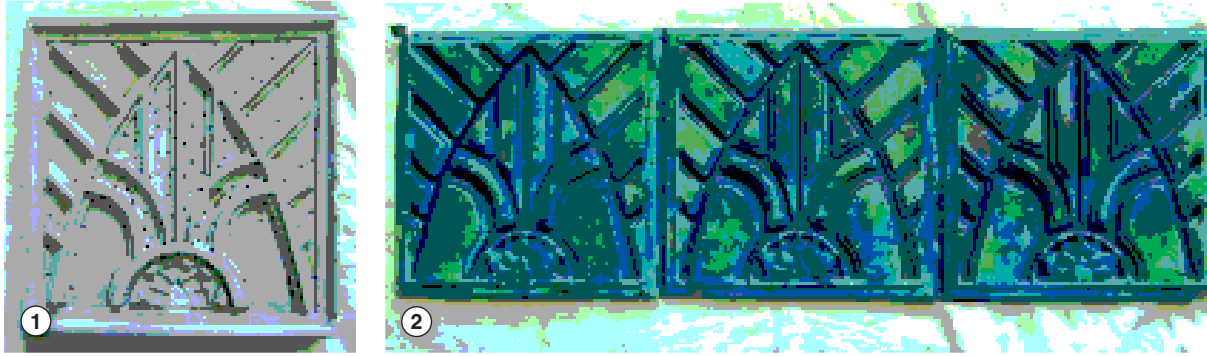
Other three-dimensional forming techniques, such as fiberglass, are discussed in Chapter 11 because they relate to properties, furniture, and costume accessories. Figure 8-26 shows some of the pieces that can be made using the techniques discussed in this section.

Mirrors

Mylar Highly reflective surfaces and optical mirror surfaces are inherently theatrical. Actual mirror is heavy, awkward, and dangerous (like glass). Mylar is an excellent facsimile because, when rigidly mounted or tightly stretched, it provides the reflection of mirror yet is lightweight and easy to handle.

Silver Shrink Mirror This kind of mirror begins with a vinyl-backed reflective surface designed to be tacked to a frame and then shrunk with heat to a smooth mirror-like surface. The heat source can be a portable electric heater or a heat gun. Because the 54-inch width of the material limits the size of the individual frame, a full stage mirror, for example, would have to be made of several frames. However, if the planes of the frames are parallel, the divisions are not noticeable.

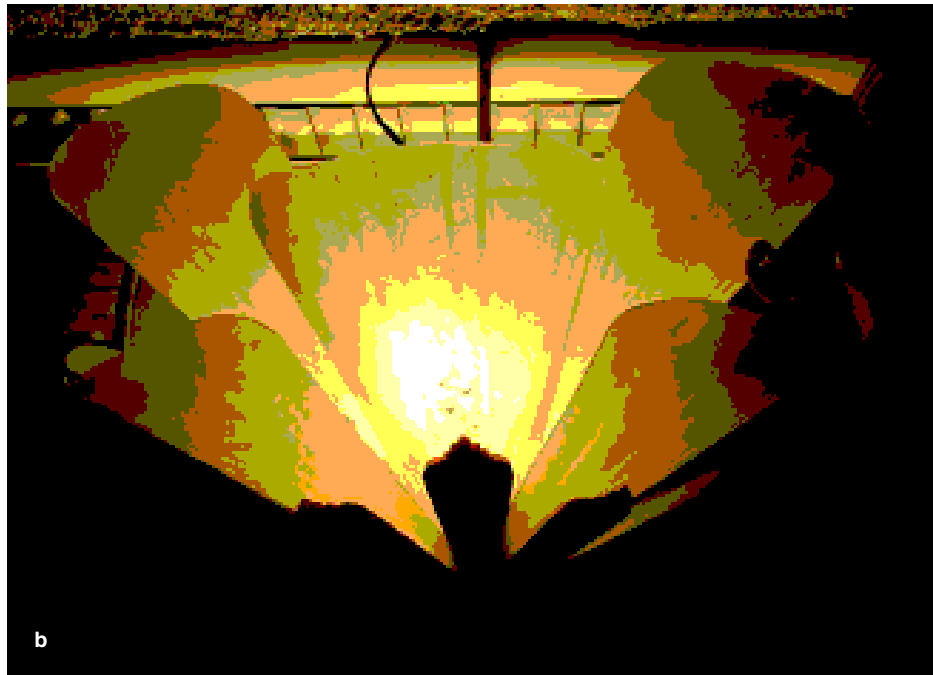
a



8-26 Thermoplastic – Vacuform

a The process for this decorative tile began with a clay (plasticene) mold. A negative was made from urethane (or rubber) into which a high performance plaster such as UltraCal was filled in order to create a positive mold that could be used to pull a large number of objects. The plaster cast show here has holes drilled into it to allow for the vacuum to work. The holes allow air to pass through. The result is a series of repeating design tiles as shown.

b The blades for this light were created in essentially the same way with a plaster positive mold made from a foam and clay (used to obtain the detail) negative. The finished material used was plastic approximately the size of a finished blade. In this case, the plastic piece was simply laid on top of the positive mold and placed under a heating element, like an oven. Over a short period of time, ten minutes or so in this instance, the plastic melted on top of the mold to form the shape. This process is called *slumping*. A little bit of trimming gave the final shape. The texture was achieved by using frost spray.



a & b COURTESY OF THE AUTHORS

Scrim-Backed Mirror This form of stage mirror is backed with a scrim instead of vinyl, giving it the advantage of being transparent when lighted from behind. When stretched and heat-shrunk, it serves as a mirror surface, transparent scrim, or a rear projection screen.

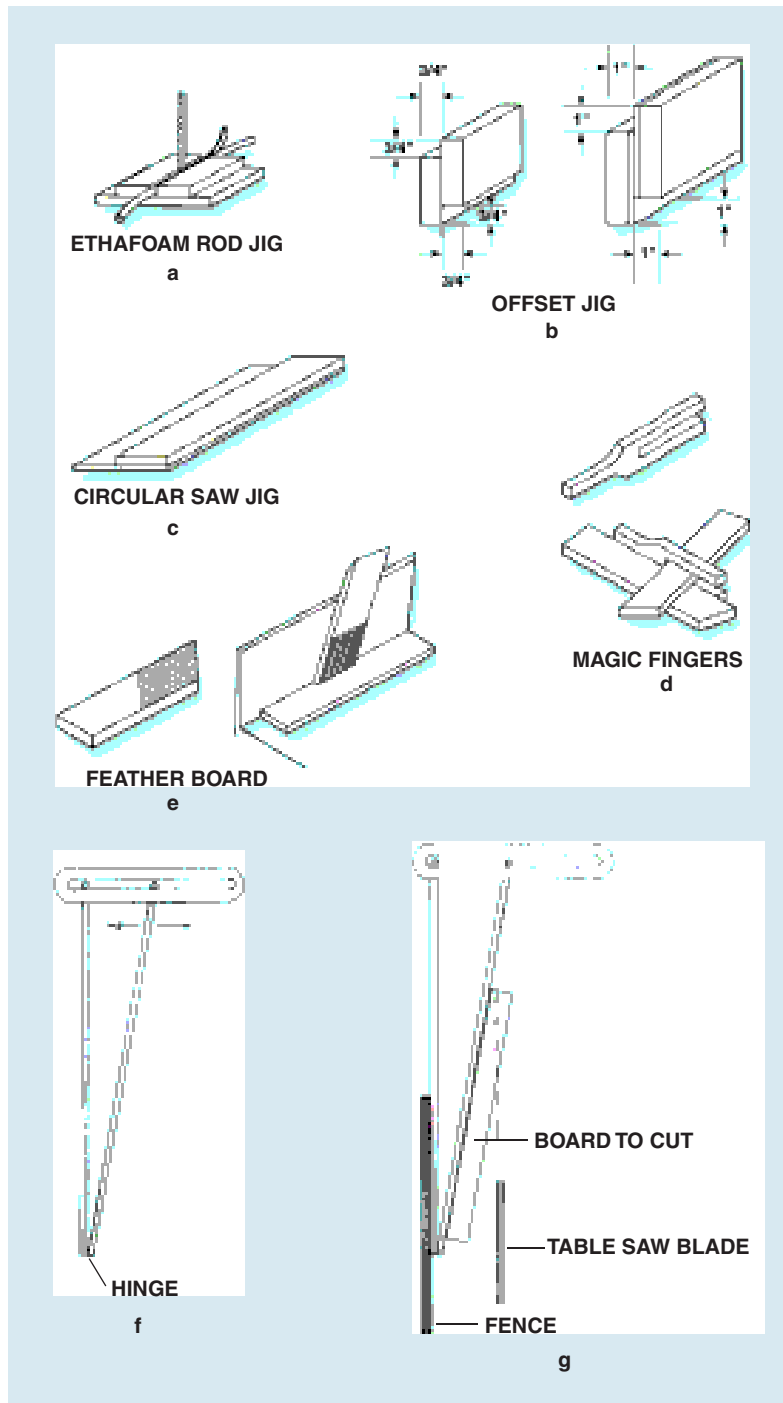
Mirrored Plexiglas Although expensive and difficult to handle in large sizes, mirrored Plexiglas has been successfully adapted for a large surface through the use of small mirrored squares. The joints are not visible at a distance.

Shop-Built Jigs

Even the best-equipped shop will find that some often-performed tasks have special or unique needs for which no tools are manufactured. These tasks are most efficiently accomplished by creating a series of jigs. A jig can be simple, such as a template to place bolt holes in a platform frame and leg, assuring that all legs and platforms conform and are interchangeable. Some jigs are built when it is difficult to perform the job in any other way, such as splitting an ethafoam rod. The decision to build a jig hinges on cost-effectiveness. If building and using a jig will save time and money, it is worth the effort.

Certain jigs are found in almost every theatre shop. The following jigs are typical (see Figure 8-27):

- *Stop block for radial arm saw.* This jig is used to cut multiple pieces of wood the same length. Perhaps the easiest jig to set up, almost all that is required is clamping a piece of wood to the fence of the radial arm saw. The wood should be held off the table about $\frac{1}{4}$ inch to prevent dust collecting at the point where the work touches the jig. Dust buildup will eventually affect the length of the boards being cut.



8-27 Shop-Built Jigs

- a Ethafoam rod jig.
- b Offset jig.
- c Circular saw jig.
- d Magic fingers.
- e Feather board.
- f Tapering jig.
- g Ripping on a miter cut.

- *Ethafoam rod jig.* The use of three pieces of $\frac{3}{4}$ -inch plywood can make splitting ethafoam rod easy. A bottom plate has a center line cut halfway through the piece so that it can fit around the band saw blade. Two more pieces of $\frac{3}{4}$ -inch plywood are attached on top, leaving a gap in the center the width of the ethafoam rod. The entire structure is clamped to the table of the band saw. This can be used to create half-round or quarter-round shapes. Each size of ethafoam rod requires a separate jig (Figure 8-27a).
- *Offset jig.* This jig is used with flattage when the joints are end to edge, not end to face. This is particularly useful when building soft-covered flats in order to inset corners, blocks, and keystones the right distance from the edge of the flat. The jig itself is simply two pieces of 1×3 stock offset $\frac{3}{4}$ inch or the thickness of a similar flat. If the flats are to be hard covered, a piece of $\frac{1}{4}$ -inch lauan is added to make the distance 1 inch. If the inset is the same in both directions, it is impossible to place the jig incorrectly (Figure 8-27b).
- *Circular saw jig.* This jig allows technicians to saw a precise, straight line with a circular saw. A length of $\frac{1}{4}$ -inch lauan is attached to an equal length of $\frac{1}{2}$ -inch plywood. The lauan must be wider than the plywood by the same measurement as the distance between the circular saw blade and the edge of the saw plate. The guide is clamped or screwed to the piece that will be kept. After the edge of the lauan guide gets roughed up to the point at which it is no longer useful, it can be trimmed and used in the same way as a router jig. This works because the plate on a router is smaller than that of a circular saw (Figure 8-27c).
- *Magic fingers.* When two boards meet at an angle, this jig allows a carpenter to mark a precise cutting line. The jig looks similar to a tuning fork in that it has a handle and two prongs. The slot between these two prongs is slightly larger than $\frac{3}{4}$ inch to fit over 1×3 stock (Figure 8-27d).
- *Feather board.* Built from $\frac{3}{4}$ -inch plywood, this jig is used to keep the work tight against the fence of a table saw, preventing it from shifting away from the blade. The angle of the jig allows the wood to pass in one direction but not kick back. The slots allow for variation or small irregularities in the work, with the “fingers” acting as springs. This jig can be clamped to the fence if desired (Figure 8-27e).
- *Tapering jig.* When ripping a board with a miter cut, hinge two boards that can adjust to a given angle with the use of pins through a slot as shown in Figure 8-27f. Bolts work well as they can tighten in place. It is easy to replicate this angle on several cuts (see Figure 8-27g).



WORKING PROFESSIONALS ■ Chris Kennedy: Technical Director

Chris Kennedy is a technical director at the Goodman Theatre, a major regional theatre in Chicago. He has risen to a position of great responsibility.

Chris received his training at Carnegie Mellon's School of Drama. After his junior year, he was accepted as a carpenter intern at the La Jolla Playhouse. The following year, he was hired for the entire summer as stage carpenter. This meant spending most of his time running shows, which allowed him to spend half days assisting in the shop. Because at that time, the La Jolla season ran only through the summer, in order to stay in the San Diego area Chris needed to freelance as a carpenter at various small theatres

in the area. One year later, he found himself on the full-time staff of the Playhouse.

A new technical director, recognizing Chris's skills and qualifications, tossed special rigging projects his way and occasionally asked him to engineer a small scenic unit. Projects that the TD and his assistant did not want fell to Chris. Within a short time, he was promoted to the position of second-assistant technical director. But soon both the TD and his assistant left for employment elsewhere, leaving Chris and two others to build the rest of the season, which is exactly what they did. This was the summer that La Jolla produced *Jersey Boys*, which proved to be a huge hit and



WORKING PROFESSIONALS (CONT.)

has since been quite successful on Broadway. “Everybody was impressed with ‘us kids.’”

This success ultimately led to a drastic change in the staffing of the Playhouse. The connection between the La Jolla Playhouse and the University of California, San Diego theatre program enables them to share theatres, facilities, shop space, and staff. Chris and his two cohorts encouraged management to hire three technical directors to share the whole workload. This is unique in regional theatre, but it has proven successful.

Because the three of them had different backgrounds and training, they brought a multitude of skills to the shop: one was “a computer brainiac, one had commercial shop experience, and my skill sets were more about specializing in engineering and tricks,” says Chris. “On one show you are the top dog, and on the next you won’t be, so it keeps everybody in check, keeps us all modest—and we trust one another.” A colleague refers to them as the “three-headed monster.” The situation works well because while one TD serves as point person for a production, another is prepping the next production, and the third is coming off the previous production, allowing them a little more time to serve the current TD. Chris likens this relationship to that of the scenic and lighting designer: trust and respect of one another is critical.

A large part of working as a TD has to do with style of management. “There are two styles of being a TD. You can be either an office TD, or you can be a shop-force TD. I think I am kind of a hybrid between the two, and it works pretty well when things get hairy. I really enjoy going out on the shop floor if there are special projects or if there are things I haven’t fully worked out in my head. But I also enjoy being in the office, more at the front end of the production, calling vendors, checking materials, doing the engineering. That duality makes it easier for me to manage my carpenters getting dirty, and they see that I know what I am doing, but at the same time they know that I also have planning type things that I have to worry about—more of a global picture that I need to take care of. And when they don’t see me on the floor, in the office, that helps reassure them that the planning side of things is getting done.”

Chris loves the challenge of problems. His most difficult project was for a production of *The Wiz* that required a 6-foot-diameter sphere that “raised up out of the floor on a lift and had to crack open. Inside was the Wiz. After cracking open, a staircase had to come down out of it. And because it was clear, any framing mechanism inside had to be minimal because we didn’t want to see any of it. Finding a 6-foot sphere is pretty difficult—that is a

great example of doing your homework on lead time. We found it at a company in England. That was the first quote I got in pounds so I had to figure what it really cost. We worked out the framing and a spider-like base, which we shopped out to be bent as we didn’t have equipment to do it here. It came back perfect but we discovered the sphere wasn’t. So back to engineering for us.”

Working in regional theatre requires the same skills as any technical director job: carpentry, welding, rigging, and engineering. A basic knowledge of electricity and plumbing is also necessary. Because no one person has all the numerous skills that might be required for a particular project, Chris talks about the need for bringing in experts when necessary, such as for *The Wiz*—especially when dealing with complex automation and extensive use of lifts and flying actors, all of which pose a certain amount of danger.

The turnover rate for staff at regional theatres tends to be rather high, Chris says, because in most cases, the work is seasonal and it is difficult economically to keep anyone busy year-round. When Chris compares regional theatre to academic theatre, he says that “the biggest difference is process versus product. Budgets are also obviously a big difference. Ultimately, the process is the same for the TD whether you have \$100 or several thousand dollars.” Lead time is different, but “you still have to budget the show, schedule the people, and engineer the scenery but on a smaller scale. There may only be two pieces of scenery, but you still have to schedule things to get those two pieces built in the time allotted.” Planning further in advance is often the advantage of regional theatre. Schools most often can’t really afford “the cool stuff,” and even when they can, they don’t have the lead time to order it.

Very early in his career, Chris considered commercial theatre. “I liked the scale and talked to people in regional theatre about ‘the connection with the artistry’; in commercial theatre it is more ‘Here are your drawings, here is the product, here is our profit line.’ This didn’t mesh well with what I was after.” What was he after? Interactions with directors, having the cast on the premises, and the scope of shows. The first time that Chris worked on a huge-scale production was for *Dracula*, a big musical bound for Broadway. Although it didn’t do very well commercially, it cemented his love for big productions.

“Anything you do that is challenging—in scenery or in life—can be the most fun and the best learning experience. The process is usually the same from show to show, but what you’re doing is always different, and that is what keeps things interesting. When I tell them I’m a technical director, people say ‘That’s cool.’ ‘That’s really neat.’ ‘How do you guys do that?’ That’s a nice little reward, too.”

9

Painting Scenery

After deciding on the look of the set, a designer communicates with the scenic artist, who uses the designer's ideas to create painted scenery. Many of the methods and techniques of handling scene paint are familiar to anyone with training in the visual arts—the difference from easel painting is scale, distance of the work from the spectator, and especially the low light under which the work is seen. Although painting scenery is a highly skilled and specialized phase of creating a setting and a critical part of the scenery process, it should not be intimidating. Like any skill, it takes years of practice to perfect, but the basics are important for anyone working backstage to understand and relatively easy to learn. It is not unusual, especially in smaller theatres when the treatment is straightforward, for the technical director or shop staff to either assist or be fully responsible for the painting of a set. This chapter provides an explanation of the process of scene painting and is divided into three sections: basic information for anyone working in a scene shop, further information for scenic designers and scenic artists, and more specific information for anyone interested in pursuing scenic art as a career.

The Basics

Anyone can hold a paint brush. Although any surface treatment of scenery is the province of the scenic artist, the fact is, almost everyone in the shop works with paint despite having no training as a scenic artist. The majority of the work is not difficult—often no more difficult than painting the walls of a room. Because the scale of scene painting is so large, the scenic artist uses a broad technique, sometimes so broad that clear forms appear only when viewed from a distance. Learning to paint this way may require some slight adjustment in thinking. A basic understanding of scenic design is certainly helpful, as are painting skills of any kind, but not critical.

Components of Paint

The safest, easiest to use, and most commonly used paints are water based, such as *latex* and *acrylic*. *Caseins*, or milk-based paints, although still used, are rarer in the paint shop than they used to be. Rarer still are alkyds, or enamel paints.

Paint is composed of three basic components: *pigment* (color), *binder* (glue), and *vehicle*. The pigment and binder are suspended in a liquid (the vehicle) that allows the paint to be brushed or sprayed onto a surface. As the vehicle evaporates, the binder holds

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For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

the pigment to the surface. Most of the paint that is used for scenery is ready-mixed, although raw dry pigment is still available.

Ready-Mixed Paints Latex and caseins are ready-mixed paints, meaning that the pigment, binder, and vehicle (water) are premixed in proper proportions into a creamy paste. The many commercial scenic paints vary in quality, price, and potential use, particularly in terms of color richness. A vinyl paint called “supersaturated,” made especially for scenery, is popular because of its excellent color richness and ability to be greatly diluted yet retain its depth of color. It is often used instead of dye or translucent color.

Although caseins offer a wide range of color, they tend to be chalkier and stickier than other paints. With casein paint, the binder is resoluble. It is the quality of this binder that gives casein matte when dry. They also can take longer to mix during color matching. Latex paints are often used as a cheap substitute for caseins, but in general they are less intense in color, do not intermix as well, and do not work well when thinned. The latex paints high in chroma tend to be as expensive as caseins. Latex and acrylic paints can be used almost interchangeably.

Universal tinting color is commonly used to alter pigment and can be used with latex, acrylic, or alkyd paints.

Whatever type of paint is used, remember to match only dry—not wet—color to samples.

Dyes (Translucent Color)

Dyes are available in almost all the standard colors. They are used for thin wash glazes, translucencies, and dip-dyed fabrics that will not come in contact with skin. Aniline dyes, which once were commonly used, are toxic and now difficult to find.

Painting with dyes differs from painting with scene paints. Scene paint changes the color of a surface by covering it with a pigment held in place by a binder. Dyeing, in contrast, is a chemical process in which the dye becomes a part of the material to which it is applied. If the dye and the material do not have an affinity for each other, a complete chemical action will not take place.

Toxicity of Paint and Dye

The daily contact with paints, dyes, and their solvents—all of which often contain toxic chemicals—can become a health hazard unless they are handled carefully. Toxic chemicals can enter the bloodstream by absorption through the skin, can be ingested, or can be inhaled.

Although the paints and dyes discussed in this text are relatively safe, basic precautions are critical, especially because individual tolerances vary. Some people have a multiple chemical sensitivity (MCS), whereas others are allergic to the touch and smell of paints. Every product has an Materials Safety Data Sheet (MSDS), which can be easily obtained from the manufacturer. It is a legal requirement that these sheets be posted in the shop. All personnel should be encouraged to be aware of any potential hazard. A stock of latex or vinyl gloves and respirators with the appropriate types of cartridges for the product being used should be kept available. Any painting with toxic materials should be done *only* in a well-ventilated area.

It must be remembered that inhaling particles into the lungs or ingesting them is never good, no matter what they are. Eating in the paint area should be forbidden and protective clothing should *always* be worn in order to keep particles off bare skin.

Solvents Used as a vehicle to put pigment into a solution, a solvent is basically a paint thinner. Water is the principal solvent for most paints used for scenery, although

an occasional chemical solvent is used in the manufacturing of some ready-mixed paints and might be needed for a particular project.

Some familiar solvents used in the theatre are *alcohol* (methanol or wood alcohol), *turpentine*, *mineral spirits* (a substitute for turpentine), *ammonia*, and *formaldehyde* (in ready-mixed acrylic paints). If any one of these toxic solvents enters the respiratory tract or bloodstream, it can cause damage to the central nervous system, kidneys, or bladder. Eye contact should also be avoided.

Most solvents are volatile and therefore evaporate quickly in a well-ventilated shop. Even under the best painting conditions, protect the eyes with goggles, the hands with gloves, and the lungs with an air-purifying respirator. The need for protection when mixing with solvents cannot be overemphasized.

Dyes Although dyes are considered nontoxic, they are hazardous in powder or crystalline state. When mixing dyes, as with any powder, wear a respirator to avoid inhalation and use extreme care when handling dye crystals before they are put into a liquid state. To avoid potentially dangerous mixing during the pressures of a heavy work schedule, some shops prepare dyes ahead of time, storing them as concentrated liquids. When painting with dyes, avoid skin and eye contact. Protect an open cut with rubber gloves.

The same conditions are true when using bronzing powders, which are true metallic crystals or flakes. They are expensive, tricky to use and need a binder such as clear polyvinyl or acrylic. Bronze powders come in many colors and many metallics. Because they are in powder form, proper protection **MUST** be used. Designate an area specifically for mixing these, especially when used in large amounts.



SAFETY PRACTICE ■ Scene-Painting Safety

Scene-painting safety considerations include:

- *Goggles.* These protect the eyes from dust and splashing paint during spray painting.
- *Gloves.* The EPT Neoprene type is best for all purposes.
- *Dust mask.* These cover the nose and mouth to prevent the inhaling of dust from dry pigment or dye crystals during mixing.
- *Air-purifying mask.* Wear a mask with twin air filters to protect against toxic fumes during prolonged spray painting. Filters must be checked and replaced regularly.
- *Clothing.* Wear appropriate clothing for the task at hand. This includes long sleeves when working with dyes. High-top shoes not only support the feet better through long hours of standing but also provide protection against paint spray and splashing solvent.
- *Respirators.* Various filters and cartridges are made for various chemicals. Be sure that the correct ones are used. Proper fit and training are a must.
- *Occupational Safety and Health Administration (OSHA) regulations.* OSHA establishes safety rules in the workplace for a reason. Shop workers and designers should be familiar with them, and they should be posted in the paint shop.
- *Fire hazard precautions.* All flammables, including alkyds, Krylon® spray cans, and solvents such as alcohol and turpentine, should be stored in a separate fireproof chamber. The local fire department must be informed of its location. Take care to ensure proper ventilation when flammables are in use. There should be no smoking, no open flame, and no sparks in the area.
- *Research toxicity of new products.* When using a new product, get information about toxicity, potential dangers in addition to the MSDS. Take the appropriate safety precautions as specified by the manufacturer.
- *Disposal of paints.* Never dump paint down the drain. Every state has specific laws and guidelines for disposal of waste products that must be followed. If there is no company that will pick up liquid waste, combine it with wood chips or sand (something that will absorb the paint). This will turn it into a meal of sorts which will generally satisfy all hazard concerns. It can then be placed with solid waste material. If possible, use excess paint for back painting, keeping it in a drum filled with remaining pigments. This saves money and helps the environment.
- Determine who is responsible for shop safety and to what extent.

Frequently, materials other than cotton—such as rayon, wool, and silk—have to be dyed. Commercial dyes are available in small quantities and for all kinds of fabrics. Packaged or household dyes may be potentially hazardous. Read the directions and handle these dyes with extreme caution.

(For additional information, read *Artist Beware* by Michael McCann and *The Health and Safety Guide for Film, TV and Theatre, Second Edition* by Monona Rossol, both of which are filled with valuable information about artists' materials.)

New products on the market include a water-based paint made for almost any given circumstance, even painting Plexiglas®. When using one of the many paints that is not water soluble, such as oil (or alkyd), lacquer-based, or acetone-based paints, note the solvent required and carefully follow safety precautions. These may, at the very least, require the use of gloves, a respirator, and a well-ventilated area in which to paint. Even seemingly innocuous paint can prove dangerous if not handled appropriately. Safety should always be the first concern.

Basic Painting Procedures

Before any painting is done, the fabric must be prepared, which is done by applying what is called a *size*, or *prime coat*, and a *base coat*. Their individual use or omission varies in accordance with the complexity of the design, the nature of the surface, and the painting technique.

Prime Coat—Hard or Soft Surface The type of prime coat used depends on the kind of painting that will be done and how the piece of scenery will be used onstage. If the scenic piece has a hard surface such as plywood or lauan that is not covered with muslin or canvas, the prime coat mostly serves to provide a reasonable surface on which to apply paint. Raw wood can soak up a great deal of paint—better to prime this with cheap white paint than expensive color. Some materials, like tempered Masonite® which has a slick surface, may take more than one coat to fully prepare it.

For soft-covered pieces of scenery such as most flats and drops, the prime coat serves to fill the canvas, which is necessary to keep the colors from losing brilliance. When old canvas is used beside new canvas on a flat, the prime coat serves to guarantee that all paint surfaces are consistent. White latex is often used for the prime coat because it is inexpensive. Whatever is used as a prime is kept thin to prevent overloading the muslin.

A translucent drop is most often prepared with a thin layer of starch. Most prime coats tend to be opaque and therefore cannot be used over areas that are to be translucent or dye-painted. The prime coat on fabric is generally done with a large brush (6 inches) in order to more easily cover a large area and with “figure-eight” strokes to get the paint into the weave of the fabric. There are also primer coats manufactured specifically for metal (which must be well cleaned) and for plastics.

Base Coat

The base coat is the underpainting for the final decorative painting and texturing. As a mixture, the base coat is kept thin in order not to overload the canvas. The application and the color of the base coat are determined by the finished surface of the scenery. For example, a base coat may be one tone as a basis for a slick, modern paneled wall; it may be a **scumbling** of two or three tones in preparation for an antiqued, weather-beaten surface; or it may be a graded wash to go under a stenciled wallpaper design. (See Figure 9-7 for an example of scumbling.) Layering in this way, the scenic artist can use the base coat to start to suggest the final surface. This technique is especially helpful in creating texture or when a particular light source is integral to the painting.

scumbling Intermixing of two or more colors on the scenery in a random pattern, allowing some areas to blend.

Surface Materials

Surface materials that are used mainly for textural purposes take a variety of forms. Each has its special handling and individual effect. Any surface treatment is generally the responsibility of the scenic artist.

Muslin Unbleached muslin is the most frequently used covering material. Although it lacks the texture and durability of canvas, its lightweight weave is useful for other purposes. Muslin is an excellent painting surface for translucencies.

Canvas Canvas (usually 8-ounce cotton duck), more expensive and heavier than muslin, is the second most frequently used painting surface for all framed scenery. It is relatively inexpensive and available in wide widths.

Scrim In addition to its general use as a painted transparency, scrim can be used as a painting surface. Unbacked scrim can also be painted with thinned scenic colors, although they tend to stiffen the scrim, which is a disadvantage if it has to fold or roll. If large areas of scrim must be painted, use of a spray will help avoid stretching the scrim out of shape.

The open mesh of a scrim can be filled to create opaque areas. One means of doing so is to squeeze pure undiluted clear latex, mixed with a casein color to a paste consistency, onto the scrim to fill the mesh. A mustard squeeze bottle serves as a good applicator. If the scrim is to be filled while it is in a horizontal position, steps should be taken to prevent the latex from sticking to the floor. Polyethylene, a clear transparent plastic, is a good separator. More expensive premixed fillers are also available.

Burlap Burlap is frequently used as a covering material, chiefly for its texture. Burlap should be backed or fastened to a firm surface because it is made of jute and may stretch or sag under a heavy coat of paint. It is excellent for approximating an old tapestry. Sometimes it helps to paint and dry burlap horizontally. Burlap will soak in a great deal of paint.

Other fabrics such as silk velvet and velour can be used, although they can prove expensive. Use whatever fabric is needed for the project.

Methods of Painting

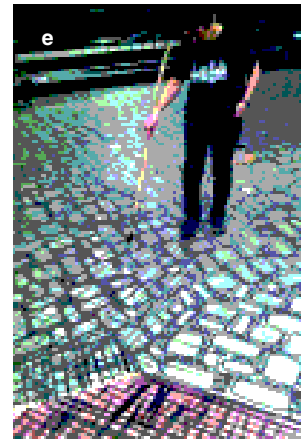
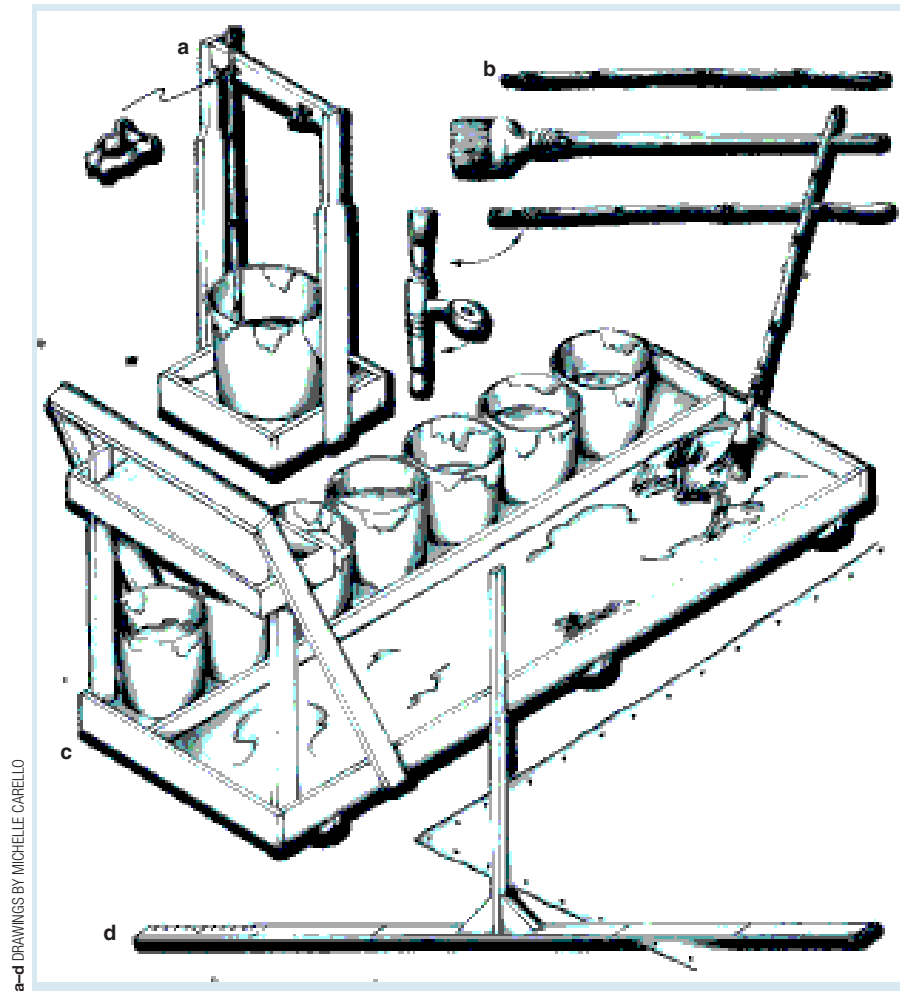
Scenery can be painted in two different positions, horizontally and vertically. The various methods of painting are devised to facilitate painting in either position. A good scenic artist trains in both methods. In either case, it is helpful to have a viewing area (even if only a ladder) some distance from the work to simulate the circumstance of the stage.

Horizontal Painting

Painting on the floor is the oldest and simplest method and requires the least mechanical assistance. The use of bamboo poles to hold the brushes, charcoal, and markers, and long handles on straightedges allow the scenic artist to work standing up, which helps to take the backache out of horizontal painting. The most essential requirement is lots of smooth floor space (preferably wood because it is easier on the legs than concrete) and good overhead illumination (Figure 9-1).

Vertical Painting

Although some painting techniques are best employed horizontally, others are accomplished more easily in a vertical position.



9-1 Painting on the Floor Extensive floor painting is made easier with the use of proper tools and the right types of brushes.

- a Individual paint-bucket carrier.
- b Long handles for brushes.
- c Paint cart with palette area for mixing paint. (Fewer and fewer painters use a palette area like this.)
- d Straightedge with handle.
- e Nadine Charlsen uses a piece of bamboo to paint the texture for *Sweeney Todd*.

Moving Frame The moving paint frame that can be raised or lowered past the working level brings the greatest flexibility to vertical painting (Figure 9-2a). The frame lowers into a well or to a second painting level. Some unusually high frames often have two or three decks so that the painters can work at different levels at the same time.

Stationary Frame and Boomerang It is easy to fasten scenery against a wall or on a stationary frame along a wall, but it is not so easy to paint all areas without using a ladder. A rolling platform, or **boomerang**, provides the painter with two or three painting levels (Figure 9-2b).

boomerang A rolling platform, usually with several levels, that allows scenic artists to work on several areas of a drop simultaneously when painting vertically.

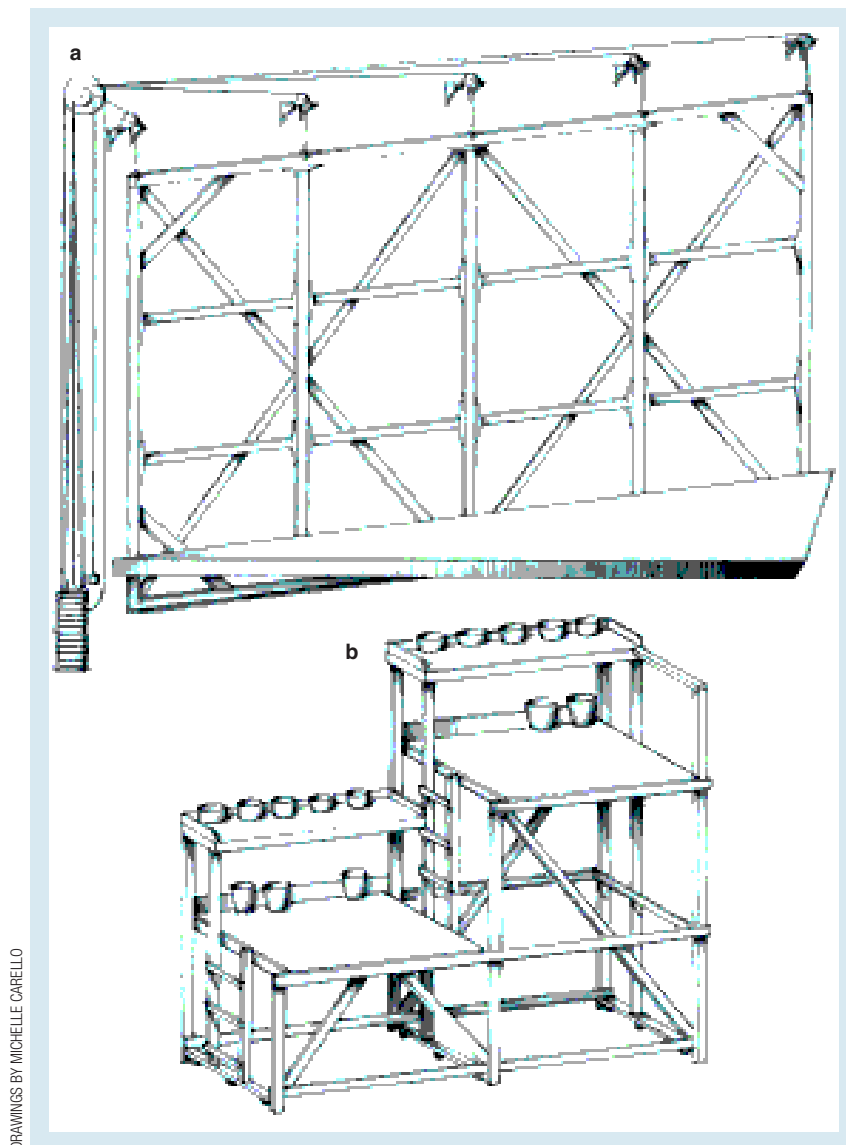
Brushes and Other Equipment

The painter's most important tool is, of course, the brush. A good brush should have long bristles and a full shape (avoid hollow centers). Natural bristles are so expensive—especially in the larger sizes—that many painters have turned to nylon brushes. A nylon brush with sandblasted tips is about half the price of the natural-bristle brush of the same size. The difference in price is offset by the slight disadvantage of nylon: watercolor tends to run off nylon, causing it to hold less paint than a pure-bristle brush does.

Cost is always a factor but it is easier to do good work with good brushes. It is worth spending the money on a good set of brushes because they will last forever if they are cared for properly.

9-2 Vertical Painting Methods

- a** The paint frame is raised from and lowered into a well extending below the main working-deck level. Scenery attached to the frame moves with it to allow painting of various sections.
- b** The boomerang, a stepped-level platform on casters, provides a variety of working levels for the painter.



Because scene-painting brushes are used predominately with watercolors, the bristles should be rubber set. Some brushes set in glue are suitable for oil paint but break down with continued use in watercolor.

Brushes

The types of brushes for scene painting are classified by the work they do, such as priming, base-coating or *lay-in*, decorating, and lining (Figure 9-3 and 9-18).

The **priming brush** is the widest brush (6 to 8 inches). It holds a large quantity of paint, which makes it good for spreading size and prime coats quickly and efficiently.

The **lay-in brush**, about 4 inches wide, is good for most painting, including base coats and back painting, as well as blending, spattering, and similar techniques.

How to Clean Brushes

Water-based paints “set up” more quickly than most oil-based paints do. This is an advantage while you are painting but a disadvantage when cleaning brushes. Because latex and acrylic paints are water-repellent when they are dry, to keep brushes from building up paint in the heel, an unclean brush should not be allowed to dry. A broad-use cleanser

priming brush Wide brush (6 inches is common) used for covering very large areas.

lay-in brush Brush, usually 3 to 4 inches wide, used for painting large areas; often used for base coating, spattering, and other such techniques.

such as Murphy's Oil Soap is standard for cleaning brushes. An unclean brush not in use at the moment can be kept in a pail of watered-down Murphy's until it is time for cleaning.

When brushes are cleaned at the end of a workday, attention is focused on getting all paint out of the heel of the brush. A wire brush can help comb out stubborn paint. After washing, the bristles of the brush should be shaped while damp and left hanging bristles down to dry. If the brush has been in dye, it may need to be soaked overnight in a mixture of whiting and water to draw out all the dye.

Flame Retarding

Every city has specific laws dealing with fire regulations and safety. A scenic or paint shop should remain in close contact with the local fire marshal. It should be assumed that *every piece of scenery* must be flame retardant unless there is special dispensation for *not* doing so. For the best results, flame retardant is brushed or sprayed onto previously dampened material. Sheer materials, such as scrim or bobbinet, should be dipped to ensure successful flameproofing. There are, of course, many commercial flame retardants available on the market.

Because the flame-retardant mixture is highly corrosive to metals, brushes and spray cans should, after use, be washed thoroughly in cold water. A small amount of acetic acid in the water helps to counteract the corrosive action. A separate sprayer should be designated to be used exclusively for flame-retardant mixtures. Also, be aware that the fumes of the flame-retarding mix can be toxic to some individuals; therefore, any prolonged exposure during the procedure requires good ventilation and the use of an air-purifying mask.

The term *flame retarding* does not mean that a treated fabric will stop a flame; it means that it will *not support* a flame. Hence when an obscure section of a drop or flat is *tested*—by bringing a lighted match to the surface—the flame will burn a hole, but if the fabric is flame retardant, it will stop burning when the flame is removed.

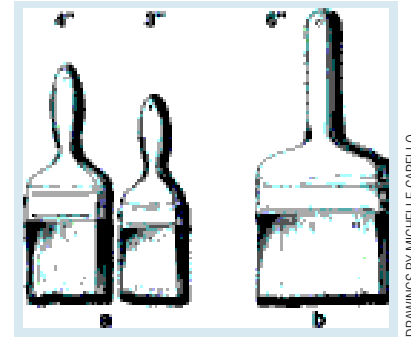
Testing and other fire regulations vary across the country. The designer and the shops are responsible for becoming familiar with local regulations before beginning production and for strictly adhering to them.

Beyond the Basics

The design of a setting can succeed or fail on the strength of the scenic art. A good scenic artist can greatly enhance a design if allowed to work with the designer in determining painting procedures; the smart designer will take advantage of this. Careful planning in the use of color can be the most important aspect of the discussion and, if done wisely, will allow the lighting designer to be far more able to tone and shape the environment as needed.

Painter's Elevations

Painting ideas are expressed in painter's elevations which, unlike sketches, remove all the atmosphere of stage lighting to show true colors and exact form. The painter's elevation, the point in the process when the designer must think through the appropriate painting technique and procedure for a design, is a scaled drawing showing in detail the line work and the actual color of each piece of scenery (Figure 9-4). It is also a clear indication of the technique to be used for each. Although a larger scale can be more accurately interpreted, most painter's elevations are done at 1/2-inch scale; the scale varies according

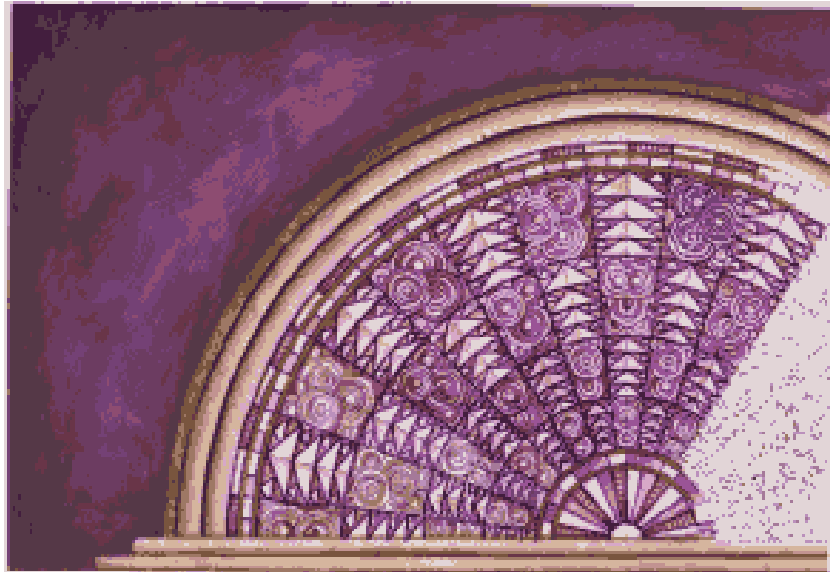


DRAWINGS BY MICHELLE CARELLO

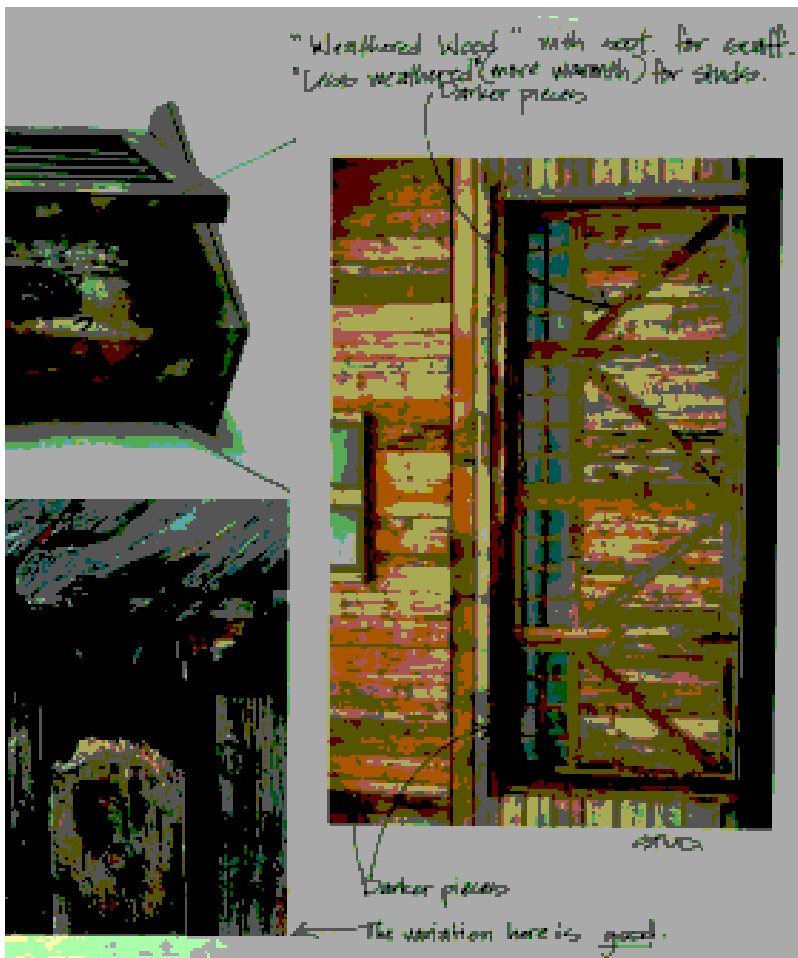
9-3 Lay-in and Priming Brushes

- a Lay-in brushes.
- b Priming brush.

9-4 Drawing and Painting a Drop The majority of this drop for *Lady Be Good* is painted in this elevation leaving the lower right portion just drawn. This allows the scenic artist to see the pattern of the entire drop in detail. Designed by Pam Knauert Lavarney.



COURTESY PAM KNAUERT LAVARNEY



COURTESY SARAH MARTIN

9-5 Research as Paint Elevation For *Street Scene*, a series of photographs of textures was provided as a guide to the scenic artist. The designer, Sarah Martin, included a series of notes to provide more details of how the textures should be used.

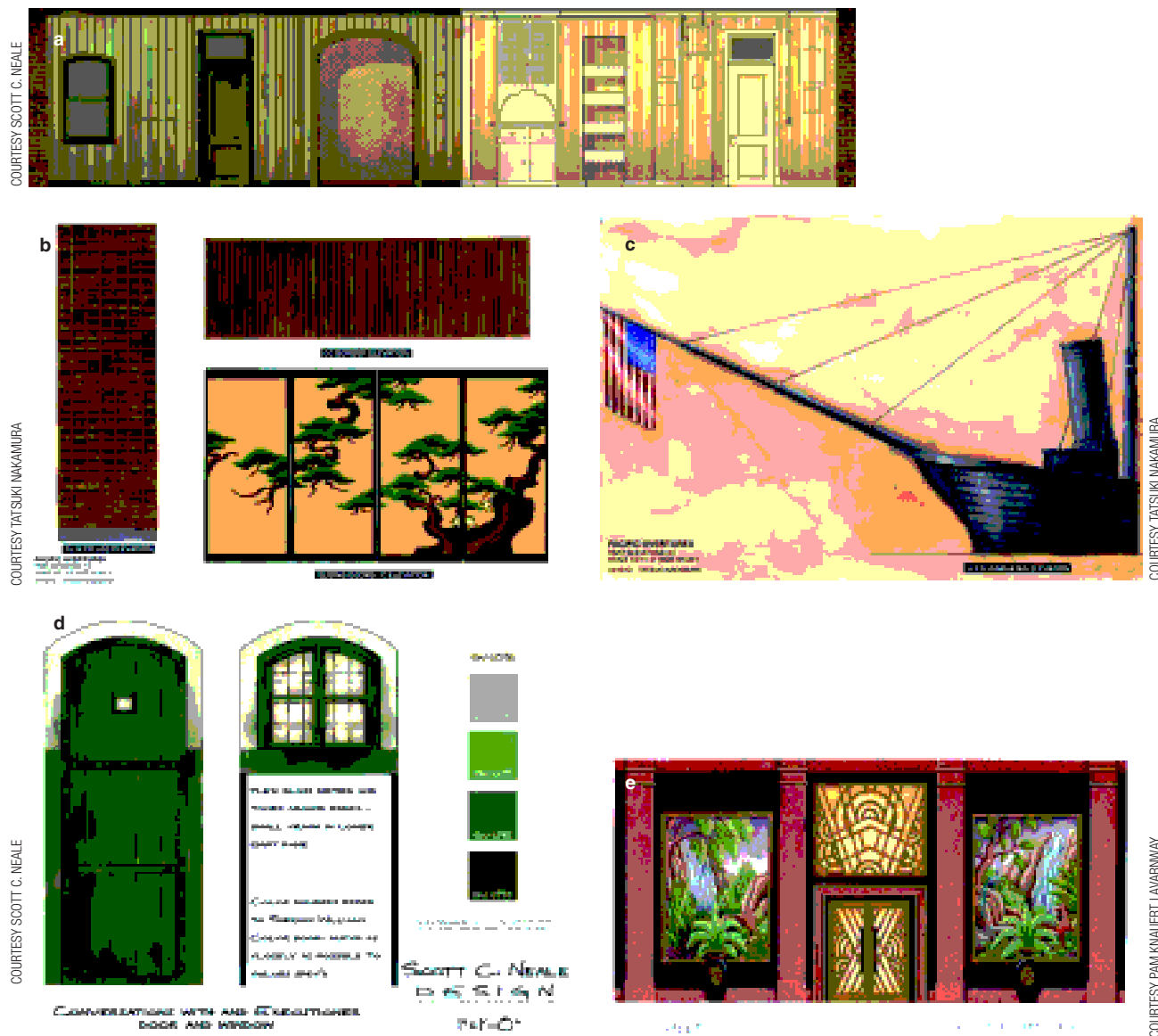
to circumstances. If the designer is painting her own show, she might be tempted not to bother with paint elevations—but this is a mistake. Important decisions—and discoveries—are often made at this point.

A black-and-white line drawing of the scenic piece, especially a drop, can provide clear information that can get obscured in the painting, although it is not commonly done.

Painter’s elevations can also provide clear information to the costume designer and especially the lighting designer, so that they have a full picture of what the set will be. The color information that these provide can be vital.

Of course, every designer creates paint elevations in her unique way. Sometimes, they are little more than research images (as in Figure 9-5), in part because they are now so readily available via the internet. But remember, research is *not* an elevation which should be production specific. If a flat is a solid color, a paint chip might do. A textured wall might require a full-scale sample to use as reference. And sometimes color/texture samples of the walls, the ceiling, and the floor are all on a single piece of foam core.

More designers are creating paint elevations on the computer using applications like Photoshop®. When this is done, it is very important to print out all examples as color on a computer screen can vary considerably from computer to computer. Generally, paint



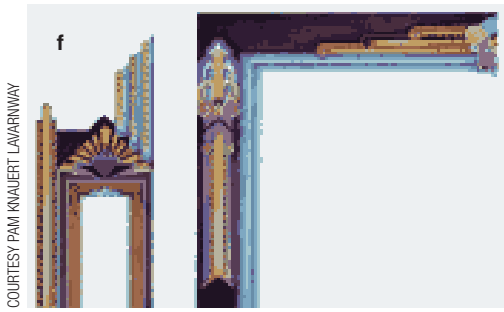
9-6 Paint Elevations

- a** Elevation for *Awake and Sing!* designed by Scott C. Neale. Even when the desired treatment is quite simple, the paint elevation provides a great deal of information, without which the scenic artist cannot do his job.
- b** Tatsuki Nakamura created this elegant paint elevation for Japanese panels for *Pacific Overtures*.
- c** The ship that appears in *Pacific Overtures* is three-dimensional but still requires a paint elevation. Design by Tatsuki Nakamura.
- d** In this paint elevation for *Conversations with an Executioner*, designer Scott C. Neale provides not just notes for guidance in the detail work but color chips to make color matching easier.
- e** A painted drop elevation for *Lady Be Good* designed by Pam Knauert Lavarney showing a great amount of detail.

elevations done on the computer require more interpretation and more specific communication.

The most important task is for the designer and scenic artist to communicate clearly in order to ensure that desired paint treatment is what ends up on the scenery. Specificity cannot be overemphasized.

A number of examples of paint elevations can be found in Figure 9-6.



9-6 Paint Elevations (continued)

- f** Two portal pieces that go with the previous drop for *Lady Be Good*.
- g** For this paint elevation of *A Streetcar Named Desire*, designer Todd Rosenthal painted directly on a copy of the drafting, saving the time of redrawing the scenic piece.



Commonly Used Painting Techniques

The sensibility of the audience has changed over the years, leading to a trend toward more three-dimensional scenery and fewer drops. There is less *trompe l'oeil* (trick of the eye) and more realistic painting, especially of textures such as stone, brick, and wood grains. The following are a number of techniques used to develop the painting for the most commonly used textures. Every scenic artist and scenic designer should be familiar with these as they provide the base knowledge for most every other painting problem. Although these are fairly standard methods of painting textures, every project presents a unique set of problems and solutions. Using the basic techniques that have been mentioned, the scenic artist should find a specific method that will satisfy the needs of the project at hand.

Texturing To avoid the starkness of a single tone and to bring more depth to a flat surface, the painter uses various texturing techniques. Many actual shadows and reflected-light tonalities are eliminated because the stage is lit from many directions. Much of this “natural” variation of tonality has to be painted into the set through the use of texturing techniques.

One of the simplest texturing techniques is to blend two or more tones of a color on a surface which can be done in a number of ways. The general term for this is *scumble*, which refers to two colors randomly painted together (Figure 9-7a). A more controlled method is called a **wet-blend**. This technique begins with two colors (or more if required) laid adjacently onto the scenery. A third brush is used to blend those colors while still wet. The result is a gradation of one color to another. This technique can be handled on a broad scale with either subtlety or obviousness depending on the contrast or harmony of the tones (Figure 9-7b).

The artist can also use wet-blending to begin the suggestion of light. If, for example, a wall has a well-lit portion and a shadowed area, a wet-blend in the base coat greatly helps to indicate this and saves time in the more detailed painting to follow.

A blending technique can also be done over a dry surface by blending the tones together with **dry-brushing** or **feathering**. *Dry-brushing*, as the name implies, is done with the tip of a relatively dry brush in order to cover the undersurface only partially, letting the dry surface as well as the brush strokes show (Figure 9-8). *Feathering* refers to the direction of the brush stroke. The brush is drawn from the wet surface toward the dry, setting down less paint as the stroke continues so that it ends in a featherlike pattern.

Figure 9-9 shows other texturing techniques used on a smaller scale include **sponging** or **stippling**, **rag painting**, **spattering**, *rolling* (using a roller to create a texture),

wet-blend To blend two or more colors on the scenery while they are wet.

dry-brushing Pulling the brush across wet paint in such a way that the bristles of the brush leave a streaky brush stroke.

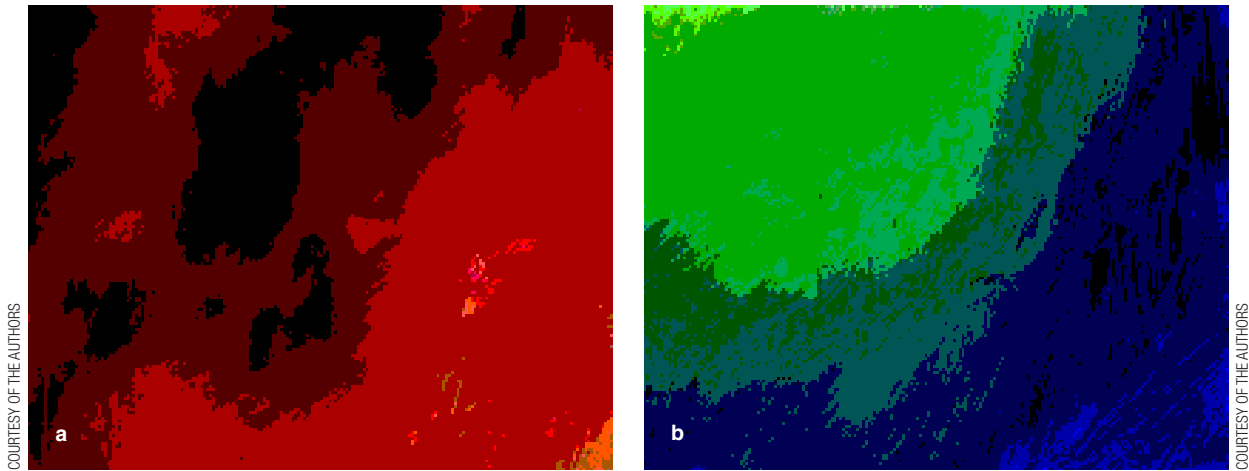
feathering Pulling the brush from a wet painted surface to a dry one so that the stroke ends in a featherlike pattern.

sponging Using a sponge to apply paint.

stippling Using the tips of the brush to apply paint in an up-and-down motion.

rag painting Using a lightly crumbled up piece of fabric dipped in paint and softly rolled or used in place of a sponge (also called *rag rolling*).

spattering Method of applying painted texture by sharply tapping a loaded brush against the heel of the hand, leaving droplets of pigment on the work.



9-7 Scumble (left) and Wet-Blend (right)

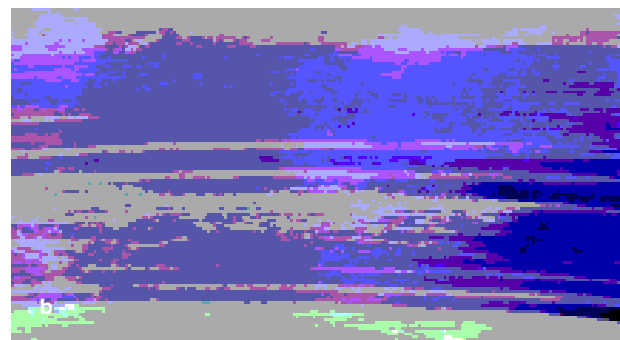
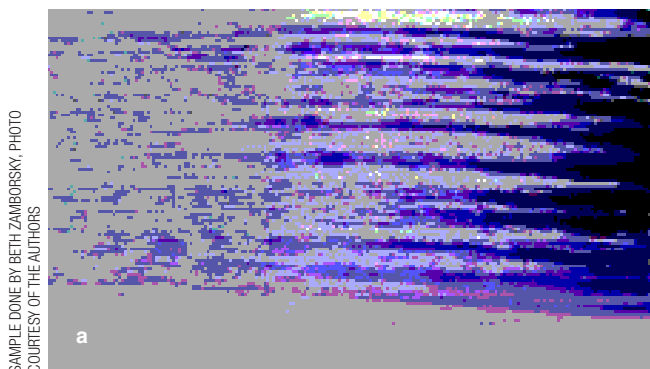
and *spraying* (likewise with a spray gun) which is really a version of spattering. Each technique creates an appearance of texture by applying tones to form a vibrant surface. Many of these scenic art techniques have become extremely popular in interior decorating for faux finishes. Many widely available books provide step-by-step instructions for these techniques, and paint companies often provide brochures with similar information at most paint retailers.

All the techniques just discussed can be used to simulate the textural qualities of stone, plaster, and wallpaper and are fairly simple to learn. Texturing techniques, especially for wood grain (Figure 9-10), foliage (Figure 9-11), and brick and marble (Figure 9-12), although necessary for any good scenic artist, take more time to learn and skill to master; however, the tenacity and patience required are worth the effort.

Wood Grain The painting of wood graining employs several of the standard texturing techniques discussed previously. The grain pattern and specific colors, of course, vary with the type of wood and its use in the design. Any attempt at realistic representation of wood graining on the stage should be preceded by a careful study of the real wood's color and grain characteristics.

If the painted “wood” needs a varnished finish, **glazing** might work. *Glazing*, an often misunderstood term, refers to painting a transparent or semitransparent layer on top of a surface. However, glazing can reduce the contrast between colors and lower their value, so this must be taken into consideration in the preparation of the grain and glaze colors. (Of course, reduced contrast may be the desired effect.)

glazing Painting a transparent or semi-transparent layer on top that subtly tones a surface or provides a finish (such as gloss, semi-gloss, or matte).



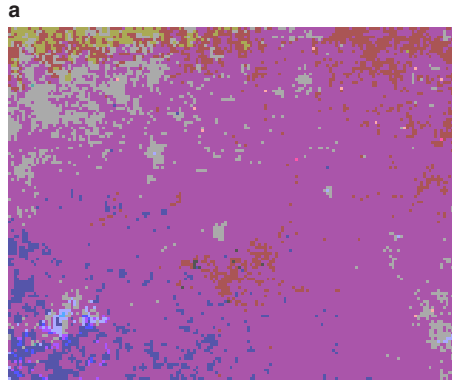
9-8 Dry Brush

a A very heavy dry brush.

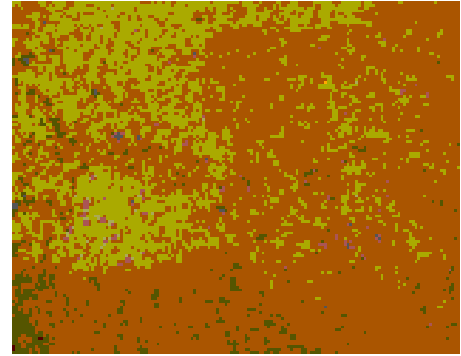
b Softer dry brush using more pigment or water.

9-9 Simple Textures

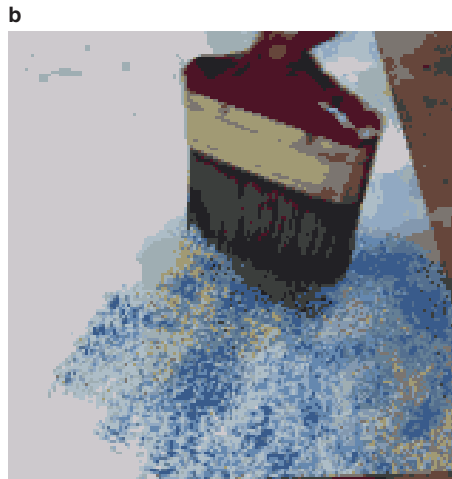
- a Spatter**—This is achieved by loading the brush with paint, holding it near the work and hitting the brush against your hand. With practice, this can be very carefully controlled both in terms of direction and heaviness of the spatter. (The image on the right is an example of a heavy spatter.)
- b Stipple/Sponging**—Stippling is the simple technique of dabbing the loaded brush onto the work, changing the direction the brush hits the canvas with each dab in order to avoid a regular pattern. Using a sponge instead of a brush will achieve a similar effect.
- c Roller painting**—Using either an old, otherwise useful roller or a roller that has been adjusted to create a pattern (in this example, a series of narrow pieces of tape are wrapped around the roller pad) can create a unique texture.
- d Rag painting**—This technique involves dipping a crumpled up piece of muslin (or other fabric) into the paint and then applying it onto the piece of scenery. As with all of these basic techniques, it is relatively easy to control how heavy the paint is applied.



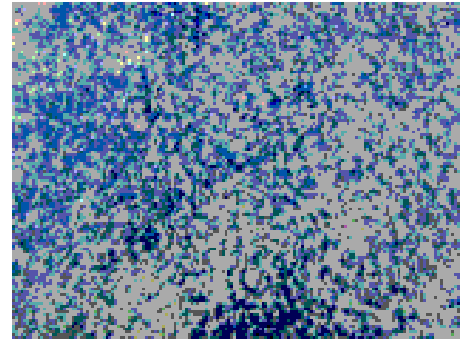
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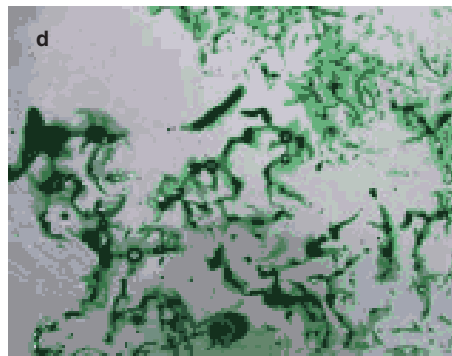
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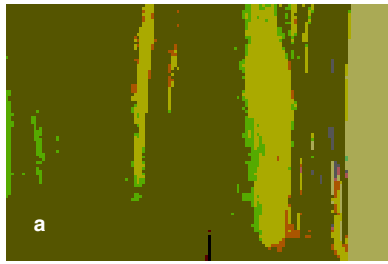
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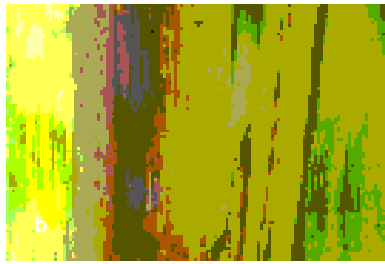
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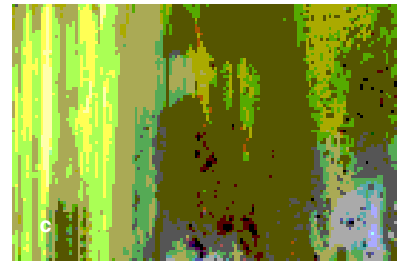
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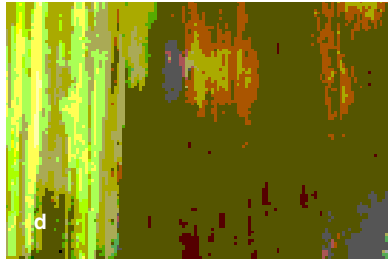
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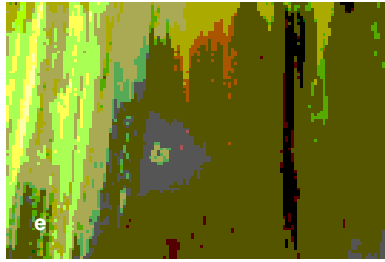
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9-10 Wood Grain There are as many ways to paint wood grain as there are scenic artists. The example here shows a series of steps of one technique.

- a** The first step is to lay in a series of colors using a wet-blend in the direction of the grain. A few brush strokes are used to begin suggesting the direction and shape of the grain.
- b** Before the base coat has dried, a spatter in a medium dark color is added.
- c** A heavier spatter of a considerably darker brown is applied in addition to a little bit of dry-brushing on the left side of the panel in a lighter color.
- d** While the heavy dark spatter is still slightly wet, a completely dry brush is used to drag across the droplets of paint, pulling them in the same direction as the grain.
- e** A few dry brush strokes are added to provide a sharper grain element.

The glazing of grain can be accomplished in several ways. One method is to grain the surface first, then apply a shellac, clear acrylic, or flat-varnish glaze. Glazing can also be effective in subtly toning scenery by adding a thin layer of yellow to warm up a wall, for example.

In many cases, one can mix a clear gloss or clear flat acrylic with the paint. This eliminates the step of painting a surface finish. Dry pigment can be mixed with shellac or varnish, which serves as a binder as well as providing sheen. Glazed surfaces created in this way must be handled with caution because they are harder to control, and there is the danger of creating a surface that is too reflective.

If a highly reflective surface for wood grain is desired, an *FEV*, or *French Enamel Varnish*, is effective. This is a mixture of shellac, (denatured) alcohol, and dye, typically painted in layers to create depth and subtly used color for aging. It is particularly good for props and furniture.

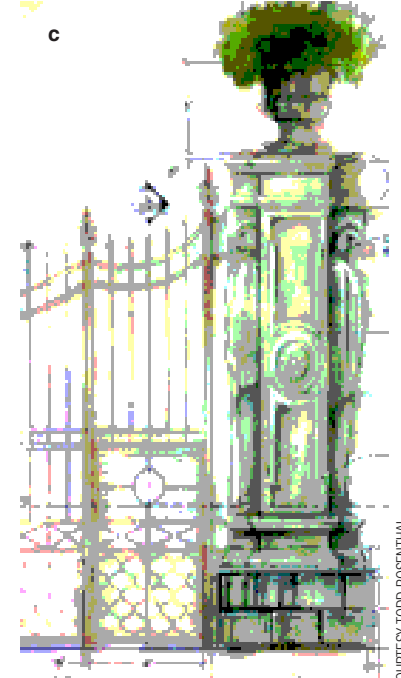
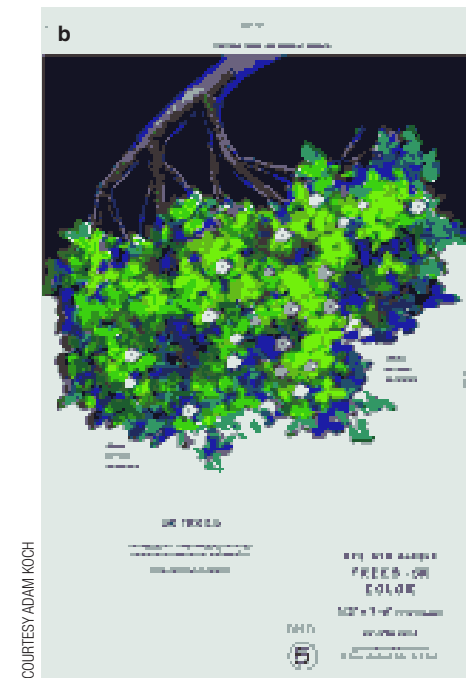
Creating Foliage The designing and painting of trees and foliage require practice and a study of natural forms. So much of what the designer and the scenic artist must do is *observe* what is around them. The designer should first study trees in their natural state. Painting them in watercolors is an excellent exercise that forces the eye to see trees in a different way. The designer soon learns to see the overall mass of foliage, then the subdivisions of smaller units relating to the branches of the tree's structure, and finally the detail of a single leaf. Careful observation allows the artist to see how light reveals the forms, passing through translucent areas. Some branches catch light, whereas others are silhouetted.

The conceptual treatment of a tree onstage can assume many forms. As with any other kind of scenery, stage foliage can be translucent, opaque, or textured. The tree can be real or stylized, or it might even be suggested with light patterns. Foliage can be carefully painted leaf by leaf or boldly painted in block areas that loosely suggest the organic form.

If the tree is to be opaque, the process often starts with the darkest tones. Leaf masses in the shadow or silhouette are blocked in first. The lighter shades and highlights are painted last. If the foliage is to be translucent and painted with dyes, the technique is reversed. The lighter tones are painted first and the darker shades last. The finished product will determine the specific method of painting.

9-11 Foliage

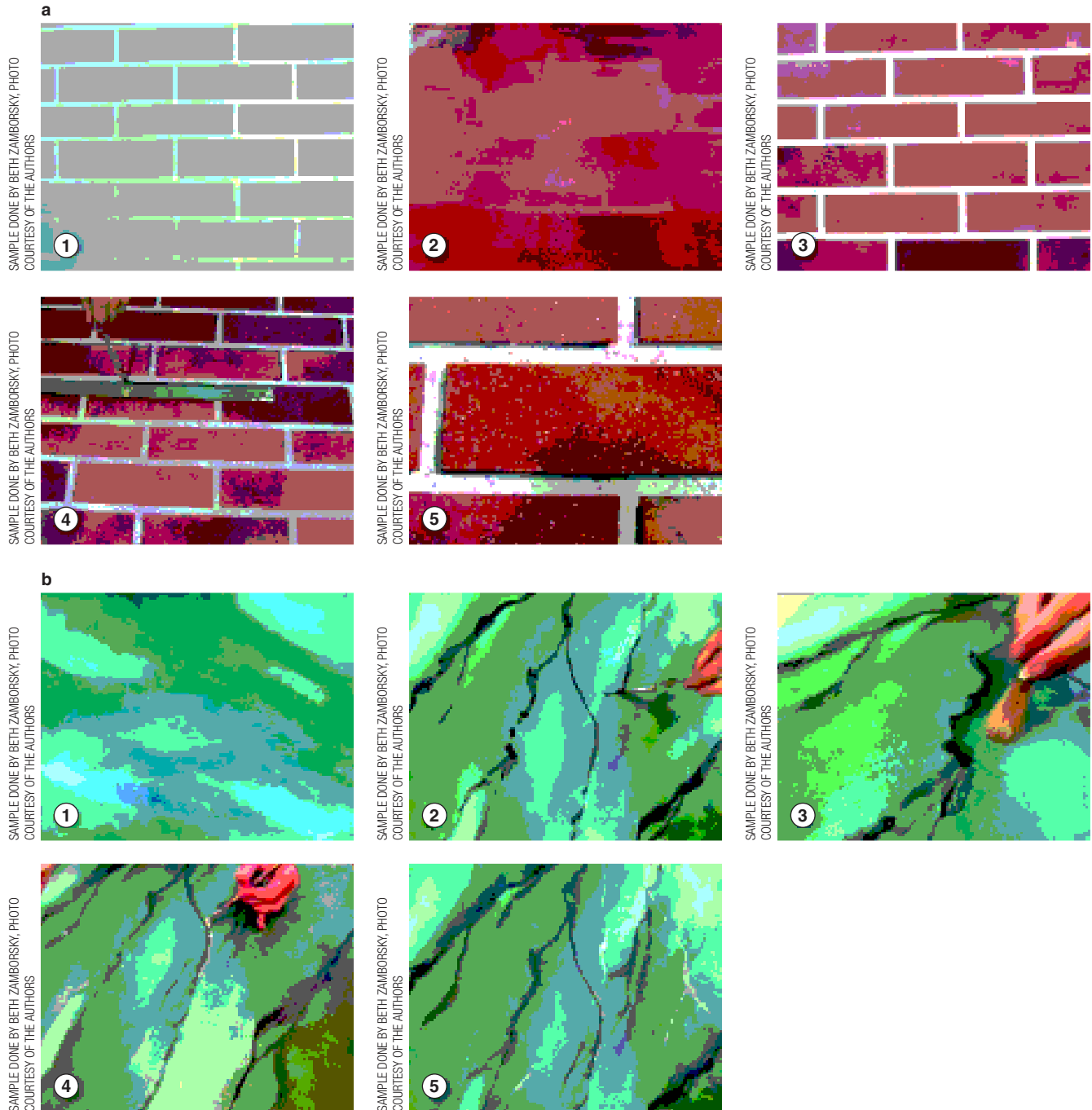
- a Stylized foliage painted for *Bye Bye Birdie*, designed by Adam Koch.
- b More foliage for *Bye Bye Birdie* designed by Adam Koch.
- c The foliage at the top of this piece of architecture is only a small part of this elevation but is important nonetheless, and quite different in style from the previous example. Designed by Todd Rosenthal.



Stenciling When there is a need for a design motif that is repeated in an interlocking overall pattern, such as wallpaper, stencils provide the fastest and most effective solution. After the means of interlocking the motif have been carefully figured out in relation to the size of the wall area, the motif is traced onto a sheet of paper strong enough to withstand repeated brushing and layers of paint.

Stencil paper is a tough, oil-impregnated paper made especially for the task. If unavailable, it can be made by applying a half-and-half mixture of linseed oil and turpentine to heavy Kraft paper. Oak tag is a cheaper and thinner substitute for stencil paper, but it must be treated the same way. Both are good only for light usage because they wear out quickly. Thin Plexiglas can be used, although it is harder to cut. More common now are drafting Mylar and Upson board. Swimming pool liner is a good choice for thick or raised textures as it is flexible.

A well-planned stencil has at least one full motif with portions of adjacent motifs to key the stencil into an interlocking scheme. The size of the motif and the amount needed



9-12 Brick and Marble

a Painting brick.

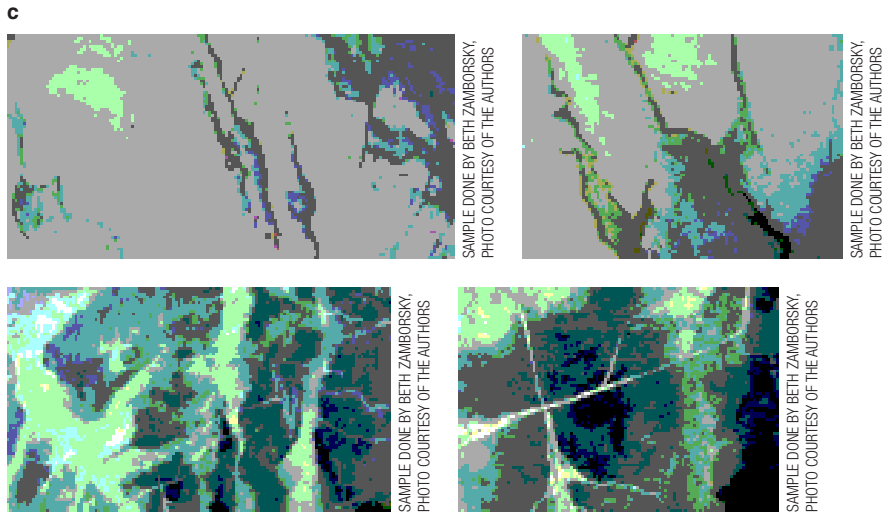
- 1 Brick shapes are laid out and the mortar masked off with ¼-inch masking tape.
- 2 The brick colors are laid in as a wet-blend/scumble. A great deal of variety in color can be added at this point.
- 3 The panel with the masking tape removed.
- 4 Shadows are added with a dark blue using a lining stick.
- 5 Detail view of the brick.

b Painting marble.

- 1 Base colors are laid in as a scumble. Many marbles can be done this way while the flat is very wet.
- 2 Some marble lines are painted in the base coat can be completely dry or partially wet for this step.
- 3 Feathering the marble lines to get some softer edges.
- 4 Adding white marble lines as a contrasting color.
- 5 The finished marble.

9-12 Brick and Marble (continued)

c Two other marble samples with details.



for interlocking the design more or less determine the size of the stencil sheet. *Register marks*, usually v-shaped notches marking the center of the pattern both horizontally and vertically, help guarantee correct placement and matching of the pattern if placement lines are snapped on the scenic unit. Care should be taken not to create too large a stencil that might become awkward to handle. The motif is cut out of the paper with a sharp knife, razor blade, or X-acto™ knife, although it is fast becoming standard to use a laser cutter which is fast, absolutely accurate, and will cut a wide variety of boards. However the stencil is cut, be sure to leave tabs within the open parts to support loose ends and strengthen the stencil as a whole. It is useful to have more than one stencil, especially if there is a large area to cover. They can be alternated to minimize the tendency of a stencil to become damp and misshapen from repeated use. The stencil is coated on both sides with clear shellac or any water-repellent plastic spray as an additional protection from the water-soaking effect of scene paint.

After the stencil is cut, it can be framed at the outside edges with 1 × 2 on edge. This strengthens it and also provides a shield if the paint is applied with a spray gun.

Artists can make a stencil print by spray gun, brush, or sponge. The spray gun is fast but sometimes messy and hard to control. Stenciling with a brush is slower but easier to control in small areas. The brush should be kept fairly dry and stroked toward the center of the openings to avoid dribbles. The use of a sponge or soft cloth to apply the paint works best on an open stencil (Figure 9-13). After every few passes, the stencil should be washed to remove excess paint.

Pouncing Another method of transferring a repeating design motif is the use of a **pounce**. It is generally used when the motif is too large for a stencil, does not repeat enough times for one to bother cutting a stencil, or is repeated in reverse. Pouncing differs from stenciling in that only the outline or drawing of the motif, rather than the painted print, is transferred (Figure 9-13c).

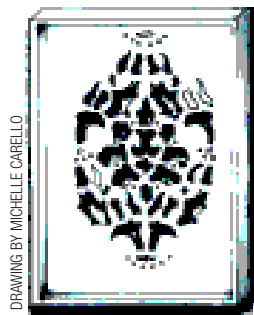
The pounce pattern is made by first drawing the design on a piece of brown Kraft paper and then perforating the outline with a pounce wheel. The best type of pounce wheel has a small, swivel-mounted perforating wheel. It works better on a padded surface, such as a blanket or fold of canvas or velour, than on a hard tabletop or floor. An electronic pounce machine is now available which is much faster, although it must be used with the scenic piece on top of a piece of sheet metal. Turning on the current and drawing the “pen” over the drawing burns holes in the pounce. There is no need to sand the back of the pounce. This is especially helpful when the pounce is large.

pounce A drawing, done on Kraft paper, that has been perforated in order to transfer it to the scenery to be painted.

COURTESY OF THE AUTHORS

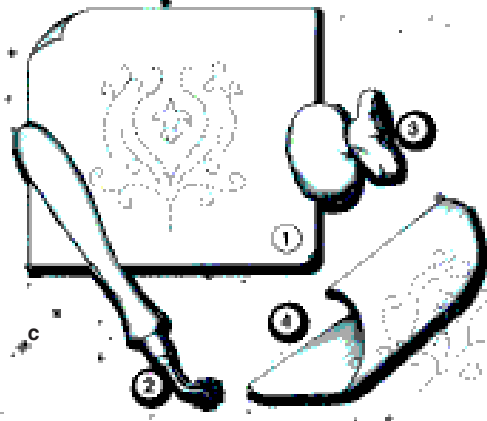


a



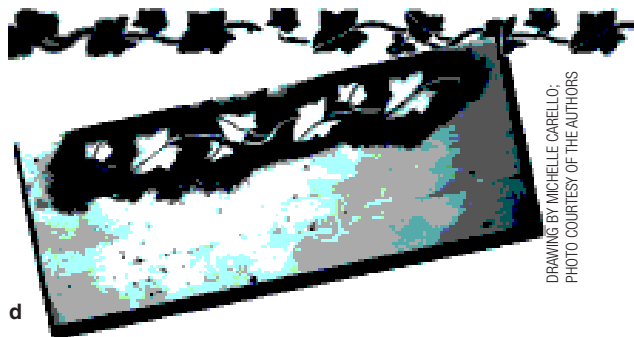
DRAWING BY MICHELLE CARELLO

b



DRAWING BY MICHELLE CARELLO

c



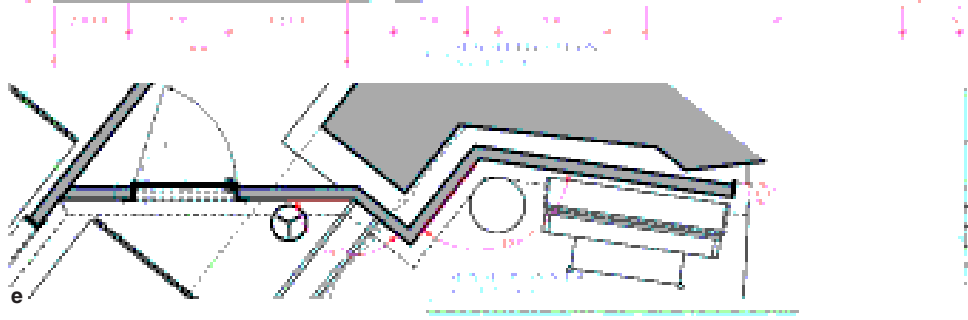
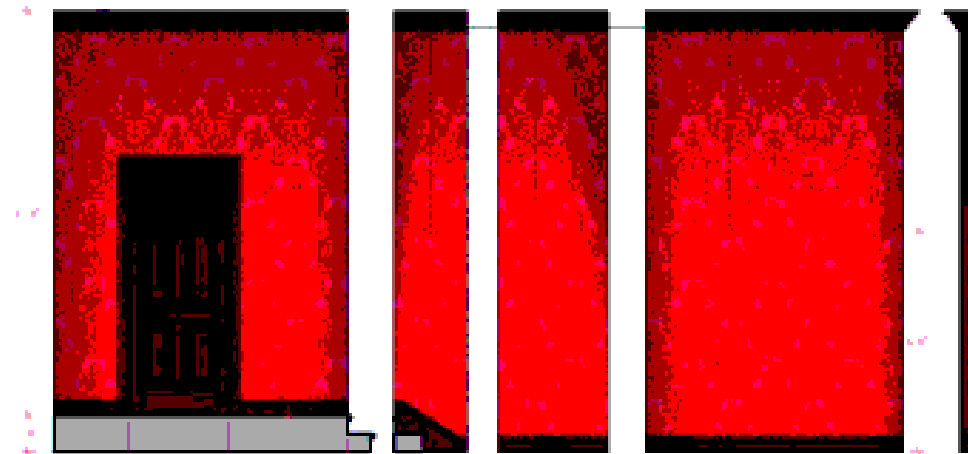
d

DRAWING BY MICHELLE CARELLO;
PHOTO COURTESY OF THE AUTHORS

9-13 Stencils and Pouncing

- a Unframed stencil.
- b Framed stencil. Note the register marks center top and center sides.
- c Pouncing:
 - 1 Pounce, or perforated, design.
 - 2 Pounce wheel.
 - 3 Pounce bag.
 - 4 The pounced design transferred onto the canvas.
- d Border stencil.
- e Paint elevation by Gianni Downs for *In the Next Room or the vibrator play* showing a stenciled wallpaper pattern.

COURTESY GIANNI DOWNS



e

General Notes

1. WALL FINISHES: UNPAINTED PLASTER or GYP. BOARD
2. WALL FINISHES: PAINTED PLASTER or GYP. BOARD
3. WALL FINISHES: UNPAINTED GYP. BOARD or GYP. BOARD

STENCILS

STENCILS	
STENCIL	DESCRIPTION
1	FLORAL BORDER
2	FLORAL CENTER
3	FLORAL CORNER
4	FLORAL PANEL

After the design is perforated and the rough edges of the back side are lightly sanded, the paper is laid on the canvas in the desired position. The pattern is rubbed with a pounce bag made of layers of thin material, such as cheesecloth filled with charcoal dust. After the pouncing, the outline is redrawn with marker, as in a cartooned drop, and the excess charcoal dust is flogged off.

In the commercial theatre, an entire drop will often be drawn as a pounce and transferred to fabric. If a second production such as a tour is produced, this method saves the company a great deal of time and expense.

Scene Painting Details and Specifics

The scenic artist is an extension of the scenic designer. He is the paint arm and is responsible for the surface treatment of all scenic pieces. He provides the knowledge and planning and solves any painting problems. He is not responsible for making design decisions, but rather figuring “how” to make it happen in paint. This requires not just the painting skills that we have been discussing in this chapter but a certain level of physical ability. Eye-hand coordination is obvious, but the scenic artist uses his entire body to do his work.

Color especially comes into play in theatre painting; a thorough grounding and understanding of its use are essential. Every manufacturer creates paint slightly differently. Burnt sienna from two companies, for example, may not be exactly the same. The scenic artist must learn the subtle differences.

Paint and Color

Scenic Paint

The scenic artist’s first act is to create a working palette of scene paint based on the 12 principal hues of the spectrum. The size of the palette will vary, depending on the individual artist’s tastes and working methods, on the requirements of the design, on the pureness of hue and mixing behavior of the available pigments, and finally on the relative cost of individual colors.

Scenic artists need to know the wide range of types of paint available. In choosing the paint to use, they must determine the kinds of surfaces to be painted as well as the type of work to be done. Some paints are general purpose, whereas others are designed for specific situations.

Color Matching The scenic artist must also judge how the color of a commercial paint matches the corresponding color in the design. Because designers use an infinite variety of colors, shops stock more than one pigment of a similar hue. For example, because a true spectrum yellow is not obtainable, two yellows are usually stocked—one that tends toward blue or green and one that tends toward orange.

In preparing a list of stock scenic colors, artists compare the quality of the pigments’ hues with the 12 principal colors of the color wheel. A good scene-painting palette includes all 12 as well as some special colors and the earth colors.

Color matching is one of the scenic artist’s most important skills. Practice allows the artist to become familiar with the available manufactured pigments as well as to develop a better eye for color. Each pigment has its own idiosyncrasies, but with practice, choosing the best combinations for matching a designer’s color choices does get easier.

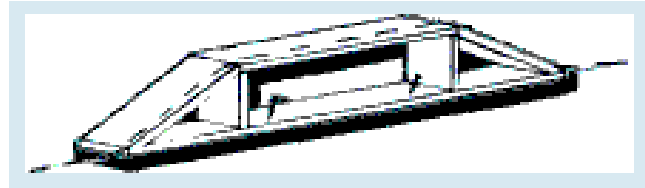
Painting Procedures

Painting a Drop

Any piece of scenery that is covered with canvas or muslin must be prepared for painting. In the case of a drop, it must first be stapled to the paint deck to prevent it from shifting. Prepping is done with a *size coat*, which shrinks the fabric and glazes the surface without filling it, most often with starch. The starch size (or glue size) prepares a canvas or muslin for dye painting on translucent work or for very thin opaque paints, especially if the opaque coat will be applied to large areas of unpainted background. Starch size can be made by adding a cup of cooked Argo starch to 4 gallons of hot water (about a 20 to 1 proportion). Every scenic artist has his own preferences as to how thin or thick to mix the starch size. (This comes with experience.) A touch of dye can be added to make the size coat more visible for brushing onto the fabric. The resulting coat is a taut, slightly glazed surface that is excellent for dye as well as paint.

When sizing a drop, the artist must allow airflow underneath during the painting and drying process; otherwise, the drop will adhere to the floor below. With a *bridge* (Figure 9-14) to lift up one corner of a drop and a box fan to blow air underneath, the drop is lifted off the floor. This is called **floating** the drop. Unless the drop is extremely large or is a soft portal, one bridge should be sufficient. It is important to keep the air flowing until the drop has dried.

For extensive *dye painting*—for a translucent drop, for example—the muslin is prepared with a starch size (discussed later in this chapter). If the painting is done on a fabric that cannot be sized with starch, such as velour or silk, a small amount of starch can be added to the dye mixture to keep it from spreading (“bleeding”) on the fabric. To prevent bleeding on detail painting, the dye can be mixed with *methocel*[™], which thickens the dye.



DRAWING BY MICHELLE CARELLO

9-14 Bridge

floating Lifting a wet drop off the floor by blowing air underneath while the paint is wet.

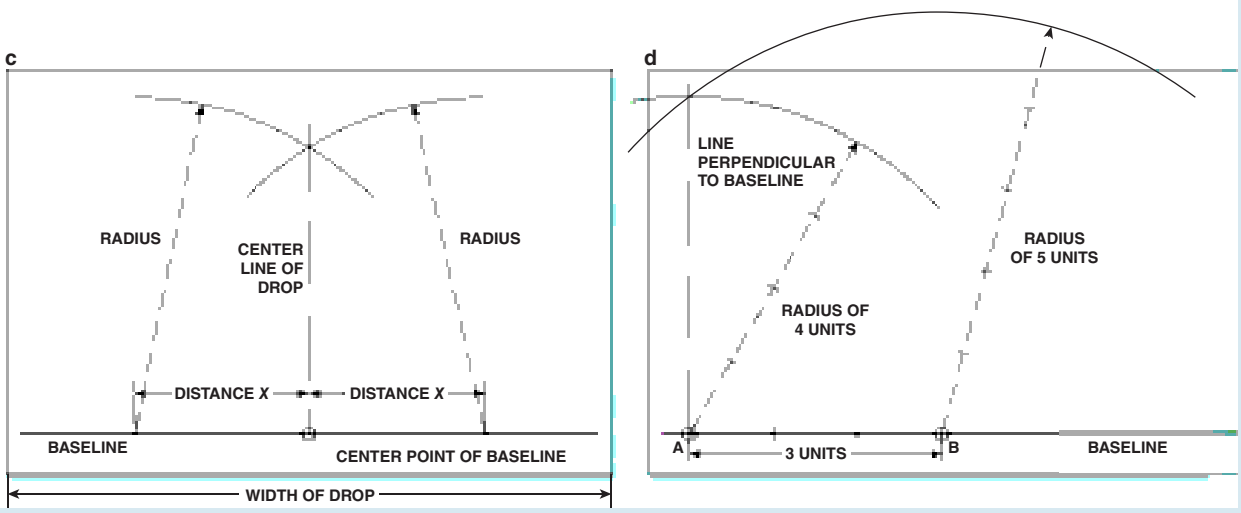
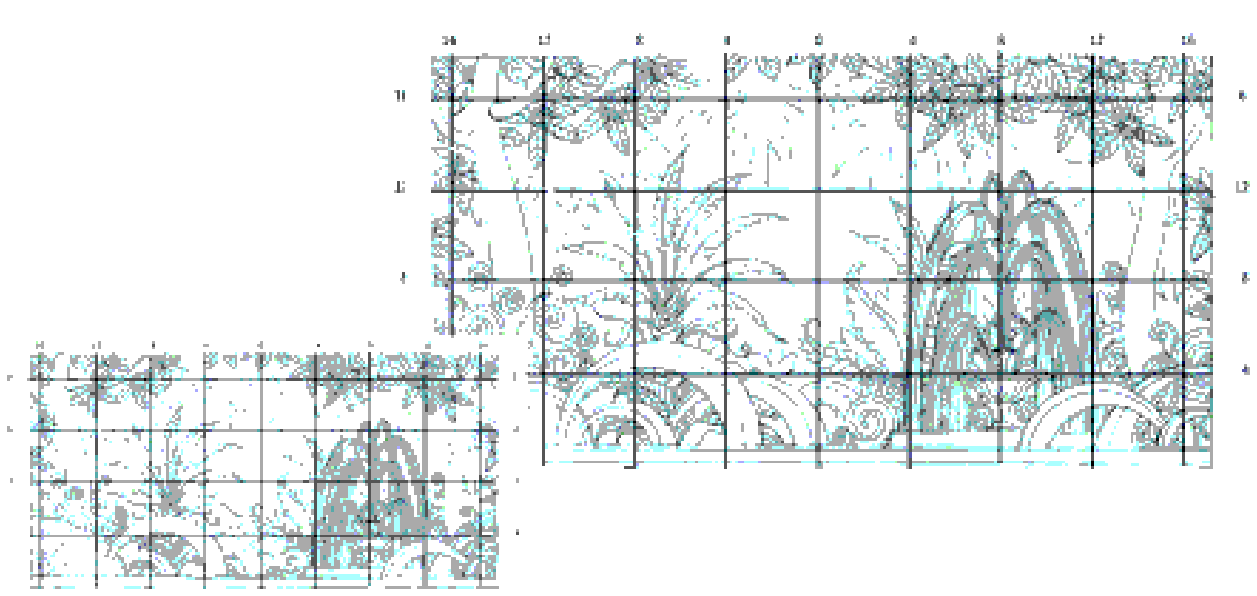
Cartooning

Working from the painter’s elevations, the scene painter can proportionally enlarge the drawing to full scale (Figure 9-15a, b). The drawing out of the paint elevation is called **cartooning**. A grid is placed over the drawing, to be replicated using either a snap line or a series of thread lines on the piece of scenery after it has been primed. A 2-foot grid is common, but circumstances vary, and the decision of grid size should be determined by the complexity of the painting. Sometimes a 4-foot grid is enough, but a 6-inch grid might be needed for minute details. It is often tempting for the inexperienced scenic artist to draw a very small grid. A too-small grid will perhaps allow the scenic artist to more easily draw a detail but will hinder the connectivity of all the parts of the drawing.

Methods of numbering or lettering the grid differ and have to do with the personal taste of the artist. Some artists prefer to number the spaces, whereas others favor numbering the lines. It is the consistency between the paint elevation and the scenic unit that is important. Proceeding square by square, the painter uses charcoal to transpose the small-scale elevation into a full-scale layout of the design.

All cartooning or layout drawing is done in charcoal on the prime coat. If there are multiple copies of the line drawing, several artists can cartoon the piece simultaneously for more efficiency. An overhead or opaque projector sometimes can speed up this process. After the drawing is completed, key points or portions of the cartoons are “inked” in using an industrial marker supplied with replaceable felt tips. Excess charcoal is “flogged” or dusted off the surface in preparation for the base coat. The inked-in portions of the design will bleed through the base coat and serve as a guide for detailed

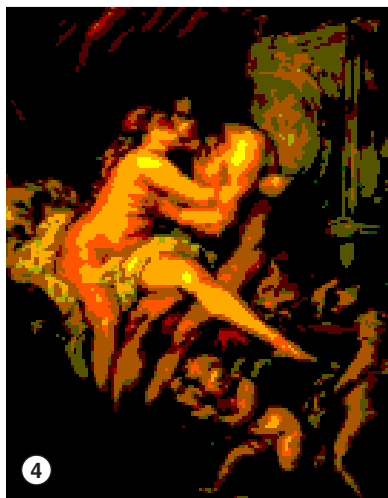
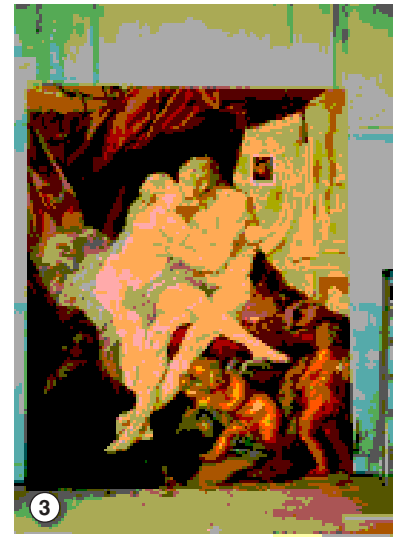
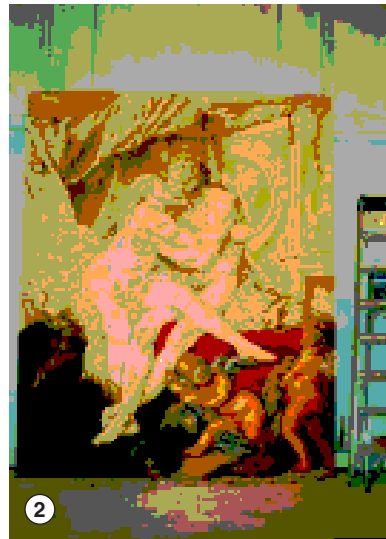
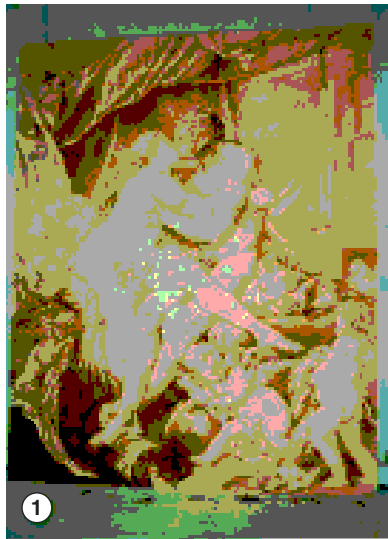
cartooning The drawing, usually in charcoal, of a paint elevation on a drop or flat.



a & b COURTESY PAM KNAUERT-LAVARWAY; c & d © CENGAGE LEARNING

9-15 Enlarging a Drawing

- a The designer’s elevation with a grid of 2- to 4-foot squares. Lines are numbered from the center line out to the left and right as well as from bottom to top.
- b Full-scale layout of the drawing with the same labeling method.
- c Finding the center line of the drop: Establish a baseline for the drop and find its center point. Swing two arcs from a point equidistant from the center of the baseline. Connecting the intersection of these two arcs with the center point of the baseline will establish the center line of the drop.
- d Squaring the drop: Creating a 3-4-5 right triangle allows the artist to maintain right angles at the ends of the drop, referred to as “squaring the drop.” Establish a baseline for the drop. Using a convenient unit of length (such as 3 feet, 4 feet, or whatever number is convenient), measure 3 units along the baseline from one corner (point A). Swing an arc 4 units long from the same corner (A). From the other end of the 3-unit length along the base (point B), swing an arc of 5 units long toward the edge of the drop. Drawing a line between the intersection of the two arcs and point A will establish a perpendicular to the baseline.



COURTESY OF MARY HEILMAN

9-16 From Cartooning to Painting Mary Heilman was the scenic artist on this quite complicated and detailed project. You can see her process in this step-by-step series of photographs, beginning with the detailed cartooning that she did.

painting. If the artist is working on the floor instead of vertically on a frame, he attaches both the charcoal and the marker to the end of a thin piece of bamboo. This allows him to paint while standing and maintain a certain distance from the work in order to see a broader picture of what he is drawing (Figure 9-16).

Painting Floors

Because more thrust and arena theatres are being built, floors are becoming more important as a design element. Wood, stone, marble, or even dirt can be needed for a design (Figure 9-17).

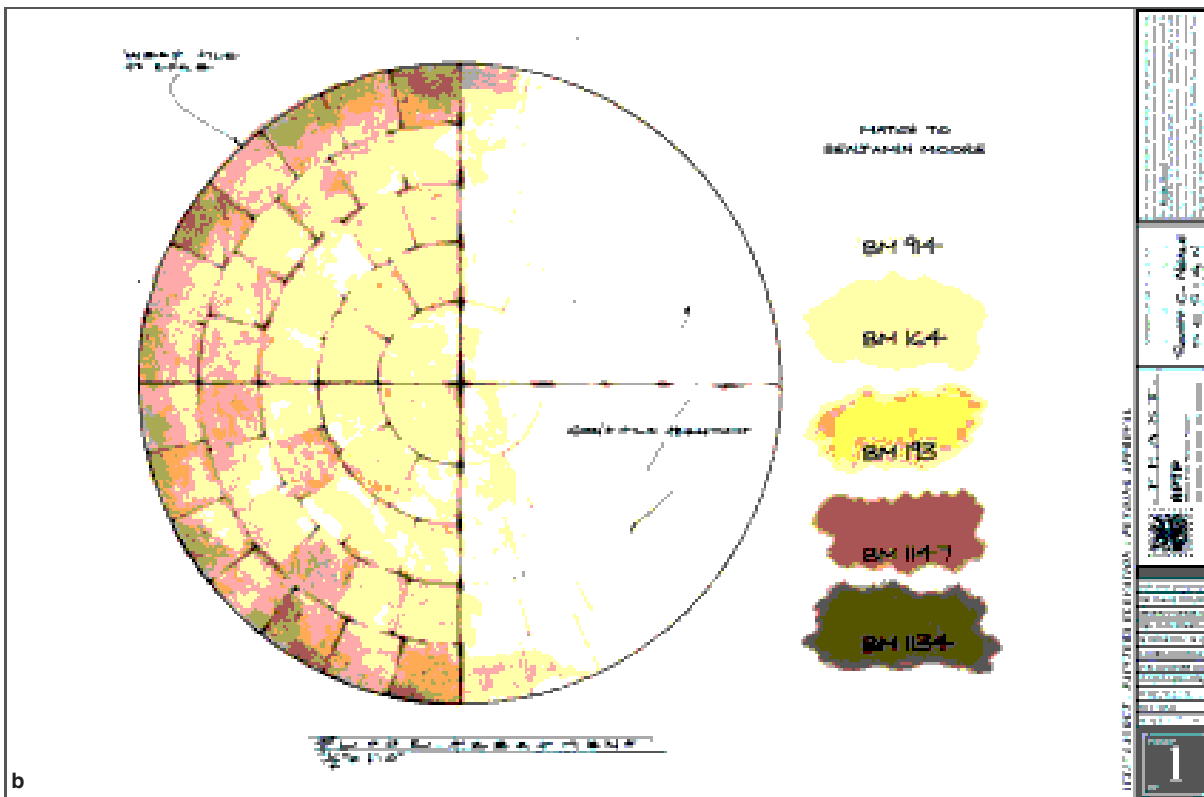
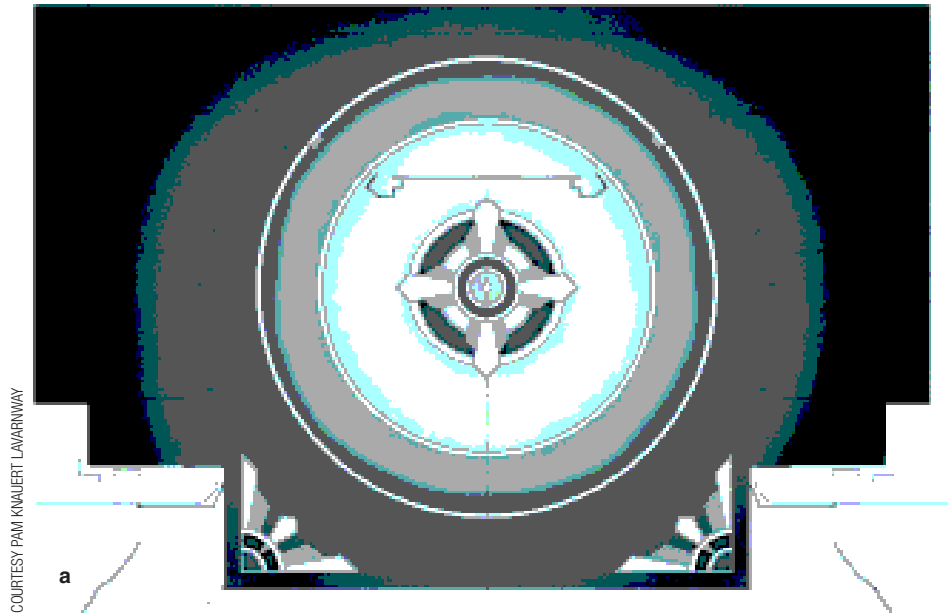
Wood floors can be achieved either by painting on a stage deck (or canvas) or using lauan (or similar material) ripped down into strips. Full sheets can be stained or painted using the techniques we have discussed and then cut into the sizes designed or they can be cut into strips before staining. “Supersat” thinned down can be used in place of stain.

A tile floor can be treated much the same. Once they have been painted and cut, the tiles can be laid on the deck in a pattern or in random order.

Dirt floors can be achieved using Jaxsan and, if more texture is desired, quilt batting helps to create an uneven but walkable surface.

9-17 Painting Floors

- a Paint elevation for *Thoroughly Modern Millie*, designed and painted by Pam Knauert Lavarway.
- b Paint elevation for *Feast*, designed and painted by Scott C. Neale.





TOOLS OF THE TRADE ■ Painting Tools

In addition to brushes and paints, the painter uses other necessary painting tools, including these:

- Beveled straightedge (6 feet)
- Rule or steel tape
- Snap line (50 feet)
- Bow snap line (6 to 8 feet)
- Charcoal stick and holder
- Large compass (36 inches)
- Tank sprays
- Spray gun and compressor
- Pounce wheel
- Buckets (14 and 16 quarts)
- Small pots or cans (No. 10 size)
- Burner and double boiler for cooking starch
- Flogger
- Paint roller and a variety of roller pads

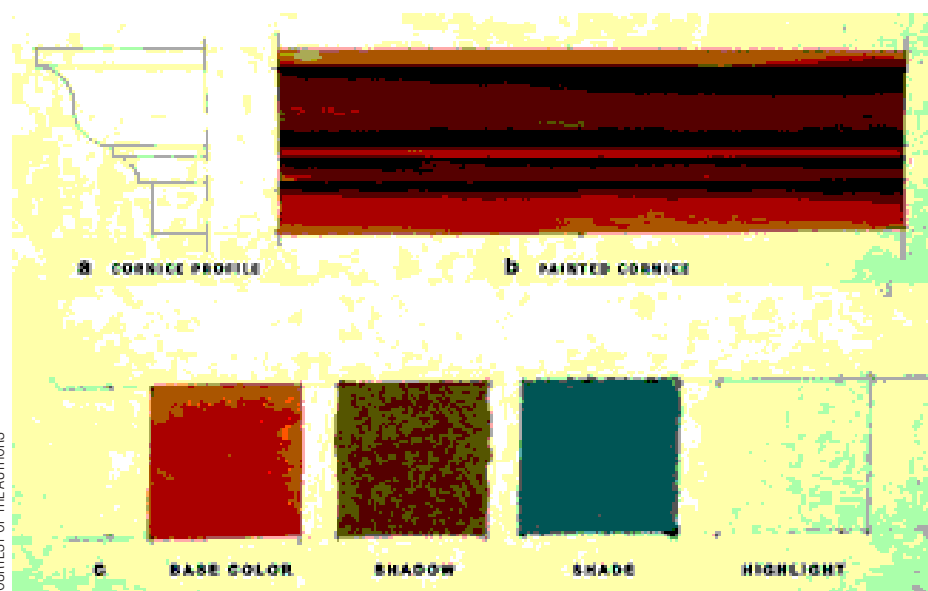
Any treated floor must be sealed in order to protect it from the constant abuse of actors and wagons moving on it. A polyurethane sealer holds up best. If a high gloss is desired and the production is long running, a two part epoxy water-based sealer, developed for use on gym floors, can be used. It is, however, prohibitively expensive.

Detail and Decorative Painting

The final step in scene painting is the definition of form through the various painting techniques of lining, texturing, creating foliage, stenciling, and pouncing. The basic techniques of creating textures have already been discussed.

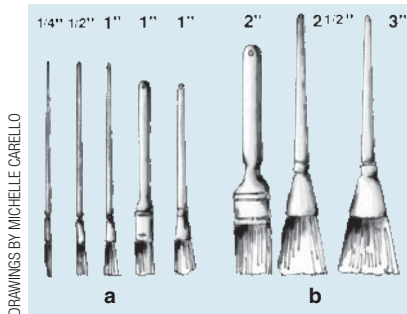
Lining The technique of **lining** freehand, or with a straightedge, helps artists represent in two dimensions the complicated surfaces of the moldings in a cornice, chair rail, panel, or door trim (Figure 9-18). Careful lining helps establish highlight, shade, and shadow. The specific choices of color for both highlights and shadows depend on the design as well as the principles of complementary colors. For a particular design, more than two shadows or highlight tones might be used. As their names suggest, highlights are lighter in value than the local color, and shadows are darker. Because they tend to recede, cooler colors are most frequently used for shadows, but warm tones can also create them successfully.

lining Using a small brush to paint lines, most often in painting highlight and shadow in painted molding.



9-18 Lining Techniques

- a Profile of cornice to be painted.
- b The painted cornice using lining work for the darkest shadows.
- c Samples of the colors used for each step in painting the cornice. Some designers include this in their paint elevations to help the scenic artist match color.



DRAWINGS BY MICHELLE CARELLO

9-19 Detail Brushes

- a Lining brushes—flat and oval.
- b Decorating brushes.

fitch Flat brush with a long handle; varies in size from ½ inch to 3 inches.

liner Narrow, long-handled brush (often ¼ inch) used for details, most often in painting molding.

The order of lining for a panel or cornice is determined after first studying a cross-section of the molding and the direction of the light that would reveal the molding if it were real. The positions of windows or artificial light sources offer clues for fixing the general direction of light for each wall in the set, but it is critical for the set designer and scenic artist to consult with the lighting designer to coordinate light direction for painted scenery.

Detail Brushes The **fitch** is a flat brush with a long handle, varying in width from ½ inch to 3 inches. It is used for decorative painting, such as architectural details or foliage. A natural-bristle brush made especially for scenic painting, the fitch can be quite expensive. A *sash tool*, which is a flat, long-handled brush for painting window sashes, can be used as an inexpensive decorative painting brush. The sash brush, however, is not made any wider than 2 inches.

Liners, or lining brushes, are also long-handled brushes varying in width from ¼ to 1 inch. Liners should have long, natural bristles to perform well. A 1-inch sash tool can do limited lining, but there is no substitute for the smaller brushes.

Other Painting Tools and Supplies

In addition to brushes and paints, the painter uses other implements for preparation, layout, and safety in creating scenery. These tools include measuring devices, buckets, rollers, and so forth. Many of them are pictured in Figure 9-20 and listed in the box on painting supplies.

One of the joys of working as a scenic artist is exploring new tools to accomplish a specific task. There is no telling what product will be most effective, whether manufactured for painting or not. Openness and creativity about how to attack a project allow for a wider range of potential tools and methods and may lead to a completely innovative solution.

Other Skills

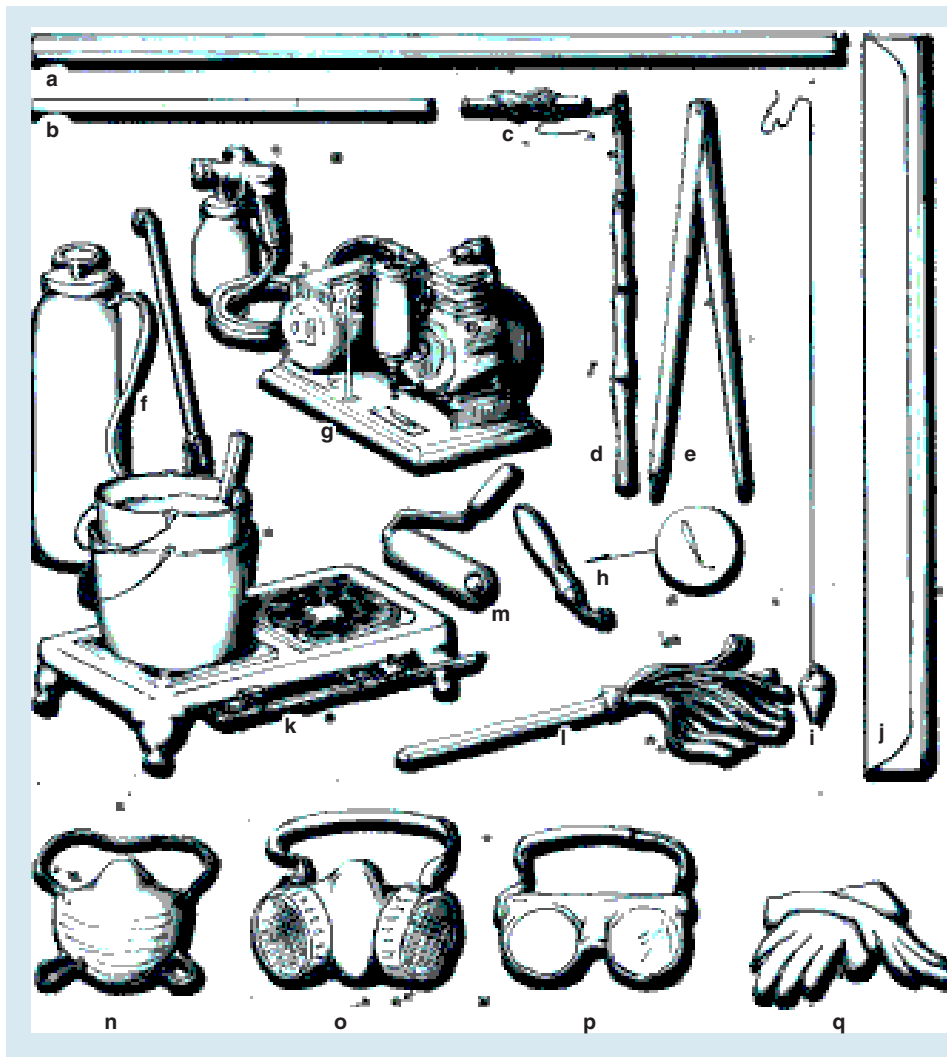
Carving It is not unusual for a scenic artist to be asked to carve an object for a design. This could be something as literal as a piece of sculpture or part of a tree. This work can be the province of the prop shop, depending on who has the appropriate skills.

Trompe L'Oeil Trompe l'oeil painting, as mentioned earlier, is an old-fashioned technique of painting that creates the illusion of three-dimensionality by very detailed work. All of the techniques previously mentioned can be used in conjunction with a firm knowledge of the way light falls on real objects to create shadows.

Lettering Lettering, as in for signage, is a unique skill that requires knowledge of spacing and how fonts work. This skill requires a great deal of patience and extremely high quality brushes. (See Figure 9-21.)

Textured Surfaces

We have discussed the illusion of texture created by paint in the theatre, but surfaces that have a truly textured surface are sometimes desirable as well. Important points to consider before texturing a surface include these: (1) a textured surface cannot

**9-20 Tools and Safety Equipment**

- a Beveled straightedge.
- b Yardstick.
- c Snap line.
- d Charcoal and holder.
- e Large compass.
- f Tank spray.
- g Spray gun and compressor.
- h Pounce wheel.
- i Plumb bob.
- j Bow snap line.
- k Burner and double boiler for starch size.
- l Flogger.
- m Paint roller.
- n Dust mask.
- o Air-purifying respirator mask.
- p Goggles.
- q Rubber gloves.

be reclaimed for a different use without recovering the piece of scenery, (2) deeply textured surfaces may not stand up to excessive handling or wear, and (3) if any texturing is done, the lighting designer must know all the details in order to light it properly. As well, the costume designer needs to know the type of texture in order to prevent fabric snags or other potential problems.

Scenic artists are always looking for new, inexpensive, and fast methods of creating a texture. Some of the most commonly used materials to do this follow (see also Figure 9-22).

Joint Compound A compound developed commercially to cement tape over drywall joints in house construction, joint compound will hold a deep texture if a little white glue is added to it before application. It is inexpensive, applies with little trouble, and dries hard. It can also be sanded after it dries. If pigment from the final color of the set is added to the mixture before application, any of the texture that chips off will match the set and not be the white of the raw material. This can save touch-up time.

Jaxsan Jaxsan is a brand name of a commonly used acrylic product developed as a water-based roofing sealer. It is flexible and works well for textures. When mixed



COURTESY ADAM KOCH

9-21 Lettering The elevation for *Bye Birdie* shows both careful and stylized lettering designed by Adam Koch.

with whiting, it will adhere to almost any surface. Once it dries, it cannot be easily worked.

Scenic Dope Scenic dope is a mixture of whiting (powdered limestone) and flexible glue. It can be mixed as thick as needed. In thinner consistency, fabric can be dipped into it and draped for sculpture. Thicker scenic dope can be used to create heavier textures.

Sawdust Coat Sawdust or wood chips can be mixed directly with scenic paint and applied as a texture coat. The binder should be stiffened a little to adhere firmly to the sawdust. A sawdust coat requires less preparation and dries more quickly than joint compound does, but it does not provide a deep texture.

Water Putty Durham's Water Putty, a commercial surface repair mixture in powder form, can also be used as a texture coat. It works best on a hard surface such as wood and can be combed or stippled into a deep texture. Although it dries off-white, it can be colored either with dye during the mixing or with paint after it has dried. When hardened, it is tough but subject to chipping. It can also be used to coat fabric on a curvilinear piece. Best used for smaller projects, this medium is handy in the prop shop.

The scene painter clearly has many responsibilities, from aesthetic choices to safety procedures. The designer who keeps the considerations that have been discussed in mind will create set designs that are more likely to be fully realized, compared with the designer who has little knowledge of the possibilities and limitations of paint as well as the paint shop.

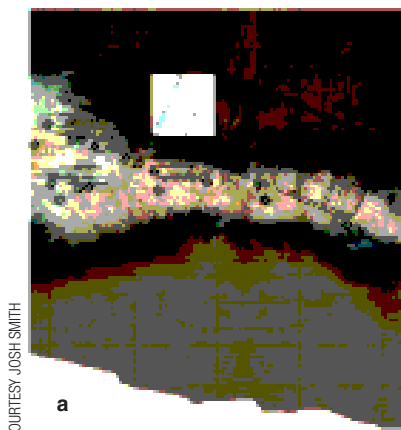


TOOLS OF THE TRADE ■ Additional Painting Supplies

- *Clear shellac.* For glazes, water-repellent finish and binder.
- *Denatured Alcohol.* Solvent for shellac.
- *Flat varnish.* Glaze finish and paint binder.
- *Turpentine solvent.* For varnish and oil paints.
- *Liquid floor wax.* Glaze finish and paint binder.
- *Metallic paints.* Powder mixed with strong size or clear acrylic for metallic surfaces; all right for scenery, but not for props; spray cans (Krylon®) have harder finish, good for props, more expensive.

Three kinds:

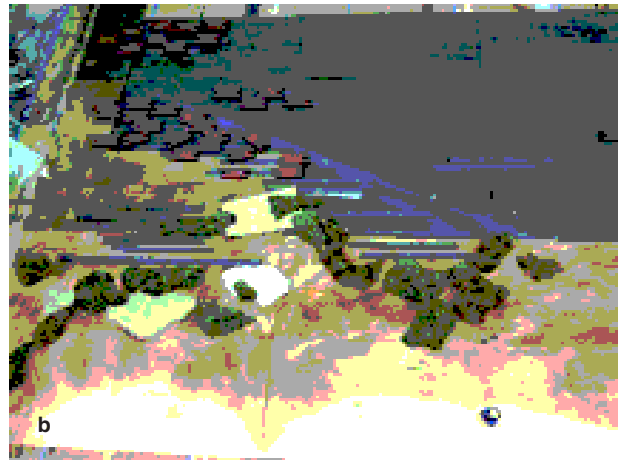
1. *Metallic—bronze powders*
 2. *Mica powders*
 3. *Plastic powders*
- *Glycerin.* Added to paints for slow drying.
 - *Lysol.* Preservative.
 - *Alum.* For shrinking soft goods.



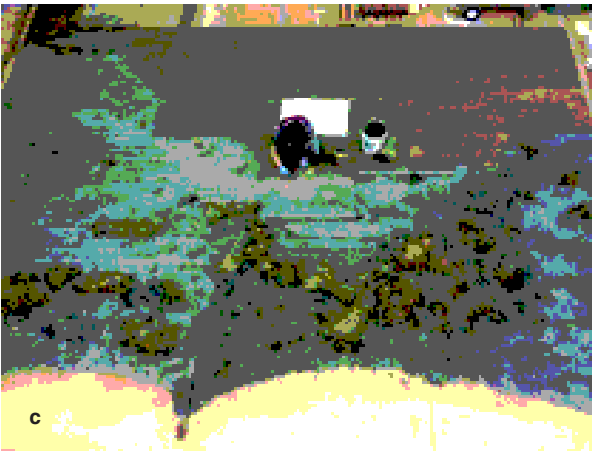
COURTESY JOSH SMITH

a

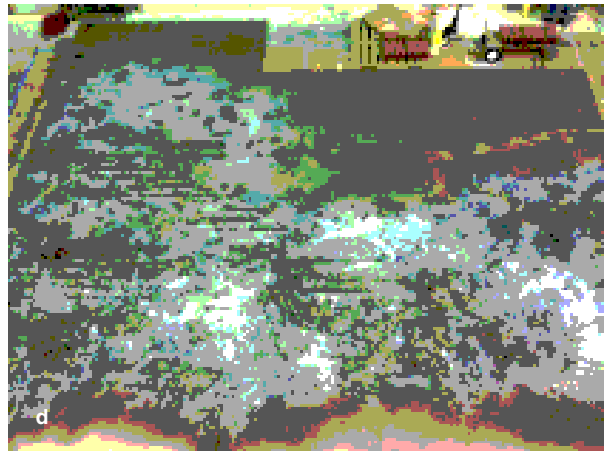
Bus Stop Stage Deck
 11' x 11' x 11' x 11'



COURTESY JOSH SMITH

b


COURTESY JOSH SMITH

c


COURTESY JOSH SMITH

d


COURTESY JOSH SMITH

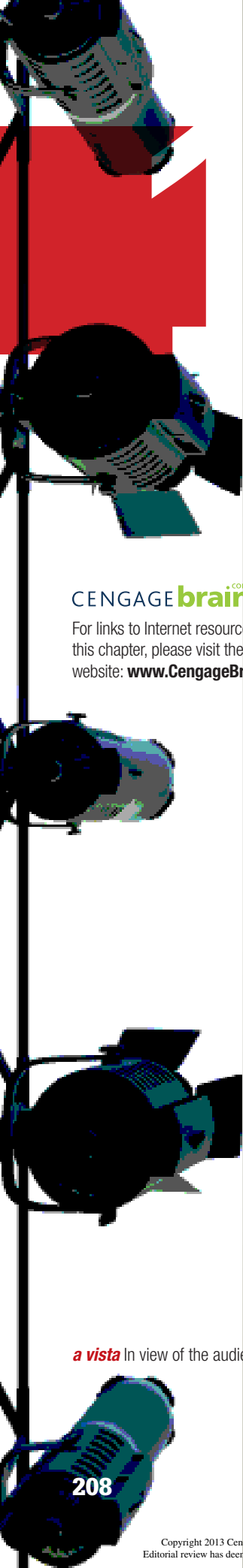
e


COURTESY JOSH SMITH

f

9-22 Textured Floor The floor for a production of *Bus Stop*, designed by Josh Smith, required a heavy texture that was done in several layers.

- a** The paint elevation of the floor.
- b** A plywood floor was cartooned by grid in order to get the correct placement for the most heavily textured and raised surfaces as well as the grasses that the props department would install. Areas for the tall and short grasses were plotted carefully and marked with long, narrow strips. “Pods” of insulation foam and felt were tacked in place.
- c** Jaxsan was used to texture the “pods” and smooth the transition to the bare plywood floor. Textures were a variety of bought real mosses and plant material pushed into the wet Jaxsan. There was little concern for color at this point.
- d** The base color is layered in. It was a scumble of browns with sprayed whites, using Preval® sprayers, on top to suggest a dusting of snow. A series of washes covered the downstage areas.
- e** Darks are added in.
- f** The grasses were added piece by piece into pre-drilled holes by the props department. The grasses were *all* flame-retarded. This was not necessary on the floor since it was covered with Jaxsan.



10 Handling Scenery

When confronted with a multiscene play, a designer has to consider the numerous ways of handling moving scenery, choosing the one that will best fit with the overall design. Consequently, the more designers know of modern theatrical techniques for moving scenery, the closer they can come to realizing their design fully. Technical knowledge can help a designer solve scenery-shifting problems with an ingenuity that is often inventively original.

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Factors Influencing the Handling of Scenery

The basic methods of handling scenery, in order of increasing complexity and considering the amount of construction needed, are: (1) the manual running of scenery on the floor; (2) the flying of scenery; (3) the moving of scenery on casters, including such large units as wagons and revolving stages; and (4) the handling of scenery through the stage floor by elevators or lifts.

Before we discuss these particulars, we need to look at the four main factors that influence the choice of handling methods employed in a production: (1) the *play*; (2) the physical *theatre* space, including its relationship to the audience and available resources; (3) the *design* of the production, both conceptual and visual; and (4) the *budget*.

The Play

The primary factors affecting the handling of scenery are the play's form and plot structure. A play may have many unrelated scenes, flashbacks, several simultaneous scenes with continuous action, or a conventional three-act form. The structure of the play (and in some cases the particulars of the production) determines the number of scenes or locale changes and their order of appearance or reappearance; it also establishes the *kinds* of changes that take place.

Ingenuity and careful planning are necessary for any scenic change, taking into account the amount of time, the stage and fly space that is available, and the kind of stage machinery that can be used. An act change with an intermission provides the most time—sometimes as long as 15 minutes—to change scenery. Changes within an act may need to happen in as few as 10 seconds. More often, especially with contemporary plays, changes can be almost instantaneous. The more limited the resources (time, space, equipment, personnel), the simpler the changes must be.

A scenic change can be handled in several different ways. It may be a *hidden* change, taking place behind a curtain or under cover of a blackout. It may be an *a vista* change, made in full view of the audience with a display of theatrical magic or by actor-stagehands openly moving elements of scenery as a part of the action. The style and manner of any change should help create a unique method of storytelling for the production.

a vista In view of the audience.

The Theatre

The shape of the theatre and the size of the stage greatly influence the movement of scenery. The amount of flying space and equipment; the placement, number, and size of any existing traps; the extent of offstage and wing space; the size of the proscenium arch and sightline conditions—all obviously help determine the way scenery will be handled. Some stages have more elaborate mechanical aids or stage machinery for shifting scenery, such as a built-in revolving stage, tracking and offstage space for full stage wagons, or elevator stages, which often influence scenery-handling techniques.

Touring productions must deal with other scenery-shifting considerations as well. Instead of one theatre and stage, the designer has to consider the size and sightline conditions of many stages and auditoriums as well as the physical limitations and extreme portability expected of scenery for a road show. To keep the physical production consistent at every stop of the tour, a **show deck**, complete with all necessary mechanics, may be built, keeping the entire production self-contained.

If a production requires a very long setup time (some tours, such as *Wicked* and *Les Misérables*, can take up to a week), sets are occasionally duplicated. Sometimes referred to as “jump sets,” they allow a crew to set up the scenery in one city while the production is playing in another. This means less down time for the production, which equals fewer days without a paying audience and less money lost in setup time.

show deck A floor or deck built for a specific production, including all necessary mechanics for moving scenery.

The Design

The scene designer reconciles the needs of the play and the physical stage and adds a third factor—the design of the production. The kind of scene or locale change inherent in the play, the physical limitations of the stage, the specifics of the production (see Chapter 4), and the movement of the scenery must fit the conceptual parameters that have been determined by the artistic team. A successful designer cannot design a multi-locale production without thinking through a basic scheme for handling the changes.

The Budget

The influence of the budget is obvious. More money in the operational budget allows for a larger production staff, more sophisticated mechanics, more efficiency in handling the scenery, or perhaps all three. Several factors affect the operational budget. A Broadway show with a prolonged run, for example, can reduce its operational costs by investing in costly mechanical aids to shift the scenery, thereby cutting down the number of stagehands on the weekly payroll. In venues such as universities and community theatre, labor can be paid or volunteer, perhaps allowing for more funds for materials. People-intensive solutions are often used when labor is free (although this should not give designers free reign for abuse). Material costs, labor costs, and reusability all must be balanced against one another.

Backstage Organization

A fast change requires teamwork and precision in order for pieces of scenery, properties, and actors to move seamlessly. Owing in part to careful rehearsing, this efficiency is largely the result of the normal division of responsibility in backstage organization and careful planning. The actors, the moving scenery, the change of costume (which may include mics), and the appropriation of props must be coordinated in a safe and efficient manner so that all fit into the world that is created for the audience.

Stage Manager

Although the stage manager has more everyday contact with the director and the actors than with other members, he is the conduit through which information flows through the entire company. Once the production is onstage, the stage manager becomes fully responsible for running a smooth operation. The stage manager officiates at the first technical rehearsal, sometimes without actors, to allow all hands to become familiar with the timing of shifts, light and sound cues, and the placement of properties. He starts each performance, gives all cues, calls the actors, and posts all daily calls, as well as provides rehearsal and performance reports. The stage manager is charged with maintaining both onstage company discipline and the production standards set by the director and designers.

Note that the stage manager and the production manager (discussed in Chapter 4) are not the same. While the jobs have their similarities, the production manager is concerned more with the business side of things.

Stage Carpenter

Taking cues from the stage manager, the stage carpenter is in charge of the shifts, the rigging, and the general condition of the scenery. The crew, made up of deckhands (stagehands) and flymen, reports to the stage carpenter.

Master Electrician

The responsibilities of the master electrician include hanging and focusing lighting instruments, maintaining all electrical equipment, and sometimes operating the control console for the lighting cues.

Property Master

The property master's duties include the care and maintenance of the set and hand props. They also include setting up the prop table offstage (conferring with stage management to guarantee that props are where they are needed) and supervising the handling of props during a shift, helped by crew assigned to the property department.

Sound Technician

The sound technician is responsible for placing microphones and speakers as well as operating the sound mixer during the performance according to the specifications of the sound designer. The sound technician is often responsible for rigging the audio communication system and providing instant communication among all department heads.

Wardrobe Supervisor

The care and maintenance of all costumes is the responsibility of the wardrobe supervisor (and, during a fast costume change, of the actors as well). The backstage organization of community and university theatre often places the supervision of makeup in the costume department as well.

Manual Running of Scenery on the Floor

As mentioned at the beginning of this chapter, the manual running of scenery is the simplest handling method and requires the least construction in preparation. Occasionally, the extreme height of scenery combined with its traditional thinness makes moving it difficult for anyone not experienced in handling scenery. If the units are strong enough

to be self-supportive, little additional bracing may be needed. Because the needs of every production differ, determining the type of support needed always presents a new challenge. Types of supports that might be required are explained the following sections.

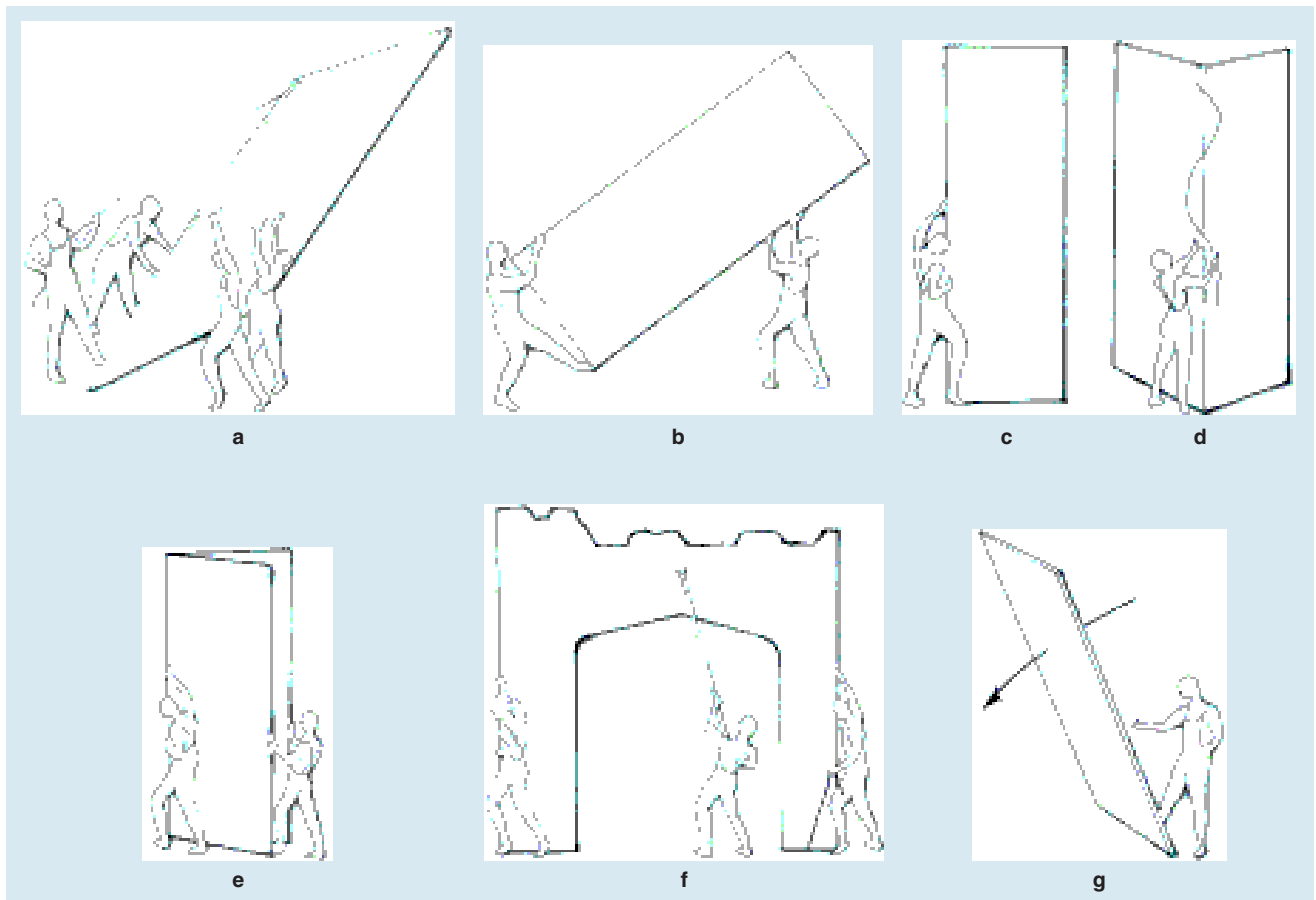
Handling

Some of the many ways of handling single flats, two-folds, and partially assembled units of scenery on the floor are illustrated in Figure 10-1.

Raising a large piece of scenery usually requires several hands. The stagehands on the back side are **footing**, or holding, the bottom edge with their feet, preventing the flat from sliding, while the other two stagehands “walk up” the piece by pushing on solid surfaces such as the stiles. This can also be done with the flat on edge: as one stagehand foots the flat and pulls, a second walks up the unit by pushing along the edge.

footing Using a foot to prevent a flat from sliding in the process of walking it up.

To “run” a single flat (Figure 10-1c), the stagehand has one hand low and the other high for balance. By lifting the lead corner slightly off the floor and keeping the trailing corner on the floor, the stagehand handles the flat in perfect balance. Running a two-fold (Figure 10-1e) requires two stagehands; running top-heavy and other special pieces requires three or more (Figure 10-1f).



10-1 Manually Handling Scenery The running or “gripping” of scenery is the simplest handling method, although occasionally the awkward shape or extreme size of a piece may require experienced stagehands to handle it successfully.

- a “Walking up” a stiffened two-fold.
- b “Walking up” a flat on edge.
- c Running or “gripping” a single flat.
- d Lashing two flats together.
- e Running a two-fold.
- f Three stagehands running a top-heavy piece.
- g “Floating” down a single flat.

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Lashing is a method of joining two flats in their playing position with lightweight rope (Figure 10-1d). This method is not frequently used.

“Floating” (Figure 10-1g) requires only one person to move a large piece from a vertical to a horizontal position. While footing the bottom of the flat, the stagehand lets go of the top, allowing it to “float” down to the floor. This works only with soft-covered flats.

Stiffening, Bracing, and Joining

Because scenery has to travel in small and lightweight units in order to be transported in and out of theatres, the joining or unfolding of smaller units into larger ones is necessary. The new larger shape requires support to be safely handled in a shift (Figure 10-2), most often in the form of a simple **stiffener**, usually a horizontal member (a 1×3 or a 1×4 on edge) that is loose-pin hinged into place as the set is assembled. Stiffeners that are more complex in form can be built to conform to any shape necessary (see Figure 10-2b).

The simplest and most common form of bracing is the use of a **jack brace** (often shortened to *jack*), a triangular form with a small base that provides maximum bracing. A jack can be loose- or tight-pin hinged to the scenery it is bracing and is held in place with stage weights or sandbags (Figure 10-2d).

There are two categories of joining: (1) fixed or permanent joining and (2) temporary joining. Which one to use relates to the portable nature of scenery and the degree of permanence of the joint. This decision, as well as the joint’s location, can affect the design because the designer and the technical director will seek ways to avoid a visible crack or open joint.

Fixed joining is done as the scenery is built (with use of nails, screws, staples, and so on). A fixed hinged joint is made with **tight-pin hinges** so that units composed of

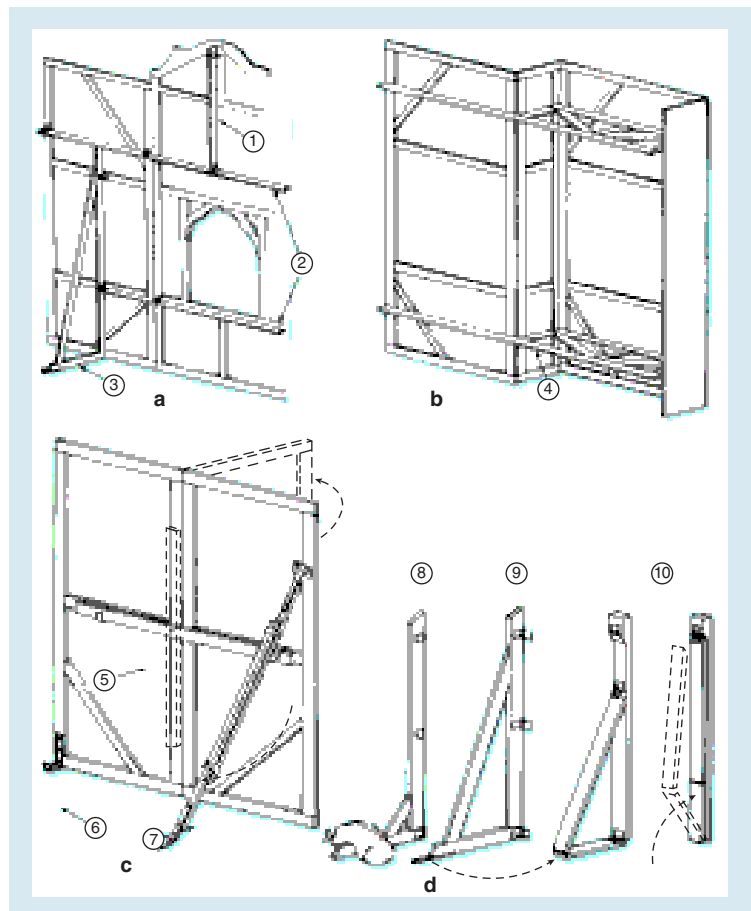
stiffener Usually a 1×3 or 1×4 used horizontally on edge to keep several flats in place, most often on the same plane.

jack brace A triangular structure used to support or brace a vertical flat.

tight-pin hinge A hinge in which the center pin cannot be removed.

10-2 Bracing and Stiffening

- a Stiffening a flat wall:
 - 1 Vertical stiffener.
 - 2 Horizontal stiffener.
 - 3 Jack brace.
- b Stiffening a jogged wall:
 - 4 A framed stiffener that conforms to the shape of the wall.
- c Other bracing and stiffening techniques:
 - 5 A swivel keeper bar and keeper hooks.
 - 6 Bent foot iron and stage screw (rarely used).
 - 7 Adjustable stage brace (rarely used).
- d Jacks:
 - 8 Jackbrace and sandbag.
 - 9 Hinged jack.
 - 10 Folding jack.



several small pieces may unfold into a larger one. A **dutchman** is a thin strip of fabric (same material as that covering the flat) glued to the face of a flat to cover the tight-pin hinges installed on the face. The smaller pieces remain fixed together and travel or move while folded from shop to stage, to be unfolded and stiffened into their final shape in the theatre (Figure 10-3a–d). The typical joining of Hollywood flats uses either bolts or screws through the stiles.

When several small pieces are to be assembled in the theatre, **loose-pin hinges**, screws, bolts, wing nuts, and turnbuttons are used and then braced. The joining of scenery during an act change commonly uses loose-pin hinges, coffin or casket locks, lashing, and stage screws (Figure 10-3e–j).

dutchman A thin strip of fabric used to hide the joint on the face of two adjacent flats.

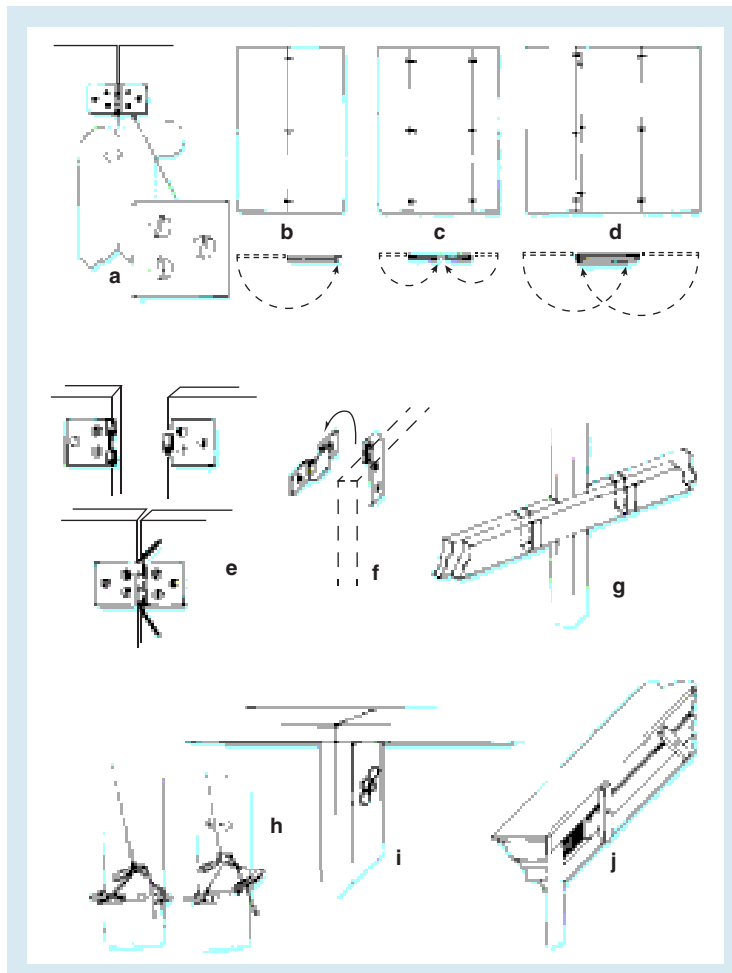
loose-pin hinge A two-piece hinge in which the pin can be removed.

Flying Scenery

A stage house designed to handle scenery in the air will have a flying system with a generous amount of hanging space, which means a high and wide loft. The two most common methods of flying scenery are the *hemp* and *counterweight systems*, shown in Figures 10-4 and 10-5. Both start with an iron grid placed over the stage to support a pulley structure that allows for control of the **line sets**, or **battens**, from one side of the stage. They differ in the complexity of the rigging, cost of installation, and flexibility of use. Other systems, such as the dead lift system, have also been developed to meet ongoing changes in the theatre over the years.

line set A group of three or more lines using the same counterweight to lift a batten or unit of scenery.

batten Pipe batten; horizontal pipe hung from a line set of a fly system.



10-3 Scenery Joints Methods of fastening scenic elements together for either easy handling or a quick scene shift.

Fixed joining:

- a Tight-pin hinge and dutchman.
- b Two-fold: two flats hinged together.
- c Three-fold: two jogs and a flat hinged together.
- d Three-fold with “tumbler” to hinge three full-width flats together.

Temporary joining:

- e Loose-pin hinge.
- f Picture hanger.
- g S-batten hook.
- h Lashing, flush, and around corner (rarely used).
- i Bolting Hollywood flats with bolt and wing nut.
- j Turnbuttons (rarely used).

loft block Any block, or pulley, placed in the grid.

liftline The line running from the batten through the loft blocks (pulley) and the head block (group of pullies) on top of the arbor in a fly system.

spotline (1) Line rigged specially for one production; not part of the standard rig of the theatre. (2) A single rope and pulley used in remote position on the grid; often used to fly scenic pieces that are not parallel to the plaster line.

sheave Pulley; the part of a block that rotates.

tandem head block A grouping of pulleys that carry the lines from individual blocks to the arbor in a counterweight system and to the pinrail in a hemp system.

trim clamp A two-piece metal clamp that is used to bind together the lines in a hemp system, for ease of operation. Also referred to as a Sunday.

pinrail The steel rail on which lines in a hemp system are secured, often by the use of belaying pins.

trim Height of something above the stage floor.

in-trim Position of scenery as it should be when in use: the “in” position.

out-trim Position of scenery when it is not in use: the “out” position.

Grid

As the name implies, the *grid* is an open floor of iron high over the stage: a series of I-beams running parallel to the proscenium arch supporting a perpendicular set of channel iron with three to seven openings, or *wells*. Across each opening, usually 6 to 8 inches wide, are the **loft blocks**, through which each **liftline** runs toward the stage floor. The channel iron strips are set far enough apart to allow the placement of additional pulleys for special **spotlines** (Figure 10-5).

Line Sets

A *line set* is a grouping of three or more lines to be handled as a single unit. The **sheaves**, or pulleys, of a line set are placed over each well and are all the same distance from the proscenium, thus forming a line parallel to the plaster line.

The number of lines in a line set depends on the number of wells in an individual grid. A stage with a wide proscenium opening might have as many as five lines in a set, whereas a smaller stage might have only three lines to a set. The line nearest the control side of the stage is called the *short line*, and the line to the far side of the stage is the *long line*. The line in between is the *center line*.

The Hemp System

The hemp system is the older and more flexible of the two flying systems. It is less costly to install but requires more skill and people to operate. The hemp system typically uses $\frac{3}{4}$ -inch rope for lifelines. As illustrated in Figure 10-4, each line in a line set (2, 3, and 4 in the figure) is attached to the batten (1), passes through the loft block (5) directly above and travels horizontally to its individual pulley in the **tandem head block** (6) located near the stage wall. From the tandem head block, in which the pulleys are mounted in a row, the lines are joined together with a **trim clamp** (7). The trim clamp is also used to adjust the length of each rope in a line set to keep the batten level. A single line attached to the bottom of the trim clamp continues downward and is tied off to belaying pins at the **pinrail** (8). The lower of the two rails is usually the **trim** tie for the scenery in its “in,” or onstage, working position (**in-trim**) and the top rail is the trim tie for the “out,” or stored, position (**out-trim**). A sandbag (9) attached to the trim clamp is used to counterweight a heavy piece for easy handling.

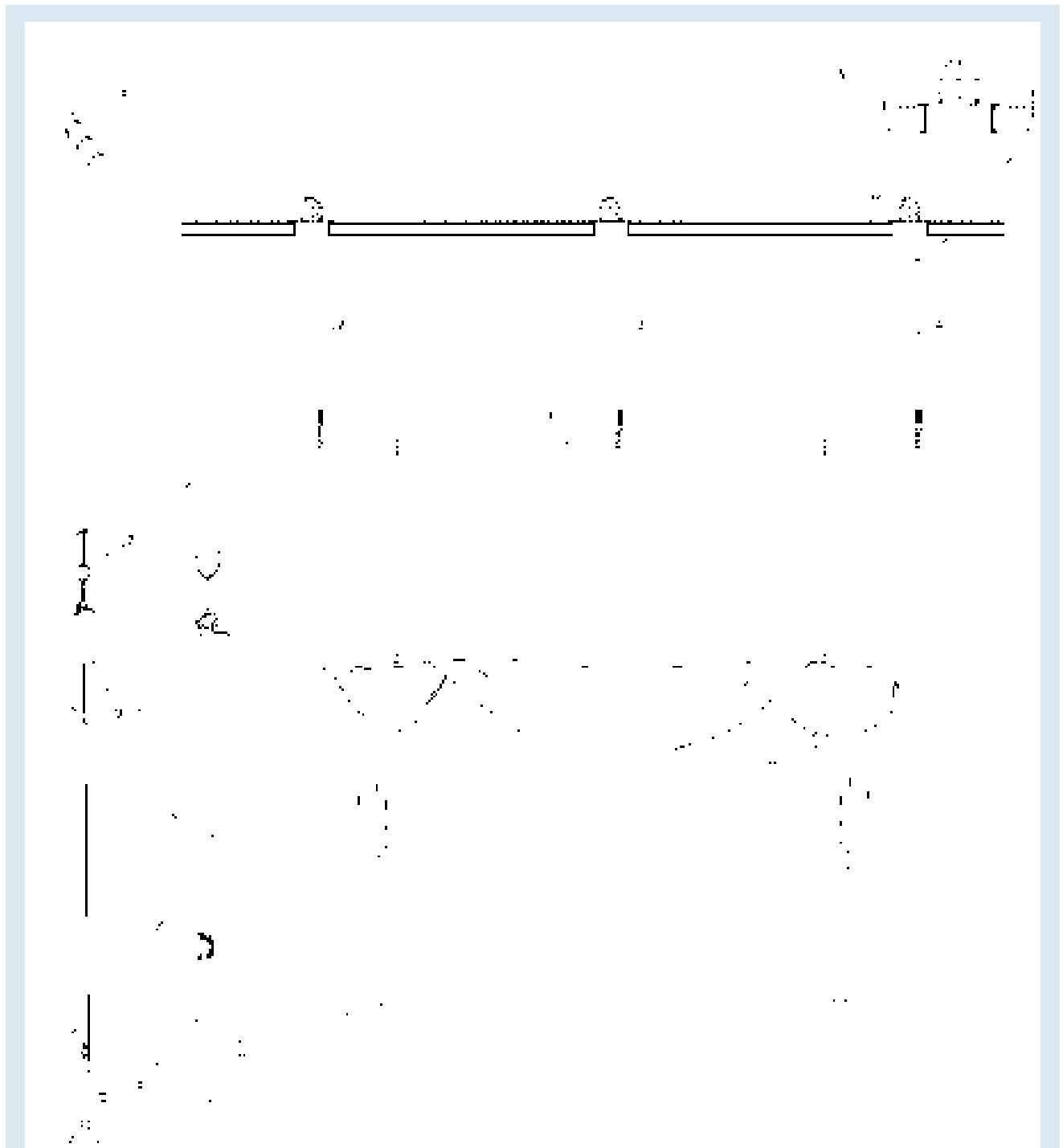
This system must be slightly “batten-heavy” (more weight on the batten and less in the sandbag) to guarantee that the scenic piece will fly in. Note also that hanging very heavy scenery can be problematic with this system. The large number of sandbags that are required to balance the weight of the scenic unit become cumbersome and can get in the way of operation.

The hemp system has great flexibility, allowing for the use of a spotline, a single pulley (or a series of pulleys), and rope in a remote position on the grid. This provides the opportunity to fly a piece of scenery at an angle to the plaster line. A spotline can also be used to pull up lighting cables when they impede moving battens.

The chief disadvantage of a hemp house is in the number of hands required to run a show, as well as the professional skill necessary to rig and safely counterweight heavy pieces of scenery.

The Counterweight System

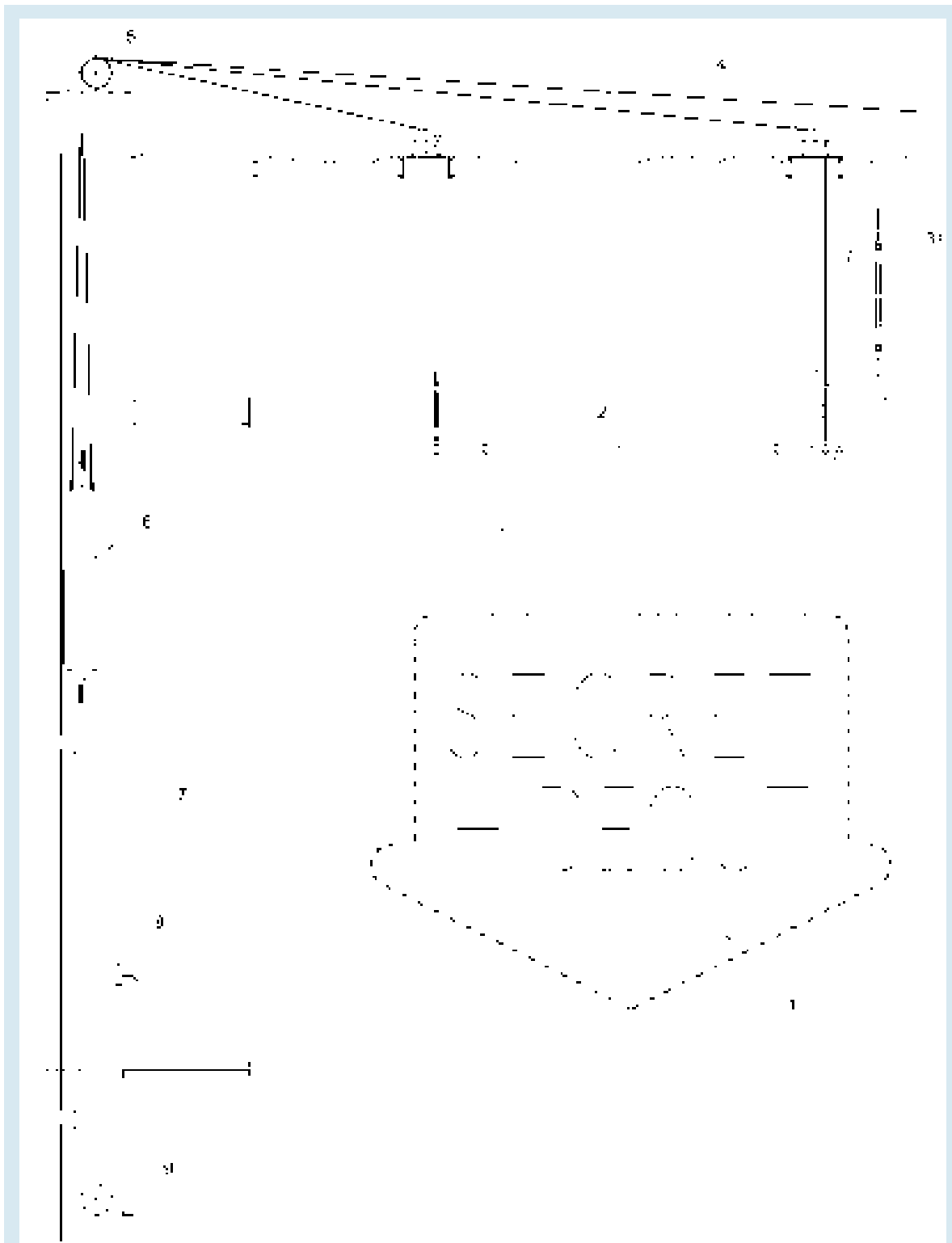
Unlike the hemp system, which can separate lines or add a single line to the line sets, the counterweight system uses fixed line sets. Although the counterweight system was born in an era of box sets and raked scenery, it is rigidly based on wing-and-drop staging. It keeps the lines in sets fixed to a batten parallel to the plaster line.



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10-4 Hemp System

- | | |
|----------------|--|
| 1 Batten. | 6 Tandem head block. |
| 2 Short line. | 7 Trim clamp. |
| 3 Center line. | 8 Pin rail on fly floor (or stage deck). |
| 4 Long line. | 9 Sandbag. |
| 5 Loft block. | |



DRAWN BY BRANDON MCNEEL

10-5 Counterweight System

- | | |
|--|---|
| <ul style="list-style-type: none"> 1 Scenic unit. 2 Batten. 3 Turnbuckle to trim batten to level. 4 Loft blocks. 5 Head blocks. | <ul style="list-style-type: none"> 6 Counterweight arbor. 7 Purchase line. 8 Lock and safety line on lock rail (may be located on the stage deck or fly rail). 9 Tension block. |
|--|---|

In this system, as illustrated in Figure 10-5, a scenic unit hangs from the batten (2), which is permanently attached to wire-rope lifelines (3). Turnbuckles or trimchains connecting the lifelines to the batten enable stagehands to adjust the level of the batten relative to the stage floor. These lines pass through the individual loft blocks (4) at each well, then over a multi-grooved, single-pulley head block (5). They attach to the top of the counterweight arbor (6) which is guided by a T-track (6), or guy wire, and controlled by a separate purchase line (7). Typically made of manila or synthetic rope, the **purchase line** is also attached to the top of the counterweight arbor. It passes up to and through a groove in the head block, turning toward the floor. After going through the locking system (8) on the **fly rail** and around a pulley at the bottom of the system (sometimes referred to as the *idler pulley* or *tension block*) (9), the purchase line turns back and fasten underneath the arbor.

purchase line Rope used to move a batten up and down in a counterweight system.

fly rail Any part of a fly system where the lines are moved in and out and locked into place; also referred to as *locking rail*.

This system leaves two ropes for the operator to use. The outside purchase line moves in the same direction as the batten holding scenery. Pulling down lowers the batten. A corresponding amount of weight placed on the arbor balances the weight of the scenery—the arbor should weigh the same as the scenery hanging on the batten (in contrast to the hemp system, which must be slightly batten-heavy for the system to work).

This kind of system is ideally designed for scenery that hangs parallel to the plaster line. The fixed line sets make this system somewhat inflexible. Most of the rigging time used to hang an angled piece is spent in overcoming rather than using the system. As in the hemp system, spotlines are used; the difference is that in the counterweight system, they are placed individually rather than as part of the entire system.

The Dead Lift System

Both the hemp and the counterweight systems use weights in some fashion to keep the system in balance. This is what allows for ease in movement of the scenic pieces in both the “in” and “out” directions. A third way to fly units of scenery is the *dead lift system*, so named due to the lack of counterweights. Instead, the work is accomplished through the use of electrical **winch**s that have been designed for this purpose. It is most often used for a specific effect such as the falling chandelier in *Phantom of the Opera*. A cable is wrapped around the large grooved drum of the winch. The grooves allow for the ability to control the path of the cable as the drum rotates.

winch A hand-cranked or motor-driven drum rigged with a cable that is used to move scenery.

Rigging

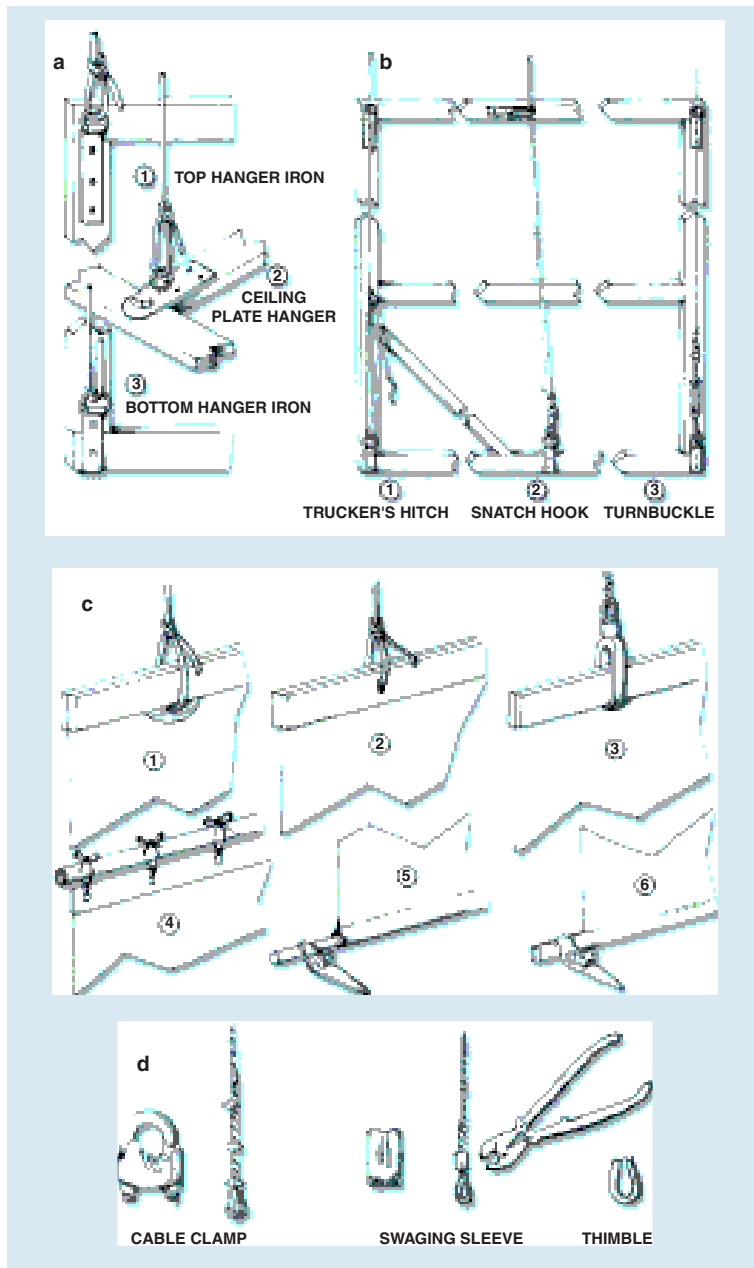
In either a hemp or a counterweight system, stage rigging begins with the relatively simple process of hanging scenery and flying no-longer-used pieces out but includes the handling of stage curtains (such as travelers, contour, etc.) as well as the more complicated maneuvers of breasting and tripping scenery elements.

Hanging Scenery An early and critical step in rigging is the preparation of scenery to hang. To do this, carpenters use hardware or other means to attach the scenery to lifelines. Typically, *hanger irons* or *D-rings* are used on framed scenery. These should be bolted to a vertical member of the frame for greater strength. Except on extremely lightweight pieces, two rings are used, the one at the top serving as a guide for the lifeline that is attached to the bottom. Lifting the load from the bottom not only is safer than lifting from the top but also provides a convenient position from which to trim each line (Figure 10-6).

Cable Clamps Framed scenery is normally hung a distance below the batten with wire rope that is attached to the scenery with special hardware. Figure 10-6 illustrates various methods of termination used to secure the cable to the batten and the scenery.

10-6 The Hanging of Scenery

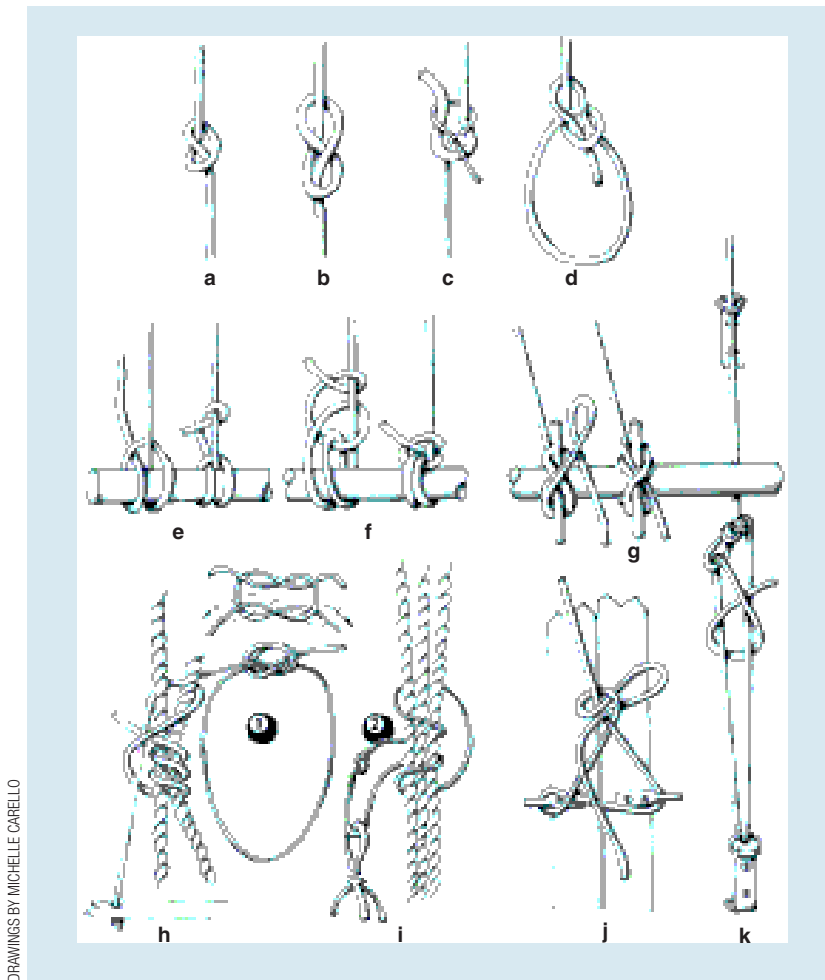
- a** Hanging hardware:
- 1 Top hanger iron, straight.
 - 2 Ceiling plate and ring.
 - 3 Bottom hanger iron (D-ring), hooked.
- b** Trim adjustments:
- 1 Trimming hitch (or trucker's hitch) using hemp rope or sash cord.
 - 2 A snatch line and hook. The snap hook on the end of the lifeline makes it possible to unhook a flown piece of scenery.
 - 3 Turnbuckle on wire cable.
- c** Various methods of hanging a drop:
- 1 Tie around batten.
 - 2 Tie through batten.
 - 3 Drop holder.
 - 4 Tie lines to batten (most common method).
 - 5, 6 Floor stays.
- d** Cable clamps and swaging sleeve (often referred to by the brand name Nicopress).



Cable clamps are used on cable as small as $\frac{1}{8}$ inch. Alternatively, the Nicopress clamp (brand name for *swaging sleeve*) is a very secure, though permanent, fastener. These soft-metal tubes are designed to slide over the cables and are crimped into place with a Nicopress tool (Figure 10-6d).

Unframed pieces of scenery, such as drops and borders, are hung from their tops and can be fastened to a pipe or picked up by a set of lines in many ways, the most common of which is the use of lines tied directly to the batten (Figure 10-6c). If a wooden batten at the top of a drop is used, numerous pickup points about every 6 feet are needed to keep it from sagging and thereby spoiling the trim of the drop. *Bridling* can help in this task, as will be discussed shortly.

Knots Safe stage rigging requires the use of a modest number of knots. Some of the most frequently used knots are illustrated in Figure 10-7. A more detailed and



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10-7 Knots Used in Stage Rigging

- a** Half hitch or overhand knot.
- b** Figure eight. Used to put a knot in the end of a line to keep it from running through a pulley or eye.
- c** Sheet bend. Knot of choice for joining two ropes of equal or different size.
- d** Bowline. A fixed loop used on end of liftline through ring.
- e** Clove hitch on a batten, finished with a half hitch. It grips firmly under tension, but it is easy to adjust or untie.
- f** Fisherman's bend. Excellent for a tie onto a batten. Not as easy to adjust as the clove hitch.
- g** Half hitch over a belaying pin. Used as a tie-off on a pinrail.
- h** Stopper hitch, made with a smaller line in the middle of a larger rope. The safety line on the counterweight lock rail uses a stopper hitch on the purchase lines.
- i** Sunday:
 - 1** A method of joining the ends of a small loop of wire cable without putting a sharp kink in the cable.
 - 2** The loop is then used to clew a set of rope lines together so as to counterweight them with a sandbag.
- j** Lash line tie-off.
- k** Trimming hitch, to adjust the trim of a hanging piece of scenery.

comprehensive manual of knots and splices can be found in the catalogs of cordage companies (see Additional Reading, at the back of this book).

However familiar we are with square knots, they are to be avoided in stage rigging because they can undo themselves quite easily. Given the potential danger involved in even the simplest rigging, the technical director and anyone who supervises rigging *must* be skilled in the use of at least a few of the knots and hitches that appear in stage rigging. Great care and caution should prevail.

Breasting Scenery Regardless of which flying system is used, two pieces of scenery cannot occupy the same space at the same time, although the designer may wish they could. Consequently, it sometimes becomes necessary to move a unit away from its natural hanging position with breasting lines to bring it to its desired or needed position, and vice versa. A **breasting** line is usually dead-tied at one end to the gridiron or side-stage position and fastened to the scenery at the opposite end. When the piece is in its stored or “out” position, the breasting line is slack, but as the piece comes into its working position the breasting line becomes taut and breasts the unit off dead-center hanging. (Several breasting maneuvers are illustrated in Figure 10-8.)

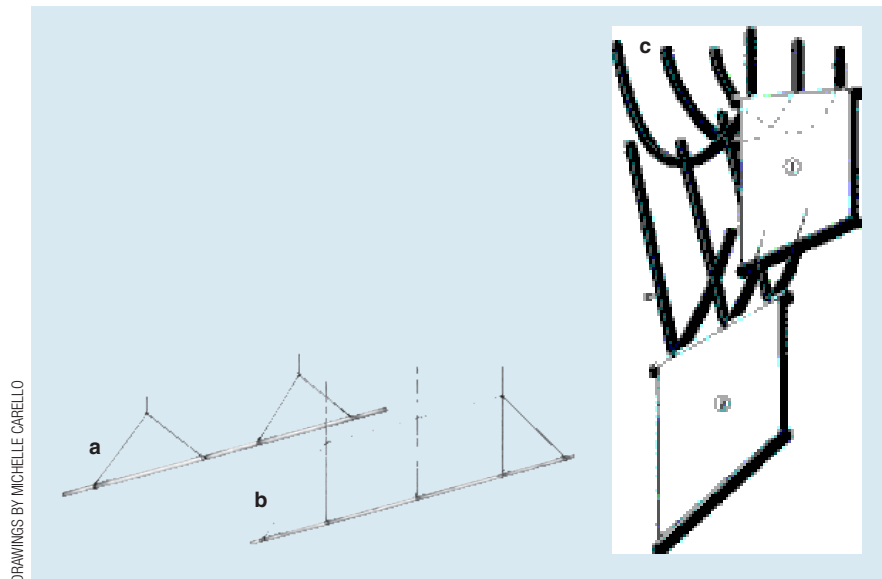
Bridling The **bridle** is a simple rigging used to spread the load picked up on one line (Figure 10-8). This is a particularly useful technique when it is necessary to extend a batten farther offstage than other techniques would allow.

breasting Moving a hanging unit of scenery away from its working position to make room for (usually) another piece of scenery or an electric (a pipe used for lighting instruments).

bridling Extending the line set by adding a length of pipe and tying it diagonally to the liftlines.

10-8 Bridling and Breasting Techniques

- a A simple bridle.
- b A bridle of a set of lines to support the overhang of an extra-long batten.
- c Breasting a drop up- and downstage:
 - 1 Stored position.
 - 2 Working position.



tripping Picking up the bottom of a drop as well as the top when there is not enough room to fly it completely out.

roll drop A drop wrapped around a long horizontal roller (usually like a big blind); also called an *oleo drop*.

Tripping Scenery Many rigging problems result from too low a grid or the complete absence of one. **Tripping**, which can be used only on soft or semisoft scenery, is one way of flying scenery in a limited space (Figure 10-9c–e). By picking up the bottom of a drop as well as the top, scenery can be flown in at half the height necessary to clear a full drop. The height can be further reduced by picking up the drop a third of the height off the floor and thereby tripping the scenery in thirds.

A **roll drop**, or *oleo drop*, is an extreme variation of tripping. In this method, the drop is wrapped around a drum attached to the bottom edge (Figure 10-9a–b). Many old opera house and vaudeville drops were rigged in this manner, and it still is a good way of flying a drop on a stage with reduced flying space.

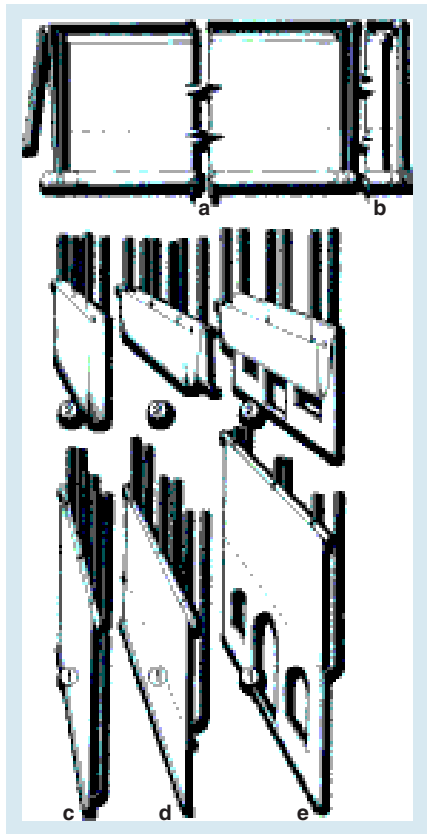
Levitation The flying of objects or persons, as if in defiance of gravity, requires special rigging. To create the illusion of floating in space, an object must be supported on as fine a wire as possible so that the support disappears from view at a distance. Lightweight objects such as a bat or a bird can be supported on fishing line (20-pound test), which becomes invisible at a short distance.

The size and strength of the support wire to fly an actor, however, is more critical. Any circumstance that requires the flying of a human being is best performed by a company that has made a specialty of flying actors. Each of these companies has developed its own proprietary method of rigging for flying.

This is *not* something an untrained person should try; it is far too dangerous. To create a workable setting for flying actors or objects, a designer must be familiar with the spatial requirements for a flying effect. The right kind of background, properly planned exits and entrances, and atmospheric lighting can serve to mask or to camouflage any exposed support wires and highlight the illusion but must be designed in discussion with the flying specialist.

Variable Load

Of the many rigging problems experienced with conventional flying systems, the most challenging is the variable load or unbalanced condition resulting from the removal of part or all of the scenery load from a set of lines. The *deus ex machina*, descending with a live cargo of gods or goddesses and then ascending to the heavens empty, is one example.



10-9 Tripping Techniques

- a The roll (oleo) drop, which rolls on the bottom batten or drum. *Note:* The rigging of the rope gives the operator a mechanical advantage of two. The drop is made with horizontal seams to make it roll flat.
- b An alternate rigging. The liftline has equal turns on the end of the drum, in reverse direction of the drop. When the liftline is pulled, it unwinds as the drop winds onto the drum and thus rises.
- c Tripping a drop. Back set of lines is attached to bottom batten:
 - 1 Working position.
 - 2 Stored or *tripped* position.
- d Tripping in thirds. Upstage batten is attached at one-third height of the drop off the floor.
 - 1 Working position.
 - 2 Tripped position.
- e Tripping a drop that has the lower portion framed:
 - 1 Working position.
 - 2 Tripped position.

DRAWINGS BY MICHELLE CARELLO

The easiest method of handling a variable load is the **dead haul winch**, which is unfortunately not always available. There is no counterweight in this system. It has instead a wide operating range of load—up to 400 pounds—so a counterweight is not necessary.

Any larger weight variation has to be handled by an electric floor winch or a hand winch, which provides a mechanical advantage to offset the unbalanced load condition. In either case, extreme care must be taken ensure that the load is properly managed.

dead haul winch A winch that lifts a load that has not been counterweighted.

Curtain Rigging

The moving of stage curtains, beyond the simple raising or lowering on a batten, involves many and varied actions. Most commonly, curtains are: (1) drawn horizontally from the sides, (2) tripped diagonally into a tableau shape, or (3) tripped vertically into the varied patterns of a contour curtain.

Traveler or Draw Curtain The horizontally drawn curtain is referred to as a **traveler**. With this kind of action, the curtain is divided in half, overlapping at the center. Each half follows a separate section of track. The track guides the carriers, which are attached to the top edge of the curtain at about 1-foot intervals. A drawline is fastened to the first or lead carrier, which pushes or pulls the rest of the carriers to open or close the curtain. Several track and carrier designs and the rigging of the drawline are illustrated in Figure 10-10.

traveler Any curtain that is drawn in a horizontal direction; also called a *draw curtain*.

On occasion, a one-way traveler is needed, in which case the curtain is drawn onstage from one side on a single long track instead of coming from the two opposite sides of the stage, as shown in Figure 10-10b. Also illustrated is a rear-fold device that causes all carriers to move at once rather than being pushed or pulled by the lead carrier (Figure 10-10c).

Tableau Curtain Like the traveler, the **tableau curtain** is made up of two curtain panels hung with a center overlap and from a single batten. Each panel is lifted or tripped by a diagonal drawline attached to the central edge, about a third of its height off the

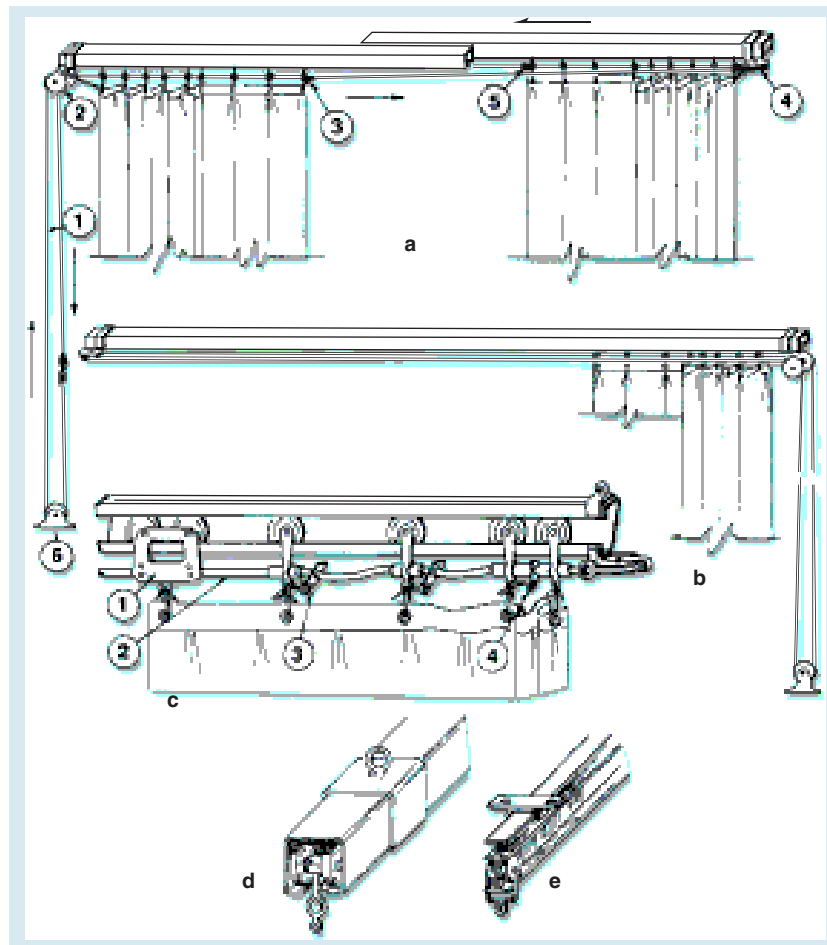
tableau curtain Two overlapping panels of fabric that are rigged to pull open on a modified (curved) diagonal.

10-10 Traveler Curtains and Tracks

- a** Rigging of a draw curtain or two-way traveler:
- 1 Drawline.
 - 2 Head block.
 - 3 Lead carrier on downstage curtain, fastened to drawline.
 - 4 Change-of-direction pulley.
 - 5 Lead carrier on upstage curtain also fastened to drawline.
 - 6 Floor block.
- b** One-way traveler curtain.
- c** Detail of rear-fold attachment. All carriers move at once with drawline and curtain folds offstage rather than bunching onstage.
- 1 Lead carrier.
 - 2 Drawline.
 - 3 Rear-fold attachment grips drawline until the attachment is straightened up by bumping into the next carrier.
 - 4 Drawline now passes through the rear-fold attachment.

Two types of traveler tracks and carriers:

- d** Square steel track with double-wheel carrier.
- e** I-beam track (hospital curtain track for lighter-weight drapery).



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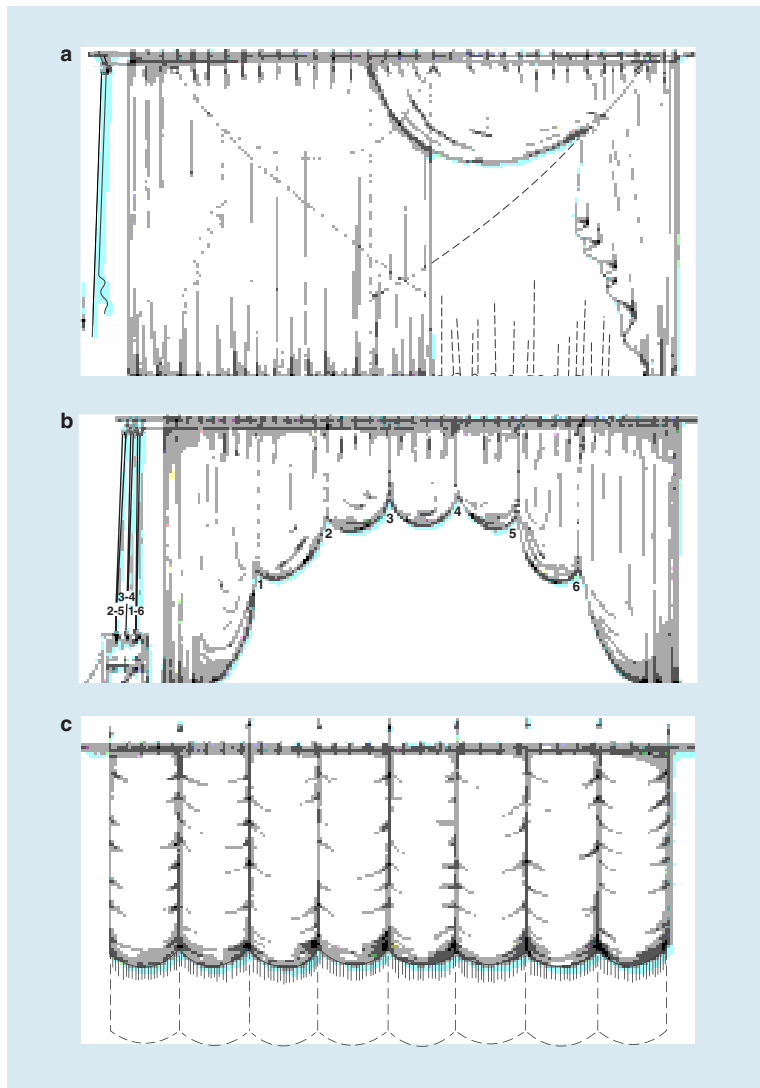
floor, that runs through a series of rings on the back of the curtain to a pulley on the batten (Figure 10-11a). The specific way the curtain drapes is determined by the placement of these rings. The rings can be individually sewn onto the fabric, although it is more efficient to use *ring tape*, a narrow band of tightly woven fabric with plastic rings stitched onto it at regular intervals. The tableau has a quicker action than does a traveler, but it does not lift completely out of sight unless the batten is also raised. Because of its picturesque quality, the tableau curtain is used as a decorative frame.

contour curtain A curtain that is rigged with several separately operated drawlines that can create a variety of shapes when the curtain is open.

Contour Curtain The **contour curtain** is one piece (typically several panels stitched together) with great fullness, usually about 200 percent of the curtain width. The curtain, which is made of material that drapes well, is tripped by a series of vertical drawlines attached to the bottom edge of the curtain and running through rings, again using ring tape on the back, to pulleys attached to the batten. If you vary the lift on certain lines, the bottom edge of the curtain can take on many different contours (Figure 10-11b).

Austrian drape Sometimes referred to as a *brail curtain*; a curtain that is rigged with a series of vertical drawlines that lift at the same time and at the same speed.

Austrian Drape To achieve a faster and more decorative lifting action than the slow side motion of a traveler, a curtain is sometimes rigged as an **Austrian drape** (or *brail curtain*). In this case, the amount of lift on each drawline is equal. Some fullness is extremely helpful to the decorative quality of an Austrian drape, although it is not absolutely necessary. To add a decorative quality, fabricators can give the curtain horizontal fullness by gathering material on the vertical seams, thereby producing a series of soft swags (Figure 10-11c). Without any fullness, when the brail curtain is raised, the side will have a strong tendency to angle toward the center. The Austrian drape serves well as the grand drape in a theatre that has little or no fly space.

**10-11 Front Curtain Riggings**

- a Tableau curtain.
- b Contour curtain. The liftlines are numbered 1–6. The lines are paired 1–6, 3–4, and 2–5.
- c Austrian drape.

DRAWINGS BY MICHELLE CARELLO

Scenery on Casters

Mounting a three-dimensional piece of scenery on casters makes moving it on the floor easier and faster. Such mounting can vary from a single caster on the edge of a hinged flat to a large castered platform or wagon large enough to move an entire set.

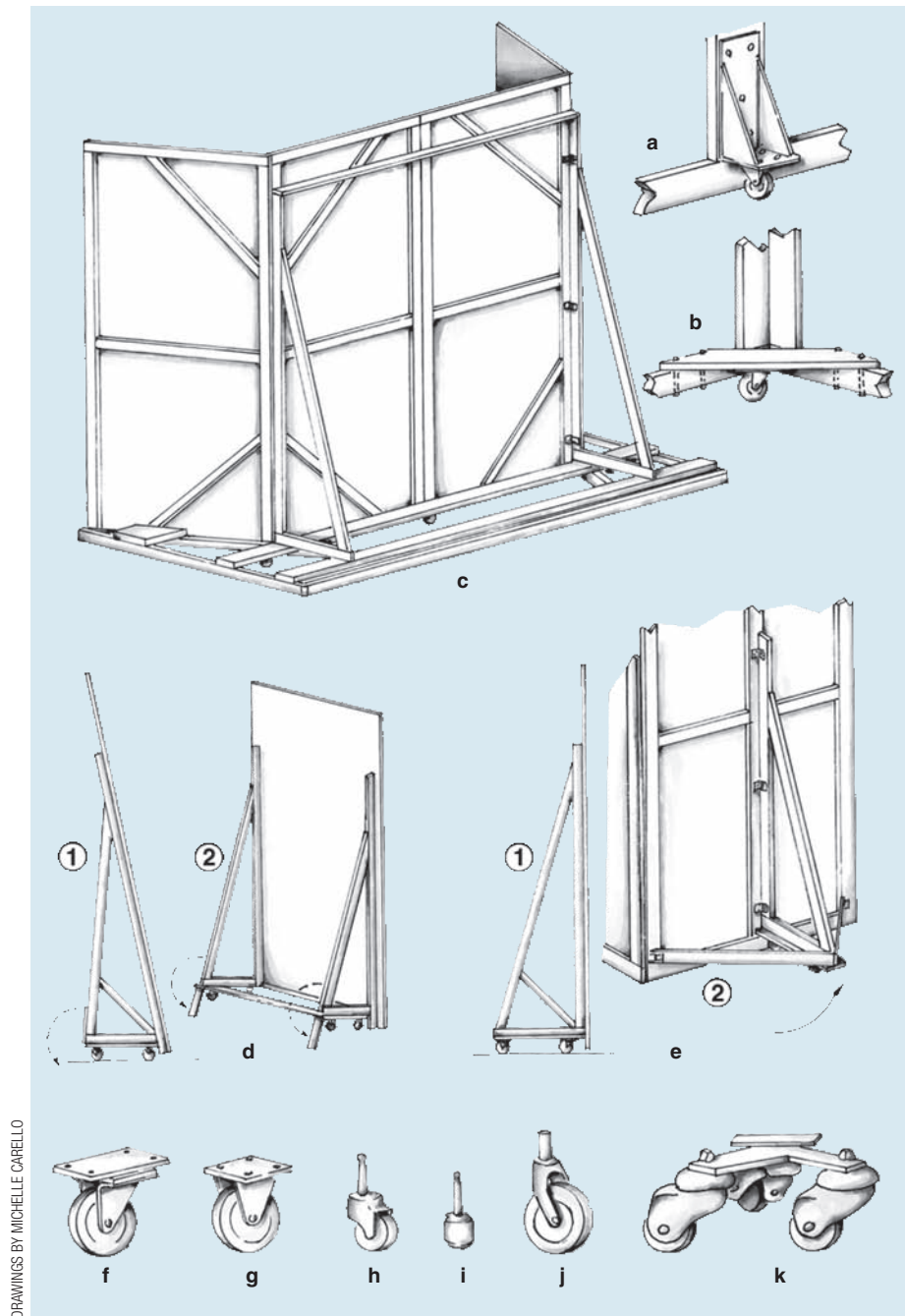
Casters

The stage places special demands on casters. A good stage caster should first of all run quietly, which requires a rubber wheel or a rubber-tired wheel. The rubber-tired wheel is a better long-term investment because the tires can be replaced as they wear. One must balance the softness of the wheel against its capacity and resistance. The softer the wheel, the quieter it is, but the harder it is to move and the lower the capacity, or load, it will take.

Second, the caster wheel should have as large a diameter as possible (3½ to 4 inches). The larger the diameter, the smaller the resistance. A wagon on 4-inch-diameter casters rolls with little effort and is not easily stopped by small obstructions such as rugs, padding, a ground cloth, or lighting cables. With the softness of rubber but less resistance and

10-12 Castering Techniques

- a Single caster mounted on rear of flat.
- b Single caster mounted in corner.
- c Outrigger wagon.
- d Tip jack:
 - 1 Scenery tipped back to rest on casters.
 - 2 Scenery upright; blocked-off caster in working position.
- e Castered jack:
 - 1 Side view showing how scenery is held clear of floor.
 - 2 Caster jack on a hinged or “wild” piece of scenery.
- f Flat-top swivel caster.
- g Flat-top fixed caster.
- h Stem-type swivel caster for furniture.
- i Small stem-type ball caster for furniture.
- j Large stem-type swivel caster; mounts into bottom of scaffolding pipe.
- k Triple-swivel caster (zero-throw caster).



greater durability, polyurethane wheels are the standard. They wear like steel, are rugged, and cost about the same as good rubber.

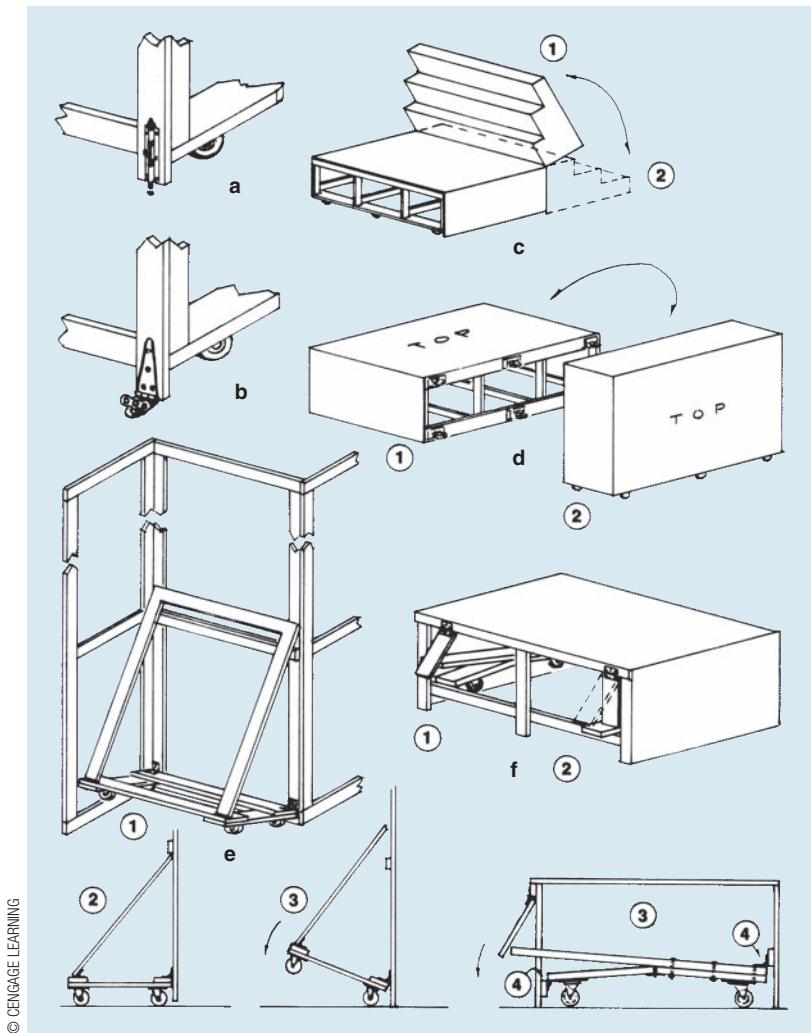
Casters are of two general types: those made to move freely in any direction and those made to move in a fixed direction. The **swivel caster** has a free action that allows it to move in any direction. Changing the direction of a swivel caster, however, requires force to alter the “throw,” or the direction the caster is facing. The **fixed caster** is limited to one direction. A refinement of the typical swivel caster incorporates a mechanism that locks the swivel action, thereby creating the equivalent of a fixed caster. (See Figure 10-12 for examples of casters.)

A third type of caster, the **triple-swivel caster**, or *zero-throw caster*, is mounted on three wheels around a central point, allowing for easy turning. Changing directions requires minimal effort compared with moving the swivel caster.

swivel caster A caster that allows movement in any direction.

fixed caster A caster that allows movement in only two directions.

triple-swivel caster Also called a *zero-throw caster*; a caster mounted on three wheels around a central point for easy turning.



10-13 Methods of Stabilizing Castered Units

- a Barrel bolt fits into hole in stage floor.
- b Hinged foot iron and stage screw.
- c Portion of platform not on casters:
 - 1 Steps hinged to castered platform fold on top for easy movement.
 - 2 Unfolded and resting on the stage floors, the steps stabilize the platform unit.
- d Casters on offstage edge of platform:
 - 1 Platform in working position, casters on back edge.
 - 2 Platform tipped onto casters for easy movement.
- e Lift jack:
 - 1 Full view of lift jack.
 - 2 Side view showing jack lifting scenery.
 - 3 Jack released, scenery resting on floor.
- f Lift jack under a platform:
 - 1 Jack released.
 - 2 Jack depressed to lift platform on casters.
 - 3 Section view.
 - 4 Note the eccentric hinging.

Lift and Tip Jacks

Mounting scenery on casters in order to make it move easily creates the paradoxical problem of anchoring, or preventing the unit from moving at an undesirable moment. *Lift* and *tip jacks* lift the scenery off the floor and onto the casters. With the tip jack, the scenery is literally tipped back onto the castered structure. The lift jack has a simple mechanism to force the casters to the floor. In both cases, the scenery sits firmly on the floor when it is in its working position.

Another way to anchor a castered platform or a bulky three-dimensional piece of scenery is to attach it to units that are sitting on the floor or by tipping the piece onto casters mounted on its offstage or upstage edge (Figures 10-13d and 10-13e).

Outriggers

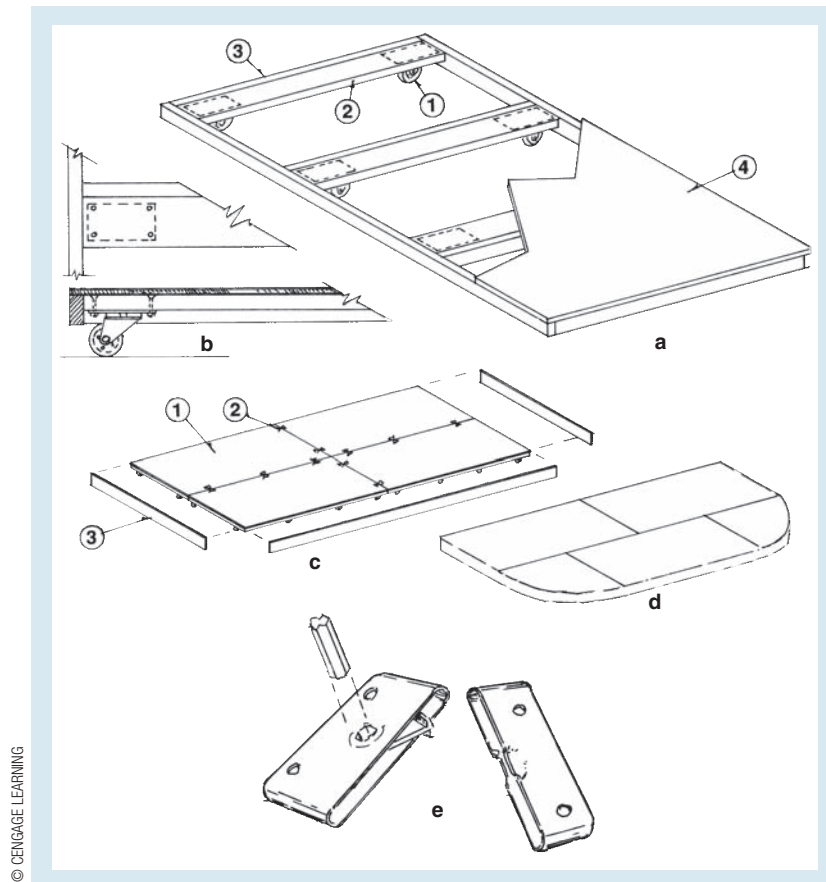
An *outrigger* is essentially a pattern of castered jacks or braces around the outside of a set or portion of a set. The scenery remains on casters. This skeletal frame braces and casters the scenery. The action of the scene is played on the stage floor (Figure 10-12c).

Wagons

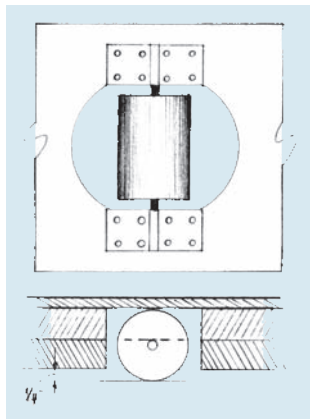
The low-level platform (6 to 8 inches) on casters, called a *wagon*, can carry a large portion of a set, props, or actors. Large wagons can carry an entire setting, allowing for a

10-14 The Wagon Unit

- a** Construction of a stock wagon:
- 1 4-inch swivel casters.
 - 2 2 × 6 caster planks.
 - 3 2 × 4 frame.
 - 4 4 × 8-foot, ¾-inch plywood top.
- b** Section view
- c** Large wagon made up of stock units:
- 1 Stock unit.
 - 2 Units pin-hinged together.
 - 3 Facings.
- d** A different shape made of three stock wagons and two special corner pieces.
- e** Casket locks to lock wagons together.



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- 10-15 Pallet** Two layers of ¾-inch plywood provide enough depth for a small roller, allowing the pallet to move.

pallet A wagon with a very low profile; also called a *skid*.

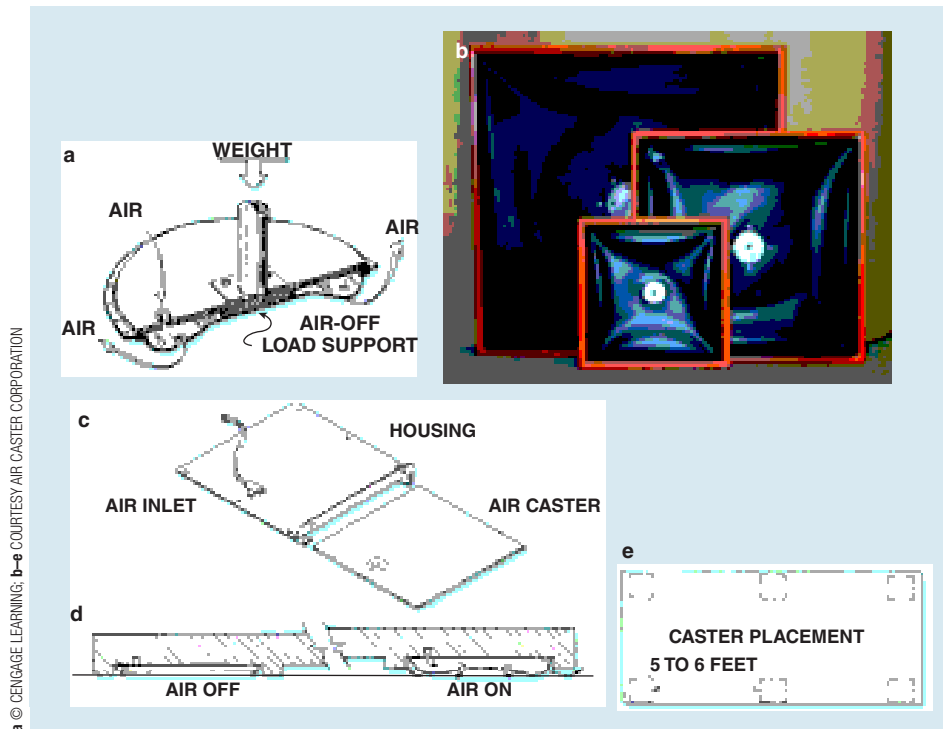
swift and easy scene change. Although it requires ample floor space, the wagon is a flexible and efficient method of handling scenery.

Wagon construction is basically the same as platform construction, with the casters serving as “legs.” Because it spreads the load, the use of a *caster plank* (1 × 6 or wider) to which the casters are attached allows for an increase in the minimum span between casters. In addition to providing a sturdy mount for the caster, the caster plank serves as a support to increase the overall strength of the wagon. Normally, unless the wagon is to carry an extremely heavy load, such as a piano, spacing the casters at 3-foot intervals is sufficient.

Stock wagon units made in a convenient size for handling (3 × 6 foot or 4 × 8 foot modules) are joined to make larger units (Figure 10-14). The flexibility of arrangements and the handling and ease of storage justify the module system.

Wagon modules can be fastened together to make up a larger wagon unit with a hidden fastener, the casket lock. The two halves of the lock are mounted opposite each other in countersunk slots. Through an access hole in the top, the two halves of the fastener are locked together with an Allen wrench–type key (Figure 10-14e).

There are times when a wagon with a very low profile is needed; this wagon is called a **pallet** (generic term) or *skid* (technically a wagon without wheels) (Figure 10-15). These very low platforms are often used to carry furniture and actors onstage. A pallet could be a thin sheet of plastic (the problem is high resistance) or ¾-inch plywood on glides. A hard surface, such as a polyurethane seal on the stage deck, will facilitate a smooth operation. If possible, the pallet should be built of two layers of ¾-inch plywood skinned with Masonite or another finished surface. Small rollers are then embedded into the structure to allow for movement. The plywood can be beveled to soften its edges, making it less visually intrusive.



10-16 Air-Bearing Casters

Round-pad air caster:

a Sectional view. Note the built-in air-off support.

Square-pad air caster:

b Single pad.

c The air-off load support has to be built into the platform structure.

d Section showing position of wagon with air on and air off.

e A perimeter placement of casters is recommended for easy access.

The Air-Bearing Caster

The air caster lifts a wagon or a heavy unit of scenery on a film of air for easy movement on- or offstage (Figure 10-16). The air supply can be from one of two sources: a low-pressure air blower or a high-pressure air compressor. The low-pressure air blower delivers an even flow of air at a constant pressure and is more economical but entails a larger air caster unit. The air compressor can use a smaller lift unit, but it is more expensive and requires a storage tank to maintain an even pressure. Even so, many shops already have a fixed air compression system with hookup positions in the scenery shop for pneumatic tools, in the paint shop for spray gun painting, and sometimes on the stage as well. An extra storage tank will help avoid a loss of pressure during use.

For air casters to work properly, the floor must be smooth and level, as you would likely find in a television studio. Stage floors are notorious for being irregular and rough, often making them inappropriate for air caster use.

The big advantage of the air caster is that it can be quite small, needing only a short wagon, yet it can still lift a huge amount of weight. A 1-foot-square caster charged at 60 psi (pounds per square inch) can lift more than 4 tons:

$$(1 \text{ sq. ft.} = 144 \text{ sq. in.}; 60 \text{ psi} \times 144 \text{ sq. in.} = 8,640 \text{ lbs})$$

Wagon Movements

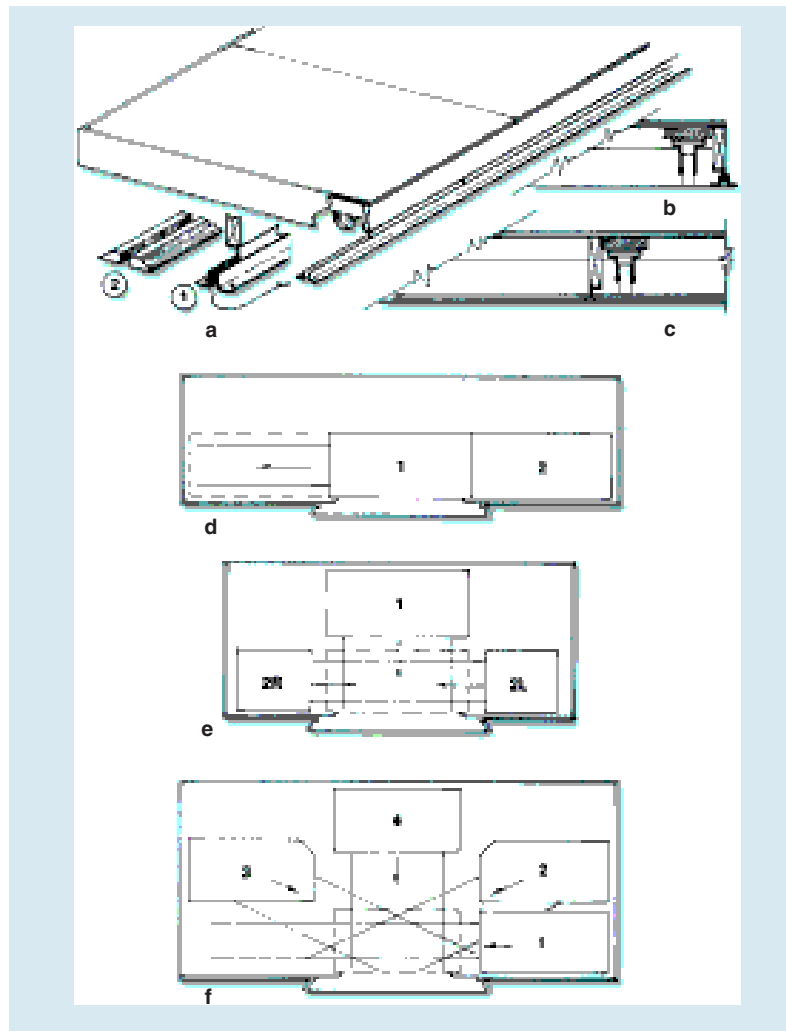
Aside from the free movement of a wagon carrying a full or partial set, there are several controlled movements that can become a scheme of production for handling scenery entirely on casters. These involve the construction of tracks either above the stage floor or recessed into it (Figure 10-17). The scheme is sometimes based on a pair of alternating wagons, allowing the scenery and props to be changed on the offstage wagon while the alternate wagon is in the playing position. The transverse, jackknife, and split-wagon movements operate on this principle (Figure 10-18). Cables drive the platforms along the tracks (Figure 10-17). Scenery rigged in this manner can be manually operated, machine operated, and, if budget allows, automated.

10-17 Tracked Wagon Movement

- a** Tracks on top of the stage floor. This technique is inherently problematic if actors need to walk in the area of the stage where there is tracking.
- 1 Steel angle irons.
 - 2 Beveled wood; quieter than steel on steel, but more subject to wear.
- b** Section detail.
- c** Section showing track cut into the stage floor. In an elaborate tracked wagon scheme such as those diagrammed in (d), (e), and (f), a *show deck*, or temporary stage floor, is installed with space beneath the track groove for cables to drive the wagon unit by hand winch from an offstage position.

Types of tracked wagon movement:

- d** Transverse movement.
- e** Slit transverse wagons and a large single wagon moving up- and downstage.
- f** Multimovements: transverse, diagonal, upstage, and downstage.



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When a production uses small sets, keeping each set intact on separate wagons can work. The stage then becomes packed with wagon sets, and the shifting is accomplished by shuttling each wagon into position. The pattern of movement varies with the size and shape of the sets, their order of appearance in the play, and the design.

Current technology has made the electric motor winch the standard for moving scenery; the biggest hurdles are the expense and the added time needed to set up the mechanism. Moreover, any winch is also rather large, so the initial plan must provide a convenient and large enough space. Advances in the control of electric winches have made it easier to use off-the-shelf components to build a custom mechanism. New technology allows the motor itself to do most of the work. Hydraulics are still used, particularly for high-end productions and in small spaces; they take up less space than do electromechanical parts.

The Mechanized Deck

Modern, large-scale productions often involve extensive use of mechanized movement. The standard today is for a multiple tracking system built into a *show deck*. All of the component parts needed to move scenic units are built into this deck (as opposed to on top of it). The tracks in the deck can be controlled by the use of manually or electrically operated winches. The easiest movement is linear.

This closed-loop system allows the scenic unit to be pulled in either direction along each *track*, or long, narrow slot built into the deck. To each piece of scenery is attached a *drop knife*, or metal plate approximately $\frac{1}{4}$ inch by 4 inches, which fits through the track. A cable following the direction of the track is wound about the winch on one side and a pulley on the opposite side, forming a long loop. Connecting the drop knife to the scenic unit is a *dog* that allows the scenic unit to follow the path of the track pulled by the cable. The previously mentioned pallets or skids are usually moved in this manner (Figure 10-19).

The drop knife can be removed in order for one winch or the same track to be used to move multiple pieces of scenery. In other words, one track can be used to move more than one wagon.

Because of the amount of scenery and the lack of wing space in many of the Broadway houses, scenic units that come offstage are often released from the dog and then lifted by chain motors into the air to keep them out of the way. It is not unusual in a big musical to see a vertical line of scenery hanging in the air backstage.

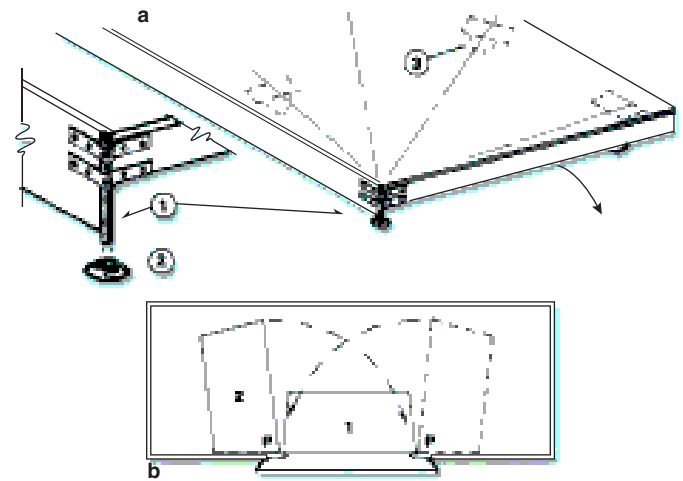
The Revolving Stage

Another controlled movement is that of a castered unit around a fixed pivot: a *turntable*, or revolving stage. Such a stage, which is occasionally built into the stage floor, has a structure similar to that of the wagon. To remain portable, a turntable is made in smaller sections that are fastened together (Figure 10-20). The fixed casters are mounted in a pattern to support each unit properly and are fixed in a position in which the axle of the caster is on a radius line drawn from the pivot point. If the casters are carefully mounted, the turntable will revolve about its pivot point with little effort.

An alternative method reverses the normal position of the casters under the table and places them upside down on the stage floor (Figure 10-20c). The casters are placed in concentric circles as bearing points on a prepared rolling surface on the underside of the table. Each caster is shimmed to the same height to ensure a level turntable floor. This compensates for any irregularities in the stage floor. Although the assembly time is longer and the table is a little higher off the stage floor, the result is a smooth-running, quiet turntable. Figures 10-20 and 10-21 illustrate the assembly steps as well as the motorized cable drive for powering a revolving stage.

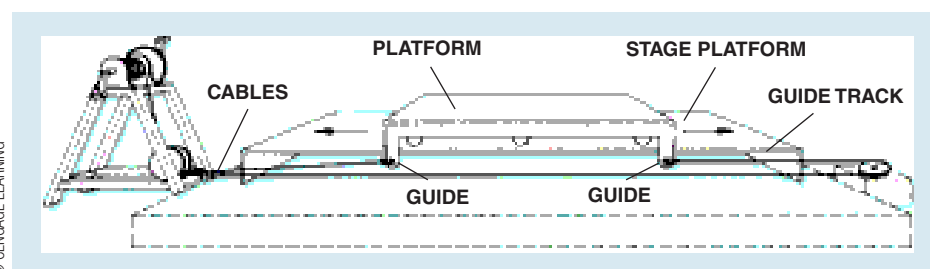
With careful planning, a clever designer can use a turntable for extremely effective scene changes. The use of one or more turntables can provide a wide variety of patterns in moving scenery as well as actors on- and offstage. The standard methods of turntable configuration are discussed as follows.

Single Turntable The large single turntable is the most common. Figure 10-22 illustrates some typical methods to power this structure. The stage's depth limits the diameter



10-18 Pivoted Wagon Movement

- a** Pivot mounted on corner of wagon.
- 1** Pivot detail.
 - 2** Socket fastened to floor at pivot point. Although the pivot and socket positions are often reversed in a turntable installation, it is best under the illustrated conditions to place the socket on the floor. Besides having an awkward mounting position, a corner pivot may also have to bear weight because the nearest caster is usually about 4 feet away.
 - 3** Fixed caster set perpendicularly to radius.
- b** Jackknife wagons.



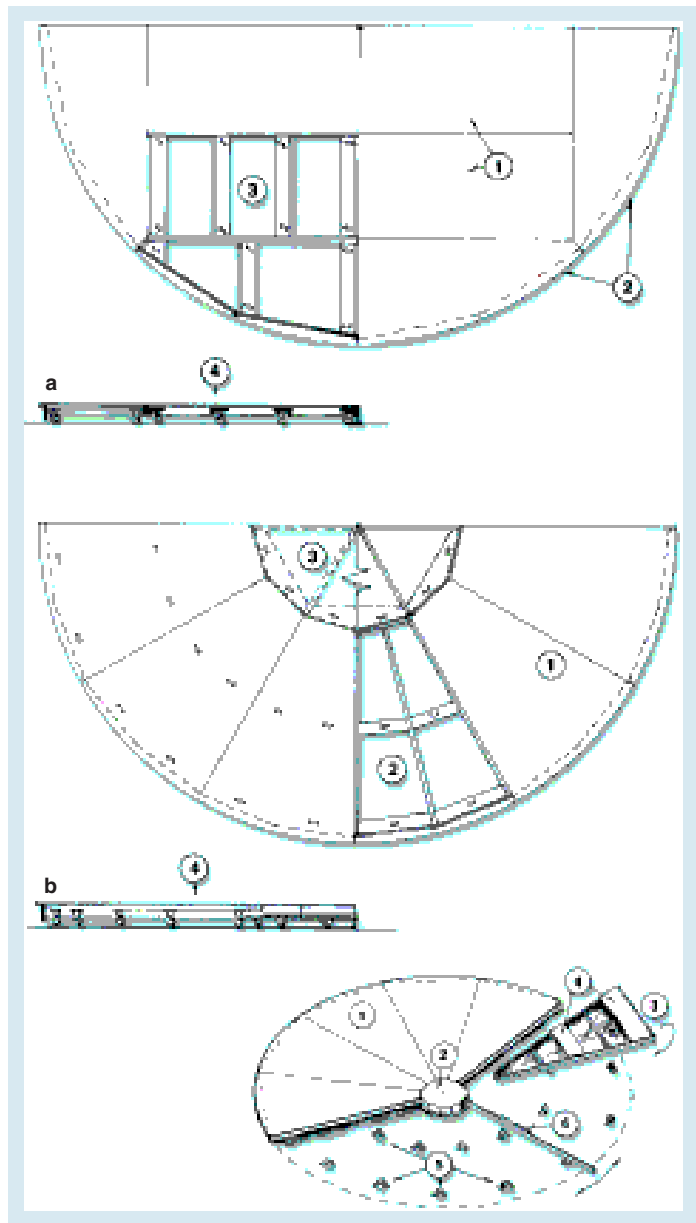
10-19 Cable Drive for Moving Wagons

The drive cable is hidden from view under a raised stage floor and attached to wagon guides, right and left. The cable turns on the drum of the winch to pull the wagon to the right or left. Remember that with cable-driven wagons, the tracks cannot cross each other.

10-20 The Revolving Stage A portable revolving stage or turntable can be built many ways. Shown here are two methods.

- a** Turntable made up of stock wagon units with special-shaped wagons to form the curve of the outside edge:
- 1 Stock wagon.
 - 2 Custom-shaped wagon to complete circle.
 - 3 Casters blocked perpendicularly to radius.
 - 4 Section.
- b** Turntable made of wedge-shaped units around central core; fewer casters are used, creating less noise:
- 1 Basic wedge-shaped unit.
 - 2 Top removed, showing the position of casters.
 - 3 Central core.
 - 4 Section view.
- c** Turntable construction, reverse castering:
- 1 Basic wedge-shaped unit.
 - 2 Central core; ball-bearing pivot.
 - 3 Single unit viewed from underneath to show framing.
 - 4 Bearing surface in path of casters; $\frac{3}{4}$ -inch plywood or particle board.
 - 5 Casters mounted on the stage floor in patterns that have the same circumference as the caster-bearing surface on the underside of the turntable.
 - 6 Spirit level and rotating bar to check the level of each caster mount to ensure smooth rotation.

Although the reverse caster turntable takes longer to assemble, it is quieter and easier to turn than the conventional castered unit.

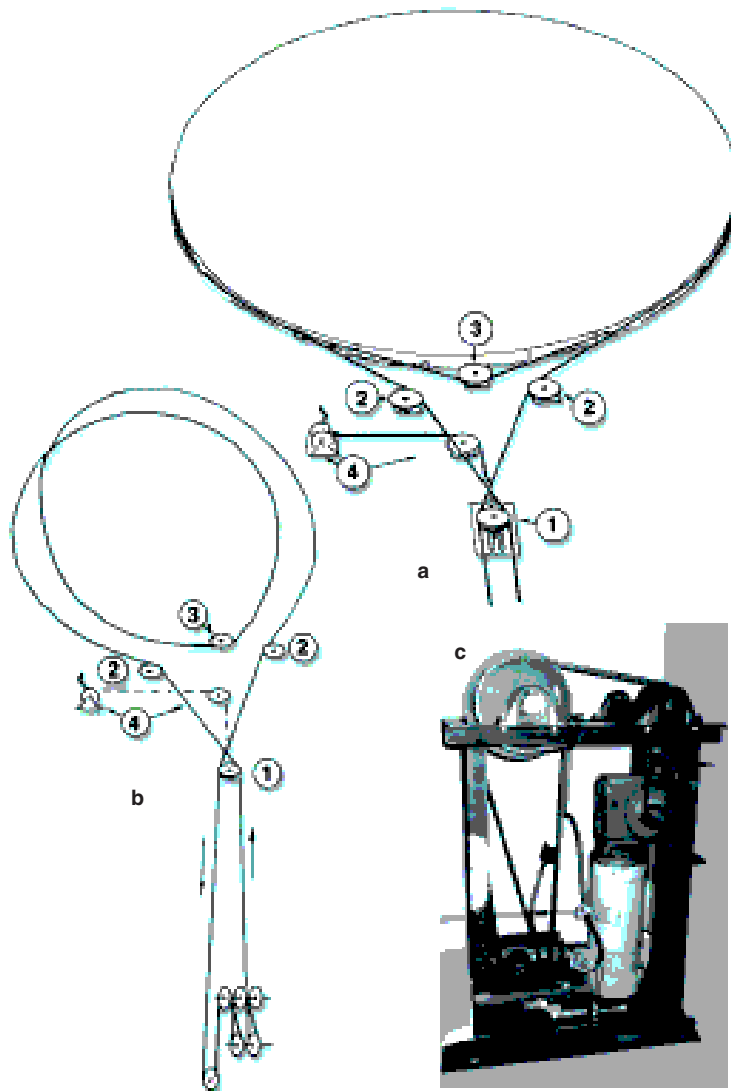


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of a turntable. If the stage happens to be shallow in proportion to the proscenium opening, a single turntable will leave an awkward corner in the downstage right and left positions. Depending on the specific use of the turntable, a show portal masking the stage portions far right and left might solve this problem. Care must be taken not to mask off too much of the stage or negate the basic function of the single revolving stage.

Multiple Turntables, Semi-Revolve, and Combinations Any number of turntables can be used within a single design—from the relatively simple use of one to the more complex “donut,” in which a smaller turntable resides within a larger one, operating separately. If they have eccentric pivots (as opposed to concentric), an amazing amount of control of movement is possible. This kind of multiple turntable was quite successfully used in the Broadway production of *Dirty Rotten Scoundrels*. Obviously, the larger the number of turntables, the more complex the set becomes, which in turn requires more careful planning and even more specific communication with the director.

There are an infinite variety of ways to use turntables and wagons, and they can ultimately be in any shape that is needed. A turntable can even be placed on top or within a



10-21 Motorized Cable Drive for a Single Turntable

a Basic turntable:

- 1 Tension idler.
- 2 Mule pulley to change direction of cable.
- 3 Centering pulley, which keeps cable from creeping and binding as it winds and unwinds on the edge of turntable.
- 4 Winch to control cable tension.

b The threading of the cable, which is $\frac{1}{4}$ inch of flexible steel long-spliced into a continuous loop (see [a] for number descriptions).

c Motorized cable drive.

wagon. With enough money and time, any combination is possible. The most important aspect is that these methods of moving scenery and actors help the designer create the appropriate and desired atmosphere for the production.

The Air Caster for the Revolving Stage Air casters can be used on a turntable or for any pivoting motion, just as with any wagon. If, however, the motion is a complete revolve, the air hose may become tangled. To avoid this problem, portable air compressors and air blowers can ride on the revolve. Although often equipped with noise suppressors, they still need to be covered with music or some other appropriate sound. If the theatre has a trap room, the air hose can feed through an enlarged center pivot.

Conventional drive systems, such as cable or rim drive, can be used on the air caster. An air-castered wagon can be tracked and driven by cable or just pushed.

Lifts and Elevator Stages

As a means of moving scenery, the elevator and the lift require sophisticated stage machinery. If the installation is a permanent part of the theatre architecture, it is referred to as an **elevator**. If it is built for a specific production, it is called a **lift**.

elevator A mechanism built to move an actor or scenery vertically; an elevator is a permanent part of a theatre, as opposed to a lift, which is a temporary structure built for the same purpose; compare *lift*.

lift A mechanism built for a specific production to move an actor or scenery vertically; compare *elevator*.

a, b © CENGAGE LEARNING c COURTESY OF THE AUTHORS

10-22 Two Methods of Powering a

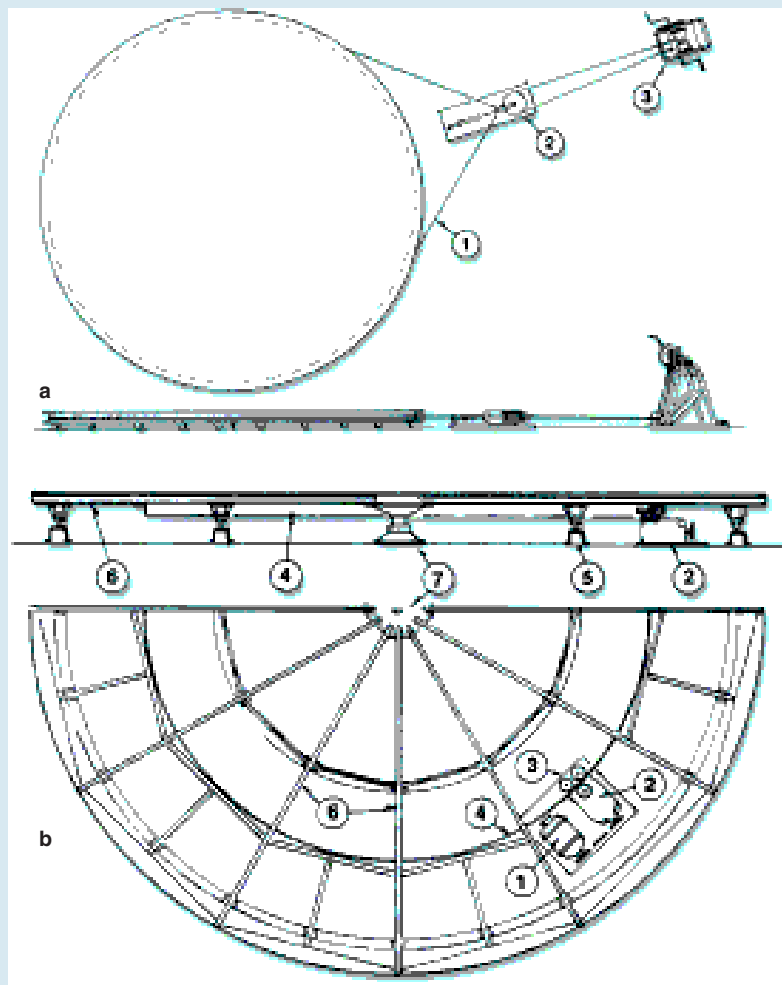
Single Turntable Both (a) and (b) turntables are usually surrounded by a raised temporary stage floor flush with the top of the turntable.

a Cable and winch:

- 1 Spliced cable with one turn around the outside edge of the turntable; held taut by tension idler.
- 2 Tension idler; powered by hand winch.
- 3 Hand winch.

b Top and sectional views of a motor-driven turntable—a reversible and variable-speed electric motor *m* underneath a highly mounted turntable:

- 1 Motor.
- 2 Reduction gear box.
- 3 Spring-loaded friction drive wheels, or bevel gears.
- 4 Drive ring for friction drive, or gear ring for bevel gear drive.
- 5 Raised, fiber-padded track for fixed caster.
- 6 Steel channel-beam framework.
- 7 Roller-bearing pivot.



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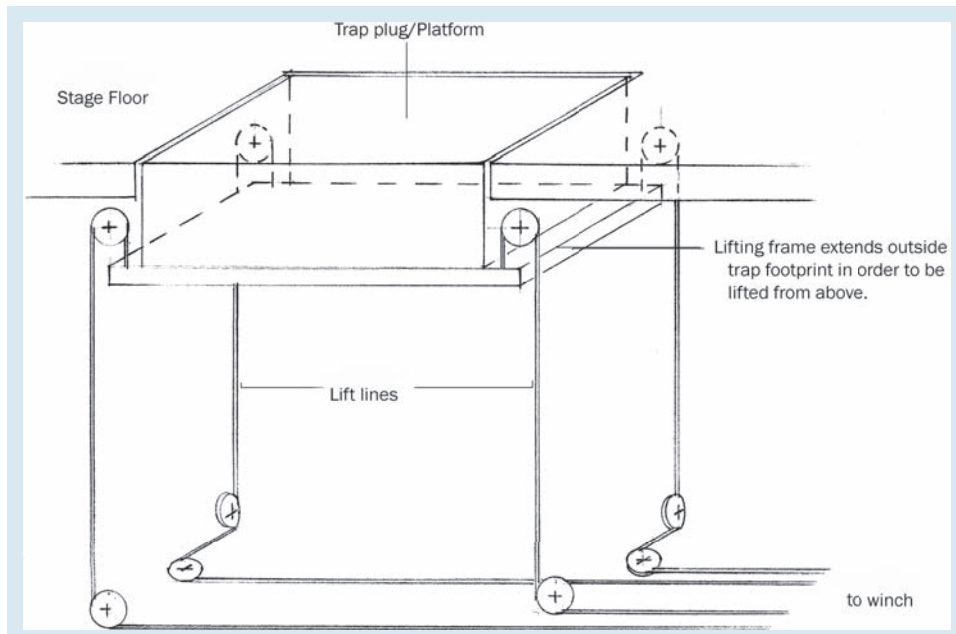
Unless the theatre will make constant use of the elevators or can use them, for example, as a scenery and property lift to and from remote storage areas, their installation would be extravagant. With few exceptions (the Metropolitan Opera House, Radio City Music Hall, and similar large presentation houses), the use of an elevator or a lift to change scenery is not common. In some cases, the elevators are used primarily to shape the stage floor, creating levels or pits, perhaps for an orchestra or a choir.

As for all other methods of moving scenery, the vertical motion must fit into the concept of the production, as was done brilliantly in the design for the musical *Sunset Boulevard*. In this case, the aging actress is seen alone in her gargantuan home while anxiously awaiting the arrival of the reporter. The entire stage lifts to reveal a small apartment underneath, where we see the reporter partying with friends, having forgotten the older actress. The audience not only sees the irony of the different age and lifestyles of these two characters but gets the visual sense of the reporter being “crushed” by the actress.

Small Lifts and Traps

Although the average stage may not have an elevator system, there is usually a portion of the floor area made in sections of **traps** that allow for vertical movement of actors or scenery through the stage floor. Removable covers placed between structural beams supporting the stage floor provide access to the area below the stage, referred to as the *trap room*. Entrances by stairs, ladder, or lift can be made from below through such traps (Figure 10-23). Note, however, that the designer must be aware of the specific position of the traps in a given theatre.

trap Any hole in the stage floor.



10-23 Beneath the Stage Because elevating an object through a trap can be quite tricky and can pose some safety issues (especially if lifting an actor), it requires solid training as well specific rigging. In this example, a winch is used to raise and lower a platform through an opening in the floor using a series of pulleys and tracks (not shown). Note that when the trap is not in use, the “plug”, or platform itself, fills the hole in the stage floor.

Stage Properties and the Designer

In addition to being responsible for large scenic background elements, the scene designer designs and selects stage properties. This activity may vary from finding a marble-topped Louis XV console table to making an exotic sofa for a Turkish cozy-corner, or from borrowing a Victorian tea set to fashioning leaves. Whether borrowed or constructed, each property must be carefully coordinated into the design, compositionally and conceptually, and must also be checked for size and ease of use by the actors.

Stage properties are in essence the design details of the visual statement. Their contribution cannot be overemphasized. Props can provide the accent or artistic touch that makes or breaks a stage set. The audience usually does not notice how carefully chosen props enhance the overall design and help the actors and, in fact, they shouldn't. However, they do notice sloppy prop work, which can seriously detract from a production.

On thrust and arena stages, properties sometimes take on even greater responsibility for establishing the locale. Because of the physical proximity of the audience and the stage in both cases, the finished detail and quality of all properties are subject to closer inspection than they are on the proscenium stage.

Under any circumstance, the designer must consider the suitability of each stage property to the unique interpretation of the particular production. In other words, designers must ask questions that relate not just to the text but to the overall approach of the production as well. The initial discussions will be with the director and then with the props mistress.

Ultimately, the design of props entails three areas of concern: style, function, and size.

- *Style.* What is the world of the play? When and where does the play take place? Is it realistic or abstract in some way? Is the prop crude, rustic, plain? How does it fit into the conceptual approach to the play?
- *Function.* How will the property be used? Will it need to be strong enough to take abuse? Will an actor use it in a particular or unusual way?
- *Size.* Will a prop be so large it might block some of the action for some of the audience? Does it need to be small enough to be hidden in a pocket, for example?

Because such questions may affect all other aspects of the production, the selection and the designing of furniture and properties are done in close collaboration with the director in order to ensure their appropriateness for the production and to determine how they work with the planned staging. In addition, there must be some consideration of how props may affect the other elements of design. Practicals

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For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

and liquids of any kind can be a particularly great concern as they directly affect the lighting and costume designers. Again, no design decisions are made without consideration of the full artistic team.

Properties should be planned and built at the same time as the rest of the scenic elements, if for no other reason than to maintain unity. Their importance to the design and the production scheme is sometimes overlooked in the planning period, particularly if the designer cannot evaluate each property in terms of its use, both textually and conceptually, and its decorative qualities. Fully staffed theatres retain a props master or mistress who must see that all the properties necessary for the production are built, bought, borrowed, or otherwise obtained. If, instead, the designer must do this, he or she must be careful to give this function as much careful consideration as the rest of the design.

To make efficient use of their time, designers should know about historical furniture styles and period decorations and be thoroughly acquainted with the traditional uses of properties in the theatre. No one expects a designer to know the specifics of every period, but a general knowledge of each is important. More important is the need to do research, even for a contemporary play, if only to get fresh ideas. As discussed in Chapter 4, research is critical to discover how the period and style can help the design. Because the world of props is so vast and broad, it requires so many different skills that this chapter is, by necessity, no more than a broad overview. The range of skills needed to be a good props person can be ever-changing.

Properties versus Scenery

What is a prop? When does a small piece of scenery become a property or a large property become scenery? The decision about whether an object is a prop or scenery (or a costume, for that matter) often depends on the staffing of the particular theatre and who is best qualified and has enough time to create the piece. Few shops have hard-and-fast rules about this. Indeed, pieces often easily fall into several categories. What follows offers no more than a guide.

Definition of Properties

Stage properties are traditionally defined as: (1) all objects carried or handled by the actors; (2) separate portions of the set on which the actors may stand or sit, such as rocks, stumps, or logs; (3) decorative features not permanently built or painted on the scenery, such as pictures and draperies, often referred to as *set dressing*; (4) the ground cloth and rugs; and (5) all sound and visual effects that are not electrically or electronically powered, such as a gunshot or snow.

The average production follows these definitions when categorizing properties, but exceptions or collaborations are made all the time. Hence, a tree trunk may be scenery and its foliage a prop; a pair of eyeglasses discovered on the stage is a property, whereas a pair brought onstage by an actor might be considered costume. Because every theatre is different, there is no hard and fast rule. The decision as to which shop builds what is needed when the definition is not clear is determined by which shop has the time and skills to do what is necessary.

Classification by Size and Use

Properties may also be classified according to their size and use, although one should not be wedded to these categories. As we have seen, categories can be fluid. Here we briefly discuss the first three types.

Hand Properties The small objects handled by the actor on the stage are hand props. They include such items as teacups, books, fans, and letters. Hand props often include personal items that a character might use or carry, in which case the design should take into account the clothing of that character. Close communication with the costume designer and the actor as well can help provide the best decisions.

Set Properties As the name implies, set properties are the larger elements somewhat related to the scenery but still used by the actors. This group often includes furniture, stoves, sinks, rugs, ground cloths, and other large domestic objects. Exterior set props consist of small rocks, stumps, bushes, foliage, real dirt, grass mats, and so on.

Set properties are under the care of the property mistress who supervises the placing of the set prop on the stage and its removal to a stored position offstage.

Real furniture is, of course, used in the modern theatre, although its use may require alteration to work well onstage. For example, scale and color are sometimes changed to improve the stage composition. If a chair gets thrown on the floor, or someone must stand on it, or it will in other ways be treated roughly, it may have to be reinforced. Finally, real furniture can take on a theatrical look, suggesting—sometimes faintly, sometimes broadly—that it is no longer real. The term *property*, or “prop,” is often synonymous with the unreal or theatrical.

Dress Properties Dress properties are integral to the setting. They function chiefly to decorate the stage and to help establish the atmosphere and character of the environment through detail. Dress properties consist of all the elements not specifically used by the actors that serve to fill in and complete or dress the set. Window curtains, pictures, wall hangings, and floral arrangements are a few typical dress properties.

Dress properties can be a strong decorative feature in a setting. Because they are usually not used by the actors, they can often be “faked” in order to be created more easily than the other set props. Bookcases, for example, may have false bookbacks attached to the scenery. The shelves behind a saloon bar are often dressed with fake plastic or papier-mâché bottles to cut down the weight. A period piano or spinet, hard to find and harder to borrow, can be easily built as a dress prop. The list of possibilities is endless.

Generating a Prop List

The first step in choosing the props for a production is to generate a prop list (Figure 11-1). This may come from the designer, the director, or the prop master and will begin with the properties mentioned in the text. The designer will add to this list any set, dress, or hand props necessary to complete the design. Ultimately, the director decides which of those props is necessary for the production. Some scripts include a prop list in the back. Although perhaps a valid place to start, this list has been generated from a specific production with a different approach from the one being planned; designers need to keep this in mind.

The prop list is a start in organizing the vast amount of information necessary to get a production done. Notations about size, shape, color, and how a prop is used will be of importance as well in determining whether the prop is built, bought, rented, or borrowed.

In the planning stage, the prop list is discussed thoroughly with the director in the same way that the set, light, costume, and sound designs are discussed. As with all the other elements of design, the props must work within the conceptual ideas of the production. Additions and cuts will be made by the director throughout the rehearsal process according to her needs in staging the play.

Prop List
SLEUTH

Qty	Item	Scene	Page	Cost	Notes
1	Jolly Jack	1	1	\$300.00	Laughing Sailor, w/ movable function
1	Suit of Armor	1	1	\$100.00	
1	Drinks Cart	1	1	\$200.00	
1	Chess Game	1	1	\$ 50.00	
1	Fish Tank			\$125.00	
1	Writing Pad	1	1	\$ 5.00	In lieu of typewriter
1	Pen			\$ -	
1	Grandfather Clock	1	1	\$ -	
	Games			\$200.00	
2	Leather Armchair			\$600.00	
1	Coffee Table	1	1	\$ 55.00	
1	Desk Chair	1	1	\$ -	
1	Desk			\$180.00	
2	Wingback Armchair			\$600.00	
	⋮				
1	China Ornament	1	41	\$ 40.00	Thrown across the room.
1	Swansea Puzzle Jug	1	42	\$ 40.00	Broken Open
1	Giant Staffordshire Mug	1	42	\$ 40.00	Broken Open
1	Dresden Shepherdess	1	43	\$ 40.00	Broken Open
1	Button on Desk	1	43	\$ -	Fake Jolly Jack response
	⋮				
1	Record Player		55	\$ -	
1	Record		55	\$ -	
1	Note		58	\$ -	Urgent we talk. Come Friday night eight o'clock. Wyke
1	Evidence Envelope		67	\$ 15.00	
	⋮				
1	Suitcase		91	\$ -	
1	Blood		92	\$ 40.00	Oral and in Shirt
1	Cymbal-clapping Monkey			\$ 16.40	
				\$ 3,935.90	TOTAL

COURTESY ROBERT ELLIOTT

11-1 Prop List This is one example of a prop list for a production of *Sleuth*. (It is not a complete list; blank lines have been inserted where part of the list was deleted for the purposes of this example.) Note the cost is included as well as notes that help explain any necessary details.

Selecting Properties

As part of the visual statement, the designer is responsible for the compositional unity, period continuity, and color relationships of the set and all properties first seen in the sketch. Once the general idea of the design has been accepted, the designer can turn to a more careful study of the period and availability of each piece.

The designer makes the final decision, with the director's approval, exactly which props to use. As we have seen, the designer uses individual sketches, research, pictures, or whatever else she thinks will communicate her ideas to the director. This can be further facilitated by the use of a ground plan that includes all furniture and that provides exact references to the size of an individual piece in relation to its surroundings. Well in advance of technical rehearsals, the director and the designer must make specific choices

on the props. Rehearsal props that simulate the size, shape, and weight of the final props are provided for use by the actors during rehearsal, allowing the actors time to explore how best to use them in the context of the action of the play.

When working with out-of-town directors, designers can work with both the props mistress and the director with increased ease and speed via the use of email and digital cameras.

Period Style and Decorative Form

A designer needs to have a full understanding of period architecture, interior design, and furniture styles. The more familiar the designer is with the historical background of a period style, the easier it will be for her to design the setting (whether realistic or not), select the set and dress props, and create the appropriate environment. (This applies to the costume designer also.) The director may ask for a specific period style, which offers both limits and opportunities for a design. The broader the knowledge of the designer, the stronger the ability to respond appropriately to the script and the director.

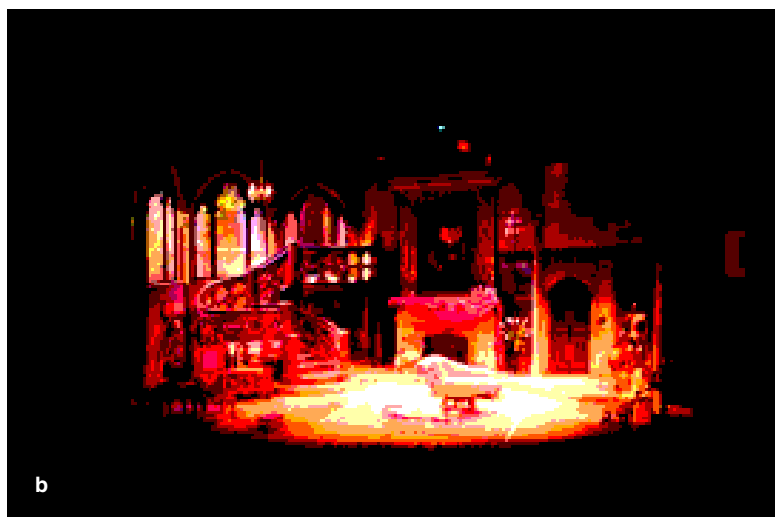
A period style reflects the historical era in which it developed. It is evident in the architecture, interiors, and furniture of each period in history; indeed, furniture alone can establish the historical period of a setting as well as make a major statement about a play. Choosing the appropriate period props can complete a design or destroy it (Figure 11-2).



COURTESY RON KELLER, FURNITURE BUILT BY GEOFF STRONG

11-2 Picking the Right Prop

- a** In his design for *Private Lives*, designer Ron Keller has carefully chosen curvilinear shapes in both the chair and table as well as animal skins for the rug and the chair upholstery to fit in with the elegance of the room.
- b** Linda Buchanan uses set props galore in establishing the right kind of world for *I Hate Hamlet*.



COURTESY LINDA BUCHANAN



COURTESY PAM KNAUERT LAVARNWAY

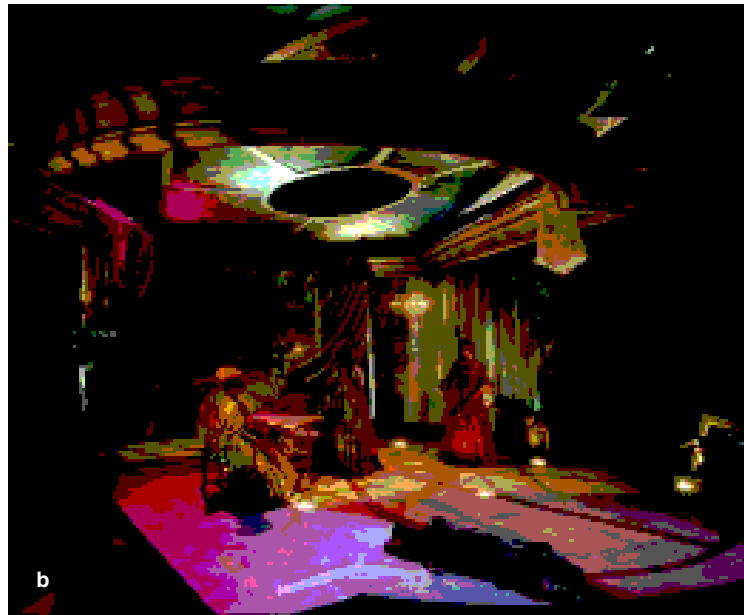


PHOTO COURTESY OF DONNA BARRY, UTAH STATE UNIVERSITY

11-3 Drapery Use on Stage

- a** Pam Knauert Lavarnway makes terrific use of theatrical draping in her design for *Aida*.
b Dennis Hassan uses drapery in a very different way in his design for *Dangerous Liaisons*.

Draperies and Window Dressings

Draperies are decorative details that can bring character to a setting. Their elegance or cheapness, period, style or lack of style, and even their complete absence contribute immeasurably to the visual expression of the kind of place and people in the play.

From historical references, the designer can use draperies that, depending on the period, may hang on a window, door, fireplace mantel, picture, or mirror. The designing of draperies is based on a knowledge of the look of a period, the way material drapes or hangs, and the methods of cutting and assembling material into desired shapes (Figure 11-3).

A designer needs to prepare a carefully scaled and dimensioned drawing of the assembled drapery, specifying the material and the action, if any. Window curtains, for example, may have to be opened or closed during the action of the play. As with the rest of the set, the designer is expected to guide the execution of the draperies and therefore needs to have a general knowledge of drapery patterns and assembly techniques (Figure 11-4).

Although draperies may serve in many places in a setting, the fundamental parts making up the decorative portion are the same as those used to dress windows. The basic parts of a window dressing—all of which may or may not be used in the same treatment—are the **blind**, or *shade*, the **glass curtain**, the **overdrapery**, and the **valance**. The overdrapery and the valance are the frame, so to speak; the glass curtain diffuses the outside light; and the blind cuts off the view into the room from the outside.

The Blind or Shade Early blinds were shutters, both outside and inside the window. They offered protection from weather and break-ins. A blind can be as simple as a plain roller-type piece of fabric or can be highly decorative. Recall from Chapter 10 the Austrian shade drape, which can be used for a luxurious window as well as a stage curtain. Roller blinds, both plain and decorative, as well as Venetian blinds are common (Figure 11-5). Materials for the shade are usually translucent but sometimes opaque. Muslin, silk, and handkerchief linen are examples of translucent fabrics.

The Glass Curtain Usually made of a semisheer or sheer material or lace, the glass curtain is used to diffuse the outside light. It may be rigged to draw closed or may tie

blind A window covering used to block out light. There are various types, the most common being Venetian blinds and roller blinds. Also called a *shade*.

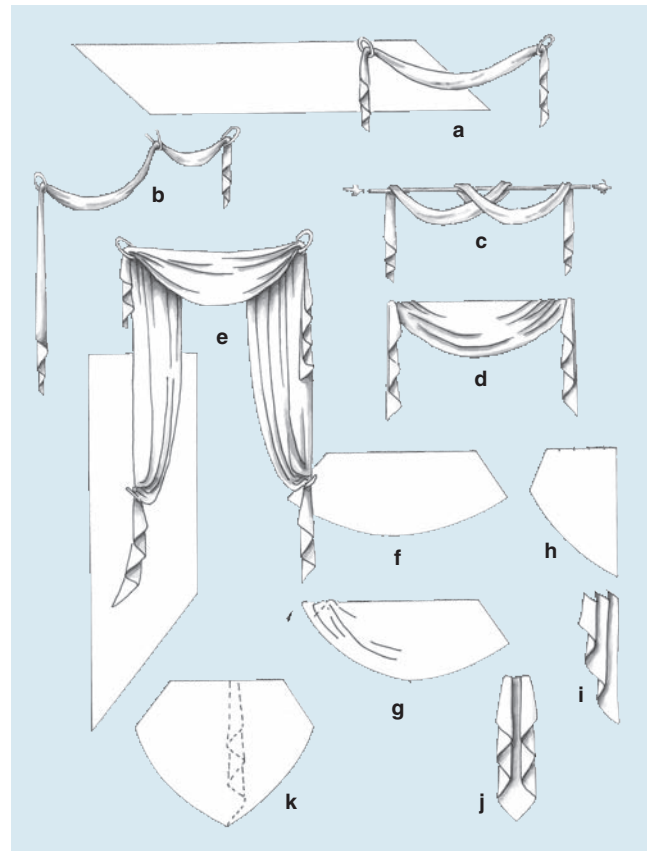
glass curtain A sheer or translucent fabric used to allow light inside a room and not allow a viewer from outside to see inside.

overdrapery Draped or gathered fabric, usually heavy and opaque, used as a decorative window treatment. Sometimes permanent, sometimes functional, it is often used in conjunction with a glass curtain.

valance The uppermost decorative frame of a window drapery treatment. Sometimes a valance is draped fabric, as in a swag, or a hard surface either painted or covered with fabric.

11-4 Drapery and Valance Patterns

- a Festoon valance and pattern.
- b Eccentrically draped festoon valance.
- c Crossed festoons as valance.
- d Valance of swag and tail piece.
- e Festoon valance and side draperies showing pattern for side drapery.
- f Swag pattern.
- g Draping swag.
- h Pattern of tail.
- i Draping or folding a tail.
- j Double or central tail.
- k Pattern for central tail.



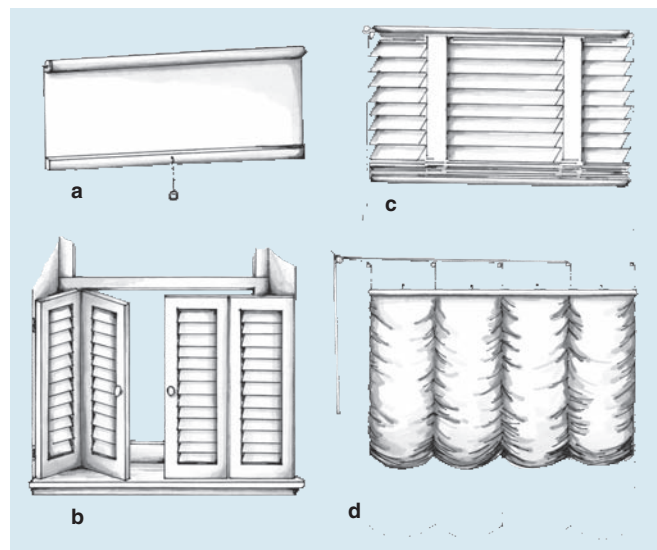
DRAWINGS BY MICHELLE CARELLO

back in a soft drape. On some occasions, the curtain might be the final decorative feature, with no overdrapery. The sheer materials include chiffon, organdy, net, and theatrical gauze, to name a few.

The Overdrapery Made of a rich and heavy material, the overdrapery serves as the vertical frame for the window. It adds decoration and color to a room. An overdrapery may have the same action as the curtain, such as drawing from right to left, or may be draped to a hook or tieback. A fixed overdrapery can be made to a pattern that enhances its drape (Figure 11-6). Although the opaque materials for overdraperies are numerous, they are usually fabrics that drape well, such as velour, velveteen, corduroy, and monk's cloth.

11-5 Blinds, Shades, and Shutters

- a Roller blind.
- b Shutters.
- c Venetian blinds.
- d Austrian shade drape.



DRAWINGS BY MICHELLE CARELLO

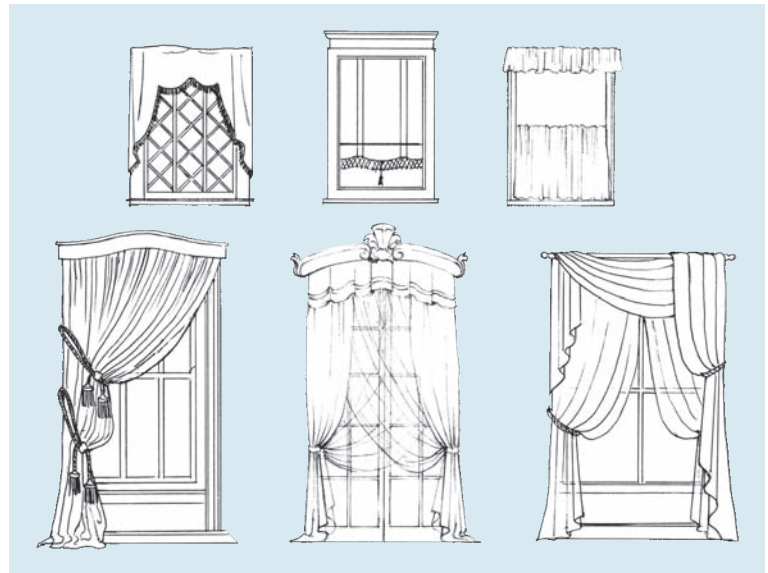
The Valance The top frame of a window is the valance, which accordingly can be of a great variety of draping styles. A valance is made up of swags, plaits, tails, and wing pieces—sometimes incorporated into one drape, such as the festoon valance (Figure 11-4a). More often, though, the valance is made of separate swags and wings that are joined together to look like a single piece of fabric (Figure 11-4b–d).

A valance can be boxed and crowned with a cornice or an architectural feature, or the swags may be padded or stiffened into a fixed silhouette.

Borrowing or Renting Properties

Nonprofessional and professional producing groups alike must rely on renting and borrowing furniture or else maintain in storage a collection of stock period furniture for continuous use. Picking from a stock of select period pieces is by far the easiest method of obtaining properties for a production and is standard practice for a repertory or stock company. Stock furniture can be varied with new upholstery and painted for reuse in future productions. However, storage is not always feasible because of space limitations.

A producing group that depends on borrowing furniture and other articles must make an effort to maintain goodwill with the community. It pays to be businesslike and courteous when borrowing properties. In many cities, groups of theatres have an arrangement in which they “pool” their props and any prop person can borrow from any other theatre in the group as long as the prop needed is not already in use or slated for an upcoming production. Developing a positive relationship with local vendors and other props people in the area always pays off in the long run. Sometimes, taking the time to chat with and getting to know a vendor goes a long way. And follow up with an offer of tickets to the production (warning them if the production might not be to their taste) and a thank-you note—this will always be appreciated (and remembered).



11-6 Window Drapery Treatments
Drapery treatments vary for different window types.

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DESIGNING IN THE REAL WORLD ■ Standard Professional Practices for Borrowing Props

- Make a list of each borrowed article, including the name and address of the owner, date borrowed and date to be returned, estimated value, description noting condition (scratches, cracks, or parts missing), and remuneration (cash, complimentary tickets, or program credit).
- Request a signed receipt from the owner upon return of the article. Most lenders will insist on this for their own records.
- Never alter a borrowed piece in any way without express permission to do so.
- Never borrow priceless heirlooms or irreplaceable antiques.
- Take special care of all borrowed properties on the stage, using dust covers and padding to prevent damage during use in production and in storage.
- Have just one person, rather than different people, do the borrowing for each production. It is easier to develop a relationship with a lender if the same person always does the borrowing.
- Return borrowed pieces promptly on the date promised and in the borrowed condition.
- Secure and file a receipt along with all pertinent information about your source. Records become an excellent resource for quickly locating and borrowing again for another production.
- Thank the person or company from whom you borrowed a prop. An acknowledgment in the program is common courtesy. Even if rent is paid for a prop, it is not a bad idea to offer a pair of tickets to the vendor (unless the production might be deemed offensive—a simple warning will suffice).



COURTESY SCOTT C. NEALE

11-7 Making Furniture This simple table was built for *Conversations with an Executioner*, designed by Scott C. Neale. Note the details in the way it is dressed.

Borrowing or renting often means less time building props and less money used on unique pieces that are not likely to be used again. Renting is usually cheaper than buying. The downside of borrowing or renting usually means the inability to alter the piece in any way. As well, extreme care must be used with these props onstage. Of course, using the same props in future productions means paying to rent them again.

Making and Remaking Furniture

Prop shops are often called on to build pieces of furniture, a sometimes difficult and time-consuming task, especially if a shop does not have a props artisan who can make complicated pieces. There are, however, several styles of furniture that may more easily be made than found or borrowed. Simple benches, stools, and cabinets can be built without a great deal of fine furniture-making skills (Figure 11-7). If the furniture is to be painted rather than stained, cheaper and varied materials can be used, and screw heads can be hidden with spackle; this is faster and easier than worrying about fine detail. Newly constructed pieces require somewhat more expertise.

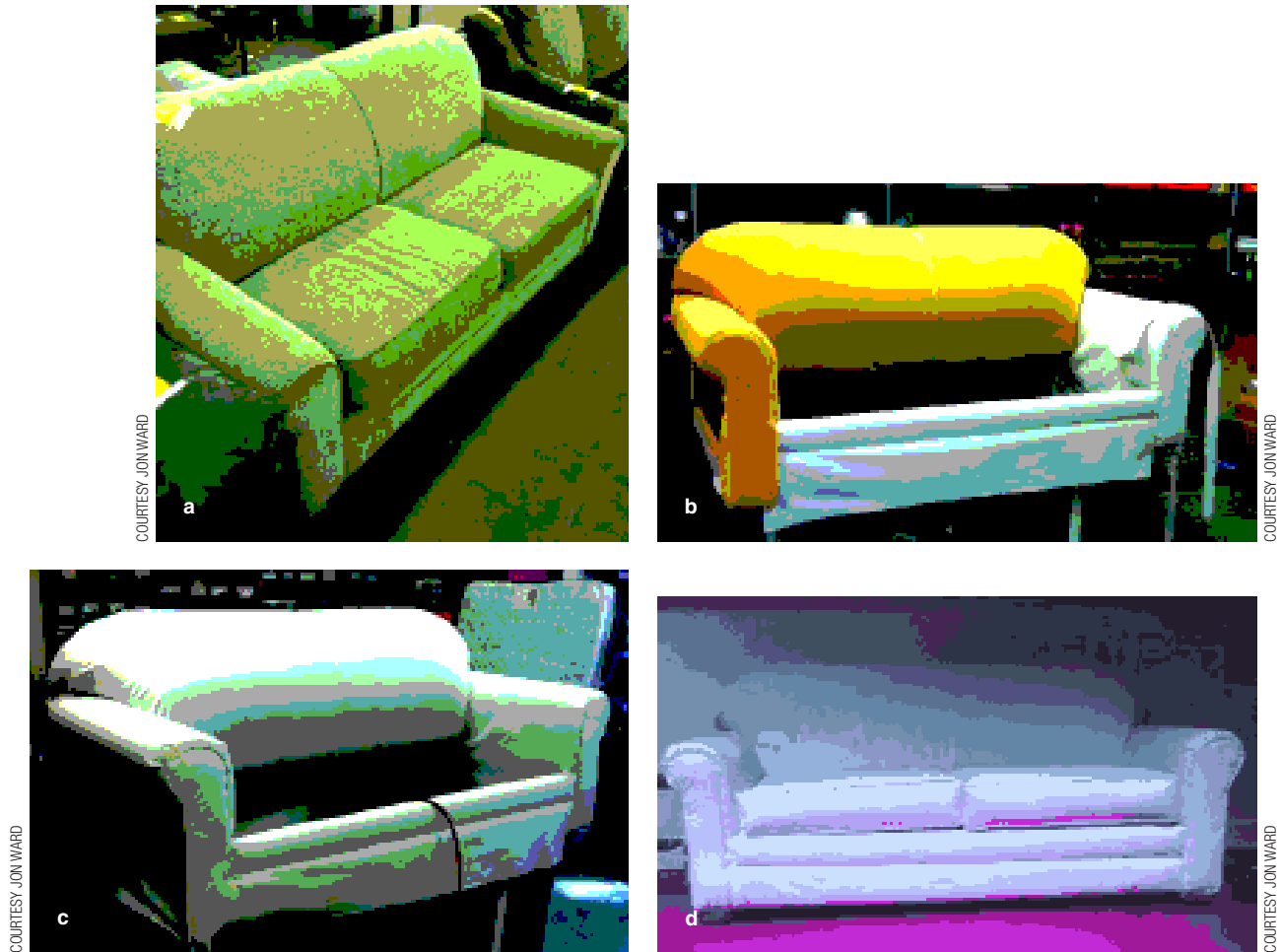
Furniture can sometimes be altered, especially if the alteration involves a reduction in size rather than an increase. Of course, it all depends on the piece at hand and what the designer wants. Sometimes, it takes a bit of imagination to see the potential in what initially looks like a dreadful piece of furniture. Given enough time, patience, and skill, a props artisan can turn a secondhand furniture store into a treasure house of “antiques.”

When sundry set properties are brought together on the stage for the first time, some or all of the furniture may have to be upholstered for either color or compositional reasons. Extensive reupholstering on borrowed pieces can be done only with the express permission of the lender, although it is sometimes possible to cover the existing surface with a new material by catching it lightly with a needle and thread. (There is the occasional situation in which the piece is lent only on condition that it be reupholstered, repaired, or strengthened, but one cannot count on this.) Real antiques, of course, require greater care. Close communication with the costume designer is important for this reason. When reupholstering, wear a dust mask, gloves and eye protection—staples fly when pulled out, and one never knows what materials might be in an underlayer that could be potentially toxic or harmful. Any treatment of furniture pieces must also take into account its use onstage. If the furniture is borrowed, the props department must obtain permission for any surface treatment or structural change.

To reupholster furniture that belongs to the theatre, it is best to follow the same method of covering used originally. If the old covering is removed carefully, the pieces can serve as a pattern for cutting the new material. This can save hours of work. A laser cutter can be used to cut the fabric. While the upholstery is off, repairs can be made to the joints, springs, webbing, and padding, and the piece can be painted. If the furniture is going to be kept in stock, the padding should be covered first with muslin, which serves as a base for any future changes in upholstery. (See Figure 11-8.)

Expert upholstery will hide or cover any tacks or staples used, which can be accomplished in many ways. The material can be tacked on a hidden edge in back or underneath, or tacked to a surface that is later covered by trim or left exposed as decoration. Exposed tacks can be covered with a decorative gimp braid or fringe. Pleating that is done to shape fabric around a curve can also be used as a form of decoration (Figure 11-9).

It is also possible to color match and paint the staples before loading them into the stapler (true for both hand staplers and pneumatic staple guns) so they remain hidden.



11-8 Reupholstering a Sofa This is an example, done by Jon Ward, of the basic technique of reupholstering a sofa.

- a** Before alterations.
- b** New foam padding on the back.
- c** Muslin cover on the sofa.
- d** The newly reupholstered finished piece.

When using a pneumatic staple gun, it is important to make sure the stapler is set at the appropriate pressure so you capture the fabric without tearing through it.

Be sure that the upholstery fabric is going in the right direction in terms of the grain of the fabric as well as the pattern (for example, natural matter such as plants grow with leaves in a vertical direction). Some fabrics, such as damask, catch the light differently depending on their direction. Be sure to use the correct side—meaning the side that the designer has chosen, even though it may mean the “wrong” side of the fabric.

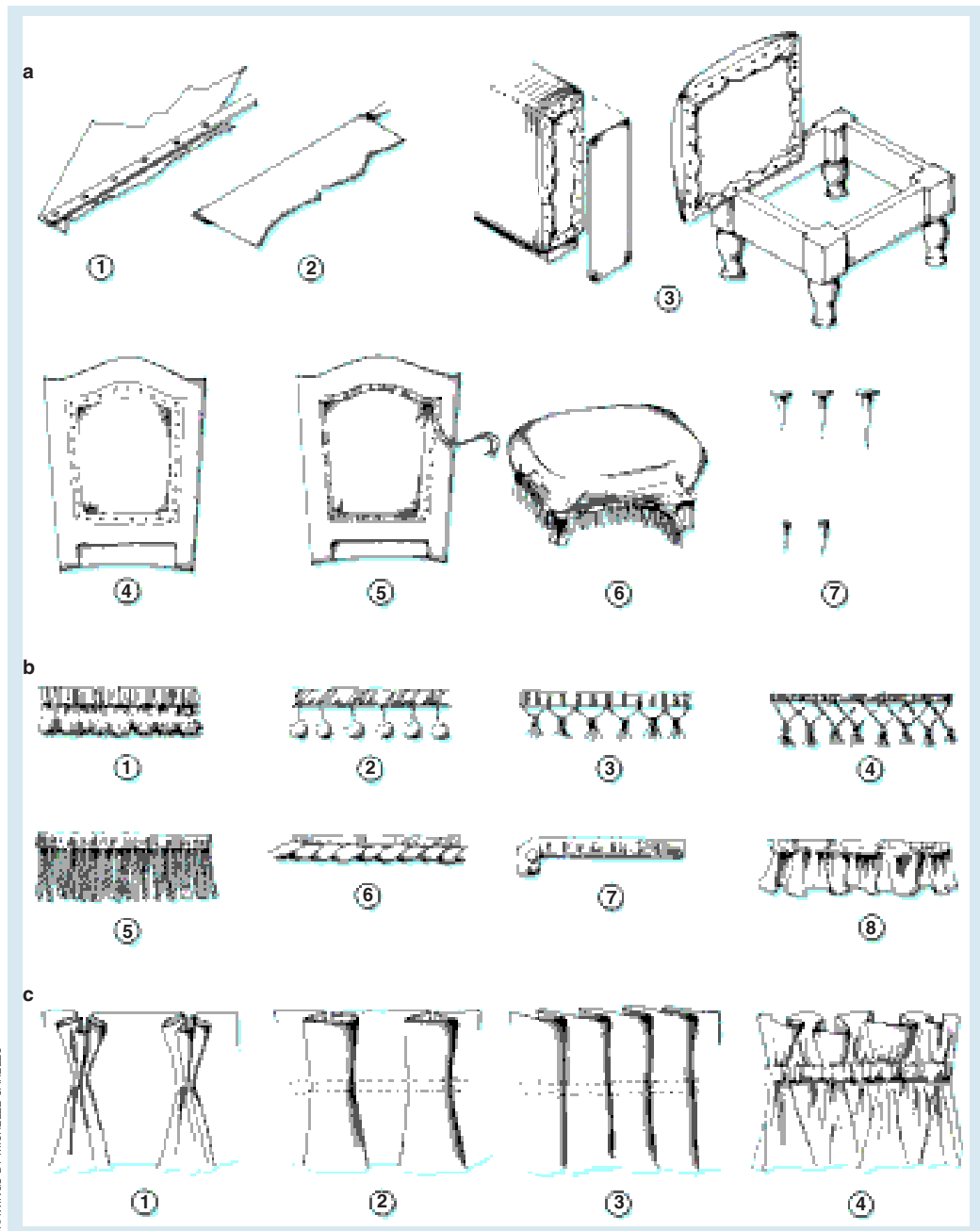
Upholstery is basically like wrapping a gift, only with very odd shapes. An infinite number of upholstery tools are available.

Floor Covering

Traditionally, any floor covering (such as rugs, carpeting, and ground cloth) was handled by the property department because it was considered set dressing. Contemporary theatres tend to be thrust or proscenium stages with arena seating, giving greater emphasis to the floor as a design element if only as a way of visually unifying the entire set. Even if the floor is not overly visible to the audience, the proper treatment can be immensely helpful

11-9 Upholstering Techniques

- a Tacking:**
- 1 Hidden tacking.
 - 2 Tacking covered by panel.
 - 3 Tacking kept on an unexposed surface.
 - 4 Decorative tacking.
 - 5 Tacking covered with gimp braid.
 - 6 Tacking covered with fringe.
 - 7 Upholstering tacks (4, 6, 12) and gimp tacks (3, 4).
- b Fringes, braids, and ruffle:**
- 1 Fringe.
 - 2 Ball fringe.
 - 3 Tassel fringe.
 - 4 Tassel fringe.
 - 5 Bullion fringe.
 - 6 Braid.
 - 7 Gimp braid.
 - 8 Ruffle.
- c Pleats:**
- 1 Pinch pleat.
 - 2 Box pleat.
 - 3 Accordion pleat.
 - 4 Gathering.



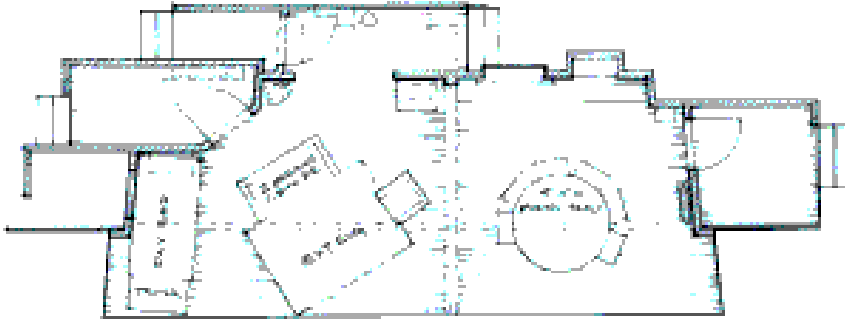
to the actors in trying to create the world of the play. A floor design might involve painting a ground cloth or a built stage deck. Any stage setting on an unrelated or contrasting floor seems to float in space. When this effect occurs, it should be intentional and not appear accidental. The plan should indicate the texture, materials, or patterns that will anchor the design visually to the floor (Figure 11-10).

If affordable, an applied material might be used. An example of this is the use of lauan pieces for a **parquet** floor or painted tempered Masonite® or particleboard for marble. If the sound of characters walking on a specific surface is desirable, the choice of flooring materials becomes more important. As always, this choice depends on cost and on the needs of the production. An arena or thrust stage increases the need for the use of real materials.

There are many examples of unusual floor coverings that go beyond conventional ground cloth or painted floor: dirt in *Tobacco Road*, for example, or artificial snow in

parquet A geometric or mosaic pattern in a wood floor.

COURTESY SCOTT C. NEALE

**11-10 Floor Treatment on the Plan**

For this preliminary ground plan of *Awake and Sing!*, designer Scott C. Neale provides clear information about the planking needed for the floor. Some designers will show only a portion of the floor treatment if the plan is complex.

Ethan Frome. There have been productions in which the entire stage floor and scenery were covered with free-form overstuffed canvas, which required very unconventional movement. There is always a new source of materials if the designer is willing to look. Granulated cork to simulate dirt and rubber tire mulch are both excellent and affordable for floors, depending on the amount and effect needed (Figure 11-11).

A stage floor may have to be covered for purely technical, rather than artistic, reasons. An entire stage, for example, may have to be built up to surround a turntable or to provide slots to guide wagon movements. Most ballet companies and dance groups cover an imperfect floor with one of several available vinyl coverings. Some dance companies even carry their own portable floor, such as D'Anser, the trademark name of a portable modular floor, designed by Ronald Bates and Perry Silvey of the New York City

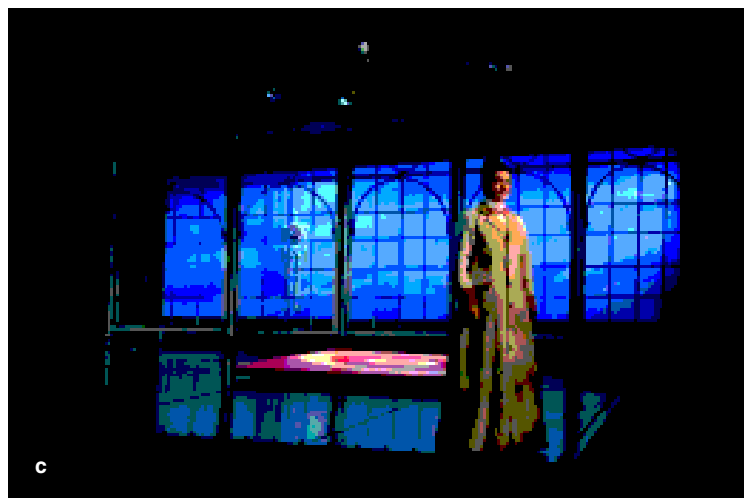
COURTESY TODD ROSENTHAL

**11-11 Floor Treatments**

- a** For *The Seagull*, designer Todd Rosenthal uses a variety of natural texture (down, left) and manmade (rug and wood planks).
- b** A more decorative, parquet floor is used, in part, to help establish the two separate rooms in *Lend Me A Tenor*, designed by Dick Block.
- c** Chris Pickart has designed two floor treatments in high contrast to one another for his production of *Major Barbara*.



COURTESY OF THE AUTHORS



COURTESY CHRIS PICKART

Ballet. Transported in 4-by-8-foot units, this floor is 3 inches thick, with offset wooden supports that allow for the “bounce” dancers want. The units connect with interlocking hardware and can cover an entire stage area.

Fabricating and Casting Techniques

Properties often require decorative details or bold relief at an exaggerated scale, beyond that of conventional furniture. These and other forms (such as architectural details, costume armor plate, small properties, and various free forms) are often made in the shop to obtain the exact shape and dimension the designer seeks. The forms may be fabricated or cast from a real object or from the prepared mold of a three-dimensional shape. These same techniques can be used to adapt a “found” object.

Papier-Mâché

The term *mâché work* has grown to include all techniques and materials used to mold or fake carved relief detail on furniture or scenery. The original papier-mâché technique used paper or paper pulp, which was either modeled directly on the surface or, in order to duplicate a pattern repeatedly, was fashioned from a plaster mold.

When modeling directly with papier-mâché, the props person uses a porous paper such as tissue, paper toweling, or newsprint. After being torn into convenient strips and dampened in water, the paper is dipped into a binder consisting of wheat paste and strong glue size. Any excess binder is lightly squeezed out of the now near-pulp mass, which is then applied to the furniture surface and modeled into the desired shape. If the relief is high, some preliminary modeling can be done with wire screening to which the mâché is applied as the final surface. The technique is similar to that described in Chapter 8 for the construction of large irregular shapes.

To duplicate identical forms, the same process can be applied to a greased positive or negative mold. As mâché dries, it shrinks noticeably; this must be taken into consideration in the planning.

Alternatives to Papier-Mâché

Because papier-mâché is fragile, a sturdier substance is often needed. The easiest and cheapest method is the use of muslin and glue. The muslin (or any other fabric) is soaked in glue and shaped or molded in a negative or positive mold. As the glue dries, the fabric hardens in the desired shape.

Thermoplastic, easily moldable when heated, can be a very useful substitute. A distinct advantage is that once it cools, it retains its shape. Cooling time and level of rigidity will vary depending on the thermoplastic. For this and for safety reasons, it is important to read the manufacturer’s information carefully. There are many products on the market that fall into this category, not all of which are manufactured with theatre in mind. Friendly Plastic® and Wonderflex™ are two examples. Both are thermoplastics that become soft enough, after immersion in hot water, to form over positive molds. Available in a variety of thicknesses, they yield various degrees of strength and capacity for detail. Both products are expensive but excellent for small jobs.

Sometimes stronger products are required. Sculpt or Coat® can be used to create irregular forms or used with felt or towels to build up forms in a mold. It is available in 1- or 5-gallon buckets.

Another alternative is an elastomeric (polymer with similar qualities to rubber) roofing compound such as Kool Seal and Jaxsan. Both are readily available at home-improvement

centers. Paper towels dipped in Kool Seal are first pulled through the fingers to remove the excess, just as with papier-mâché, and then draped over a form to create a tough, flexible, and waterproof coat that will not chip or crack.

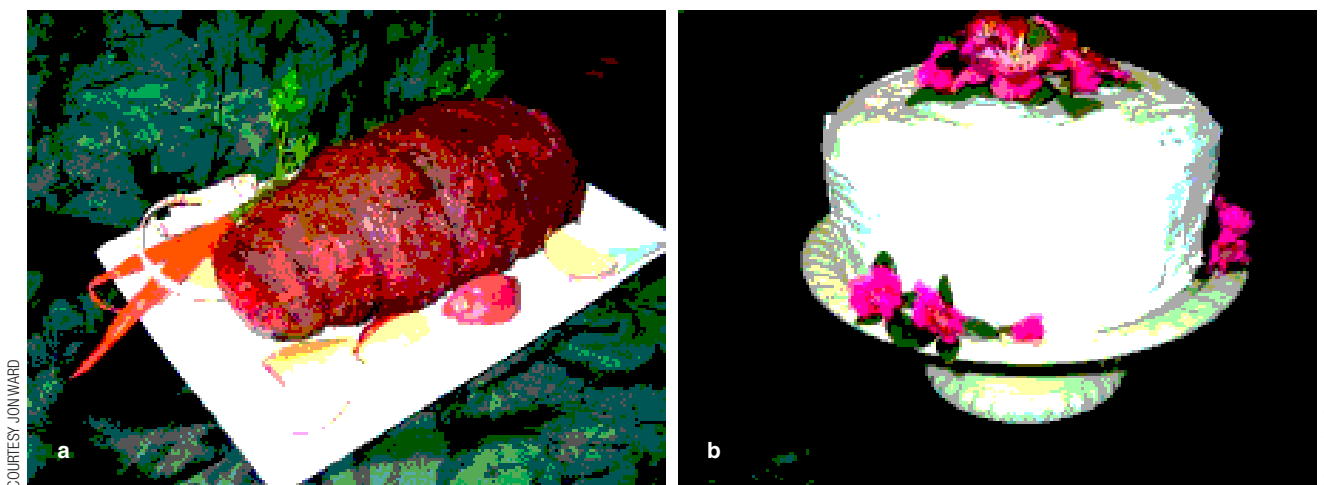
Insulation foam and upholstery foam are also very handy when creating smaller “sculptures.” They are inexpensive, easy to find, and easy to work. A pair of good cutting shears or even an electric carving knife combined with a bit of ingenuity will allow a prop person to create any number of objects for the stage when the real thing can’t be used. (See Figure 11-12.)

The specific product that is used should be determined by the particular needs of the job at hand. If a prop is going to get a great deal of onstage abuse, papier-mâché, which is inherently fragile, might not be the best choice. A sturdier product should be used. Factors such as size, rigidity, texture and finish, weight, and cost should all be considered carefully. Any one of them could be a limiting factor.

Polystyrene Foam

Architectural detail, sculptural pieces, and out-of-the-way dress props may often be fashioned out of polystyrene foam. The big advantages of polystyrene foam are that it is easy to carve (a CNC router can be used) and is quite lightweight. However, since polystyrene foam is fragile, its surface needs to be protected or hardened. Either a seal of flexible glue alone or cheesecloth adhered with glue or Foamcoat™ (a water-based, nontoxic coating manufactured especially for coating polystyrene foam) will work, but one must still be careful.

More importantly, the user also needs to be aware of the dangers inherent in using polystyrene foam. It has high flammability (as do all foams), and it releases toxic gas when heated. This means that cutting it with any kind of power tool, including a hot-wire, will produce toxic fumes. Care should also be taken when gluing polystyrene foam pieces. Most adhesives contain solvents that will dissolve polystyrene foam. A panel adhesive or mastic should be used, but they are generally not heavy duty. Liquid Nails® is one adhesive made specifically for foams.



11-12 Carving with Foam Assuming it only needs to be seen, many food types can be replicated for stage using an easily worked material like insulation foam as seen here in this ham and frosted cake. Created by Jon Ward, both were then painted and decorated appropriately.

- a** The ham is simply a roll of insulation foam covered by a nylon hose and tied to the appropriate shape.
- b** The cake was formed with Styrofoam™, “frosted” with joint compound, and decorated with bought fake flowers.



WORKING PROFESSIONALS ■ Robert Elliott: Prop Master

Robert Elliott, currently the prop manager at the Alliance Theatre in Atlanta, began his training in stage management at Boston University, only to discover that he preferred to build things. After exploring the world as a carpenter and then as a scenic artist, he found himself looked at as a special projects expert if only because he was willing to tackle projects that no one else wanted. This eventually led him in the direction of props—in a way, the “special projects expert” moniker defined him as a prop master. Unsuccessful at finding a mentor as a student, he discovered that he could “sort out answers on my own,” which, in a way, makes him ideally suited for props because so much of the work is figuring out how to create something never seen onstage.

It is not surprising that, as a prop person, Robert has worked in a wide variety of positions. “I got a job stage managing a show at a university theatre in Florida, and the director told me her theatre needed an ATD [assistant technical director].” However, the technical director got fired shortly after this, and Robert was promoted. Eventually, his interests evolved into the world of props. He worked as a prop carpenter at the Goodspeed Opera House, eventually becoming prop manager. And along the way he has done stints at the Pittsburgh Civic Light Opera and the Arden Theatre.

According to Robert, one of the problems and joys of being prop manager is that “it encompasses all skills.” It is not necessary or possible to be expert in everything. “Props people are uniquely qualified to do their job because they need some of the skills of the scenic artist, the carpenter, and others.” Robert says that the most important skill is the “knowledge of the uses of adhesives.” This, as much as anything, suggests the wide variety of specific jobs that a props person is likely to encounter.

Although quite serious about his work, Robert is clear about the kinds of jobs he truly enjoys, based in part on his particular skills: “I am terrible at building wooden things with squared corners. My mind is much happier forming organic shapes, trees. So I hope that I will be able to hire a carpenter who finds joy in making perfectly square dresser drawers. Similarly, I lean toward wanting to throw away things when a show closes, and I am not gifted at remembering where things are stored. If I have someone on my staff who loves hoarding things and then remembers where every thimble lives, I think we complement each other. To unite these conflicting viewpoints requires that we respect and value each other’s abilities. I want that. I want to work with people whom I admire, whose opinions I seek even when they don’t mirror my own.”

When Robert talks about what he really likes about props, it becomes obvious that he really likes to create. He says that the most fun is merging ideas and skills. One of the characters in *A Funny Thing Happened on the Way to the Forum* carries a bust of his wife. Robert describes the joy of combining the Roman statue

research showing draping and hairstyles with a photograph of the actress, figuring out how it will work and then actually making it.

Robert hopes for a “certain kind of bond between the prop master and the designer. Ideally, the prop master is the scenic designer’s ‘buddy,’” in a way, because they spend a great deal of time together shopping and exchanging ideas of taste; yet the prop master has a certain amount of control, at least of the budget. “I expect the designer to do his homework.” The relationship works best when the prop master doesn’t try to “impress [the designer] that you do your job well. Convince them that they want to drink a beer with you.” When the relationship is problematic, it is usually because the designer is late with drawings or ignores the limits of the budget. “If I get my information soon enough that I can make something beautiful, I will happily work round the clock for you.” He says the same of the relationship with directors.

He sees his ability to organize and work within a given budget as one of the reasons he gets hired. “I try to get the big things done first. I try not to do the things that will change and make our work pointless.” When there is not enough time to do exactly what is asked, Robert makes the effort to find a different solution that is still artistically satisfying.

In organizing the props at the beginning of the production, Robert naturally starts with a prop list. Although much of the necessary information might not yet be available, he provides a ballpark estimate of costs, and he notes all “must-have” items. He goes into the tech rehearsal with 20 percent of his budget still available “because it will be spent there, whether I choose to do so or not. So when I get down to only 40 percent of my budget left, I start pushing for cheaper options.”

Describing the people he likes to hire to work with him, Robert first states: “Attitude matters in many ways more than every other skill.” The obvious skills he looks for are basic carpentry, welding, and sewing abilities, but taste and a certain level of sophistication are always necessary. As indicated, he looks for those who complement his own skills. What seems to be of critical importance is that he hires “people who can take the provided information and not reshape the artistic vision”—in other words, those who can uphold the vision of the designer. “I try to give my staff a fair distribution of interesting, challenging long projects, and boring repetitious someone-has-to-do-it projects. I try to use people’s abilities well. I try to hire people who are flexible.” He strives to allow his staff to best use their own skills, giving them time to explore the best solutions while being specific about how a project needs to be done when there is little time (such as during tech week).

It is inevitable that the prop master and the designer disagree about a prop at some point. When this happens, Robert offers his opinion and points out any problems that the designer might



WORKING PROFESSIONALS (CONT.)

have missed (such as a sightline concern). Issues of taste are, of course, trickier. Here is when the positive relationship can pay off. A trusting relationship allows him to ask: “Do you really want this?”—perhaps suggesting different materials or solutions. But ultimately it is the designer’s decision and not his.

Robert identifies a problem typical of props people in general: they tend to be self-deprecating. This is perhaps an occupational hazard: because props are often undervalued, props people don’t generally promote themselves as well as they might. We “should be proud of our work, and we deserve respect.” There is a “fine line between keeping your self-respect and being willing to say ‘No, no, I will do what you want’” to the designer or the director.

When a prop issue arises during tech week, rather than blindly delivering a requested solution, Robert has learned to ask: What’s the original problem? What are we trying to solve? “You have to look beyond the face of things and solve the problem.”

But, ultimately, Robert is quite positive about his job and works to serve the production as a whole. “My best experience was with a director named Whit MacLaughlin. He has a unique gift to find the abilities of those around him and draw out these skills. The process was often stressful, but all the same, I came away feeling like what talents I have in myself had been fully utilized. I was proud of the work we did together, proud of my contribution, and proud of the people around me for their gifts as well.”

Fiberglass

Fiberglass is another medium for creating three-dimensional details on scenery or properties, although it is used less than in the past. The technique is similar to working with papier-mâché, although heavyweight gloves are a must. Fiberglass cloth is applied over a positive form or into a negative mold after first coating the mold with a releasing agent. However, fiberglass is used only rarely in the theatre because of its expense, toxicity, and inherent danger (working with tiny pieces of glass fiber). Safety is a critical concern when working with fiberglass. Extreme precautions must be taken. Because of its toxicity, fiberglass should be used only in a well-ventilated area. An appropriate respirator, especially when working on large scale projects, is an absolute must. Asbestos gloves, eye protection, and protective clothing are equally important. The only reason to use fiberglass is if the scenery is to be used outdoors or must be waterproof. Even then, it should be used when absolutely no other product will work.

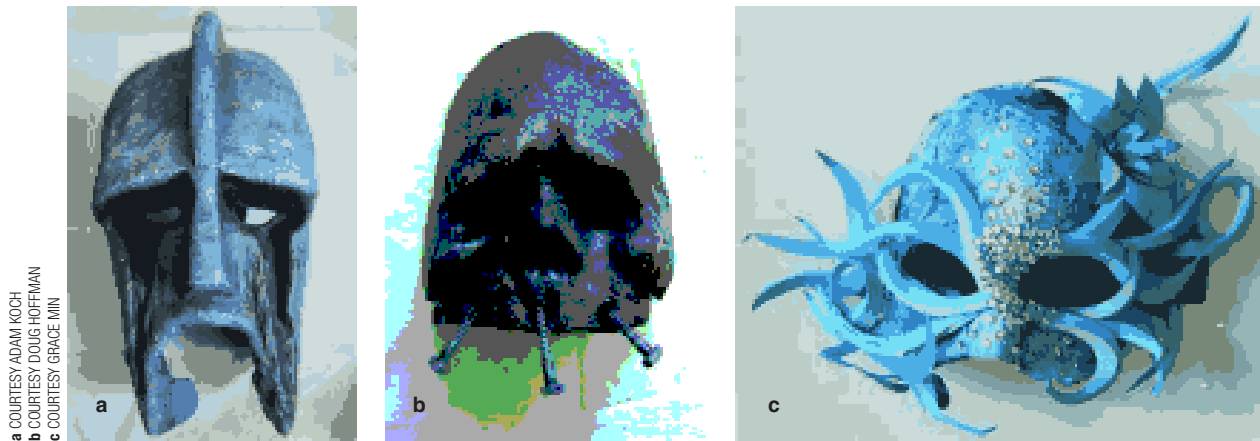
A safer alternative to fiberglass is a product called Aqua-Resin®. This is used and works exactly like fiberglass but is completely nontoxic.

Mold Making and Casting

Mold making and casting are two of the cheapest ways to duplicate objects, especially when mass producing them. Mold making is the process of creating a *negative* of a shape and then lining it or filling it in; casting is creating a *positive* form from a negative. A wide range of materials can be used for both mold making and casting. Silicone, plaster, clay, or even an object already in existence are often used in mold making; latex, plaster, foam, and resin are often used in casting. Neither is an exhaustive list. As mentioned before, the right product will be determined by its use and the desired final product.

Mask Making and Body Armor

Some of the mâché molding and casting techniques can be applied to the making of full or partial masks (Figure 11-13) or, in some cases, to appear as decorative details on scenery. Many forming techniques can be used, such as papier-mâché. As with any prop, the type of mold used and the qualities and use of the finished piece determine the choice of materials. One must also consider the build time available as well as the skills of the prop shop.



11-13 Mask-Making Techniques

- a A heavily sculptured and abstract mask for Titus in *Titus Andronicus*. Designer, Adam Koch.
- b Mask for *Hamlet* made from paper towels and clear flat acrylic medium. Designer, Doug Hoffman.
- c Mask for Wendy in *Peter Pan*. Designer, Grace Min.

Leather is also a good option, especially for making masks. It requires some time to learn the best techniques for working and shaping it but can result in extremely intricate shapes that will last a long time with proper care.

Visual Effects

Visual effects can be either simple to produce or require special skills and knowledge. Many effects such as fire, smoke, and explosion are usually electrically controlled; others, such as rain and snow, are mechanical. All stage effects call on the ingenuity of the stage technician and property person to rig and trigger on cue (See Figure 11-14).

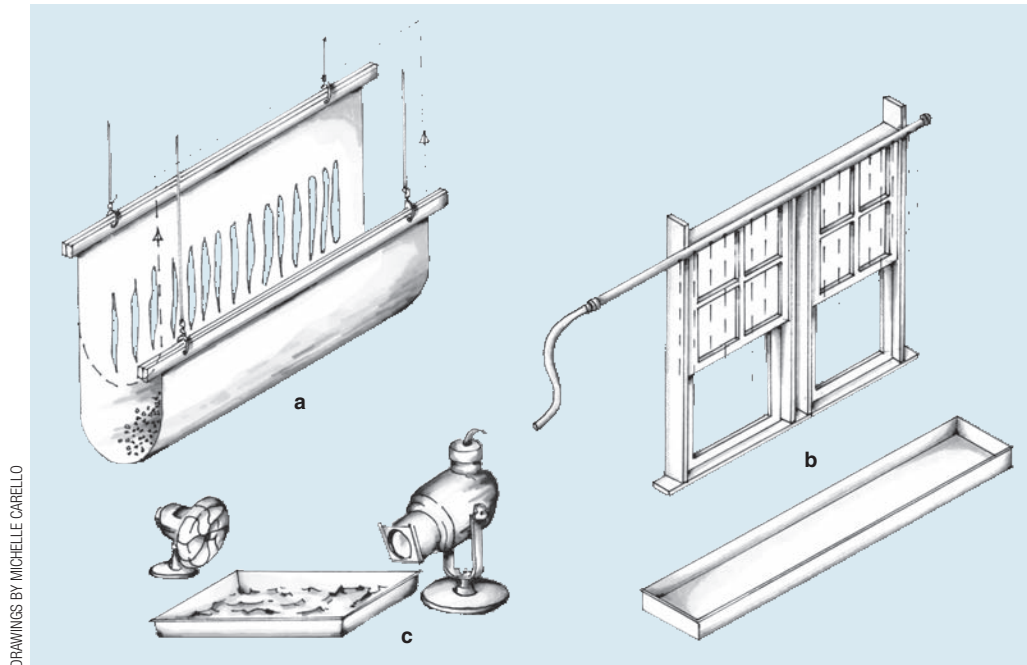
Foliage

Artificial flowers and the foliage of hedges, bush pieces, and small trees are considered properties, as are live flowers, potted plants, and sprays of real leaves used to dress the setting. The expression *prop bush* means that the bush is not real but also implies that it is shaped in three dimensions, as opposed to a flat, painted set piece.

Lifelike artificial flowers can be obtained easily from display houses, local variety stores, or a local wholesale floral distributor. Stylized or caricatured blossoms have to be specially made. Their scale and design determine the material used. Exotic tropical flowers in a musical comedy, for example, have been made of velveteen or satin, with leaves made of wire loops covered with sheer chiffon. This is really a lost art, and for good reason—the process is extremely time-consuming and expensive.

A fairly realistic box hedge can be made of chicken wire holding sprays of artificial boxwood (Figure 11-15). Large-mesh chicken wire can support clumps of leaves as well. Scraps, cut-up pieces of fabric for leaf material that are stabbed into foam, can be quite effective. Using a variety of fabrics such as tulles, sheers, and textured fabrics will provide variety as each fabric grabs the light in a unique way. Any of these methods requires fireproofing of the materials.

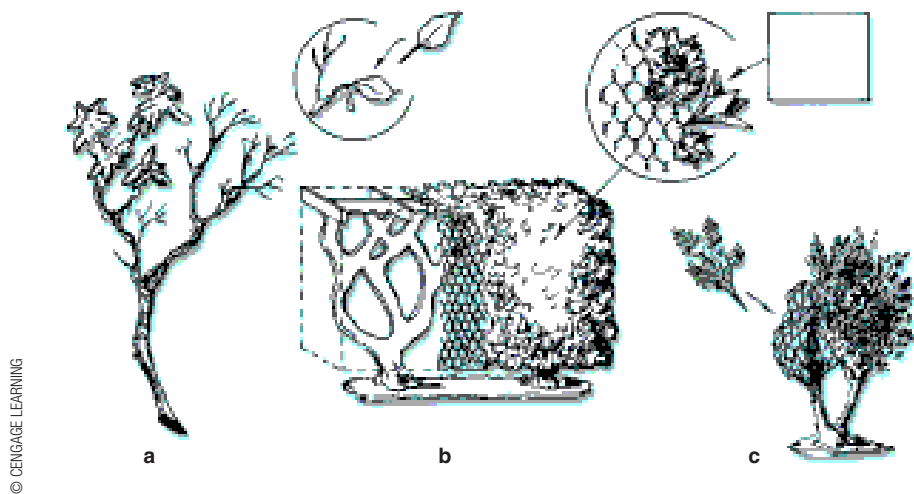
Trees are more difficult. Given their size and the difficulty of achieving the right kind of detail, it is likely that they will need to be purchased. Scavenging in the forest can be successful, but there is always the chance of bringing in bugs with the trees. Fire



DRAWINGS BY MICHELLE CARELLO

11-14 Tools for Visual Effects

- a Snow cradle.
- b Rain pipe.
- c Water reflection trough.



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11-15 Foliage

- a Artificial leaves wired or taped to real tree branches.
- b Trimmed boxwood hedge made of frame covered with 1-inch-mesh chicken wire. Fabric squares or artificial leaves are pushed into openings (two or three shades of green used for a more convincing color).
- c Chicken wire shaped over basic frame and filled with sprays of artificial boxwood.

retardant must be sprayed on any natural products. Store-bought trees will already be flame retardant (See Figure 11-16).

Fire Onstage

The use of an open flame onstage is always a problem. The dangers are obvious. As such, every city has specific fire laws that must be strictly followed. Check these local fire laws even if only a single lit cigarette is to be used and contact the local fire marshal.

There are standard safety procedures that everyone should follow regardless of what is required. Flameproofing all scenic pieces and props is the first step. If there is an open flame of any kind onstage, be sure that there are multiple places to extinguish the flame on- and offstage. Sometimes these are obvious; sometimes they need to be well-disguised. A little water in an ashtray or sand in a bucket are efficient and cheap ways of extinguishing flame. As a general rule, there should be one extinguishing port for each live flame (each match has its own receptacle).



COURTESY FRANK LUDWIG



PHOTO BY JOSH SMITH

11-16 Foliage on Stage Two examples of foliage used in a set.

- a Frank Ludwig uses vines decorating a pergola in his design for *Much Ado About Nothing*.
- b The grasses for *Bus Stop*, designed by Josh Smith, were store-bought but actually real and glued into pre-drilled holes in a series of low boards to create the desired field. Props by Jon Ward.

There are several commercially available and safe substitutes for live flame. Candle substitutes are probably the easiest to find and use. Battery-operated candles can be built fairly easily or bought relatively cheaply. Flickering bulbs meant to look like live flame are now very convincing.

Adhesives

Most of the prop-building techniques that have been discussed require some kind of adhesive and there are numerous types readily available. It is important that the right kind of adhesive be used for the specific material used. There should also be some consideration for the function of the prop. One that gets extremely hard use might need a strong adhesive in order to last through the production.

There are a number of categories of adhesives with which a designer should be familiar:

- *Natural*. Adhesives made from inorganic mineral sources, such as animal hides, hoofs, and bone, generally have a high gap fill.
- *Air drying*. Most common types are white glues and rubber cements. As the solvent evaporates, the adhesive hardens. They tend to be inexpensive but universally useful.
- *Contact adhesives*. This adhesive is good for adhering wood to other materials. Accuracy is necessary, although remounting is possible with some. Adhesive is applied to both surfaces to form a strong bond.
- *Hot melt glues*. These harden as they cool and are easy to use for porous materials. They should be used with care because there is the possibility of burning skin.
- *Reactive*. These adhesives require a chemical reaction to work. Epoxy, for which one must mix two compounds for a bond, is the best example.
- *Pressure sensitive*. Some form of clamping is required for these adhesives. They can be permanent or temporary adhesion but generally hold only small amounts of weight. Post-its and masking tape are good examples.

There are many adhesives designed for specific materials, and it is always worth investigating the best adhesive for an unusual material. A variety of spray glues are available for gluing porous to nonporous materials, although they can be dangerous for the environment and for the user if not employed properly and with appropriate protection (both respiratory and visual).

Whatever adhesive is used, caution must be taken. Many adhesives must be used in well-ventilated areas, some with respirators and gloves, and some should be used only if nothing else will work.

Working as a Professional Props Person

As with any other job in the theatre, getting employed is a combination of having the right skills for what a theatre needs and knowing the right people. As discussed in Chapter 4, the first job might be unpaid in order to gain some experience and get known. One way to get re-hired is to prove that you fit in with that team, that you are willing to work hard, and that you will be proactive in the artistic process.

Job postings can be found on various artistic job sites, at local theatre companies, in newspapers and online. Theatre is done everywhere, and a highly skilled props person is always in demand. Word of mouth about a particular theatre as well as a particular props person is very effective for both employers and potential employees. Many theatres have apprenticeship and intern programs and hire from within. Prop masters are often hired from the staff in the prop shop.

It is important to be aggressive but not annoying in looking for work. Both a production manager (who is likely to do the hiring) and the props master are almost always happy to meet potential employees. Identifying individual strengths will make it easier to find the appropriate job. Someone who has particularly good skills in sculpture, painting, or sewing, for example, should make sure that this is clear in any correspondence or conversation.

There are a number of positions that a prop shop might staff. No shop will have all of the positions listed below but will have some combination of the following:

- **Props Master or Mistress** The props master is responsible for overseeing all props used in and produced for a production. He or she also manages all resources—money, time, and labor—available to the prop shop. The props master maintains good relationships with vendors and encourages reciprocal benefits within the community (as in other local theatres, universities, other institutions). He or she serves as a liaison between the prop shop and the artistic team and so must be fully aware of the entire design and production process. It is also the props master's responsibility to facilitate what happens in the shop and in rehearsal. On those occasions when the designer needs research done, the props master will do so.
- **Assistant Props Master or Mistress** The assistant does all of the above under the guidance of the props master and fills in when he or she is absent. It is wise for a theatre to hire an assistant props master who has different skills than the props master.
- **Props Artisan** The props artisan does all of the crafting and building of paper props and soft goods, and is a jack-of-all-trades. Depending on the particular skills, he or she might paint, dye, sculpt, or even do research. This is typically the kind of person who likes to experiment, do research and development, and just find solutions to problems. The artisan is the one who is likely to discover new products and needs to be able to do anything and be willing to try new things.
- **Props Carpenter** The props carpenter collaborates with the props/scene designer on the construction of any custom-built pieces or furniture (or large prop pieces). His or her skill set would typically include woodworking, drafting, welding, and fine furniture-making.

- **Props Buyer** The props buyer is in charge of all procurement, although given the appropriate information about an object, might well be asked for suggestions as to the best place to buy something. A broad knowledge of local vendors and online vendors is vital, especially in order to become a “regular” customer, which often helps in getting deals and discounts. The props buyer might also get tips and “insider knowledge” from a vendor that can prove useful. The props buyer must be able to work easily with money transactions and most often will need to be able to drive in order to get props to the theatre space.

Working Props in Television

Working props for television is a bit different from working in a theatre. The *production designer* has overall control of the scenic visuals and will hire an *Art Department* to get the design ready for the various shops. The *art director* works closely with the production designer and will draw the overall shapes of the room and the walls in sketch form. The art director might also do research and make major decisions, including molding and other materials that are to be used on the set. The props are handled by a separate department now referred to as the *Set Decoration Department*. This shop controls all furniture, wall treatments, draperies, and floors; in short, all of the decorative details of the set. The *Prop Department* will only handle props that the actors physically touch. It will most likely be the only props crew on the set during shooting. All others will be on to the next project.

Working Props on Broadway

Props for a Broadway production are handled in a similar way to television in that the designs go to various shops for bidding out the costs to produce them. It is also similar to working in a regional theatre as described above in terms of staffing, buying, building, and otherwise procuring props. What *is* different is the hierarchy and the hiring. A Broadway producer will hire the entire creative team—director, choreographer, and designers—as well as the general manager (who handles all of the finances). The general manager hires the technical supervisor (who is in charge of seeing the production built), who in turn hires the props person in consultation with the scene designer. Some scene designers will specify in their contract the right to choose the prop person.

The process for getting the props to the stage begins with the prop list and an estimate of the overall costs. A bid session is held with a number of shops to determine which one will actually build the props. While the props are in the shop, preparation is done for rehearsals, making sure that the actors will have facsimiles of the props. Props are loaded in around the same time as the scenery and the technical rehearsals follow much the same procedure as in a regional theatre. The big difference is that a Broadway production will likely have much more previews, allowing time to perfect the production.

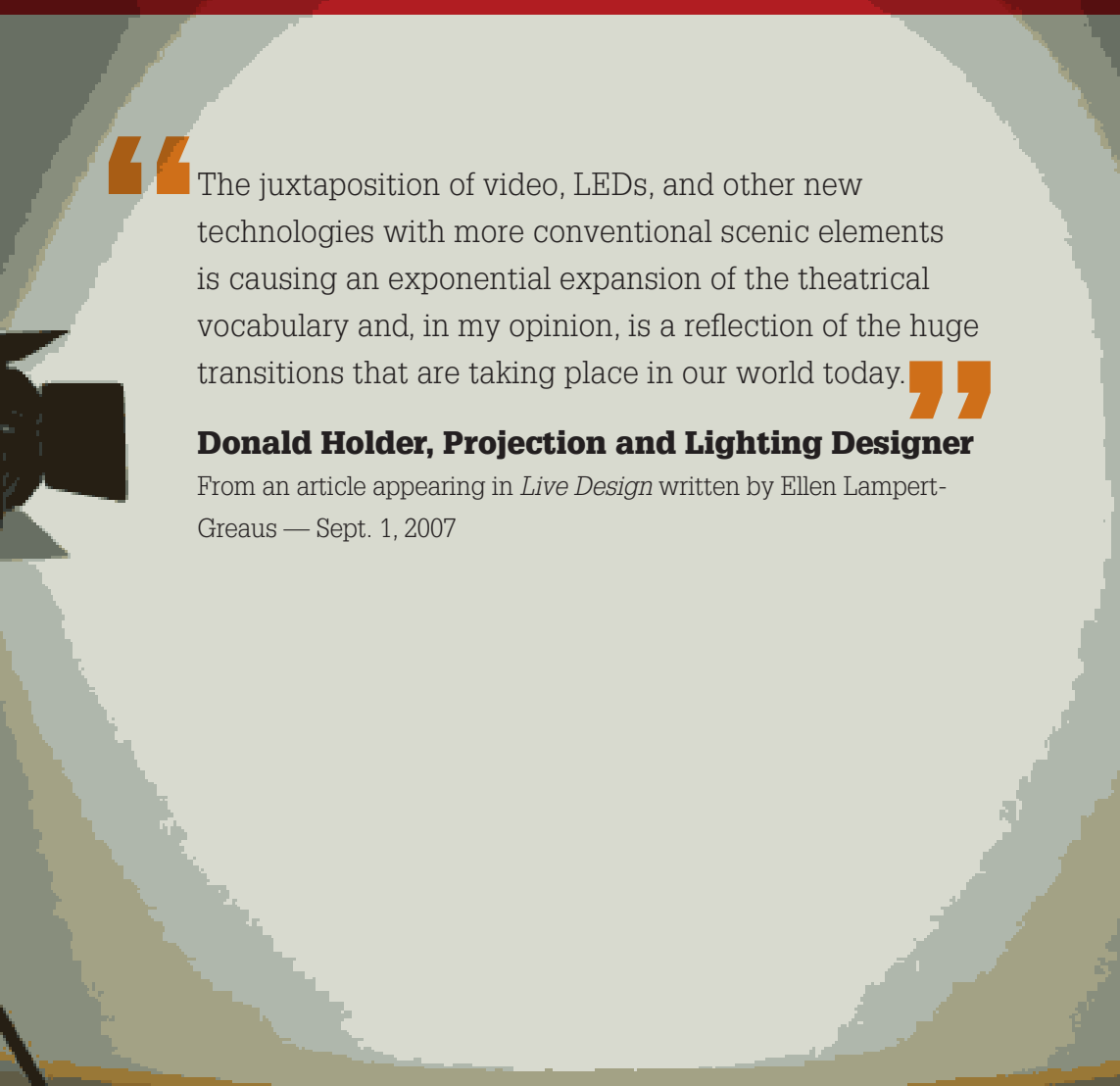
Typically, the props people are hired in the middle of the entire process and often after the big ticket items are already determined from meetings among the designer, director, and choreographer. As with any props situation, the first step is acquiring all possible information about the production and the design—ground plan and elevation, paint treatment decisions, transition between scenes, and anything else that might be helpful.



PART II | **DIGITAL AGE INTEGRATION: SCENERY AND LIGHTING**

12 | **Projection in the Theatre**

13 | **Automation in the Theatre**



“The juxtaposition of video, LEDs, and other new technologies with more conventional scenic elements is causing an exponential expansion of the theatrical vocabulary and, in my opinion, is a reflection of the huge transitions that are taking place in our world today.”

Donald Holder, Projection and Lighting Designer

From an article appearing in *Live Design* written by Ellen Lampert-Greus — Sept. 1, 2007



12

Projection in the Theatre

Projected images have been with us for a long time. Theatrical use of projection goes back as far as the “Magic Lantern,” which entered the theatre in the 1860’s, predating the incandescent lamp. However, recent advances in technology have greatly altered the way we think about and use projection, so much so that a new design team member—the projection designer—has become an integral member of the collaborative team.

CENGAGE **brain**.com

For links to Internet resources pertaining to this chapter, please visit the book’s companion website: www.CengageBrain.com.

Theatrical Use of Projection

As noted above, projections have been used in the theatre for decades. The Czech designer Joseph Svoboda experimented with the use of projection in the 1960s and 1970s with his *Laterna Magicka* theatre, in which projected images were used in addition to and as an extension of scenery. He even experimented with live actors interacting with filmed and projected actors in a scene.

Of course, what is new about projection are the huge advances in technology that have made this area of design more feasible for many theatres. There are now an infinite number of new ways to produce an image on stage and to help an audience understand the play through the design. We primarily have the computer to thank for this.

Projection design can include still images, video, interactive visuals, and cameras on stage for live feeds. Projected imagery certainly does not need to be shown only on a dedicated “screen” that lives within a set. Images can be projected on nearly any surface with varying degrees of acuity and success. They can be static or constantly changing, they can be a major element of the design or a small part of the overall look, or they can be a backdrop to the action or directly interact with it; but, regardless of the image specifics and how they are used, they must always support the action of the play.

The Development of Theatrical Projection

Designer-directors such as Robert Edmond Jones (1887–1954), Edward Gordon Craig (1872–1966), and Adolphe Appia (1862–1928) envisioned using light as a central production scheme in their work. However, the technology of the time could not support their imaginations. It took the genius of the Czech scenographer Josef Svoboda (1920–2002) to show the theatre world what could be accomplished with light and projections. An example of his work is illustrated in Figure 12-1.

At his theatre in Prague, Svoboda experimented extensively with low voltage light sources. He was the first to develop, on a large scale, a way to suspend electrostatically



12-1 Projection by scenographer Josef Svoboda Shown is Polycran (multi-screen) devised by Svoboda for the 1958 Brussels World Fair.

charged particles in the air to act as reflectors of light (a precursor to today's haze). His highly imaginative use and manipulation of projection surfaces was inspirational. Every theatre designer should examine Jarka Burian's fine book *The Scenography of Josef Svoboda*. There is no doubt that Svoboda's use of projected images pioneered new ways of thinking about scenic projection.

Projection as a Scheme of Production

Contemporary use of projection is widespread: we see projected images in advertising (New York's Times Square and downtown Tokyo are perfect examples), in sports, in entertainment (Figure 12-2), and in corporate use (Figure 12-3). This is due in large part to the immediacy of projected images and their ability to demand attention. And this is precisely the aspect of projection that makes its use in the theatre challenging. In nearly every case, projected imagery must not overpower the action on stage.

Defining projection design in the theatre is tricky. It is often used as both scenery and lighting, making it imperative that the projection designer collaborate effectively with those other two designers. It is important to note that projection design is not a substitute for either lighting or scene design; it is its own art form. Like scene design, it can quickly establish in detail or in the abstract the location of a scene; like lighting design it can participate in the immediate storytelling from moment to moment. Projection is all about providing information on stage in ways that scenery

12-2 Projections in Concert Design

TV on the Radio at Ryman Auditorium, Nashville, TN. Marc Janowitz, lighting/production designer; Ben Silverstein, lighting director; Ben Price, associate designer.



RODERICK TRESTRAIL II

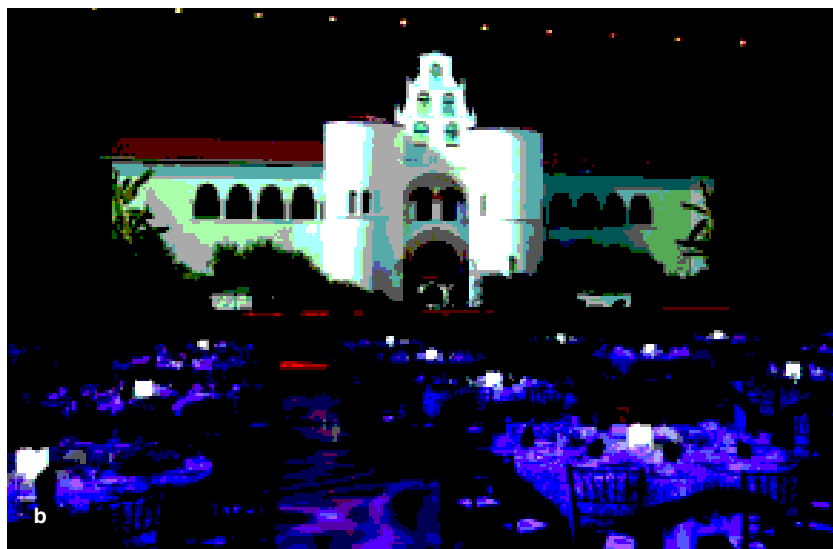
12-3 Corporate Theatre Projection

San Diego State University Campaign Kick-Off Gala held at Viejas Arena. Design and execution by ShowTec, San Diego.

- a** Custom build hard set before projection and lighting.
- b** Projection by two Catalyst Media Servers and four 12,000 lumen LCD projectors.



COURTESY JONATHAN MARTIN/SHOWTEC



COURTESY JONATHAN MARTIN/SHOWTEC

and lighting cannot; projection can provide huge amounts of information but with a new set of rules. The trick is knowing how to take advantage of what can and cannot be done on stage.

Categories of Projection

There are three broad categories of theatrical projection:

- Projected Scenery
- Integrated Projection
- Documentary Projection

Projected Scenery Projections used as a backdrop for the action of a play or musical is a common theatrical technique. Images may be realistic or abstract in nature and are used to establish mood and/or set locale. Projected scenery is intended to support the action of the play but not interact with the action. A good example of such use of projections can be seen in the scenes from the Broadway productions of *Tommy* and *American Idiot* (Figure 12-4).

Designers must always keep in mind that a projection is light, not paint. Color in light is more brilliant than in paint and has a limited value scale by comparison. Therefore, the use of color in projection is more dramatic and eye-catching. If projections are used in place of painted scenery for backgrounds, the actor may have to fight them for visual attention. Projections, no matter how subtle, convey a heightened sense of theatricality. By far the most successful use of projection is not as a substitute for realistic background, but as a medium of its own.

The inexperienced designer may be tempted to consider projection as a means of saving either time or money. This reasoning is totally false. Good projections require a great deal of effort and often more lead time than does standard theatrical scenery.

PHOTO BY JOAN MARCUS, COURTESY THE ESTATE OF CHRIS PARRY



12-4 Projections on Broadway

- a** The Broadway production of The Who's *Tommy* made extensive use of projected scenery. Directed by Des McAnuff; scenery, John Arnone; costume design, David C. Woolard; lighting, Chris Parry; projection design, Wendall Harrington.
- b** The Broadway production of Green Day's *American Idiot* used projections to enhance the mood and support the action of the story. Directed by Michael Mayer; scenery, Christine Jones; costumes, Andrea Lauer; lighting, Kevin Adams; video and projection design, Darrel Maloney.



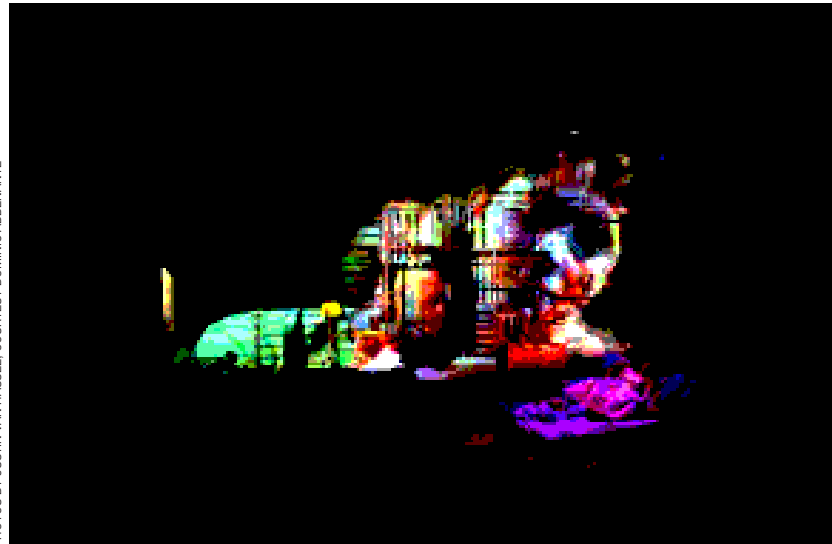
PHOTO COURTESY GREEN HIPPO

integrated projection Projection that interacts with the action as an integral part of the production scheme.

Projections must never be considered a last minute production detail. In addition, projection equipment is very expensive to buy and sometimes difficult to rent.

Integrated Projection Projection that interacts with the action as an integral part of the production scheme is **integrated projection** (Figure 12-5). Although this form of projection might use static images, it most likely will require movement, either as a series of still images or as video. This demands a great deal of planning and rehearsal time. Refreshing new attitudes toward projection in theatrical production, as well as technological advances in media servers and projection equipment, have made this form of projection accessible. Integrated projection normally is complex, requires extensive imagery, and certainly calls for a projection designer. It often involves the production's cast—either filmed and seen in the projections themselves and/or interacting with the projected images. Good collaboration among the director, the scene designer, the lighting designer, and the projection designer is essential. Projection of any sort requires additional rehearsal and technical time, but integrated projection may double or even triple the time needed for technical rehearsals.

12-5 Integrated Projection These images show the use of integrated projection in a production of *Lydia* by Octavio Solis. Projections were carefully coordinated among the director, scene designer, lighting designer, and projection designer. Produced by San Diego State University; directed by Peter Cirino; scenery, Ryan Grossheim; lighting, Sarah Scardino; costumes, Jordyn Smiley; projection design, Dominic Abbenante.



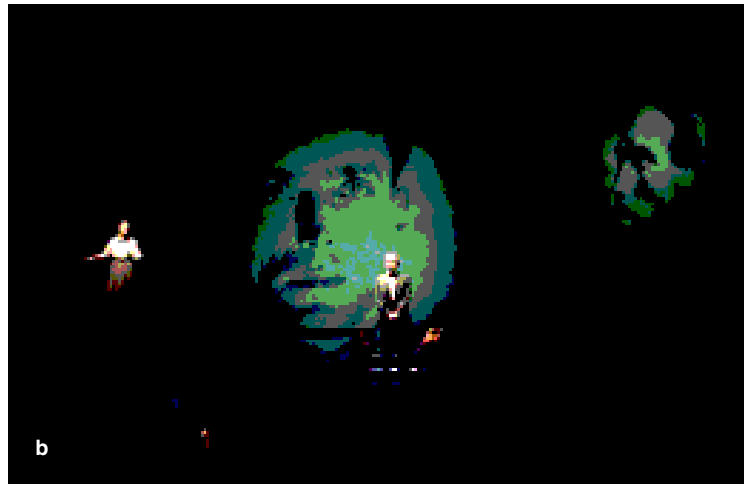
PHOTOS BY JUSTIN VAN HASSEL, COURTESY DOMINIC ABBENANTE



PHOTOS BY JUSTIN VAN HASSEL, COURTESY DOMINIC ABBENANTE



COURTESY OF THE AUTHORS



COURTESY OF THE AUTHORS

12-6 Documentary Projection

- a** Front projected images in this production of *Oh What a Lovely War* are used to comment on and support the action. Lighting and projection design by R. Craig Wolf.
- b** Projections in this production of *Bread and Roses* reinforced the action by rear-projecting images of the historical individuals being depicted by the actors. Lighting and projection design by R. Craig Wolf.

Documentary Projection Projection that supports and comments on the action is **documentary projection**. The Epic Theatre of Bertolt Brecht used projected messages to remind its audience that they were in the theatre. Names of a city or a date might be projected on a screen above the stage to immediately inform an audience of a scene's local or time. Documentary projections such as those in Figure 12-6a may be used to reinforce the action. Images of historical figures being portrayed by the stage characters can be projected to help the audience associate with the action (Figure 12-6b). This form of projection is the least complex of the three and may not seem to require a specific projection designer; however, it is wise to have one as part of the collaborative team.

documentary projection Projection that supports and comments on the action.

Designing with Projections

The first question the projection designer must ask is “How does the use of projection enhance this production?” Like any new technology, it is exciting to explore and use—it is also easy (and dangerous) to get carried away with the flashy nature of projections and the new gear. The danger is that projection (or any other new technological “toy” for that matter) is used simply because it is available. The initial decision to use projections in the theatre must be based upon their appropriateness to the style and scheme of production. Each and every choice of a projected image must have a real purpose on stage and should be motivated by the telling of the story, just like every set piece and light cue. To ignore this may result in projection actually getting in the way of the storytelling or, at the very least, drawing attention to itself and making the designer seem self-indulgent.

The Projection Designer

As a designer, it is important to be sure that the use of projection is worth the time and the money that will be spent on it, as both are likely to be significant—projections must

be crucial to the manner in which the story is being told. This begins with a discussion involving the entire artistic team (the director and all of the designers) to determine what the production will be about and how exactly the story should be told. The entire artistic team must consider the role of projection in the narrative, how the content of the projections will move the story forward, and how directly or indirectly the projections will be integrated. If the reasoning for projections does not make sense, it is the responsibility of the projection designer to inform his colleagues.

The Text Nothing is more important than understanding the text. After all, it is the playwright's words that are used to tell the story. Whereas images can be stronger than language, designers (and directors, for that matter) are bound by the text in hand. When using projections, it is important to learn the nature and the "rhythms" of the play. Every playwright is unique in the way that he or she tells a story, and it is a wise designer who pays close attention to this technique. Neil Simon and William Shakespeare both wrote comedies but the way in which they find humor is quite different.

Design Considerations Be aware that audiences are accustomed to responding to images in a literal manner. For example, consider how more and more plays are often written like screenplays. Putting a moving image on stage suggests to the audience that those moving images should be the focus, to the exclusion of everything else, including the actors. In a way, projection design has to enable an audience to view the images not as entities unto themselves, but as part of a larger whole. We are asking the audience to "see" what is put on stage in a different way.

Skills There are, of course, basic skills that the projection designer should develop. It is important that projection designers learn to draft on the computer as well as have the ability to create three-dimensional models both physically and electronically. These are the tools with which designers communicate. And, naturally, the knowledge of the mechanics of design is critical. As with any designer, the ability to tell a story in the theatre requires a full understanding of the structure of plays and how the visuals can be of use.

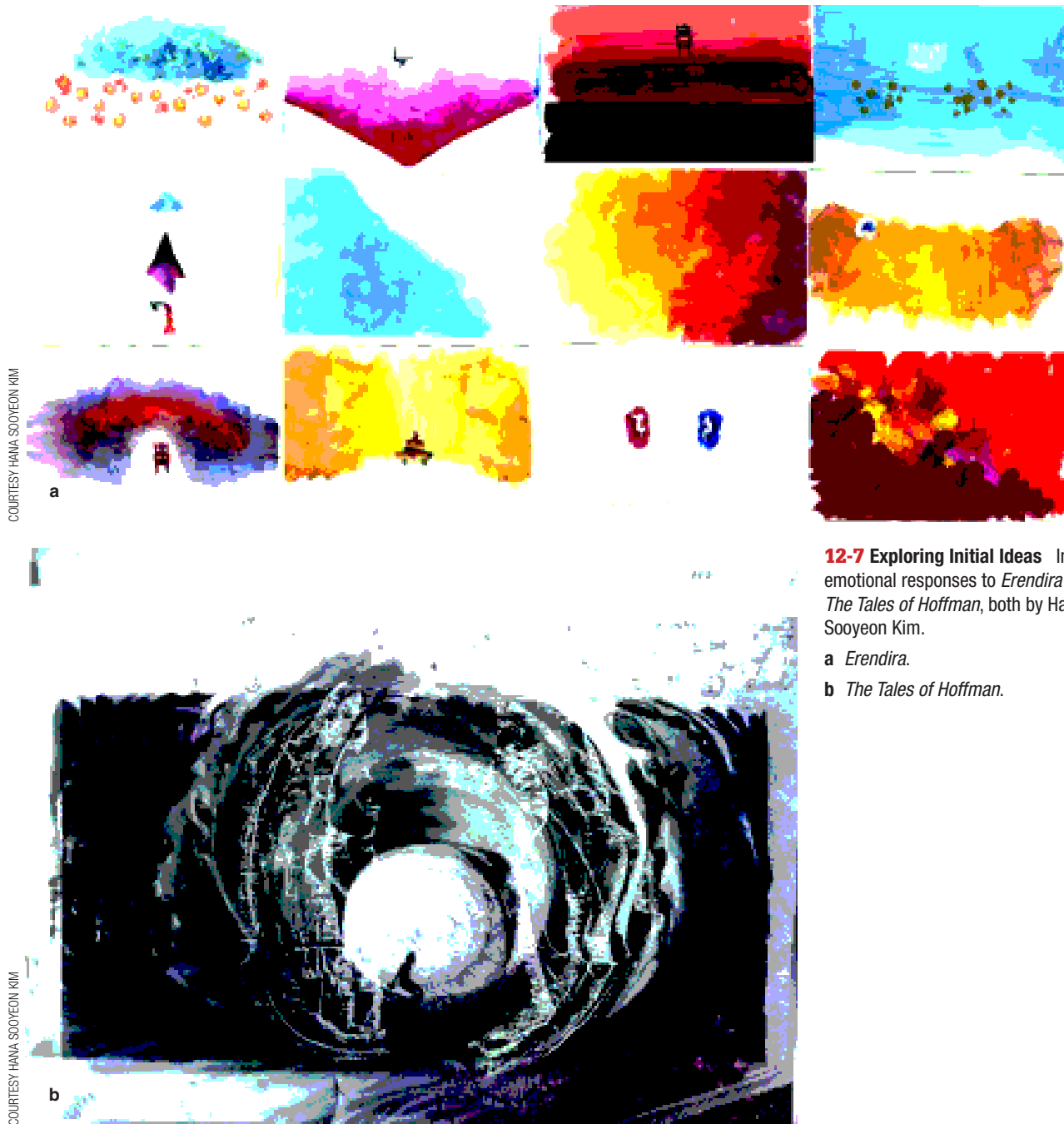
Solid communication skills cannot be overemphasized. It is difficult to discuss projections with a director who doesn't fully understand their potential. The earlier collaboration begins and the more specific the projection designer is with the director, the better chance of averting unpleasant surprises later in the theatre.

A working knowledge of the software and hardware involved in theatrical projection is also imperative. This includes editing software, surface materials, media servers, and the projectors themselves.

The Design Process

As noted, the process begins with a full understanding of the text and the direction that the artistic team chooses. The first task of the projection designer is to develop the ideas of the play in a way that will best enhance the story within the parameters set by the director and the artistic team (and, of course, within the budget). Consider why an image of any kind is necessary and how projections will fit into the world of the play. What is the "feel" of any given scene or moment? Accepting the first idea is never a good strategy for any artist. There is no way to know if that initial thought is the "best" idea. Although a designer might ultimately use that first idea, it only becomes useful after more exploration has been done. If that has happened, the first idea will no longer be seen in the same way.

Most importantly, early in the process stop *talking* about projections and start *looking* at images with the director (Figure 12-7).



12-7 Exploring Initial Ideas Initial emotional responses to *Erendira* and *The Tales of Hoffman*, both by Hana Sooyeon Kim.

a *Erendira*.

b *The Tales of Hoffman*.

Research The time a designer spends on research pays off threefold in later decision-making. Research should begin early—as soon it has been determined that projections are indeed appropriate for the production. Identify the aesthetic of the production and begin looking at images that address it directly. Be sure that an idea is clearly articulated, even though it may change later.

In the early stages, it is more important to find examples of the style itself with little regard for the specific image—this helps the entire design team get a fuller understanding of the style. This initial research is of utmost importance because it is at this point that the director and designer are most open to multiple ideas. It is impossible to tell when a particular image will strike as being exactly right for what the director and designer want. In addition, finding images at this early stage might encourage an adjustment or

development of ideas in a different direction. It is possible that one image can be used as a guide for everything else.

Be relentless in the research. Find as much as possible so that there is more than could possibly be used. Keep asking, “Isn’t there something better?” Remember that no two people talk the same way about the same ideas and certainly won’t describe them in the same manner. It is not unusual to pull hundreds of images early on for consideration and exploration.

The next step is to organize all of the images collected—perhaps in multiple ways. Identify each image carefully so that it can be found easily. Images can be grouped thematically, in terms of text, or in any other manner that will be useful. This does not necessarily mean that the search for more images stops, but it is necessary to find some way to sort those images on hand. The specific method of organization is not as important as having the ability to find a particular image.

Attending rehearsals allows any designer to see firsthand how the director is tackling the issues of the play. Careful observation at rehearsal helps to determine the emotions of each moment; knowing exactly what the director and the actors are doing and how they are telling the story is very important as it can lead to better ways of using the projections. It is also a way of guaranteeing that the projections won’t distract from the action on stage.

Projection Surfaces The choice of projection surfaces is most often made by the scene designer in consultation with the projection designer. The possibilities are endless: hard scenery, fog curtains, steam, haze, water, and the actors themselves are all potential projection surfaces. The size and shape of the projection surface, as well as placement, must be explored. Although rectangular screens are simple to use and appropriate to the aspect ratio of unaltered projections, they can be quite dull and obvious. Projections are often most effective if they surprise the audience or appear in unexpected places. They should always be an inherent part of the design (Figure 12-8). More detailed information concerning projection surfaces will be found under *Technical Aspects of Production* section on page 272.

Creating Content The creation of projections can take a great deal of time. Although there are many software programs available, such as After Effects®, Photoshop®, Final

12-8 Projection on a Less-than-Obvious Surface *Suddenly Last Summer*. Projection design by Michael Epstein; Scenery designed by Helen Jun.



PHOTO COURTESY HELEN JUN

Cut, and 3D Studio, they are all a bit different with a variety of strengths and weaknesses. Cameras can also be used to create media for both programmed images and live feed.

Working with the script by breaking it down scene by scene allows the designer to create a list of potential images in terms of content. This step is when proper organization of images will be hugely helpful. A tentative cue list is a good idea at this point as well.

Sources for imagery are nearly unlimited. Images may come from the Internet, a book or magazine, the world of art and photography, or designers may take photographs or video on their own. It is not unusual for a photographer or a videographer to be hired for a given project. It is not necessarily expected that the designer must manufacture all raw material. Archival footage or stock photographs are often used and then fashioned into the specifics needed for the production.

Finding the images may be slow work but is only about 10 percent of the job. It is almost certain that every image gathered will be changed or adjusted in some manner to adhere to the ideas of the production. There are an infinite number of ways to alter an image—both with and without a computer. The function of the image and the original source material will determine what needs to happen. If an image is used counterpoint to the action on stage, it will likely be treated differently than if it is more in line with the action. Consider all options with any given image: is it the *meaning* of the image that is important? Should the image be a shadow, a close up, a master shot? Again, these decisions are based on how the image is to be used and for what reason.

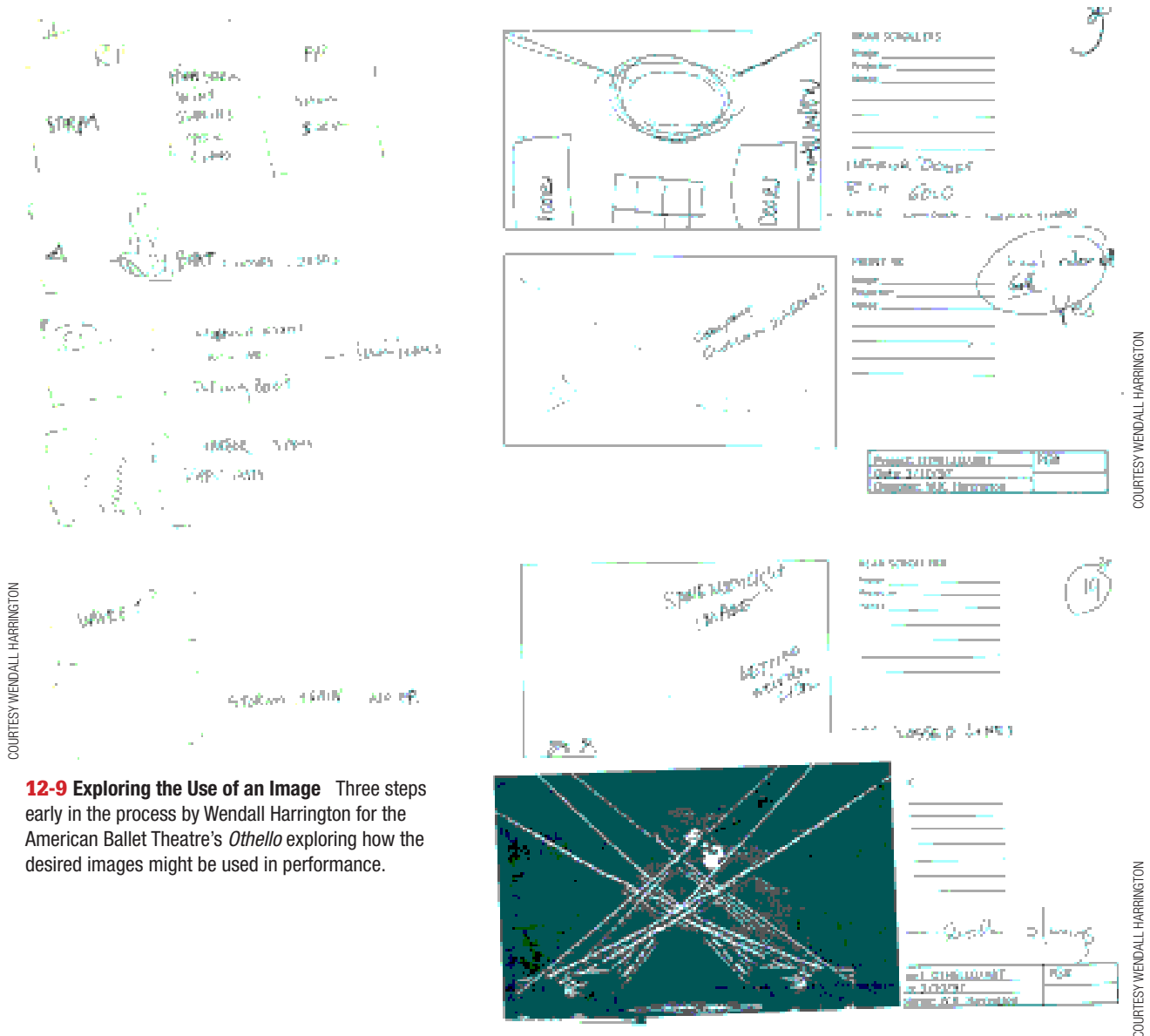
One reason to adjust each image is to make it the designer's own—to make it unique to the production. Of course, some images will need more work than others. It may involve speeding up or slowing down a video, changing the color or the focus, or using an image as part of a larger collage. The speed of video can be a real issue on stage as footage at actual speed is often distracting to the audience and will certainly demand attention. Pushing light into the images and putting more “life” into the pictures by losing the edges are ways of making sure that the images are “in the play” and not imposing on it.

It is also critical to be aware that images on a computer and images projected on stage may not look the same. Given the variety in color calibration on computer monitors, an image can look quite different from one computer to another. The projection surface, the projector itself, and the software used all must be taken into account when manipulating an image for the stage. Color especially can be difficult to handle. This is true in part because the light is utilized differently on the computer monitor than in a projection.

A key factor in image manipulation is the resolution of the initial image. The higher the resolution of that image, the more manipulation is possible and the more control is available to a designer. It may be that a lower resolution is acceptable or even desired for the final image, but this should be a *design* decision, not a circumstance beyond control.

Working on image content is an important part of the process. Some projection designers have assistants and/or editors for much of this work. Students are more likely to do most, if not all, of this work themselves. This entire process is extremely time consuming and can be tedious as anyone who has worked with programs like Photoshop® can attest. But, like many aspects of any form of art, the difficult aspects of a job are worth it if the designer is paying attention and knows what he or she wants (Figure 12-9).

There are few real limitations (beyond time and money), but resist the urge to do something just because it is possible. There must be a need for it in the production. The designer should continually be asking, “What is the story?” One way to answer this question is to consider not just the image itself but the way in which it will be shown in performance. The size, the resolution, the timing, and the duration of the image on stage are all factors that will have an effect on the audience's reaction and the image's effectiveness in the storytelling.



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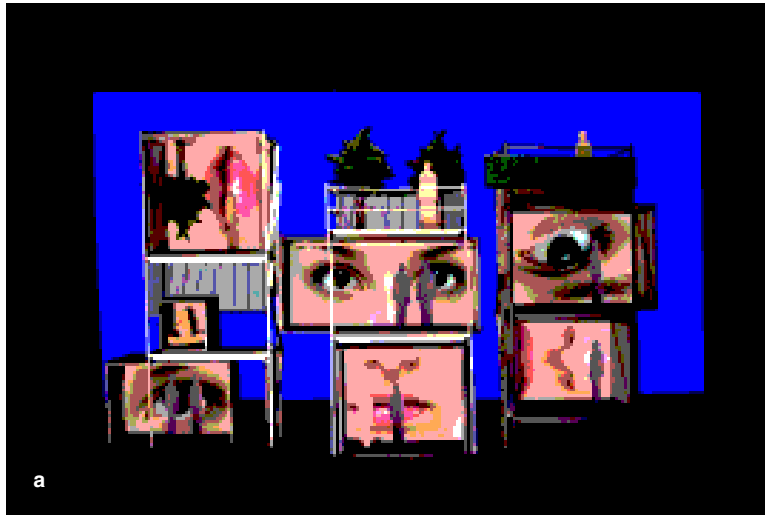
12-9 Exploring the Use of an Image Three steps early in the process by Wendall Harrington for the American Ballet Theatre’s *Othello* exploring how the desired images might be used in performance.

Consider how these images will best be communicated to the director. The solution may well depend on what the director expects and what kind of relationship the designer and director have. A PowerPoint presentation, a series of flash cards, or a grouping on the computer are all options that might prove useful; the 3-D sketches for a production of *Alice* and the model for *The Tales of Hoffman* shown in Figure 12-10 are good examples.

Careful thought about how a director likes to view design ideas and visuals can make any presentation much more successful. A director who only sees the world three-dimensionally will no doubt want a model with the projected images included. That request might involve changing a series of still images on the model or actually projecting the images into the model. Caution must be taken when doing the latter, as projections onto a model will never be the same as on stage, especially in terms of brightness.

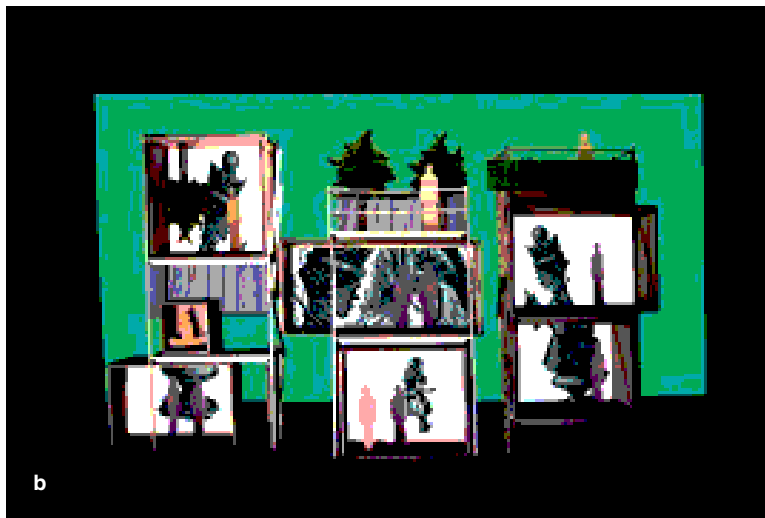
Rights Issues Keep careful track of the source of every image. It is easy to grab an image from the Internet, forgetting the possibility that someone actually *owns* that image. Getting the rights to an image is a very real cost just like buying a piece of lumber for scenery (Figure 12-11). It is very important that all copyright laws be followed or a

COURTESY CAT WILSON AND ROBERT FIGUEIRA

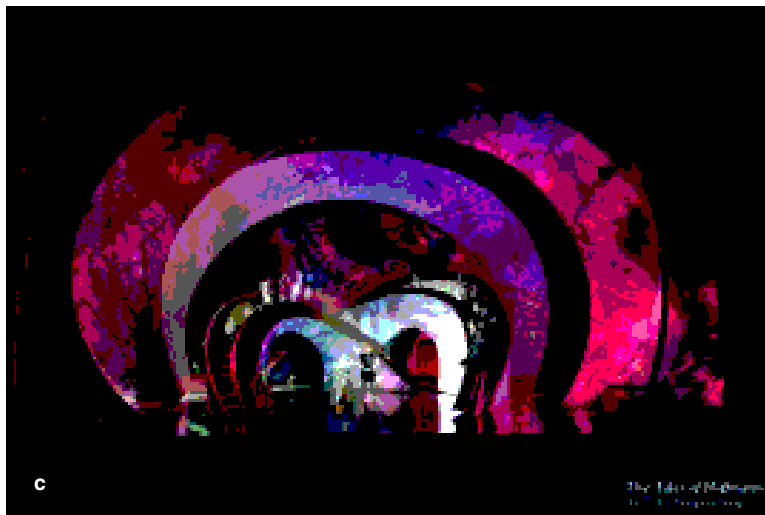
**12-10 Presenting Projection Ideas**

- a A sketch for *Alice*, created in 3-D designed by Cat Wilson and Robert Figueira.
- b A second sketch for *Alice*.
- c Model for *The Tales of Hoffman*, Act 2, designed by Hana Sooyeon Kim.

COURTESY CAT WILSON AND ROBERT FIGUEIRA



COURTESY HANA SOOYEON KIM



designer can find himself in serious legal trouble. Copyright laws vary depending on the source material. Getting permission to use an image can be as easy as asking for it. Many owners will simply agree to it and that is the end of it. It is just as possible that the use of an image will be approved but only under certain conditions. These conditions could include use for a limited amount of time, use only once or for a limited number

12-11 Image Source List For *Othello*, Wendall Harrington wrote a letter to the general manager of the ballet company listing the source of her images.



To Claudette Donlon
General Manager
Ballet Theatre Foundation, Inc.
May 15, 1997
Dear Ms. Donlon,

Following please find a list of sources for copyrighted material used in the creation of the design of the projection for *Othello*. As we have not yet begun to tech the show there is a possibility that some of this will change, but as it is due, here it is:

Interior of the Dogra Palace:

Yemeni Palace, pg 104-105 Photographs by Paolo Marton, Publ by Rizzoli 1989
ISBN 0-8478-1200-6

Cathedral Interior:

Venice: An & Life in the Lagoon City pg 79 photo Claudio Estamer Newsweek Book Division 1973 ISBN 0-88-225-028-0

Cathedral Interior

Glory of Venice p15

Tennil Books 1994 ISBN 2-87-939-096-6 photo by Erich Lessing

Harbor:

Venice, World Photographs p56 Photo Giuseppe Brodyen 1895

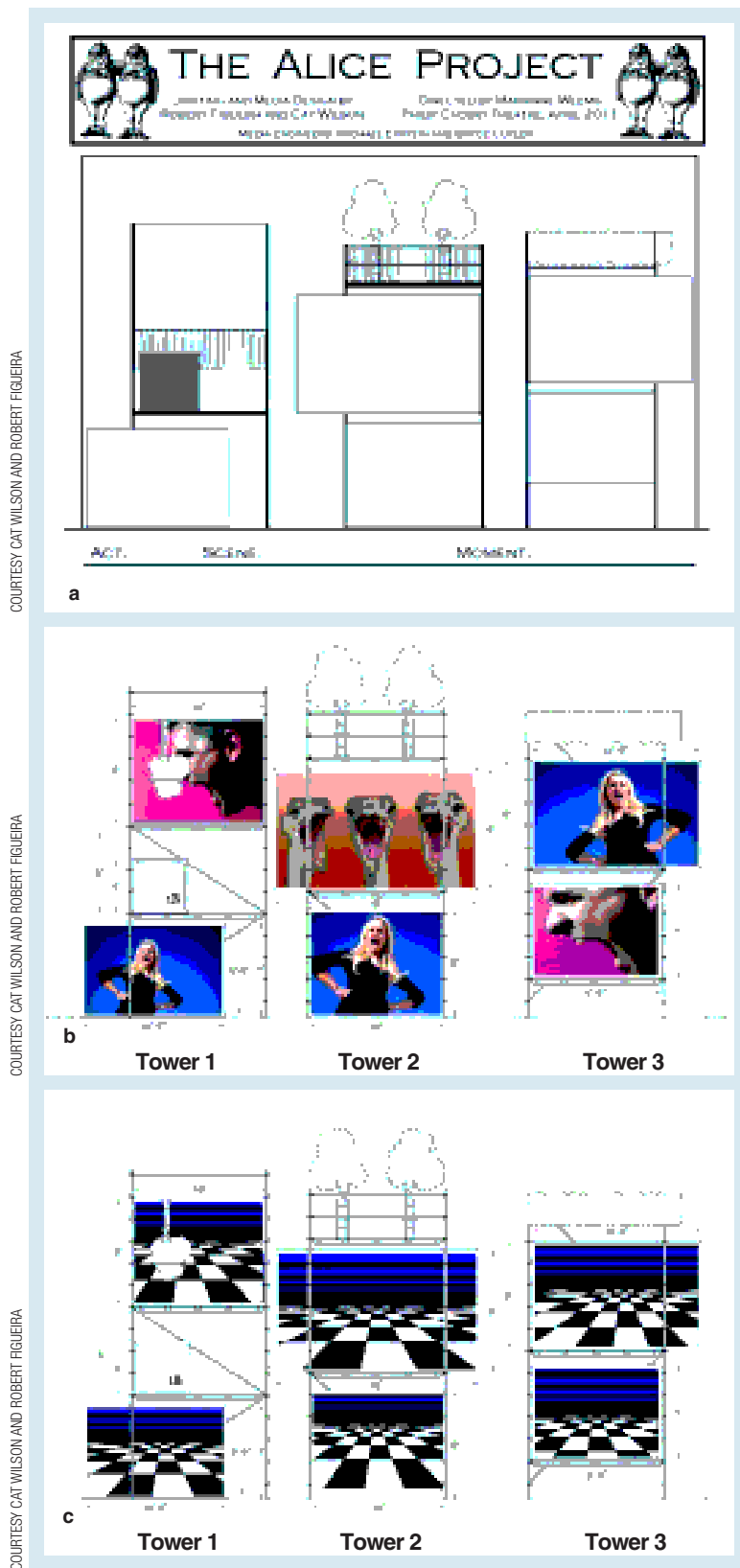
COURTESY WENDALL HARRINGTON

of performances, or limits on geographical locations. It may be necessary to buy the rights to an image outright. Images that are in the public domain are of course free for use. It is possible to alter an image and avoid obtaining the rights to it, but this gets into dangerous copyright territory. The owner of the image may argue that changes made are not significant enough to be a new image. Many lawsuits have been built on this disagreement.

Some production organizations have a staff member to assist in obtaining rights, but ultimately it is the designer's responsibility. This should not be postponed until the last minute as rights can be expensive and it might be too late in the process to change an image. It is also wise to maintain a readily available *Source Use Report* that keeps track of all licensing and rights issues. Finally, always insist on *written* permission of the rights to an image.

Preparing for Technical Production

Gathering and altering the images, along with attending rehearsals, allows the designer to assemble a “package” of images—whether still, video, or a combination—that directly



COURTESY CAT WILSON AND ROBERT FIGUERA

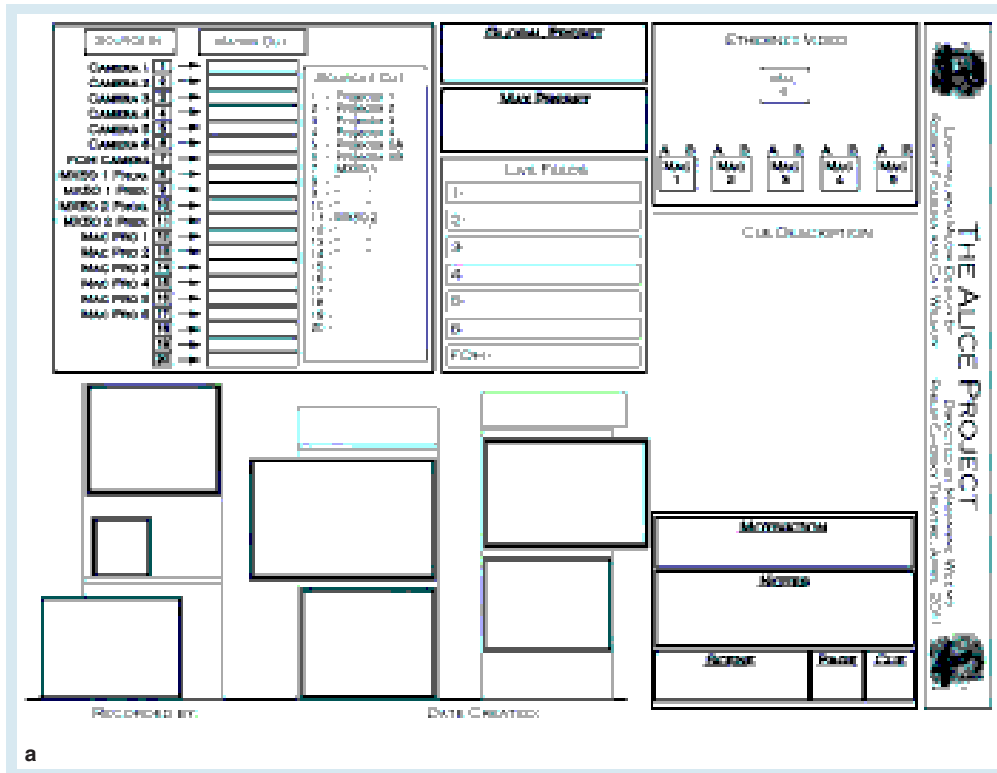
COURTESY CAT WILSON AND ROBERT FIGUERA

COURTESY CAT WILSON AND ROBERT FIGUERA

12-12 Organizing Images

- a This is a template used by Cat Wilson and Robert Figueira to organize all of the images used in *Alice*.
- b Images considered for *Alice*.
- c Images considered for *Alice*.

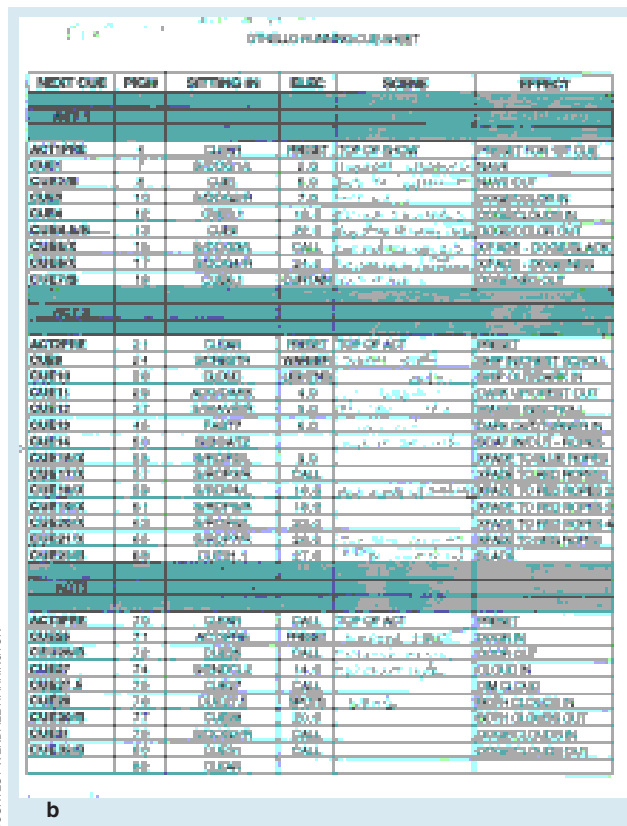
addresses the design as promised. Many designers prepare a storyboard of imagery that outlines the movement of the images throughout the play (Figure 12-12). This storyboard is valuable to share with the director and also becomes an important organizational tool for the designer. The cue sheet is further refined, moving closer to what will finally be seen on stage (Figure 12-13).



COURTESY CAT WILSON AND ROBERT FIGUEIRA

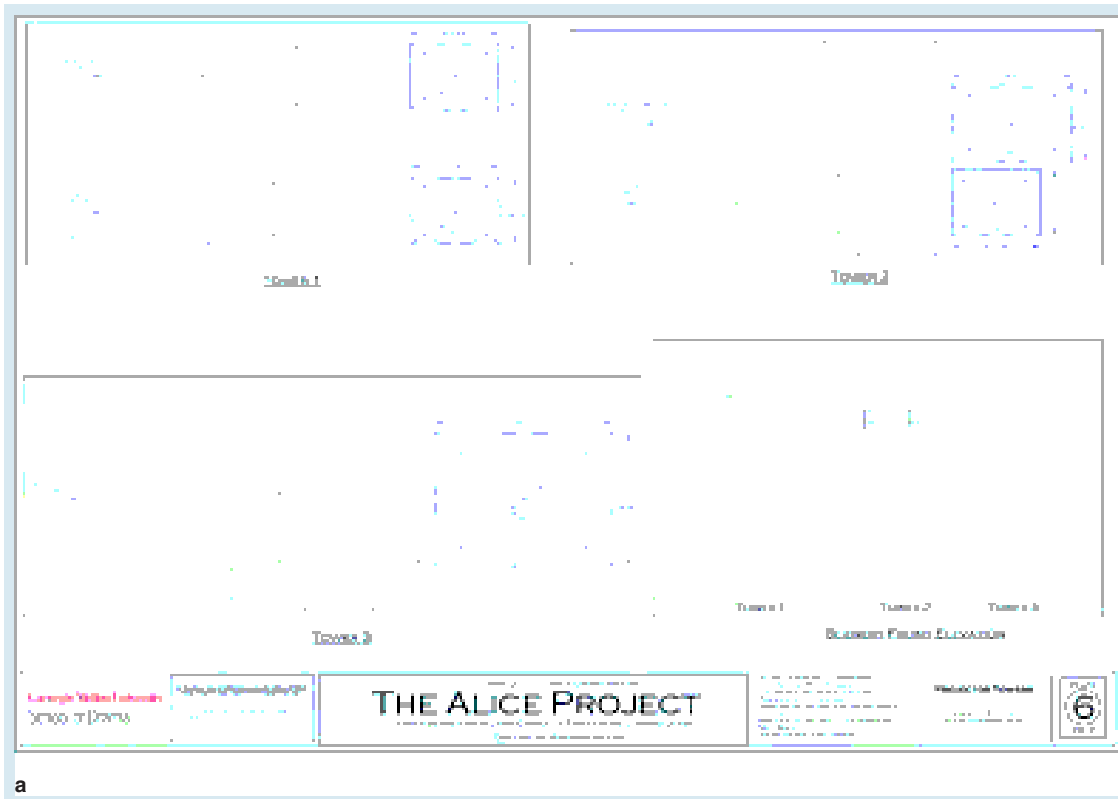
12-13 Cue Sheet

- a Example from *Alice*, designed by Cat Wilson and Robert Figueira.
- b Example of cue sheet from Wendall Harrington for the American Ballet Theatre's *Othello*.

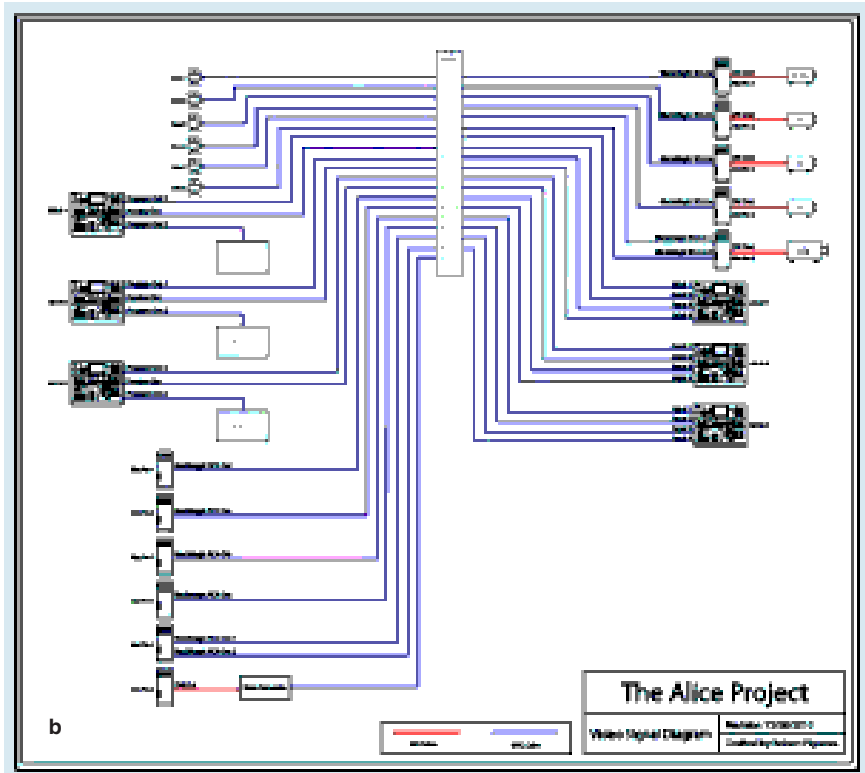


COURTESY WENDALL HARRINGTON

Documentation In the same way that the lighting designer creates the light plot, the projection designer must create a plan and section of the space for placement of projectors (and potentially projection surfaces). This plan likely will affect both the lighting and scene designs, so clear and consistent communication is a must. This allows the stagehands to get the space prepped for tech rehearsals (Figure 12-14).



COURTESY CAT WILSON AND ROBERT FIGUERA



COURTESY CAT WILSON AND ROBERT FIGUERA

12-14 Documentation

- a Section showing positions relative to the projection surfaces of some of the projectors used in *Alice*.
- b Video diagram for *Alice*.

Equipment If the projection designer is working in a regional theatre or a school setting in which there is standard equipment available, he or she must provide a list of what is needed. This could include sound equipment (if different from what the sound designer is using), microphones, mixers, cameras, media server(s), projectors, etc.—in short, all of the gear that needs to be in the theatre. If more equipment is necessary or

media server Software or a dedicated computer that allows for complex playback of media.

if there is not stock equipment, a shop order listing all of the gear needs to be created. Every piece of hardware and other equipment that will be used must be on this list with specific information about each unit. This is the only way to ensure that the gear that is needed is in the theatre at the appropriate time.

The Media Server In order to be ready for working on stage, the images must be loaded into a **media server**, software or a dedicated computer that allows for sometimes very complex playback of media. In addition to cueing order, programming details include: where and how quickly the audience sees the images, their duration, their intensity, their opacity, and how they change from one to another. These decisions must be made carefully in conjunction with the director.

Resolution of the image is critical. It must be large enough to visually produce the image as desired, but no larger; the larger the resolution, the more work the computer must do. Larger files can slow the computer down or even cause it to crash. Keeping the system as simple as possible will help prevent a very slow technical process.

It is good to set up a database that includes all information about the images, including content and use in the production. This database will make it very easy to assemble a cue list. Often, projection cues are coordinated with lighting cues.

Projections must be set up in the media server in a way that will allow the designer to change or adjust images at a moment's notice. Some degree of testing can be done with images projected on a model of the set but only if the model is at least 1 inch = 1 foot scale. More information on media servers will be found later under *Technical Aspects of Projection* (see below).

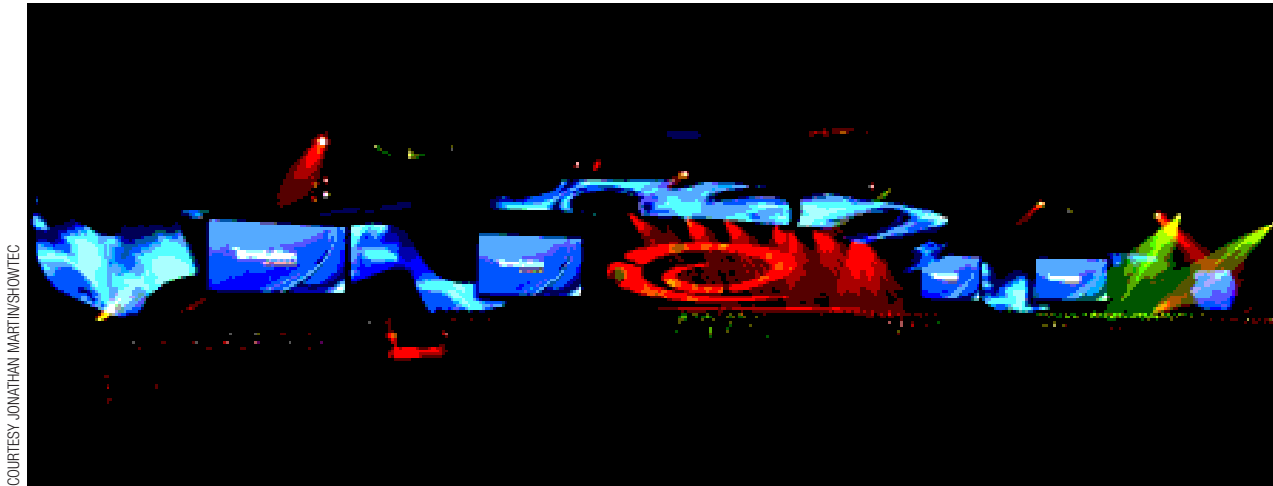
Technical Rehearsals Every designer should be overprepared for tech rehearsal. A designer can never be sure exactly what he or she will see until it is on stage, on the set, and under lights. The more prepared the designer is, the more easily changes and improvements can be made at a moment's notice. The design must create the production that the entire artistic team imagined—major adjustments often have to be made. Remember that because what is seen on the computer screen is going to be different than what appears on stage, the sooner the projection designer has a chance to see the projections in the actual space, the better. Scale is vastly different and the speed of video will seem much faster when enlarged. Never assume the project is completed just because the image on the computer screen seems correct.

Technical Aspects of Projection

Knowledge of technical elements involved with projection facilitates the realization of a conceptual vision. It is important that designers understand the potential and the limitations of projection surfaces as well as the mechanics involved in getting images onto them. In the theatre, this involves all three designers: scene, lighting, and projection.

The Projection Surface

Innovative use of the projection surface by designers such as Svoboda made a significant contribution to the imaginative use of light as scenery. In a very short time, projected scenery graduated from a large single screen background to multiscreen compositions in a great variety of sizes, shapes, and three-dimensional forms. For example, Figure 12-15 illustrates an exciting scheme of multiscreen projection for a corporate theatre event produced by ShowTec.



COURTESY JONATHAN MARTIN/SHOWTEC

12-15 Multiscreen Projection Annual corporate meeting at the Hilton Anatole, Dallas, TX. Wholehog III Show Control, Catalyst Media Server, Encore Video Switching System, eight 10,000 lumen DLP projectors, and six Christie HD 12,000 lumen projectors. Design and execution by ShowTec, San Diego.

As soon as the use of projections has been confirmed as a desired technique for a given production, the three designers turn to consideration of surfaces. As noted, any material capable of reflecting light can be used as a front projection surface. Of course, some materials reflect light more readily than others. Furthermore, one surface may reflect light differently (in terms of direction) from another. Brightness and proper dispersion of the projected image are of primary concern to a projection designer.

Concern for brightness is alleviated by using an LED screen (discussed below). Audiences are familiar with LED projection surfaces in advertising and sports facilities—they produce an excellent image that is bright enough to be viewed in daylight. When considering LED screen projection, the designer must keep in mind the high cost and the unique quality of light produced by LED sources (see Chapters 16 and 23).

Rear Projection Single-screen rear projection has been used as background for dramatic productions for some time. The original location of the projector was behind the screen because early projection required an operator.

A rear projection screen must be translucent enough to diffuse the bright spot of the projector's source, yet transparent enough to transmit the image. Few materials can do so. The stage-left and stage-right shadow projections in Figure 16-10 are rear projections on common plastic drop cloth material. As can be seen, the sources show through the plastic and are distracting. To solve this problem, professional rear screen material must be used.

A professionally made rear projection screen is constructed with the greatest density in the center to offset the hot spot of the projector's source. It is seamless and polarized to allow for equal distribution of light. Because of its high density, a rear projection screen causes a good deal of light to be lost by absorption and reflection. Consequently, rear projection requires a brighter source than front projection does to create a similar effect. An advantage of rear projection is that the projectors can be centered behind the screen and are hidden from audience sight. As we shall see, front projection most often requires a light pitched at a high angle.

Projectors can be equipped with lenses of various focal lengths. However, even the widest lens can achieve only a 1:1 ratio of image size to throw distance. In other words, to achieve a 10-foot image, a projector must be at least 10 feet away from the screen. Some theatres have been designed with extra depth or a special rear projection booth.

However, many stages in the United States are simply too shallow to accommodate rear projection on any large scale.

Before making a final decision on using rear screen projection for a production, the designers must consider the cost of purchasing or renting a screen. Projecting onto surfaces other than good rear screen material will produce an inferior image. Rear screen material is available in many sizes and colors from several theatrical suppliers, including Rosco and Gerriets International (www.gerriets.us).

Front Projection The greatest advantage of front projection is that the image can be projected onto a variety of surfaces. It allows for much greater creativity in the design of the screen. Front projection surfaces can be three-dimensional or be broken up to allow for action behind or through the screens. Figure 12-16 illustrates front projection on a unique screen shape used in the production of *War Horse*.

As mentioned earlier, front projection has to throw from a more extreme angle or a greater distance than rear projection (Figure 12-17). A high projection angle causes an image to distort, or **keystone**, because the top of the screen is so much closer to the projector than the bottom is. Angled front projection, therefore, requires a source image that has counter-distortion built in. Fortunately, higher quality digital projectors come equipped with built-in keystone correction. With modern high intensity lamps, light loss associated with long projection throws is less of a problem than it was in the past.

keystone Distortion of an image owing to projection at an oblique angle to the screen.

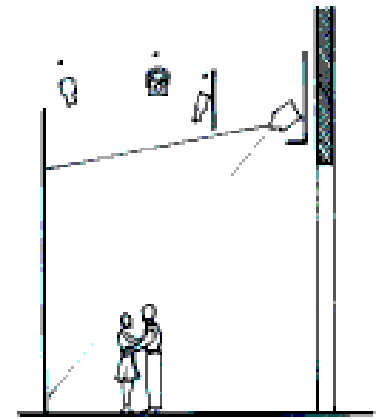


COURTESY PAUL KOLNIK

12-16 Projection for *War Horse* Front projection on this unique surface plays an important part in the visual design of the West End and Broadway productions of *War Horse*. Scenery and costumes by Rae Smith; lighting, Paule Constable; animation and projection design, 59 Productions.

Not all distortions need to be corrected. There are times when the distortions of an angled projection are accepted as part of the design, especially if the image is abstract or nonobjective in style.

LED Screen Projection LED screens are made up of many small LED lamps arranged in clusters of three (red, green, and blue). Each cluster corresponds to a pixel in a conventional projected image. The smaller the lamps and the closer they are together, the better the “resolution,” but LED-generated images can never be viewed at a close range. Their primary advantages are brightness and vividness of color; disadvantages are cost and the fact that the screens are limited to modular shapes and sizes. Modules manufactured by various companies come in different sizes: the MIRAGE from Clay Paky is roughly 2' × 2'; the Martin LC Plus panel is roughly 3' 4" × 6' 8"; and Barco's LED tiles are 1' 4" × 1' 4" (Figure 12-18). Of course, a group of modules can be masked in front to create any shape, but custom-made shapes are extremely expensive. Another advantage of LED projection is that its viewing angle is very wide. Standard projection images fall off in intensity when viewed from the side—the viewing angle of LED screens can be as great as 170 degrees. With LEDs, a projector is unnecessary—only a media server designed to work with LED images is needed. As prices fall, theatrical use of LED projection will become more and more common.



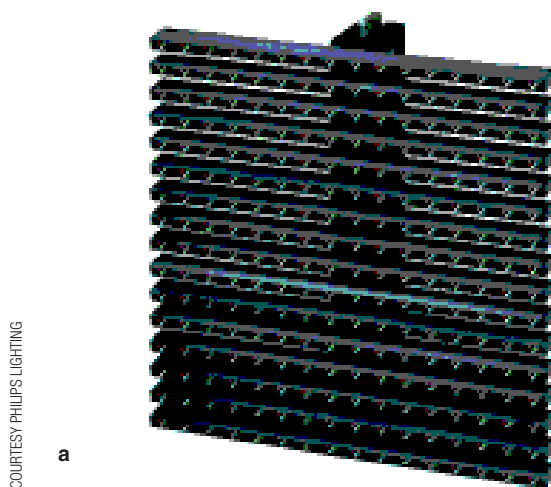
COURTESY OF THE AUTHORS

12-17 Projections and the Actor Front projection from a first electric position. Actors are lit with high side-, back-, and steep front-light—all designed to keep as much light off the projection screen as possible.

Lighting the Actor

Projections in the theatre are most often used in conjunction with live action. Unless LED projection surfaces are used, ambient light must be controlled and kept to a minimum when projected images are in close proximity to the acting space. At times, an actor may need to be lit well enough to compete with bright and vivid projected images.

Lighting actors in relation to a projected background requires special attention. Light from acting-area fixtures that hits the screen causes the image to wash out. As such, lighting designers must take care to choose lighting angles that do not hit the screen or cause light to bounce off the floor onto the screen. Side-light is particularly useful here. Additionally, back-light is important for separating the actor from the projected background. An ERS is the best fixture choice because it produces the least



COURTESY PHILIPS LIGHTING



COURTESY MARTIN PROFESSIONAL, INC.

12-18 LED Projection Screens

- a** The Philips Vidiwall LED display shown provides flexibility in size with wide viewing angles.
- b** Shown is a detail of the Martin LC Plus Series LED panel. It has 60% transparency and is lightweight.

amount of light flair. Top hats are recommended for all fixtures in the vicinity of the screen. (See Figure 12-17.)

Bounce light can be minimized in ways other than control of distribution. The reflectivity of the floor can be deadened with a cover of black or gray cloth or carpeting. Even a common ground cloth can reduce floor reflection. In the case of rear projection, technicians can keep reflected light off the screen by hanging a seamless black scrim about a foot downstage of the screen. It serves to absorb the reflected light without adversely affecting the quality of the image.

The problem of reflected light can also be helped by the design and position of the screen or the image on the screen. A projected image is less likely to suffer from bounce light if it begins 3 or 4 feet above the stage floor. In addition, it is best if a so-called neutral zone of approximately 4 feet is maintained between the screen and the acting areas. This practice makes it easier both to light the actor properly and to preserve the projected image.

Projection Techniques and Equipment

Projections can be achieved by a variety of methods. A common ellipsoidal reflector spotlight makes an excellent pattern projector. Video projection and digital imaging require specialized projectors that accept computer, DVD, or high definition inputs. Most recently, the projection light source is part of the screen itself. Companies such as Barco, Philips, Martin, Lighthouse Technologies, and Daktronics are using clusters of color mixing LEDs for large image projection (Figure 12-19). Although this technology is exciting, it remains expensive. For scene projections, a lens projector is the most commonly used device. Lens projectors for both moving and still projection come in various sizes and types. The requirements of a specific task dictate which projector is best suited for the job.

Lens Projectors

Two basic types of lens projectors exist: **image projectors** and **digital projectors**. An image projector uses a slide or some other sort of transparency (film, for instance) and shines light through it onto a projection surface. A digital projector receives a digital signal and transforms it into a light source using one of two technologies: LCD (liquid crystal display) or DLP (digital light processing).

Image Projectors An image or slide projector uses two sets of lenses, each having its own separate function. As illustrated in Figure 12-20, the **condensing lens system** concentrates the light from the source onto the slide. The image of the illuminated slide is then transmitted through another lens or set of lenses called the **objective lens system**. A reflector is most often used to increase the light output of the lamp.

Normally, the body of a projector includes the reflector and lamp, condensing lens, and slide holder or mechanism to move the film, as well as a fan for cooling. To provide a choice of image sizes, the objective lens assembly is housed in an interchangeable **lens tube**. Much like the lens barrel of an ellipsoidal reflector spotlight, this tube fits into the front of the projector body.

Digital Projectors As noted earlier, two types of digital projection systems are in use today: LCD and DLP.

- LCD projection involves passing colored light through glass panels made up of millions of tiny cells, each one representing a pixel or color dot in the projected image. White light from the lamp is divided into the three primary colors (red, green, and blue) by means of dichroic mirrors. When each of the colors is passed through its

image projectors A projector that focuses light onto a slide or moving film by means of a condensing lens system. The resulting image is then projected onto a screen by means of an objective lens system. Also called a *slide projector*.

digital projectors A projector that receives a digital signal and transforms it into an image to be projected onto a screen by means of an objective lens system.

condensing lens system The first lens or set of lenses in an image projector; the condensing lens(es) concentrate the light from the source onto the slide.

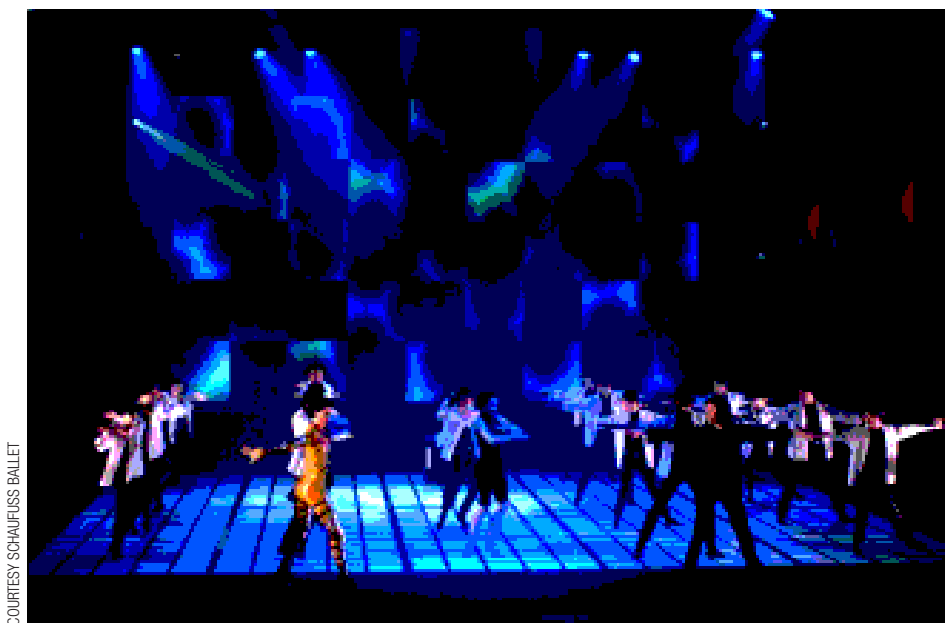
objective lens system The second lens or set of lenses in an image projector; the objective lens system receives the image of the slide and transmits it to the screen in a size determined by the spread (focal length) of the lens.

lens tube The housing for the objective lens(es) of a projection system. The housing is normally interchangeable to provide a variety of beam spreads.



COURTESY SCHAUFUSS BALLET

12-19 LED Projection Martin LED panels used for background images in Denmark's Peter Schaufuss Ballet production of *Michael—I'm Bad*. Lighting and video design by Bo Kudsk Kristensen.

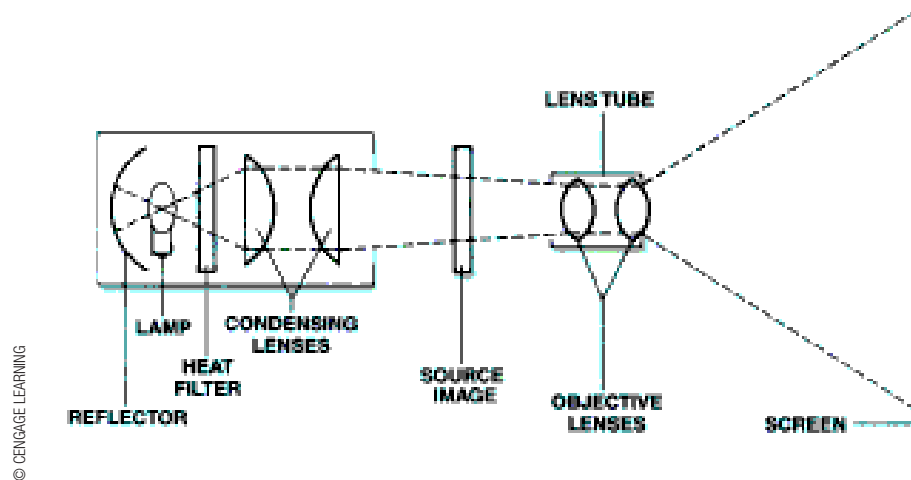


COURTESY SCHAUFUSS BALLET

respective panel, the individual cells regulate how much of that light is actually transmitted. The three colors are then recombined using a prism and sent on to a lens to project the resulting image.

- DLP projection involves reflecting light off an array of tiny mirrors that act together to create the projected image. Light from the lamp is projected onto a panel called the Digital Micro-Mirror Device, which contains up to 2 million microscopic mirrors each mounted on its own hinge. These mirrors are able to direct the light toward the projector lens (on) or away from it (off); and, by rapidly switching “on” and “off,” they control exactly how much light is passed through the lenses. A mirror that stays “on” all the time reflects all the light; one that switches off and on reflects less light and appears gray. To add color, the white light is first shown through a rapidly spinning color wheel made up of the three primaries. Rapid pulses of red, green, and blue light strike the mirrors and are sequentially reflected in a strobe-like manner to the lenses.

12-20 The Lens Projector The optical train of a typical lens projector.



Although fairly technical, the preceding information illustrates the functional differences between image projectors and today's digital projectors. However, both types require an objective lens system to capture the light image and focus it onto a projection surface.

Choice of Lenses Projector lenses are available in different focal lengths with the shortest focal lengths providing the widest spread and largest images. The size of a projected image is determined by three things: source image size, focal length of the objective lens system, and throw distance from projector to screen. A projection designer normally knows the size of the desired projected image first. The throw distance is found next by determining where in the theatre the projector can best be located. Finally, the proper lens is selected by using the formulas presented in the following box on lens projection.

Choice of Projectors Except for the smallest and the largest applications, digital projection has taken over the market. However, despite the fact that Kodak stopped manufacturing its popular Carousel projector in 2004, 35 mm slide projection is still used in small venues or for short throw applications because it is inexpensive, and 35 mm slide production is relatively simple. Large format image projectors with bright light sources remain in use for applications that require very long throws or large image sizes. For nearly everything else, the theatre has turned to digital projection.

In selecting image projectors, source image, or slide size is an important factor in the brightness of the projected image. The size of the slide a projector uses varies from



TOOLS OF THE TRADE ■ The Mathematics of Lens Projection

To eliminate trial-and-error methods of selecting lenses and placing projectors, use the following simple formulas:

$$F = \frac{D \times S}{I} \quad D = \frac{F \times I}{S} \quad I = \frac{D \times S}{F}$$

In which:

F = Focal length of lens

D = Projection throw distance

S = Source Image size

I = Image size

Note that all these measurements must be expressed in the same units, normally inches. If the source image is not square and its horizontal dimension is used, the horizontal dimension of the image will be obtained; if the vertical measurement of the image is needed, the vertical measurement of the source image must be used.

the convenient 35 mm (1.346 × 0.902 inches) to the large continental size of 9 × 9 inches. However, any given projector will accept only one size. Determining which image projector is most appropriate involves three main considerations:

1. The longer the throw or the larger the projected image, the brighter the light source should be.
2. The larger the source image or slide, the brighter and clearer the image.
3. The larger the source image or slide, the more expensive and bulky the equipment.

Large Format Image Projectors

Two companies manufacture large format image projectors suitable for theatre use: Pani, an Austrian company whose projectors are available in the U.S. from Atlas Specialty Lighting (Tampa, FL); and Pigi (*Projecteur d'Images Geantes Informatise*), manufactured by the French Company E/T/C Audiovisuel and available in the United Kingdom from ETC UK Ltd. These projectors are quite specialized, with the brightest models costing more than \$50,000 (Figure 12-21).

Pani offers the largest range of image projectors:

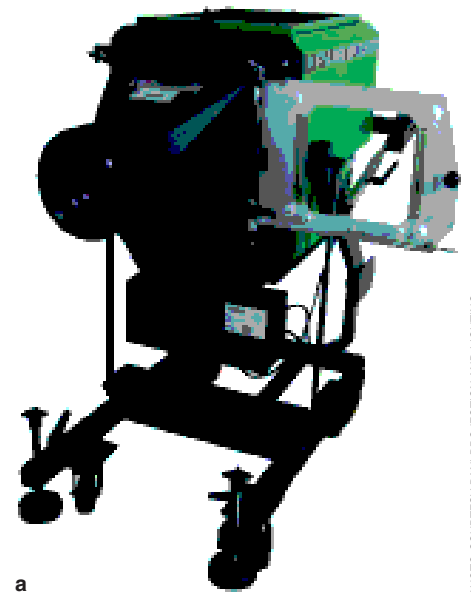
- Two incandescent lamp projectors are available: the BP 2500/3000 Halogen (2,500 or 3,000 watts—about 52,000 lumens) and the 2,000-watt BP2/II Halogen.
- HMI arc lamp projectors are available in five models: the BP 1,2 (1,200 watts—about 110,000 lumens); the 2,500-watt BP 2,5 CT (Figure 12-21a); the BP 4 CT (4,000 watts—about 410,000 lumens); the high power BP 6 GT (6,000 watts—about 850,000 lumens; Figure 12-21b); and the super bright 12,000-watt BP 12. All except the BP 12 take slides that are 18 × 18 centimeters (roughly 7 × 7 inches). Optional equipment includes remote control slide changers and effects machines. Lenses for all but the BP 6 and BP 12 are available with focal lengths from 60 centimeters (8 degree beam spread) to 11 centimeters (65 degree beam spread). Two zoom lenses are also available. The BP 6 and BP 12 offer eleven lenses with beam spreads from 8 to 71 degrees.
- Pigi projectors can be used for slide projection but are most valuable as moving film projectors. The single and double film scrollers available can be used with either Pigi or Pani projectors.

Slides for large format scenic projectors are expensive. If transparencies are used, they are normally sandwiched between two pieces of glass held together in a metal frame. Common sizes are 4 × 5, 5 × 5, and 7 × 7 inches. Photographic production houses can make either black-and-white or color transparencies from any original material in any size desired. Such slides are expensive and take time to produce—two factors that must always be considered. Of course, a designer can transfer design work directly onto the clear glass slides of large format slide projectors. Rosco manufactures a transparent dye called Colorine™ designed to be used on glass.

Video Projectors

As noted, the two basic types of video projectors are DLP and LCD. The difference between the two in terms of theatrical use is slight:

- *LCD projectors* project a sharper image and can create more saturated colors, but they exhibit image degradation over a long period of time.
- *DLP projectors* can achieve a higher contrast ratio and they are smaller in size.



a



b

12-21 Large Format Image Projectors

a Pani BP 2,5 CT Stage Projector.

b Pani BP 6 GT high performance projector.

PHOTO COURTESY PANI PROJECTION AND LIGHTING

PHOTO COURTESY PANI PROJECTION AND LIGHTING



12-22 Projection Dowser
DMX-controlled universal dowser
from City Theatrical.

Comparing one video projector with another for theatre use involves examining contrast ratios, resolution, and brightness as well as audible noise. In addition, several features are desirable:

- *Interchangeable Lenses.* Unless the projector is being used from a fixed position, the ability to select lenses for variable throw distances is quite important.
- *Keystone Correction.* Built-in keystone correction is an extremely valuable feature for theatrical use owing to the odd locations from which the projection emanates.
- *Dowser or Dimming Shutter.* “Video Black” is not true black: light is leaked from all video projectors unless they are equipped with a mechanical means of blocking this light. It is worth noting that City Theatrical sells a projector dowser accessory that works with nearly any video projector (Figure 12-22).

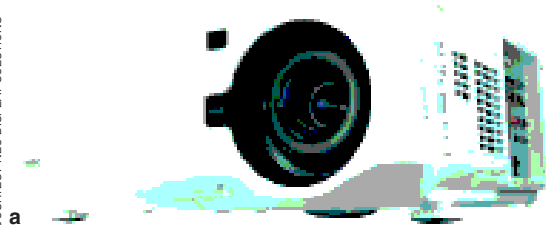
The real limiting factor of current video projectors is intensity versus cost. Minimum projection intensity for general theatre use should be approximately 3,000 lumens—eliminating most consumer models, of which there are many. Technology is available to produce brighter projectors, but low demand keeps prices up. Following is a range of video projectors suitable for theatre use listed from bright to brightest; their retail price starts around \$6,000 and increases by intensity:

- NEC’s NP 4100w DLP projector produces 5,500 lumens with wide screen resolution. It has a high contrast ratio and offers five interchangeable lenses along with keystone correction (Figure 12-23a).
- Epson’s PowerLite Pro Z Series of LCD projectors have a light output from 7,000 to 10,000 lumens. They have very high contrast ratios, offer six interchangeable lenses including a very wide rear projection lens, edge blending, and keystone correction (Figure 12-23b).
- Digital Projection International (DPI) manufactures a large variety of projectors for various applications. Figure 12-23c shows the Titan Pro Series 3 1080p-660, a three-chip DLP projector that is rated at 10,000 lumens. It is very quiet, offers a wide range of 16 interchangeable lenses, and weighs only 80 pounds.
- Barco has long been known for high quality projection equipment. They offer a number of projectors from the 11,500-lumen RLM W12, a powerful three-chip DLP projector weighing only 70 pounds (Figure 12-23d), to the 18,000-lumen HDX-W18 and the 30,000-lumen XLM HD30. Barco claims that the HDQ-2K40 is the brightest video projector available at 40,000 lumens—it weighs in at a proud 463 pounds (Figure 12-23e). All have a good range of interchangeable lenses and built-in dimming shutters. Barco projectors are not cheap, but are fine projectors.
- Christie, which has been in the projection business for a number of years, offers a wide range of superior projectors. Its brightest projector, at 35,000 lumens, is the Roadie HD+35K three-chip DLP projector. A wide selection of nine lenses is available. The projector head and ballast weigh 470 pounds (Figure 12-23f).

Media Servers

Professional quality media servers are dedicated computers that store and control the playback of projected images. Software is also available which can serve the same function, but usually with limited capabilities. A media server is necessary equipment for any sort of complex projection work. In addition to providing playback, servers allow

COURTESY/NEC DISPLAY SOLUTIONS



a



b

COURTESY EPSON

COURTESY/DIGITAL PROJECTION, INC.



c



d

PHOTO COURTESY BARCO

PHOTO COURTESY/BARCO



e



f

PHOTO COURTESY/CHRISTIE

12-23 Video Projection

- a NEC NP4100w—a 5,500 lumen projector.
- b Epson's Z8255NL projector—7,000 to 10,000 lumen output.
- c Digital Projection Titan Pro Series 3 1080p-660—a 10,000 lumen projector.
- d Barco's RLM-W12—a 11,500 lumen projector.
- e Barco's HDQ-2K40—a 40,000 lumen projector.
- f Christie Roadie HD + 35K—a 35,000 lumen projector.

for show control from a production's lighting console—often using either DMX or MIDI signals. Professional servers include those manufactured by Green Hippo (Hippotizer) and Coolux® Media Systems (Pandoras Box Server), both distributed by TMB in Los Angeles and New York (www.tmb.com).

- The Hippotizer HD is Green Hippo's most powerful server (Figure 12-24a). It can handle multiple layers of very high resolution images and is industry-proven. Green



12-24 Media Servers

- a Green Hippo's *Hippotizer* high resolution media server.
- b *Pandoras Box* media server from Coolux Media Systems.

Hippo also manufactures the smaller capacity GrassHopper and HippoCritter as well as the HippoPortamus laptop.

- Coolux® Media Systems offers their Pandoras Box Server systems in several models (Figure 12-24b). Their rendering features provide real-time compositing and editing in 3D—a critical feature for live performance. Coolux also manufactures Pandoras Box Player, a software solution for controlling media playback, as well as Pandoras Box Editor, a 2D/3D content editing and compositing system.

Software that can assist in compositing, editing, and playback of media includes Isadora® by TroikaTronix and WATCHOUT by Dataton. Both programs allow the designer to compose sound, images, and live feed and playback to multiple displays. Other software programs such as Keynote and PowerPoint can be used for simple composition and playback.

Automated Fixture Projection

Combine a sophisticated video projector with a media server and place it in a moving yolk, and the result is the Digital Light from High End Systems, now a division of Barco. The DL3 has an integrated media server, 7,000 lumens of intensity, and a choice of lenses including a zoom and wide angle (Figure 12-25a). High End Systems also manufactures the smaller (and less expensive) DLV as well as the very bright and sophisticated DML-1200 which produces 12,000 field lumens in light mode (Figure 12-25b). The DML also has an internal optical dimming mechanism which fades its light to true black (as opposed to video black).

COURTESY HIGH END SYSTEMS



a



b

COURTESY HIGH END SYSTEMS

12-25 Automated Projectors

- a** High End System's DL.3—a 7,000-lumen automated projector with an integrated media server.
- b** High End System's DML-1200—a 12,000-lumen automated light and projector combined.



3 Automation in the Theatre

There is no question that the ubiquitous nature of the computer has allowed scene and lighting designers incredible and previously unimaginable flexibility in terms of complex movement of scenery and lights. It has radically altered the body of knowledge necessary for the technical director, electrician, and stage technician as well. New software programs are continually being developed that have applications in all parts of the production process, including the initial stages of design, the mounting and running of a play, and even keeping a careful accounting of expenditures. But perhaps the most astounding application is the use of the computer to handle the production onstage.

The term “automation” is used by theatre artists quite freely, so perhaps it is best to begin this chapter with a working definition. It is not unusual for theatre makers to use the term automation when they really mean mechanized. *Mechanized* scenery simply means that an individual piece of scenery is moved mechanically (perhaps by winch), rather than just by hand. The operator has knowledge of and immediate control of the desired movement, be it a wagon, turntable, or a lighting fixture. **Automation** is defined as a programmable interface allowing for many variables including timing, acceleration, speed, and location with limit. This is, of course, how the computer can be effectively used. The obvious advantage is that this system is not prone to human error within the confines of a cue.

Automation in Scenery

The varied number of ways in which scenery can be moved physically, as in the use of wagons, turntables, lifts, etc, has been discussed in Chapter 10. It is the manner in which these movements can be achieved that we discuss here.

The simplest method of moving scenery is having a grip, or stagehand, pushing or pulling it on or off stage. This is certainly the cheapest and simplest way of doing so and allows the grip complete control of the unit, assuming it is not too heavy or too large in size to be moved easily. (Remember: scenery should be “light and portable.”) Often, in order to allow the grip to be unseen by the audience, a pull rope or a large stick is used to provide some assistance for the desired movement. Although this might involve tracking the stage, brakes, or other helpful devices, the energy for the movement comes strictly from the grip.

Once a piece of scenery becomes too large or weighs too much for a grip to handle, some kind of mechanized movement must be introduced. Typically, this is in the form of a winch and cables, again as described in Chapter 10. There is a decided mechanical advantage to doing this even, as is often the case, when the winch is turned by a hand

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For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

automation A programmable interface allowing for many variables, including timing, acceleration, speed, and location with limit.

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		← SIMPLE		COMPLEX →	
“GRIPPED”	POWER MECHANIZED	MECHANIZED ACTUATED	LIMITED MECHANICAL ACTION	“AUTOMATION”	ROBOTICS
Moved directly by person (grip)	Powered by grip	Directed (piloted by grip)	Grip runs switches for “Go”, speed	Grip runs switches for “Go”, speed	System determines the timing, the speed, and potentially limits
No mechanical advantage	Uses mechanical advantage	Uses motor power to run a machine	Some control given over to system; possible mechanical limit switch	System controls limits	
		Still complete control by operator but using power from source other than grip. Operator has responsibility for moving the object but no longer in complete control of all parameters of machine. Start, stop, speed, and limits are still controlled by operator. Degree of accuracy determined by proficiency of operator.	Elements of control are now part of the system - top speed, limit switch, acceleration control are pre-set. Operator still hits “Go” and might control speed but limit switch is part of the operation. When and where unit stops is pre-set then piloted. Operator sets parameters.	All aspects of the machine are controlled by some kind of processor, having been programmed earlier by an operator. Operator hits “Go” at appropriate time.	

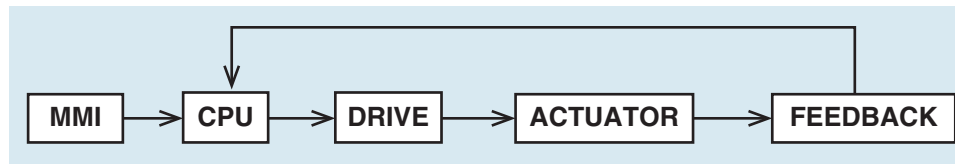
13-1 Simple to Complex Control

crank. Using a winch allows the grip to move considerably more weight, often including actors, about the stage. Starts, stops, and speed are still regulated by the operator. This is a fairly reliable system, but it depends on the stagehand’s proficiency. With the use of a motor, the system can be equally simple, but the operator has relinquished a degree of control; because the operator must allow for the slowing down of the scenic unit, it is more complicated to hit the spike mark. Even the use of *limits*, or the end location on stage along a predetermined path of travel, is not as exact as may be desired. The more machinery is introduced into the system, the more challenging the control proves to be.

The requirement for precise motor-assisted motion has brought about the need for automation. Although the operator still must hit a “Go” button, all aspects of control are now part of the system—top speed, limits, acceleration/deceleration are all pre-programmed.

How does a designer or technician determine how complex a control system to use? The best advice is to go as far along the continuum of simple to complex as is *necessary* and no farther. The more complicated the movement gets, the more mechanized or computerized the system, the more time is required for pre-production preparation, load-in and technical rehearsals, and the more parts that can fail. The expense is a serious consideration as well (Figure 13-1).

Specialized training is absolutely required for set up, implementation, and operation of any automated scenery (and lighting for that matter). The industry has generally figured out the control aspects of automation so it is not necessary to start from scratch. Packages are available that are used to control scenic movement. These systems are quite sophisticated; theatre technicians who use “automation” need to learn the best way to implement the system for their specific use in a production. The nature of scenery is

13-2 The System

COURTESY DAVID BOEYERS

ever-changing and unique, which necessitates that machinery is often purpose-built for a specific effect, requiring engineering on the machine—not writing computer code. The concern is to make sure that the unit of scenery will do what it needs to do in the time allowed to do it.

Engineering has become a major consideration particularly for some larger productions. When *Phantom of the Opera* initially went on tour, an engineer was present at each new theatre as part of an advance team. In many cases, an extra steel structure was permanently installed in the theatre to safely achieve the effect of the falling chandelier. Technically ambitious and highly structured productions are building theatres specifically for that show—Cirque du Soleil’s *O* and *Ka*, both in Las Vegas, are good examples of this.

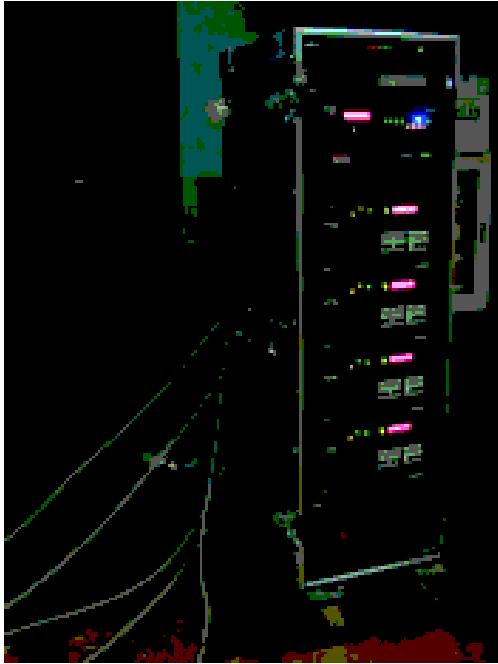
The System

The actual system used for automation is similar to that of mechanized scenery (see Figure 10-19) in that the same elements are used in addition to some kind of computer. Until there is a robotic system that makes decisions as to when to start, there is still a stagehand or operator hitting a “Go” button. The computer, or *CPU*, sends the appropriate signal to the drive, which converts a control signal from the *MMI* (man-machine interface) to power for the *actuator* (that which actually does the moving—a motor, cylinder, pneumatic, or hydraulic) which subsequently provides *feedback* to the *CPU* (Figure 13-2).

Feedback is critical to the operation and one of the aspects of automation that makes this system so useful. Because of the specificity and the precision of the computer, it is possible to have at hand a great deal of information about the scenic unit, its movement, and its position at any given moment (Figure 13-3 and 13-4).

13-3 The Winch A typical cable-driven winch used in automation.

COURTESY OF THE AUTHORS



COURTESY OF THE AUTHORS

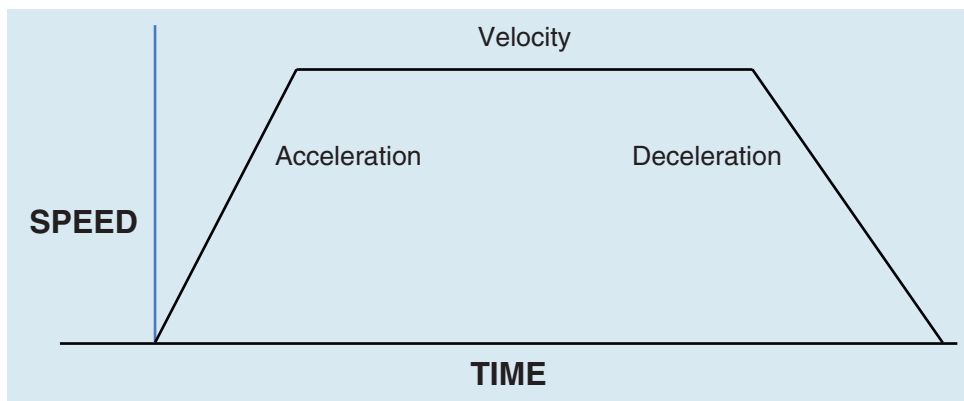
13-4 The System Rack Any automated system requires a number of components, in this case placed in a rack. The bottom component is the power distributor. Four motor drives sit directly above with the server on top of the distributor. The part of the system that controls the e-stop lives above with a network hub and surge protector at the top (often done this way for easy access).

Motion Profile

Every individual instance of a device moving a piece of scenery is referred to as an **axis**. The complete range of movement for any given axis is its **motion profile** (Figure 13-5). Its speed, the distance it travels, its acceleration and deceleration, and its limit—the position at which the movement stops—all must be recorded into the computer. The easiest way to think about this is with a trapezoid, showing the acceleration of the axis's movement, its travel or velocity, and finally its deceleration to a stopping position (commonly referred to as its *AVD*). One of the advantages of automating this is that effects can start and stop faster than if done manually.

The *quality* of the motion, including how it starts and stops, is an important consideration for both the designer and the director and should be discussed from the start. The specific effect desired might have an influence in the way that the scenic piece is constructed and may help determine whether mechanization or automation is needed. A wagon with walls and furniture can potentially be pushed by a stagehand fast enough that the walls could fall over. Acceleration and deceleration by themselves can cause a load to increase so greatly that it could damage the structure. As well, abrupt starts and stops can not only be disconcerting to actors who are riding on the unit but to the audience as well—they tend to get uncomfortable with pieces moving too quickly.

axis Any device moving a piece of scenery.
motion profile The speed, distance traveled, acceleration, and deceleration of a scenic unit.



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13-5 Motion Profile

There are basically three types of moves:

1. A move from one known position to a second known position: This kind of move is the best way to test what might be a “cue” before the cast arrives on the set.
2. A move from a known position to an unknown position: This kind of move is used when trying to determine exactly how the unit should move during performance. Start and stop positions, acceleration, speed, and deceleration can all be explored using this kind of move.
3. A move as a “cue”: This kind of move is used during performance and is determined by the set of commands written in the software. In this case, of course, the AVD (acceleration/velocity/deceleration) is specified (which is what defines it as a cue).

Limit Switches

limit switch A device that, when tripped by a moving scenic unit, will cause the movement to stop.

A **limit switch** causes the scenic movement to stop. Mechanically, this could be as simple as an on-off switch that is tripped as the unit moves past it (a binary system). The earliest forms of this would be an “on” position until the unit arrived at which point the switch would move to the “off” position. In an automated system, limits are programmed as part of the motion profile, taking into account deceleration. This program alleviates the need for an operator to attempt to hit a specific spike mark on (or off) stage and allows for a much more exact positioning of the unit.

It is here that feedback is of great importance. The information provided to the computer indicates the position of the unit on or off stage, allowing the operator to be fully aware of the position of each piece of scenery at any given time. Different *encoders* which provide this information can display the exact position (*absolute encoder*) or the position relative to a specified position (*relative encoder*) such as its “home base” or off-stage position.

e-stop A button or switch that interrupts the motion of a moving scenic unit outside of the cueing parameters.

This method includes an **e-stop**, which typically refers to an emergency stop. Every unit of moving scenery has a desired travel path. Limits are set at determined points where the unit should stop. Every unit has what is called its *end of travel*, or *EOT*, that point beyond which the scenery cannot safely continue moving. The e-stop is a button or switch that will interrupt the motion of a moving scenic unit when it hits its EOT or travels outside of the cueing parameters. The obvious use for this is in an emergency, but it is an important safety factor in other circumstances as well. Not all situations are dire, but it is a good idea to be able to stop a piece of moving scenery if continuing the motion will cause a problem, however minor. It is wise to have a number of e-stops placed conveniently around the set and the stage, both onstage and offstage and in areas where a stagehand will likely be in proximity. In short, an e-stop should be wherever it is needed. The “required” number of e-stops that are needed is unique to each production but should at least include one on the stage manager’s console and one with the assistant stage manager offstage. Placement and number will depend on the complexity of the set as well as the offstage positions that allow a clear view of the scenic movement.

The computer is used to control wagons, hydraulic and scissors lifts, electric winches, and flying mechanisms, as well as various other scenic effects. It is conceivable that in the near future we will see the use of robotic-controlled scenery, so that a human operator will no longer make the decision to move a piece of scenery. Imagine programming a unit to move on a certain note of music or on a certain line spoken from an actor. As the technology continues to change, more complex movement becomes possible. Without the use of a computer, this complexity of movement that is so desirable would not be possible.



TOOLS OF THE TRADE ■ Advantages/Disadvantages of Mechanization and Automation

ADVANTAGES

Better, more exact control.

Allows for more complex movement and more repeatable movement.

Better flow of movement with fewer stagehands.

Portability—complicated interactive cues can be programmed so no need to create the cueing more than once. Especially useful for tours.

Smaller packages—devices fit into smaller space than would a person (varies wildly with effect). (True for mechanized as well as automated scenery.)

DISADVANTAGES

Steep learning curve—advances continue to change but at a slower rate than in last 10 years. Likely to see more discreet, nuanced changes in the near future.

Specialized training needed in both operation and implementation.

Expensive.

Once past the capacity of humans to physically control scenery, movement becomes potentially dangerous; trusting system to *very* large loads. (True for mechanized as well as automated scenery.)

Time-consuming in terms of preparation, load-in, and especially technical rehearsal.

Automated Stage Lighting and Control

Automated fixtures which allow remote control of beam size, color, focus, direction, and effects have become an important tool in stage lighting. They are found today in venues ranging from 100-seat storefront theatres to 3,000-seat civic auditoriums. They have absolutely revolutionized the way lighting designers think and work.

However, we should heed the words of Broadway lighting designer, Donald Holder:

... as a growing designer, you should learn about how to read a play—learn how you fit into the rest of the world—read a newspaper every day—go to museums—become a fully rounded, fully informed member of society—understand history, understand art, understand literature. That's infinitely more important than learning all the attributes of a moving light.

Designing with Automated Fixtures

The practice of using automated fixtures in theatrical lighting design is a fairly new one that warrants discussion. To begin, let it be noted that automated fixtures, while a great addition to the lighting designer's tool box, are not the end-all and be-all of lighting. Their use must be tempered with good judgment and appropriateness. Physical movement of light draws attention to itself immediately—our eyes are highly sensitive to movement of any kind. Most moving lights have arc sources and any light source with a high color temperature will stand out among incandescent sources. Finally, control and programming takes a great deal of additional time.

That being said, the impact of a super bright animated beam of light is undeniably impressive. In addition, these fixtures offer tremendous color mixing potential, moving texture and patterns, and effects like prisms and strobing (Figure 13-6).

Following is a rather detailed discussion of moving light design and technology. The reader may want to read it in conjunction with Chapter 17, *Lighting Fixtures*.

Distribution The question of where to locate automated fixtures for a production is an important one. By far, the most successful placement of automated fixtures is

PHOTO BY RICHARD TAPPER, COURTESY MARC JANOWITZ



13-6 Automated Lighting Fixtures

Use of automated fixtures in a Matisyahu concert as part of the Festival of Lights at Roseland Ballroom in New York City. Lighting Designer/Director, Marc Janowitz.

planned well in advance and is based on their function in the production. Their use as a front-light visibility source is generally not desirable. At a low angle they wash out features, and any use of movement or texture tends to be highly distracting. On the other hand, high angle (60 degrees) use from any direction can be very effective. Their brilliant color and high intensity make them perfect as back-lights. Likewise, the form-revealing sharp-edged illumination from a side-light position is wonderful (Figure 13-7).

The designer must decide whether to use automated fixtures in a system (several working together from a similar angle and direction) or as individual “specials.” Perhaps the best choice is to position them so that they can be useful as both.

Color The color-mixing capabilities of automated fixtures is a tremendous feature and today’s control consoles make color picking very simple. Remember that the color is either LED or dichroic—meaning that it won’t match exactly with conventional filters (especially if LED). Also remember that arc and LED colors don’t experience amber drift as they are dimmed.

Movement Most automated profile fixtures provide two kinds of movement: physical movement of the light beam itself and movement of color and/or texture within the beam. As noted, any physical movement of light must be carefully considered by the designer. It is highly noticeable by an audience and can easily be distracting.

Be aware that “dark sets” are a fundamental part of programming automated fixtures. A dark set is a cue placed between moving light cues which pre-sets the fixture for the next cue. An example would be if an automated fixture is used as a stage-left special in cue #1 and is needed as a stage-right special in cue #2. If we don’t want to see the light beam physically move, a dark set cue inserted between the two cues will pre-position the fixture for cue #2.

Using an automated fixture as a follow spot is certainly possible and has been done so very effectively. However, such use requires very careful coordination with the

13-7 Automated Side-Light Use of low side-light on a performer in a TV on the Radio concert at Ryman Auditorium, Nashville, TN. Lighting/production design by Marc Janowitz; lighting director, Ben Silverstein; associate designer, Ben Price.



RODERICK TRESTRAIL II

director and actors in terms of blocking and timing. A director may simply not want his or her actors worrying about the precise blocking and timing that is required with a pre-programmed movement of light.

Be aware that a rapid simultaneous pan of moving heads on an electric pipe can cause it to sway.

Automated Fixtures

There is a large variety of sizes and types of automated fixtures available, from accessory-type devices which attach to a conventional ERS to extremely bright and sophisticated moving head fixtures. By far the most popular, moving heads are generally categorized as either wash or spot fixtures with different models determined by brightness and features. On a basic level, wash fixtures act like Fresnels. They often have some sort of spot-flood capability along with color mixing as well as a mechanical dimmer. They are normally brighter and less expensive than spot fixtures with comparable lamps. The spot fixture resembles an ERS with gobo and effects capabilities as well as some sort of color control. They should at least have dimming and an iris, and zoom capability is preferable.

The minimum requirement of an automated fixture is that it must accurately and repeatedly reproduce a focus assignment. To achieve this, remotely controlled pan and tilt motors receive a DMX signal from the control console. Normally, a single channel of control is assigned to each of the fixture's functions (commonly called *attributes*). Sophistication varies greatly, but the more advanced fixtures change focus, intensity, color, beam size, gobo pattern, and light quality.

Many companies build automated fixtures, but major manufacturers in the U.S. market include Philips Vari*Lite, High End Systems, Martin, and Clay Paky. Each offers a wide range of fixtures; for clarity of presentation, we have categorized them in four groups according to their light source and lumen output: incandescent and LED, bright arc, brighter arc, and brightest arc.

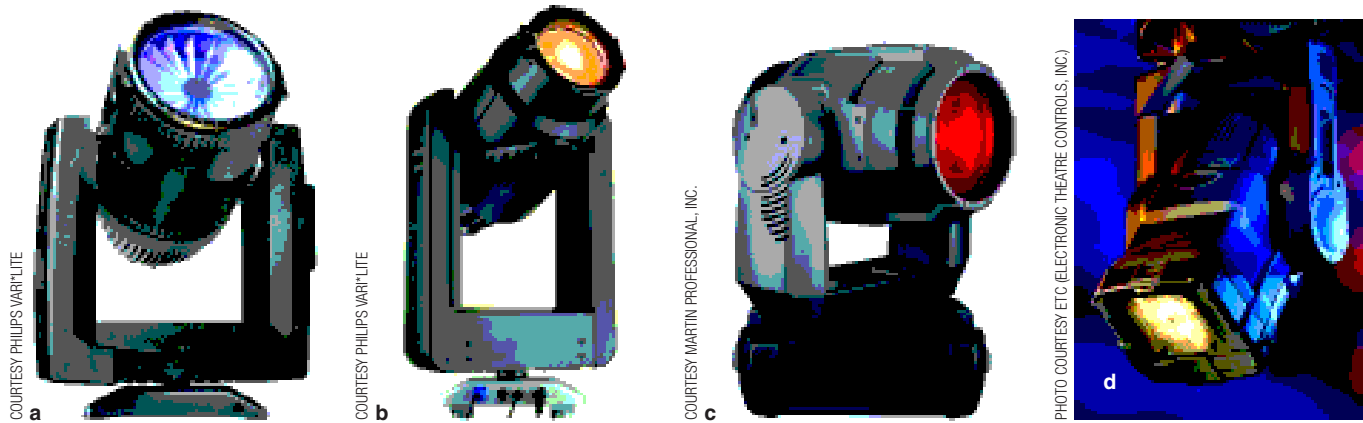
Incandescent and LED Fixtures

Incandescent-source automated fixtures are entirely compatible with conventional fixtures in terms of light quality and color temperature and do not require an on-board dimmer. They are available in both wash and profile models with a variety of features.

Incandescent Philips Vari*Lite, Martin, and ETC manufacture incandescent automated fixtures with intensity ranges from 6,000 to 10,000 lumens (Figure 13-8).

Philips Vari*Lite manufactures two incandescent fixtures—the VL550 Wash and the VL1100 Tungsten ERS:

- The VL550 Wash fixture (Figure 13-8a) takes either a 1,000 or 1,200 watt lamp and is available with one of two color-mixing systems, a variable diffusion system, and six lens options. Both color systems mix magenta, blue, and amber dichroics, but one system is more saturated and the other more pastel. The six lenses offer field angles from 14 to 43 degrees. Intensity is 6,000 lumens with the clear, 14 degree lens. Eight to 13 control channels are required. The VL550D model has an on-board dimmer.
- The VL1100 Tungsten ERS (Figure 13-8b) has a 1,000 watt lamp, CYM color mixing, variable diffusion, a six-position rotating gobo wheel, and a zoom range from 19 to 36 degrees. Model VL1100 TS has four framing shutters and model VL1100 TI has an iris. It delivers 10,000 lumens at 19 degrees and requires up to 27 channels of control. An on-board dimmer is available.



13-8 Incandescent Automated Fixtures

- a Philips Vari*Lite VL550 Wash.
- b Philips Vari*Lite VL1100 Tungsten ERS.
- c Martin MAC TW1™ wash fixture.
- d ETC Source Four Revolution®.

Martin makes the MAC TW1™ (Figure 13-8c), a wash fixture with CYM color mixing and a motorized zoom lens. Lenses are available in narrow (14 to 27 degrees), standard (20 to 41 degrees), and very wide (97 to 105 degrees). It takes a 1,000 watt tungsten lamp and produces up to 14,200 lumens. Both internal and external dimming is possible. It requires 14 to 20 control channels.

ETC makes the tungsten ETC Source Four Revolution®. It is an ERS with a 750 watt lamp, dichroic reflector, and a 15 to 35 degree zoom lens. It has an integrated 24-frame color scroller and offers four optional beam-control plug-in modules: iris, shutters, gobo wheel (3 gobos), and rotating gobo wheel—maximum two modules per fixture. It delivers up to 10,000 lumens.

LED Spot Fixtures LED spot or profile automated fixtures are just beginning to enter the stage-lighting market. Martin manufactures the MAC 350 Entour™ LED profile fixture and High End Systems has converted its trackspot incandescent and arc fixtures into a moving-mirror LED spot called trackspot Bolt™.

- Martin MAC 350 Entour™ offers shutters, motorized focus, an iris, a color wheel with eight interchangeable dichroic filters, a rotating gobo wheel with six interchangeable gobos, and electronic dimming. It has a fixed field spread of 25 degrees and the seven LED source delivers 8,000 lumens at 6,500 K. It requires 14 to 17 control channels (Figure 13-9a).
- High End's trackspot Bolt™ has similar features to the MAC. It does not have shutters, but offers an iris, strobe, a color wheel with nine colors, a rotating gobo wheel with seven patterns, and electronic dimming. It has a fixed 15 degree beam angle and an intensity of 3,000 lumens at 7,500 K. Twenty-one control channels are needed (Figure 13-9b).

LED Wash Fixtures Although automated LED spot fixtures are rare, LED wash fixtures are abundant, due in part to their inherent color mixing capabilities.

High End Systems currently offers two rather unique LED wash fixtures: StudioPix™ and SHOWPIX® (Figure 13-10). Unlike most fixtures, they are intended as much for visual image display as for stage illumination.

- StudioPix™ (Figure 13-10a) has a large 13½-inch head containing 61 individual LED engines with a brightness of 11,500 lumens. Its beam spread is 45 degrees and the field is a wide 80 degrees. Color mixing is RGB with the possibility of separate control of each LED—requiring 253 channels for complete pixel mapping.
- Bigger brother SHOWPIX® (Figure 13-10b) has an 18-inch head with 137 LEDs and delivers 24,000 lumens. It, too, is RGB color mixing, has the same beam and field spreads as StudioPix, and its LEDs can be controlled individually. In addition, High End provides over 400 stock content animations and patterns for display.



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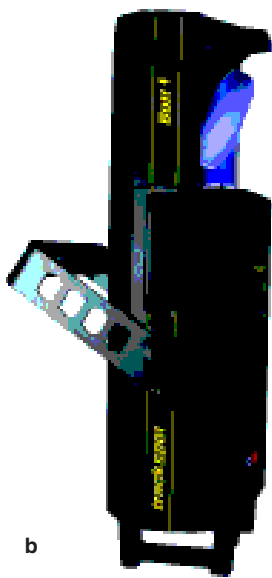


PHOTO COURTESY HIGH END SYSTEMS

13-9 LED Spot Fixtures

- a Martin MAC 350 Entour™.
- b High End Systems trackspot Bolt™.

Philips Vari*Lite also manufactures two LED wash fixtures: VLX3 Wash Luminaire and VLX Wash Luminaire (Figure 13-11).

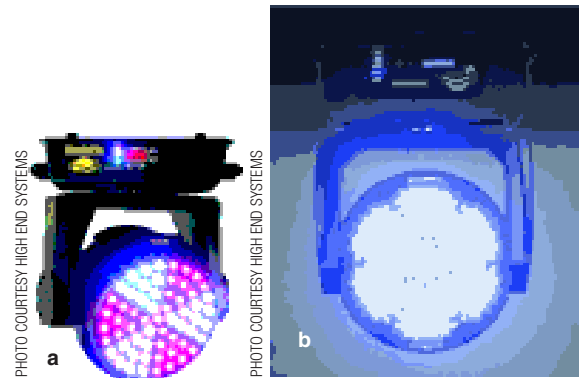
- The Philips Vari*Lite VLX3 Wash Luminaire has three RGBW color-mixing LED engines and delivers up to 6,000 lumens. It offers a high-speed strobe effect, has an optical zoom with a field angle range from 15 to 55 degrees, and requires 23 channels of control.
- Philips Vari*Lite’s VLX Wash Luminaire also mixes RGBW LEDs, but has seven engines for a maximum brightness of 14,000 lumens. It also has a high speed strobe, a zoom field angle of 23 to 58 degrees, and requires 23 channels.

Martin has three models in its LED Wash Fixture line: the MAC Aura™; the MAC 101™ family of fixtures, and the MAC 301 Wash™ (Figure 13-12).

- The MAC Aura™ (13-12a) is a compact RGBW color-mixing fixture with an 11 to 58 degree zoom and an output of 3,850 lumens. It has a unique “background” color-mixing feature that produces a variable-colored lens effect that is separate from the LED colors—Martin refers to it as Aura’s “eye-candy.” It requires from 14 to 25 control channels.
- The MAC 101™ family includes four fixtures, all with 13 degree field angles. MAC 101 CT™ is a white LED fixture that allows for a range of color temperatures from 2,800 to 6,200 K. It has a 4,400 lumen output with all LEDs on and is controlled by 10 channels. MAC 101 WRM™ has a color temperature of 2,800 K and produces a maximum of 3,900 lumens—seven channels of control. MAC 101 CLD™ is a 6,700 K fixture producing 5,900 lumens with seven channels of control. The MAC 101 RGB™ (shown in Figure 13-12b) has RGB color mixing, produces 2,400 lumens, and requires 8 to 12 channels of control.
- The MAC 301 Wash™ fixture (Figure 13-12c) is RGB color mixing with a variable field spread of 13 to 35 degrees. It has a brightness of 3,900 lumens at 35 degrees with all LEDs on. It requires 12 to 19 channels of control.

Arc Source Automated Fixtures

An arc source offers the brightest light available for stage lighting fixtures. It produces a high color temperature light (normally around 6,000 K) which cannot be electronically dimmed. Note that most fixtures have a fixed color wheel in addition to dichroic CYM color mixing. This allows for a greater range of color production and is in part due to the fact that CYM color mixing does not provide good primary colors—particularly green. In general, as the lumen output of a fixture increases, so does its size, price, and complexity. Greater sophistication of features, such as multiple color mixing and effects, is found in the larger, brighter fixtures. However, control requirements are likewise increased to the point of absolutely requiring a control system with specific moving light capabilities. Automated fixtures with arc sources are so numerous that this text can only present a representative sample—see the websites of the various manufacturers for greater detail.



13-10 LED Wash Fixtures from High End Systems

- a High End Systems StudioPix™.
- b High End Systems SHOWPIX®.

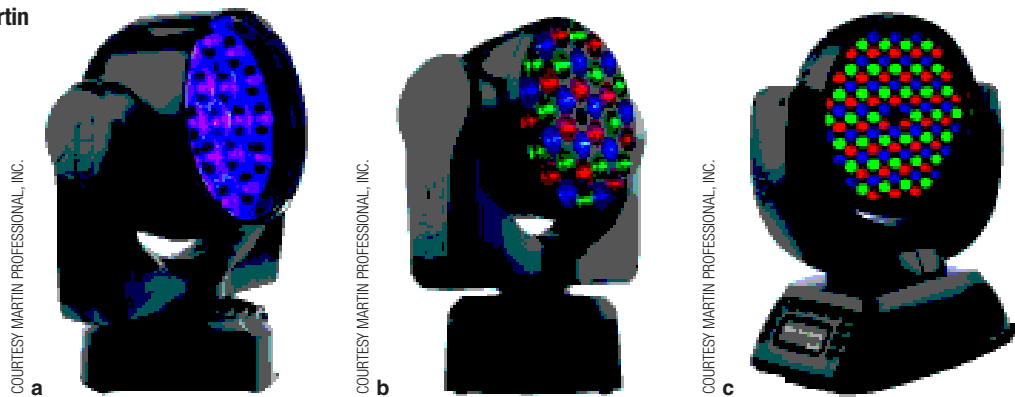


13-11 LED Wash Fixtures from Philips Vari*Lite

- a Vari*Lite VLX3 Wash Luminaire.
- b Vari*Lite VLX Wash Luminaire.

13-12 LED Wash Fixtures from Martin

- a Martin MAC Aura™.
- b Martin MAC 101™ RGB.
- c Martin MAC 301 Wash™.



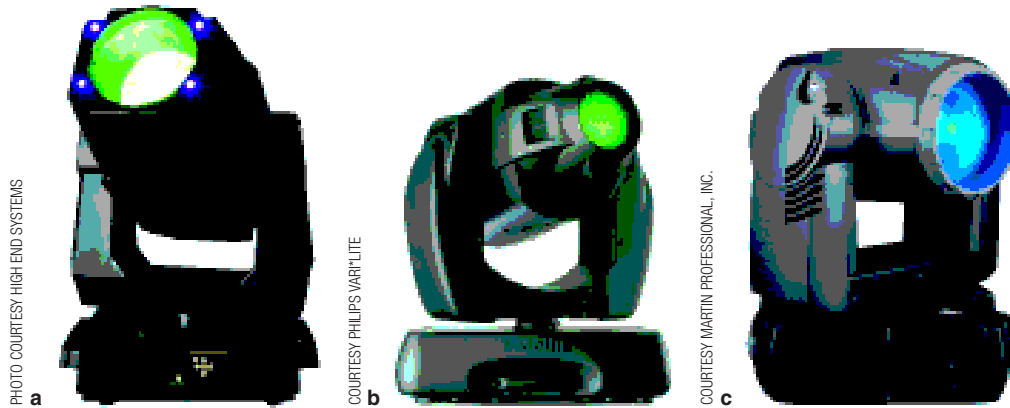
Bright Arc Spot Fixtures Philips Vari*Lite, Martin, High End Systems, and Clay Paky make automated spot fixtures that range from 8,000 to 16,000 lumens in intensity.

- The Philips Vari*Lite VL770 Spot has a zoom range from 15 to 36 degrees with a maximum brightness of 15,000 lumens. It has a built-in color wheel in addition to CYM color mixing. There are two gobo wheels: one 10 slot fixed wheel and one seven slot rotating wheel. A mechanical iris and dimmer complete the package. It requires 30 channels of control (Figure 13-13a).
- The Martin MAC 700 Profile™ has a 16 to 30 degree zoom with up to 16,700 lumens. Like the Vari*Lite, it has a fixed color wheel (eight colors) as well as CYM color mixing. There is also a static as well as rotating gobo wheel. In addition, the MAC offers an interchangeable three-facet rotating prism. There is a mechanical dimmer and iris. It requires 23 to 31 control channels (Figure 13-13b).
- The High End Systems Technospot™ has an 11 to 34 degree zoom range and provides 12,000 lumens of illumination. It also has both a fixed color wheel and CYM color mixing. It has two six-position rotating gobo wheels, an animation wheel, and a rotating four-facet prism. Mechanical dimming and iris are provided—37 channels of control (Figure 13-13c).
- The Sharpy from Clay Paky is a compact and affordable spot fixture with a very narrow parallel light beam—the maximum spread is 3.8 degrees. It delivers 8,000 lumens (an impressive 5,100 footcandles at 65 feet) and has an interchangeable color wheel with 14 colors and a gobo wheel with 17 fixed gobos. There is an eight-facet rotating prism and mechanical dimmer. With such a narrow beam spread, it is clearly an effect unit rather than an area light (Figure 13-13d).

13-13 Bright Arc Spot Fixtures

- a Philips Vari*Lite VL770 Spot.
- b Martin MAC 700 Profile™.
- c High End Systems Technospot™.
- d Clay Paky Sharpy.





13-14 Bright Arc Wash Fixtures
 a High End Systems TechnoArc™.
 b Philips Vari*Lite VL2500 Wash.
 c Martin MAC 250 Wash™.

Bright Arc Wash Fixtures High End Systems, Philips Vari*Lite, and Martin manufacture bright arc wash fixtures with lumen outputs between 7,700 and 14,700 (Figure 13-14).

- The High End TechnoArc™ (Figure 13-14a) delivers 14,000 lumens with an 8 to 32 degree zoom range. It offers a fixed color wheel plus CYM color mixing. It has a mechanical iris, dimming, and strobe, and requires 21 control channels.
- Philips Vari*Lite VL2500 Wash (Figure 13-14b) provides 14,700 lumens of intensity with a 14 to 55 degree zoom. It has an 11-color fixed color wheel as well as CYM color mixing. A coated glass dimmer wheel does the dimming—15 DMX channels are required.
- Martin's MAC 250 Wash™ (Figure 13-14c) is an affordable fixture that produces 7,700 lumens of intensity with an interchangeable lens system. It has a fixed color wheel along with CYM color mixing and a mechanical dimmer. It requires 16 to 19 control channels.

Brighter Arc Spot Fixtures Martin, High End Systems, and Philips Vari*Lite market automated arc fixtures that produce between 19,000 and 25,000 lumens (Figure 13-15).

- Martin's MAC Viper Profile™ (Figure 13-15a) delivers 25,000 lumens with a zoom range of 10 to 44 degrees. It has CYM color mixing, variable color temperature from 3,200 K to 6,000 K, and an eight-color, fixed color wheel. There is a four-facet, rotating prism effect, mechanical dimmer and iris, and pre-programmed effects. It takes 26 to 34 control channels.



13-15 Brighter Arc Spot Fixtures
 a Martin MAC Viper Profile™.
 b High End Systems intellaspot™.
 c Philips Vari*Lite VL880 Spot.

COURTESY PHILIPS VARI*LITE



a

COURTESY MARTIN PROFESSIONAL, INC.



b

13-16 Brighter Arc Wash Fixtures

a Philips Vari*Lite VL3000 Wash.

b Martin MAC 700 Wash™.

- intellaspot™ from High End Systems (Figure 13-15b) produces 20,000 lumens of intensity with a zoom range of 11 to 55 degrees. It also has a fixed color wheel as well as CYM color mixing, a rotating prism effect, and two seven-position rotating gobo wheels. An iris, mechanical dimming, and a variable soft edge feature are included. It needs 41 DMX channels for all this to work.
- Philips Vari*Lite VL880 Spot (Figure 13-15c) produces 19,000 lumens and has a zoom range of 15 to 36 degrees. Color is provided by an eight-position fixed color wheel along with CYM color mixing. There is a rotating gobo wheel holding seven patterns and a fixed wheel with 10 patterns, mechanical iris and dimming, and variable beam focus. Thirty DMX channels are required.

Brighter Arc Wash Fixtures Philips Vari*Lite and Martin offer arc source automated wash fixtures with a lumen range around 20,000 (Figure 13-16).

- The Philips Vari*Lite VL3000 Wash fixture (Figure 13-16a) produces 20,000 lumens with an impressive variable beam angle from 10 to 60 degrees. Color is produced by CYM mixing, a fixed color wheel that can be rotated for effect, and variable color temperature control. It requires 16 channels of control.
- The Martin MAC 700 Wash™ (Figure 13-16b) delivers 18,600 lumens of intensity with an equally impressive 12 to 66 degree zoom. It also has CYM color mixing, a fixed color wheel, and variable color temperature. It requires 16 to 23 DMX channels.

Brightest Art Spot Fixtures Although there are numerous options in this category, we have selected four automated spot fixtures with lumen outputs from 25,000 to 135,000:

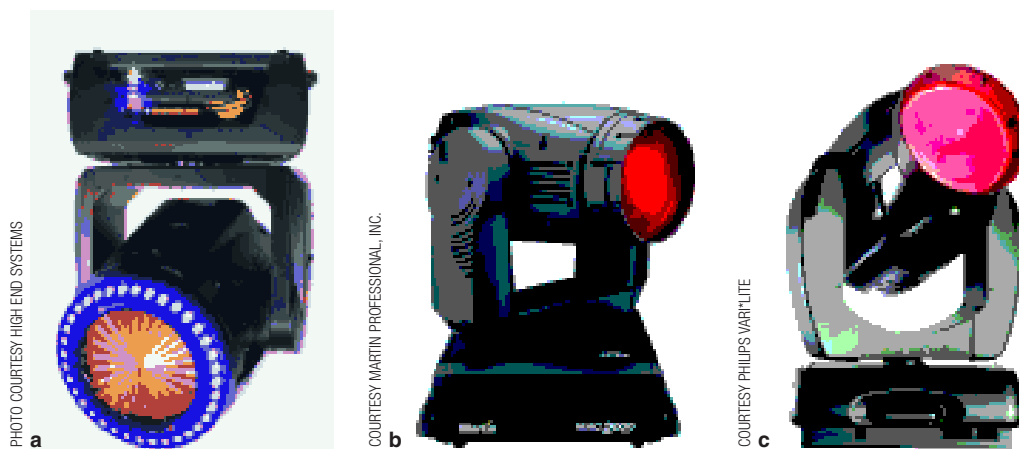
- The brightest of all is from the Clay Paky Alpha 1500 family of fixtures. Shown is the Alpha Profile 1500 with its 135,000 lumen output and a zoom beam spread from 7 to 60 degrees. Color is by CYM mixing, a fixed color wheel, and variable color temperature control. Effects include six rotating gobos, eight fixed gobos, and a rotating prism. It has mechanical iris and dimming. It requires 39 to 43 control channels (Figure 13-17a). Other members of the Alpha 1500 family include Alpha Beam 1500 with a parallel beam of light; Alpha Wash 1500, a powerful wash fixture; and Alpha Spot HPE 1500, which offers an impressive effects package.
- High End Systems' SHOWGUN 2.5 produces a brilliant 130,000 lumens with a narrow zoom range from 9 to 18 degrees. It has rotating gobos, unique variable soft-to-hard edge focusing, a variable iris, and electronic dimming. Color is provided through CYM mixing and it has an array of RGB color-mixing LEDs surrounding its lens—they alone give off 5,000 lumens (Figure 13-17b).
- More down-to-earth is the VL3515 Spot fixture from Philips Vari*Lite. It has 25,000 peak lumens with a nice zoom range from 10 to 60 degrees. Color is the standard CYM mixing, a fixed color wheel with rotation for effect, and a variable color temperature wheel. There is one fixed and one rotating gobo wheel, variable beam focus, and mechanical dimming. One model has a four-blade shutter mechanism like the familiar ERS and another a mechanical iris. Thirty-one control channels are necessary (Figure 13-17c).
- Martin's MAC III Profile™ delivers up to 33,900 lumens with a zoom from 11.5 to 55 degrees. CYM color mixing, a fixed color wheel, and variable color temperature are standard. Effects include a four-facet rotating prism, gobo animation wheel, and strobe. It has a mechanical iris and requires 27 to 30 DMX channels (Figure 13-17d).


13-17 Brightest Arc Spot Fixtures

- a Clay Paky Alpha Profile 1500.
- b High End Systems SHOWGUN 2.5.
- c Philips Vari*Lite VL3515 Spot.
- d Martin MAC III Profile™.

Brightest Arc Wash Fixtures High End Systems, Martin, and Philips Vari*Lite offer automated arc source wash fixtures with lumen outputs from 50,000 to 140,000 (Figure 13-18):

- SHOWBEAM 2.5™ from High End Systems (Figure 13-18a) produces 140,000 lumens of light with a zoom range from 11 to 42 degrees. It provides the usual CYM color mixing, a color wheel, and variable color temperature. A unique feature is its Twin Beam effect, which allows independent control over two light beams with separate effects and movement from each. Like the SHOWGUN 2.5, it also has a ring of RGB color-mixing LEDs around its lens. All this requires 32 channels of control.
- Martin MAC 2000 Wash XB™ (Figure 13-18b) produces a brilliant 60,000 lumens. There is a choice of three zoom lenses: a PC zoom from 12.5 to 35 degrees, a Fresnel zoom from 12.5 to 39 degrees, and a super-wide lens from 73 to 91 degrees. It has CYM color mixing, two fixed four-position color wheels, and variable color temperature. It requires 19 to 21 control channels.
- The VL3500 Wash from Philips Vari*Lite (Figure 13-18c) delivers 50,000 lumens in 1,500 watt mode. Beam control is provided by a zoom beam spreader in addition to three interchangeable lenses: a clear PC, a spread PC, and a Fresnel. Rather convoluted photometric data indicates possible beam spreads between 9.5 and 44 degrees. Color is CYM mixing, two fixed color wheels with rotation, and variable color temperature control. For some reason, it has a five-position aperture wheel rather than an iris. Nineteen control channels are needed.

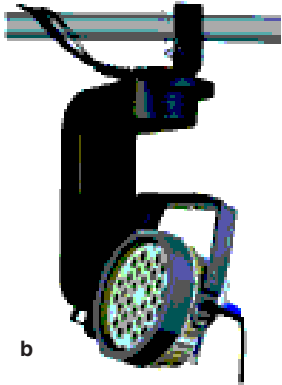

13-18 Brightest Wash Fixtures

- a High End Systems SHOWBEAM™ 2.5.
- b Martin MAC 2000 Wash XB™.
- c Philips Vari*Lite VL3500 Wash.

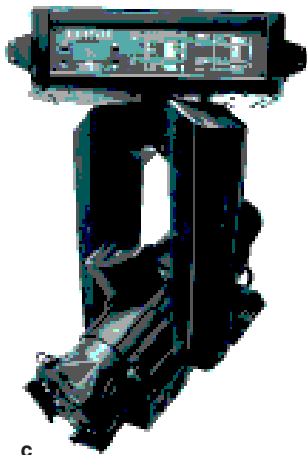
PHOTO COURTESY ROSCO LABORATORIES, INC.



PHOTO COURTESY APOLLO DESIGN TECHNOLOGY, INC.



COURTESY CITY THEATRICAL, INC.



13-19 Other Automated Devices

- a Rosco I-Cue Intelligent Mirror.
- b Apollo Right Arm.
- c City Theatrical AutoYoke®.

Other Automated Devices

Several manufacturers have developed remote-controlled devices to provide low-cost alternatives to sophisticated automated fixtures. These include the I-Cue, Right Arm, and AutoYoke (Figure 13-19).

- The I-Cue Intelligent Mirror from Rosco attaches to any fixture with a 6¼-inch color frame slot as shown in Figure 13-19a. The mirror, controlled by two or four DMX channels, offers a pan of 230 degrees and a tilt of 57 degrees. If used with a very wide beam spread (50 degrees), the light out of the lens exceeds the size of the mirror and causes unwanted spill. It is quiet, and the entire unit weights only 3½ pounds.
- An advantage of Right Arm, distributed by Apollo (Figure 13-19b), is that it can control a variety of lighting fixtures, including small projectors (maximum width = 17.3 inches). To attach, one simply bolts the yolk of the lighting fixture to the Right Arm. The unit weighs 30 pounds and has a load capacity of 40 pounds.
- One version of AutoYoke® from City Theatrical (Figure 13-19c) takes a 6-inch ERS, and a second controls a Source Four PARNel. Optional AutoIris and AutoFocus is available for an ERS and variable beam spread for the PARNel. Pan range is 360 degrees, and tilt range is 270 degrees.

Automated Fixture Control

As can be seen by the numbers of DMX channels required for an automated fixture, controlling more than just a few fixtures can become difficult if not impossible with a standard control console. An operator must have easy access to the many attributes of today's sophisticated moving lights. This requires organizational tools that make fixed lighting control seem simple. Improved specialized control systems have made theatrical design with moving lights considerably simpler.

Background In the early 1980s, Vari*Lite (then Showco) developed the first Vari*Lite automated fixture in conjunction with the band Genesis; thus, concert lighting automated fixtures were born. Of course, the fixtures required a companion control console designed to handle the new lights. This early proprietary console was operated only by company-trained personnel who went on the road with the band and helped maintain the system. This was standard operating procedure until 1986 when Vari*Lite introduced a new console that anyone could operate: The Artisan. This was about the same time that USITT was developing DMX protocol, but the Artisan remained proprietary to Vari*Lite fixtures. Features included:

- Manual and programmed control of up to 1,000 channels and 2,000 cues per channel.
- “Matrix control”—50 patches assigning up to 1,000 channels to 20 Matrix faders.
- 200 programmable chases containing any sequence of cues.
- Programmable channel groups.
- Bi-directional digital data link to and from fixtures providing system response and feedback.
- Disk storage.

Since then, Vari*Lite has abandoned the control console manufacturing business, leaving that task to other manufacturers including MA Lighting, High End Systems, ETC, and Philips Strand.

MA Lighting Consoles MA Lighting is a German company established in 1983 with its products managed by A.C.T Lighting in the United States. The grandMA

series of automated fixture control consoles has gained a solid reputation as reliable and powerful interfaces with today's automated fixtures. MA Lighting manufactures the grandMA2 full size, the grandMA2 light, and the grandMA2 ultra-light (Figure 13-20). Features of the grandMA2 full-size include:

- Control of over 65,000 parameters (a specific attribute of a specific fixture).
- 30 motorized executor faders with the possibility of adding 60 more in an auxiliary fader wing.
- A simple method of selecting gel numbers or choosing from a color palette.
- Three touchscreens.
- Six-universe DMX output.

A series of cues called a *cue stack* is written and then assigned to a fader for playback. The process of writing and editing cues is fairly straightforward once the operator learns and understands the console's syntax.



PHOTO COURTESY A.C.T. LIGHTING, INC.

a



PHOTO COURTESY A.C.T. LIGHTING, INC.

b

13-20 MA lighting Consoles

a grandMA2 full size.

b grandMA2 ultra-light.

High End Systems Consoles High End Systems (now owned by Barco of projector fame) was born in Austin, Texas in the 1980s. They developed their first color-changing luminaire, the Color Pro™, in 1988; the Intellabeam® moving-mirror fixture in 1989; and Cyberlight™ in 1994. In 1999, they acquired Flying Pig Systems, developers and manufacturers of their current line of control systems: Whole Hog®. The Whole Hog family consists of four control systems: the Wholehog® 4 Console, the Full Boar 4 Console, the Road Hog 4 Console, and the Hog® 4PC (Figure 13-21). Features of the Wholehog® 4 Console include:

- Control of over 8,000 fixtures per show.
- An unlimited number of simultaneous crossfades.
- Ten playback faders.

13-21 High End Systems Consoles

a Wholehog® 4 Console.

b Road Hog 4 Console.



PHOTO COURTESY HIGH END SYSTEMS

a



PHOTO COURTESY HIGH END SYSTEMS

b

- Two touchscreen displays allowing instant access to fixtures, groups, and palettes (presets).
- A quick function to add new fixtures to replicate existing programming.
- Gel and color picker.
- Unlimited DMX channels via Ethernet.

A fixture library stores all attribute information (personalities) for major automated fixtures so the operator need only identify a fixture by name. The Whole Hog has been a very popular console for concert lighting applications.

ETC Consoles ETC was founded in 1975 by four individuals who were interested in developing a lighting control console operated by a new technology—chips called microprocessors. Their first products were bought by Colortran and their own first console, the Concept, was marketed in 1982. The Source Four was introduced in 1992 as ETC grew into a major manufacturer of stage lighting equipment. Today, ETC markets three families of consoles: Eos®, Congo™, and Smart. We will look at the Eos Family, which includes Eos®, Gio®, Ion®, and Element™. The Eos® was introduced in 2006 and won the LDI Product of the Year Award (Figure 13-22). Some of its features are:

- 10,000 channels or devices.
- Up to 16,384 outputs or parameters.
- 999 cue lists.
- 200 active playbacks.
- 300 submasters.
- Dedicated pan/tilt encoders and four pageable encoders.
- Two touchscreen monitors.
- Four Ethernet ports.

The Eos family developed from theatre consoles and, as such, finds its main popularity in the theatre world rather than the concert world. The Gio® has the capabilities of Eos® in a smaller desk—designed for touring. The Ion® is a powerful, reasonably priced console for both conventional and automated fixtures.

Philips Strand Consoles Strand Electric is by far the oldest of these four console manufacturing companies, making its debut in London in 1914. It joined forces with America's Century Lighting in 1969 and was taken over by the Philips Entertainment Group in 2008. Strand Century's Light Palette was an early electronic lighting control console that soon became an industry favorite. Today, Philips Strand Lighting manufactures a large line of consoles with the VL series specifically designed for automated fixtures (Figure 13-23). Features of the Light Palette VL include:

- 8,000 control channels/attributes.
- Direct access control of up to 1,000 fixtures.
- Two timed playbacks.
- 12 direct access playback faders.
- 24 submasters with unlimited submaster pages.
- Four rotary encoders.
- Four universes of DMX.
- Color picker for direct color selection.

Like the Eos family, the Light Palette originated as a theatrical console and many of its features favor stage rather than concert lighting.

13-22 ETC Consoles

- a ETC Eos® lighting control console.
- b ETC Gio® lighting control console.

PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)



PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)



Programming There is a good reason that Broadway musicals often require two lighting control systems—one for conventional fixtures and one for automated fixtures. The programming process can be extremely time-consuming. Programming moving lights in an efficient manner is an art unto itself. Individuals make a living today solely as programmers because they are experts at interpreting what a production designer has in mind for the moving lights and being able to make that happen. Until humans can telepathically communicate with an automated fixture, the process of informing it exactly what to do is going to remain highly complex.

A lighting designer seldom, if ever, specifies channels or fixtures when using a capable programmer. Instead, the designer tells the programmer what he or she

13-23 Philips Strand Consoles

- a Strand Light Palette VL.
- b Strand Palette VL.

COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON



a

COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON



b

would like the look to be. The programmer then decides how to best implement that visual effect.

If using moving lights to any great extent, the designer must be absolutely certain that the individual programming the board is capable. Knowledge of the moving lights themselves as well as the board's interface with the fixtures is imperative. Good communication skills are an added benefit. Time *must* be allotted for moving-light programming—this fact cannot be overstated. Whereas a normal show may take five hours to program, one with moving lights can take two days. The more skilled the programmer, the quicker it will go.



PHOTO COURTESY ERIC ASHLEIGH

13-24 Automated Concert Lighting My Morning Jacket's *Evil Urges* tour. Lighting Designer and Director, Marc Janowitz.

Finally

Certainly, a single automated fixture can do the job of several fixed instruments. Although automated fixtures are valuable tools, they will not completely replace conventional fixtures in the theatre. Successful designing with light requires as much control as possible over color, angle, distribution, and movement. In many ways, automated fixtures offer much more control than standard fixtures do. However, unless used in great quantities, automated fixtures lack certain flexibility because the angle of light remains dependent on a fixed source. In this way, several conventional fixed instruments are more flexible than one automated fixture.

Automation in the Theatre

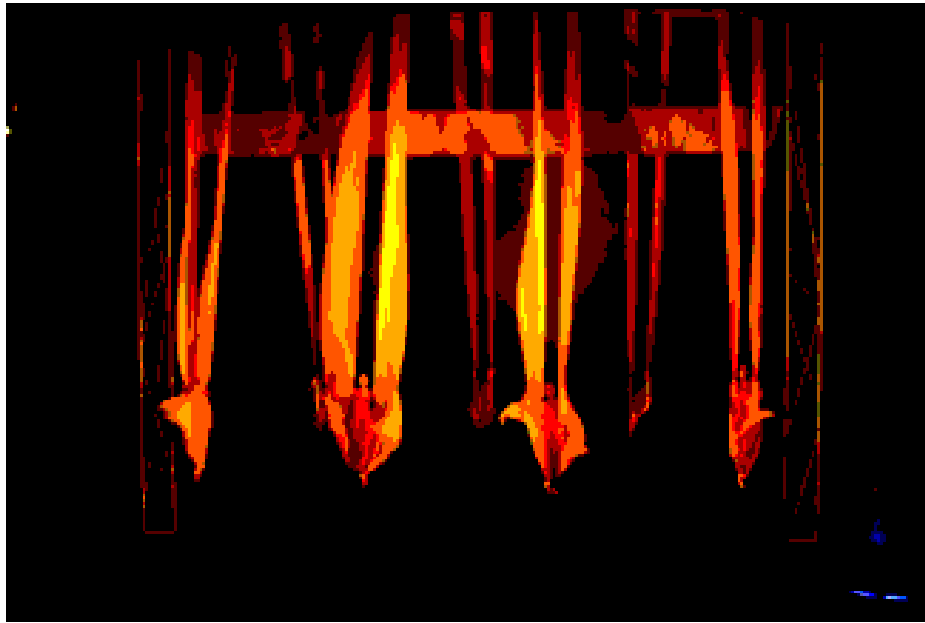
What has made automation even more complex is our expectation of the integration of many kinds of movement—that is, scenery, lighting, sound, and special effects. The more complicated the combination of movement, the more important the planning and integration of all the parts becomes. **Show control** is the term for using the computer to control two or more kinds of stage movement, such as planning a light cue, a set change, and a sound cue to coincide. Thanks to great advances in technology, it is currently possible, if not desirable, to use the computer to control all the action of a production (aside from that of the actors). This is especially true in the concert and video industries and, in fact, in creating new forms of entertainment, such as Webcasts, podcasts, and storytelling in gaming. (See *Control Systems for Live Entertainment*, 2nd edition, by John Huntington, for an excellent and thorough discussion of show control.)

Computer technology continues to advance rapidly. Blockbuster shows such as *Cats* and *Phantom of the Opera* in scenery and *A Chorus Line* in lighting were pioneers in using advanced backstage technology.

Changes since then have been astonishing, enabling not just extensive use of all kinds of projections and special effects, but coordination of all of this action. The Broadway production of *Wicked* and the even more current *Spider-Man: Turn Off the Dark* have taken automation of both scenery and lighting to new heights (Figure 13-25).

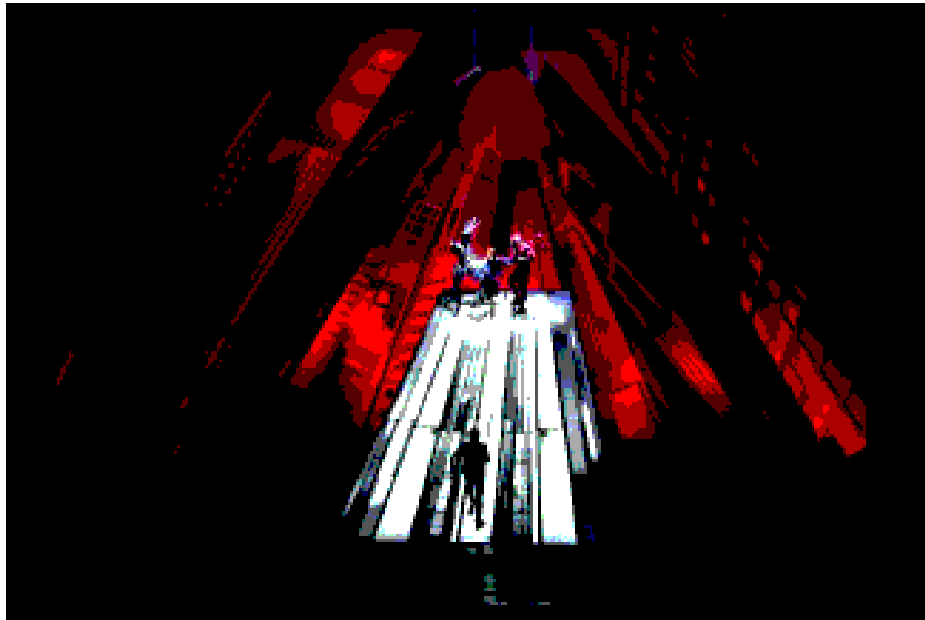
show control Using a computer to control the timing of two or more stage movements (light, scenery, sound, effects).

JACOB COHL/SPIDER-MAN TURN OFF THE DARK



13-25 SPIDER-MAN Turn Off the Dark
 Music and lyrics by Bono and The Edge;
 book by Glen Berger, Roberto Aguirre-
 Sacasa, and Julie Taymor. Directed by Philip
 Wm. McKinley; scenery, George Tsylin;
 costumes, Eiko Ishioka; projections, Kyle
 Cooper; lighting, Donald Holder.


JACOB COHL/SPIDER-MAN TURN OFF THE DARK





PART III | STAGE LIGHTING

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“The basic concern in theatre lighting is with the dramatic intention of a particular moment. The visibility, or the kind of light, in which you see the actors and the scenery, the place, must have a logic. The logic is based on tying all of these in with the idea of being there, in the scene, in the first place.”

Jean Rosenthal
The Magic of Light

4

Introduction to Stage Lighting

Although each of us reacts uniquely to our environment, we generally take light and lighting for granted. Like the veterinarian who is aware of things in an animal that even its owner does not notice, the lighting designer must be acutely aware of the presence of light: its quality, color, intensity, shadow and direction, warmth or coolness, texture, and movement. The first thing a student of lighting seeks to develop is such an awareness—not for theatrical lighting, that will come later—but for the light that surrounds us each and every day.

The design of lighting begins with an *idea*. In the theatre, this idea results from interpretation of the script by the director and the production design team (lighting, scenic, costume, sound, and perhaps projection designers). In dance, the idea comes from the choreographer, the movement, and the music. In opera and concert lighting, it begins with the music. In advertising, it is inspired by the product. It does not matter if the lighting designer works in a theatre or a theme park or a film studio or an exhibition hall—the design will have its roots in a collection of impressions, an idea.

The theatre has historically been the source of lighting design and continues to be a prime training ground for today's lighting designers, no matter what the field.

Stage Lighting

Lighting is perhaps the most powerful of the theatrical design elements. In its simplest form, light reveals what needs to be seen. Its intensity determines how well an object is seen, its direction dictates in what way it is seen, and its color controls the object's color. Because light has such a strong impact on scenery and costumes, the lighting designer must be a good collaborator with fellow designers as well as with the director.

The primary concern of stage lighting is, and will always remain, *visibility* (a rule that the designer must never forget). Yet, visibility is much more than simple intensity or brightness of light. *Contrast* has a great influence on visibility: intensity contrast, color contrast, and contrast in direction. Good lighting ties together the visual aspects of the stage and supports the dramatic intent of the production. The lighting designer must also be concerned with revealing three-dimensional form, the mood of the scene, and the **composition** of the stage picture.

Scripts may call for special effects such as a campfire, a lightning storm, or haze in the air—all of which normally fall under the auspices of the lighting designer. Most often, however, the concern is with lighting the actor, a moving target that can be illuminated in an endless variety of moods and degrees of visibility. Herein lies the real challenge and the excitement of stage-lighting design.

CENGAGE **brain**.com

For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

composition The organization of design elements into a unified form. Light reveals composition.

The Scene Designer

Unlike the other visual arts, scene design depends enormously on the use of light as a part of the final composition—the dramatic picture. Stage lighting contributes so much to the total visual effect that every scene designer should be familiar with its potential.

The design of lighting may begin with the scene designer's sketch or lit model, which presents a suggestion of the light that will illuminate the scene. It may appear to be coming from natural sources, such as the sun, the moon, or a fire; or from artificial sources, such as table lamps or ceiling fixtures. Alternatively, the light may appear to have no particular source and serve solely to support the desired mood or composition of the scene. A sketch, rendering, or lit model is the scene designer's best means of conveying a sense of mood (see Chapter 3 for more information).

Scenic renderings or sketches represent an artistic vision that must be technically sound to be properly realized. The ground plan and section that accompany the sketch give the first clues as to the credibility of the designer's lighting ideas. Many a beautiful sketch has been based on a floor plan that revealed, on closer study, impossible lighting angles and insufficient space for the lighting instruments.

Today's production design team is normally made up of four or five designers and the director. A unified approach or concept for a production is imperative for a successful design. Diverse ideas and views must be brought together into a single outlook by active and open communication among the members of this collaborative team as well as by strong leadership from the director (Figures 14-1 and 14-2).

The Lighting Designer

The history of modern stage lighting is relatively brief, beginning not much more than a century ago with the advent of electricity and the invention of the incandescent lamp. Except for a few scene designers who enjoyed lighting their own scenery, the lighting of most Broadway productions up until the middle of the twentieth century was neglected and became, by default, one of the innumerable duties of the stage manager or house electrician. It was inevitable that lighting specialists would eventually move into this neglected field and demonstrate with startling results what could be done if one person devoted full attention to the planning of lighting. This trend continued as lighting designers developed their art and craft, inspired by the work of such people as Stanley McCandless, Jean Rosenthal, and Abe Feder.

Light's potential as a design element is recognized well beyond the theatre. The value of light as a merchandising tool in sales and retail stores has long been realized; the significance of light to the appreciation of a meal in a fine restaurant is not a secret; and light as a means of establishing mood and atmosphere in the entertainment industry has never been more recognized. As a result, people trained in lighting design are in demand by many diverse industries as well as by the theatre.

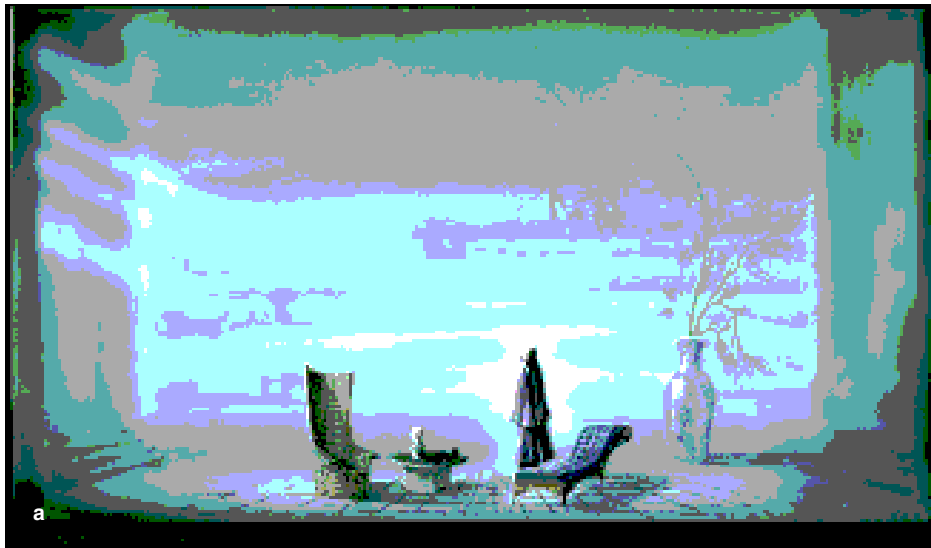
As a collaborative artist, the theatre-lighting designer must understand and appreciate the total design effort, particularly because he or she is the only member of the visual design team who does not submit, in advance, a complete statement of what is intended. Costume and scene designers present a multitude of sketches, material samples, and models as visual examples of their intent. Lighting designers, in contrast, may submit research, **lighting storyboards**, or digital light renderings. Such renderings most often begin with a scanned photograph of the scene designer's model. Light is then manipulated in Photoshop® to incorporate the lighting designer's vision (Figure 14-3). However, more often than not, lighting designers must rely on verbal exchanges until the time comes to actually produce the light onstage. Of course, this mode of operation demonstrates the need for a strong collaborative process. Fortunately, the lighting designer commonly has the advantage of attending rehearsals before the final plot is completed.

lighting storyboard A series of value sketches or color renderings depicting the quality of light for the various "looks" of a production.

14-1 Scene Designer's Sketch and Models The planning of stage lighting may begin with the scene designer's sketches and/or models, which indicate the kind of illumination and its distribution, color, and general atmosphere.

- a Sketch: Act I—The Sculptor's living room for *La Gioconda* by Gabriele D'Annunzio. Scenery by Beeb Salzer.
- b Sketch: *Master Harold and the Boys* by Athol Fugard. Scenic design by Adam Koch.
- c Model: *Julius Caesar* by William Shakespeare—Belasco Theatre, Carole Shorenstein Hays, producer. Directed by Daniel Sullivan, scenery by Ralph Funicello.

COURTESY BEEB SALZER



COURTESY ADAM KOCH



COURTESY RALPH FUNICELLO





a

14-2 *Burn This* Models and Production Photo

- a A scenic model viewed from house right for a production of *Burn This* at The Mark Taper Forum. Designed by Ralph Funicello.
- b *Burn This* model—night.
- c Production shot from The Mark Taper Forum's *Burn This*. Directed by Nicholas Martin; scenery, Ralph Funicello; costumes, Gabriel Berry; lighting, Ben Stanton.



b



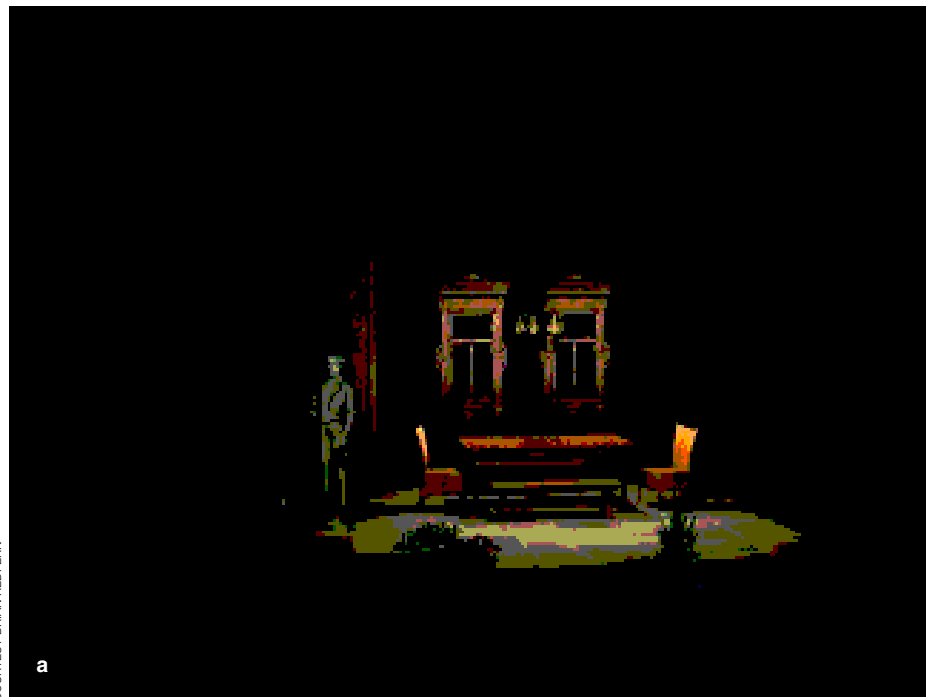
c

ALL PHOTOS COURTESY RALPH FUNICELLO

14-3 Digital Renderings Digital renderings present a good way to convey lighting quality and mood. Shown is a rendering and performance photo from a production of *Fathers and Sons* by Richard Hoehler, adaptation by Brian Friel.

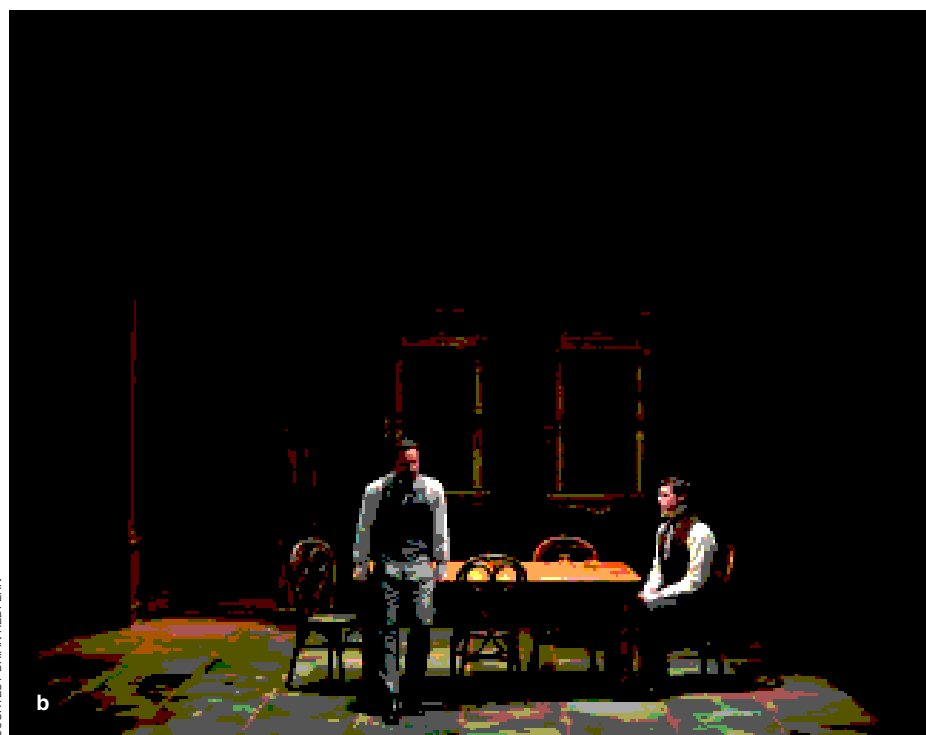
- a Digital rendering of the scenery for *Fathers and Sons*. Design by Brian Redfern.
- b Production photograph from *Fathers and Sons* at the Old Globe Theatre in San Diego. Directed by Ray Chambers; costumes, Jeannie Galioto; lighting, Jason Bieber; scenery, Brian Redfern.

COURTESY BRIAN REDFERN



a

COURTESY BRIAN REDFERN



b

Setting aside the technical aspects of instrumentation and control and details of plotting, the lighting designer is concerned first with the aesthetics of light. To develop a sense of composition, movement, and taste in color, a lighting designer must start with the properties and limitations of the medium itself.

Properties of Light

Just as paint has traits particular to its medium, so light conforms to its own set of attributes. The physical characteristics of light in relationship to scenery are discussed in Chapter 3. The study of light as applied to stage lighting involves four properties: intensity, distribution, color, and movement.

Intensity

The first and most obvious property of light is its *intensity* or brightness, which may be actual or comparative brightness. The actual brightness of the sun, for example, can be compared with the relative brightness of automobile headlights at night. Lighting fixtures in a darkened theatre offer the designer the same comparative brightness under more controlled conditions. To some degree, apparent intensity is also influenced by the color and distribution of light.

The entire composition of a stage picture depends on varying intensities of light. In addition, intensity greatly affects the mood and the atmosphere of a scene.

Varying the intensity of a light source is most often achieved by means of a *dimmer*. Groups of dimmers working together can direct audience's focus as well as alter stage composition. Light intensity is commonly measured in **foot-candles**.

foot-candle A measurement of intensity of light reflected off a surface. Average stage brightness is approximately 70 foot-candles.

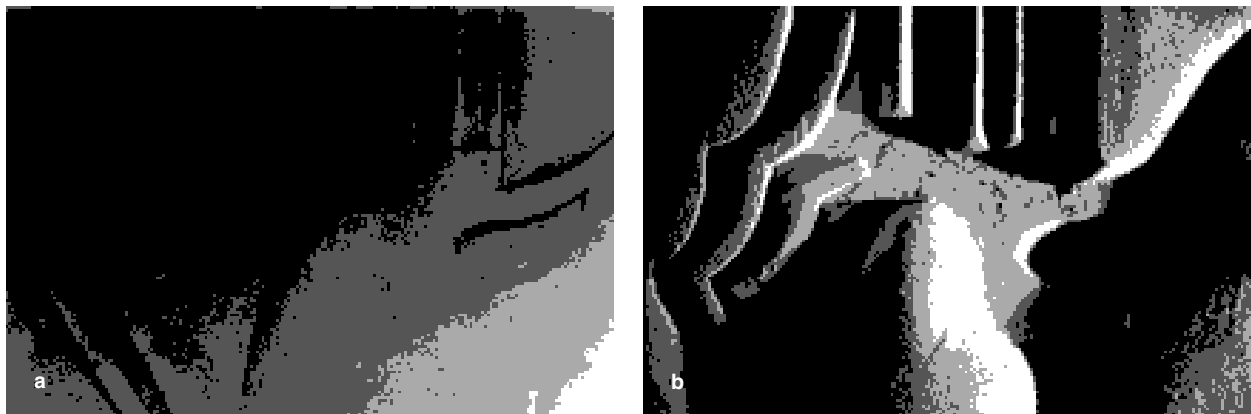
Distribution

Most often we see light as it is reflected off various surfaces. How it is distributed onto these surfaces depends on the source's *direction* and *quality*—attributes completely controlled by the lighting designer.

Direction (and Angle) The visibility of an object greatly depends on the direction of the light striking it. Light can strike an object from behind or from the front, or from one side or the other. In addition, it can come from a variety of heights. To clearly define the direction of a light source, one should specify direction (front, side, back) and height (in degrees).

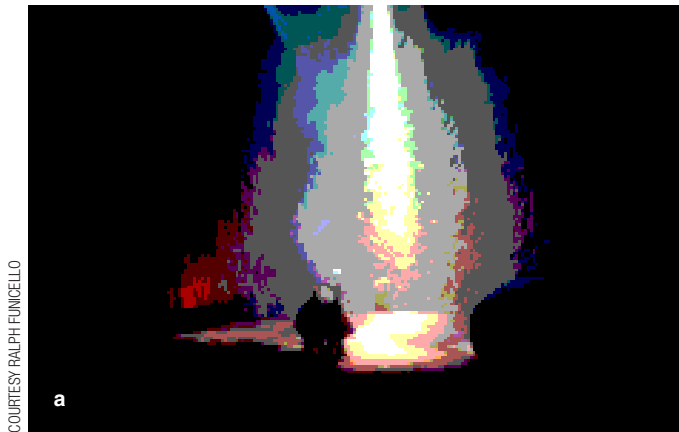
A change in lighting direction or angle can radically alter the perception of the size and/or shape of any form (Figure 14-4). Highlight and especially shadow are the best indicators of direction and angle. A theatre audience feels most at ease with light coming from the natural direction of above and in front of the performer. Like intensity, direction has a strong effect on mood and atmosphere.

Quality and Texture The concept of quality is closely related to texture and depends on a source's intensity and diffusion. A highly diffuse light tends to have divergent rays, whereas a less-diffuse light has coherent and parallel rays. Diffuse light is perceived as soft and lacking in intensity. More coherent light is harsher and more intense and creates harder edges (Figure 14-5). In its simplest form, texture in light is the product of a specific type of lighting instrument. Accordingly, one of the considerations in selecting a lighting fixture involves the textural quality of its light. Quality can be altered by adding diffusion



14-4 Distribution Changing the distribution of light on a highly textured surface can produce amazingly varied effects.

- a** A low-relief sculptural form lit with a single source from the front.
- b** The same form lit with two side-angle sources of different intensities or colors.



COURTESY RALPH FUNICELLO



PHOTO BY CRAIG SCHWARTZ; COURTESY CHRIS RYNNÉ

14-5 Texture in Light

- a** A soft texture can be created by the use of frost or diffusion media. Note the soft quality of light in the air and on the floor in this production of *King Lear* directed by Jack O'Brien for the Old Globe Theatre, San Diego. Scenery design, Ralph Funicello; costumes, Robert Morgan; lighting, David Segal.
- b** Harsh texture is created using a strong top light source in this production of *Lincolnesque* at the Cassius Carter Center Stage, Old Globe Theatre, San Diego. Directed by Joe Calarco; scenery, Michael Fagin; lighting, Chris Rynne.

gobo A pattern, normally cut into a thin stainless steel plate, which is placed at the aperture of an ERS to project an image.

filters to a light beam. Blatant texture can be created by introducing pattern into the beam in the form of a template, or **gobo** (Figure 14-6). Creative use of the direction and texture of light introduces highlight, shade, and shadow into the stage composition.

Color

The third property of light is its ability to transmit and reveal color. A forceful element in all areas of theatre design, color may be considered to be the most effective and dramatic quality of light. The use of colored light to enhance the mood of a scene is a common theatrical technique. The lighting designer may use color in a theatrically realistic way to convey time of day or atmospheric conditions; additionally, color choices may be heightened or exaggerated in order to stylize the look of a production.

Colored light is commonly created through the use of filters. However, the beginning lighting designer needs to recognize that light sources have an intrinsic color that can vary greatly from one type of source to another. This difference in the **color temperature** of various light sources is a valuable tool for the lighting designer.

The ability of colored light to alter the color of a surface it strikes adds to its potential as a powerful design element. Modification of the natural color of a scenic form or costume by colored light is a design technique unique to the theatre. Color modification and the additive mixing of colored light are two rather basic concepts of color as a quality of light that all designers in the theatre must understand.

color temperature A measurement in degrees Kelvin (K) of the color of light emitted from a source. Stage-lighting instruments with incandescent lamps have a color temperature of about 3,200 K; candlelight is a warm-colored 1,800 K; and arc light is a cool-colored 6,000 K.

LIGHTING DESIGN BASICS

The Properties of Light

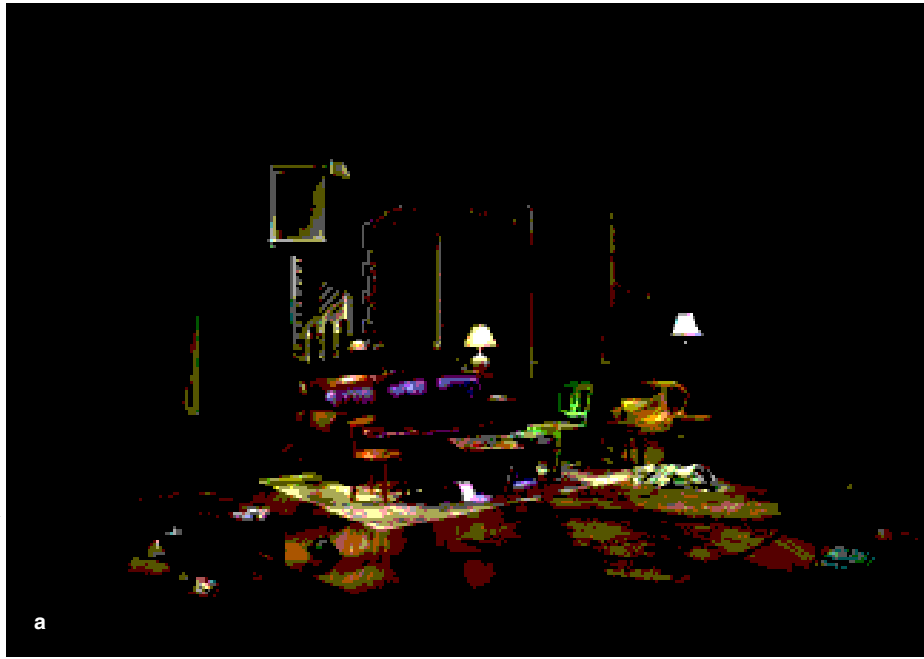
- Intensity
- Color
- Distribution
- Movement

Movement

Although it is not an intrinsic property of light, movement is an extremely important characteristic of stage lighting. Besides the physical movement of a light beam, movement includes a change in intensity, distribution, or color that might be as subtle as a slow progression from predawn to daybreak or as blatant as a blackout.

Although movement in light is often controlled by means of dimmers, theatre audiences have long been accustomed to physical light

PHOTO BY LUKE OLSON, COURTESY MICHELLE CARON

**14-6 Texture Created by Gobo**

- a** Gobos help to create the atmosphere in this production shot from *Living Together*, part of *The Norman Conquests* trilogy by Alan Ayckbourn, produced by Cygnet Theatre. Directed by Sean Murray and Francis Gercke; scene design, Sean Fanning; lighting, Michelle Caron.
- b** Photo from San Diego State University's production of Steinbeck's *The Grapes of Wrath*. Directed by Nick Reid; scenery, Sean Fanning; costumes, Kelley Convery; lighting, Maureen Hanratty.

COURTESY SEAN FANNING



movement in the form of follow-spotting. More recently, physical movement from automated fixtures creates a strong visual impact. Careful use of automated fixtures to direct the audience's attention or create specific moods adds significant tools to the designer's palette.

A lighting **cue** in the form of a shift from one "look" to another encompasses movement. Movement can take and control focus. Movement alters composition.

cue The movement of light from one stage "look" to another. A cue is usually assigned a specific number.

Stage Lighting and Theatrical Form

Several factors greatly influence the development of a lighting idea and the subsequent light plot. The production approach and the resulting scenery and costume designs influence color palette as well as style. In a more technical view, the scenery may affect the

specific placement of lighting fixtures. The style of the production as well as the script guides the lighting designer toward an approach. Finally, budget and the physical form of the theatre will affect the lighting design.

Production and Lighting Approach

Style As we have seen, the term *style* is subject to overuse and misunderstanding (see Chapter 4); nevertheless, we use it here in its broadest sense. In a recent conversation with a gathering of students, scene designer Ming Cho Lee commented: “I don’t know what style is. I think Howard Bay referred to it as a peculiar way of drawing.” An individual artist’s work possesses a unique look—a particular flair or technical approach referred to as a *signature*. If Monet and van Gogh had painted the same landscape, their works would appear quite different—the difference being a collection of viewpoints and techniques composing the artist’s style. In the professional theatre, like in the art world, designers are known and often hired for their particular style.

A good theatrical production also has a style of its own. A production’s style (defined earlier as “degree of reality”) is related to and often a result of the production team’s approach. After analyzing the play, the director and designers agree on an approach that normally establishes a style for the production. The designers then contribute their own techniques to this style, resulting in a unique interpretation of the dramatic work.

Lighting Approach While many factors influence the lighting approach and the final design, the lighting designer’s handling of each is always tempered by his or her initial reaction to the script. For example, a limited inventory or budget will undoubtedly affect the final light plot, but the use of those few instruments will be determined by the designer’s reaction to the script. It is the lighting designer’s responsibility to give meaning and logic to the action. Knowing how to do so begins with the script.

In formulating an approach, the lighting designer must think of numerous things:

- The script and resulting research that inform and guide all decisions
- Scenery color, texture, style, ground plan, form (including size and space usage), specifics such as windows and practicals, and masking
- Costume color, texture, value (light or dark), and mass
- Physical plant (theatre) limitations such as sightlines, lighting positions (including follow spots), available power, and inventory
- Budget and time
- Blocking, focus, and isolation requirements

Once all these are considered, the designer begins to develop a plan. It involves decisions concerning what specific kind of lighting systems will best accommodate all of the production requirements. Even given the restrictions noted above, the possibilities are endless: perhaps time of day is highly significant, dictating multiple systems of light to show time and mood differences; perhaps actor blocking and movement and a need for focus and isolation require tight area control, indicating higher angles and narrow-beam fixtures; or perhaps the style and mood of the production would be best reinforced by using colored light, requiring several color systems, color changers, or color-mixing LED fixtures.

Motivational and Nonmotivational Lighting Two broad approaches that are often determined by the style of the production are motivational and nonmotivational lighting. As its name implies, **motivational lighting** attempts to represent the look and feel of an actual light source such as the sun, a candle, or a streetlight. Such an approach tends to be appropriate in a realistic style of production. Strict motivational lighting attempts to exactly duplicate a specific light source, fitting in with a naturalistic production

motivational lighting The theatrical use of light based on an actual source or sources.

style. Environmental conditions such as time of day, weather, time of year, and locale are all taken into consideration.

In choosing **nonmotivational lighting**, the lighting designer ignores concerns about realistic light. Instead, he or she determines lighting colors, fixtures, and angles in response to a desired mood, a compositional requirement, or simply a “feeling” about the scene. Of course, strict motivational and nonmotivational styles stand at either end of a spectrum that includes endless variations and combinations of the two (Figure 14-7.) The beginning lighting designer should start by concentrating on motivational lighting while realizing that a nonmotivational approach can be quite as valid and sometimes more expressive and exciting.

nonmotivational lighting Light used as a pure element of design, without reference to any actual sources. Often such use is based on the designer’s emotional reaction to the script.

Physical Plant

The physical theatre itself has great influence over lighting potential, particularly in terms of distribution. Where lighting fixtures may be placed, and therefore how their light strikes the actors and scenery, is chiefly determined by the space’s architecture.



14-7 Lighting Styles

- a** Highly stylized motivational lighting in *You Can't Take It with You*. Scenery design, Doug Grekin; lighting, R. Craig Wolf.
- b** Motivational lighting is often required to support realism, as in this production of *A Streetcar Named Desire* at San Francisco's American Conservatory Theatre. Directed by Richard Seyd; scenery, John Iacovelli; costumes, Ann Bruce; lighting, York Kennedy.
- c** Color in light adds to the style of this production of *The City Club*. Book by Glenn M. Stuart; scenery, Rob Bissinger; costumes, David C. Woolard; lighting, David F. Segal.

COURTESY OF THE AUTHORS
a PHOTO BY KEN FRIEDMAN, COURTESY YORK KENNEDY

PHOTO BY CAROL ROSEGG, COURTESY DAVID F. SEGAL

Proscenium Theatre In the *proscenium theatre*, with its traditional audience and stage arrangement, lighting is essentially shadow-box illumination that caters to theatrical realism or illusory theatre. Although it is common today to see a proscenium theatre with lighting totally exposed, traditional proscenium lighting called for its instruments to be concealed behind masking legs and borders onstage and in ceiling “ports” or “beams” or side “coves” front-of-house. In older theatres, front-of-house positions were limited, sometimes to only a balcony rail. Scenery permitting, the proscenium stage is the most versatile form for side-lighting possibilities.

Thrust Stage The *thrust stage*, with its audience on three sides, minimizes the use of scenery and gives the lighting designer greater responsibility for creating illusion. This new-old form of theatricality (popular in the sixteenth century) relies chiefly on lighting, costumes, and properties for its visual composition. Additionally, in most thrust houses the audience’s viewing angle makes the stage floor quite prominent. In some cases, the floor is more of a background to the actor than are any upstage scenery or properties. The lighting designer must keep this in mind when choosing color and texture in the light. Thrust staging requires full-coverage lighting (360 degrees). An exciting and challenging theatre form, modern thrust theatres provide flexibility in lighting positions both front-of-house and overstage.

Arena Stage Staging “in the round” increases the demands on stage lighting and virtually eliminates scenery because the audience surrounds the stage area. Like thrust, the arena requires 360-degree coverage but is often a bit more restrictive in terms of lighting possibilities. The floor of most arenas is also quite prominent, requiring special attention from the lighting designer. A good arena theatre will be equipped with a lighting grid that covers the entire space and allows total flexibility in hanging position.

Black Box *Flexible or black box staging* should not be neglected because it can provide, on a small scale, any of the aforementioned audience–stage arrangements and more. By its sheer flexibility, it supports a frankly impromptu form; its exposed lighting fixtures and temporary seating arrangement allow great latitude. Like the arena, the ideal black box offers unrestricted lighting positions by virtue of a grid covering the entire space.

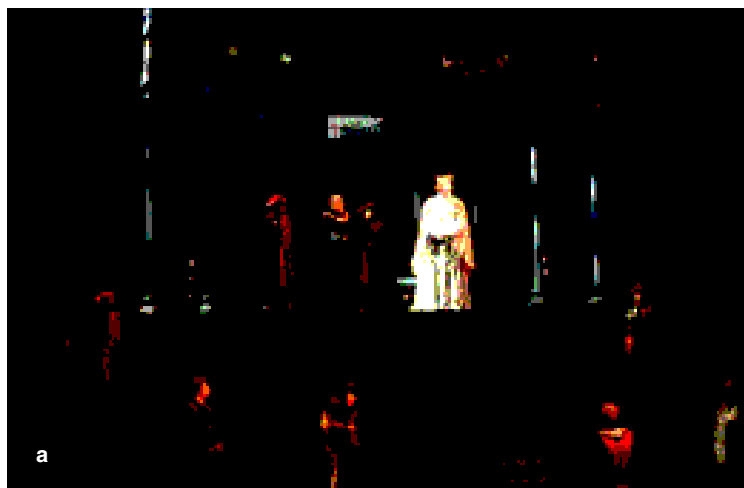
Functions of Stage Lighting

The basic obligation of stage design is to give performers *meaning* in their surroundings, providing an atmosphere in which the role may be logically interpreted. Through the manipulation of light in all its aspects—intensity, color, distribution, and movement—the lighting designer assists in creating an environment for the play by achieving *selective visibility*, by providing appropriate *composition* and *revelation of form*, and by establishing *mood* and reinforcing *the theme*.

Selective Visibility

The actor must be seen in order to be heard. *Visibility* cannot be defined as a fixed degree of brightness or an established angle of distribution; rather, it is the amount of light needed for a moment of recognition deemed appropriate for that point in the action of the play. Good theatre lighting guides the audience’s eye; selective visibility establishes focus (Figure 14-8). “To see what should be seen” may mean revealing the mere silhouette of a three-dimensional form, the solidity of its mass, or the full decorative and textural detail of all surfaces. Although visibility certainly relies on intensity, contrast also plays a significant role in achieving good stage visibility.

a COURTESY OF THE AUTHORS
b COURTESY RALPH FUNICELLO



14-8 Selective Visibility

- a** Focus is clearly created by costume and light in this production of *Richard II*, while the dramatic stage composition is accentuated by the lighting. Lighting design, R. Craig Wolf.
- b** Focus is created by both scenery and lighting in this production photo from *Cyrano de Bergerac* produced by San Diego's Old Globe Theatre. Directed by Darko Tresnjak; set design, Ralph Funicello; costumes, Anna Oliver; lighting, York Kennedy.

Composition

Stage composition begins with the scenic design and floor plan, is further defined by the placement and the movement of actors, and is completed when lit by the lighting designer. More than any other design element, light directs the audience's eye and controls what is and is not seen. Points of visual focus are determined by the blocking and the action. Because light possesses the additional quality of incredible fluidity, stage composition can be altered with relative ease.

The study of art can reveal much about composition. For instance, cast shadows and highlights significantly influence the composition of Edward Hopper's *Morning Sun* (Figure 14-9).

COURTESY OHIO MUSEUM OF ART



14-9 Composition *Morning Sun* by Edward Hopper emphasizes the significance of light and shadow as an element of composition.

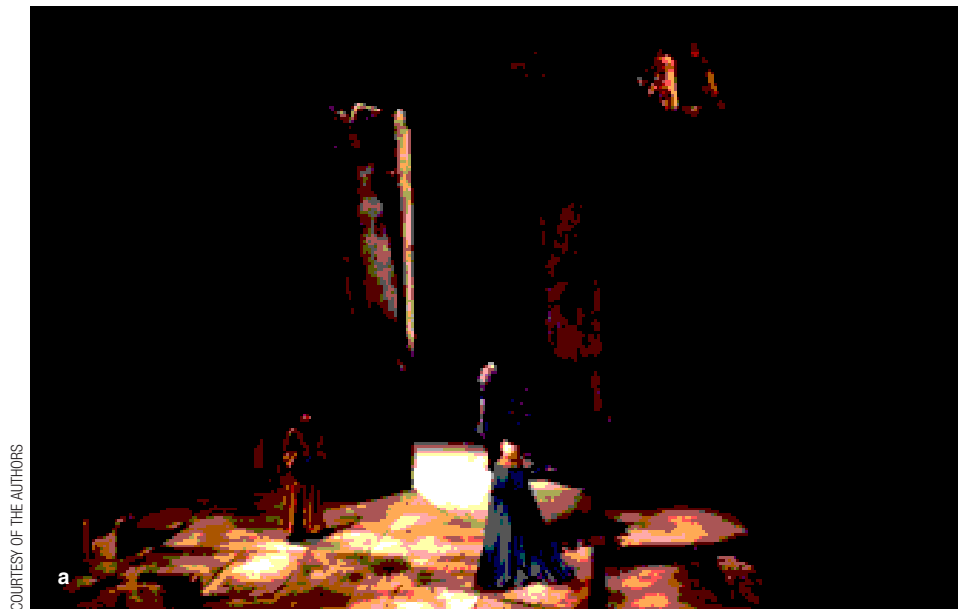
Although light can have composition of its own (projected patterns or light beams in haze), its chief function is to selectively reveal actors and stage forms in the proper relationship to other forms and to the background. Here the complexity of compositional lighting begins. Compositional lighting means lighting one form and not another; controlling shadows, keeping them off the background; lighting three-dimensional forms to make them look three-dimensional (not as easy as it seems); and other similar problems, including the most significant—lighting the actor (Figure 14-10).

Revelation of Form

Figure 14-11 illustrates that a form can be revealed in a variety of ways. The appearance of scenic forms as revealed by light can be varied greatly by the simple movement of several dimmers. However, the three-dimensional form of the actor must be shown in

14-10 Composition Enhanced by Light

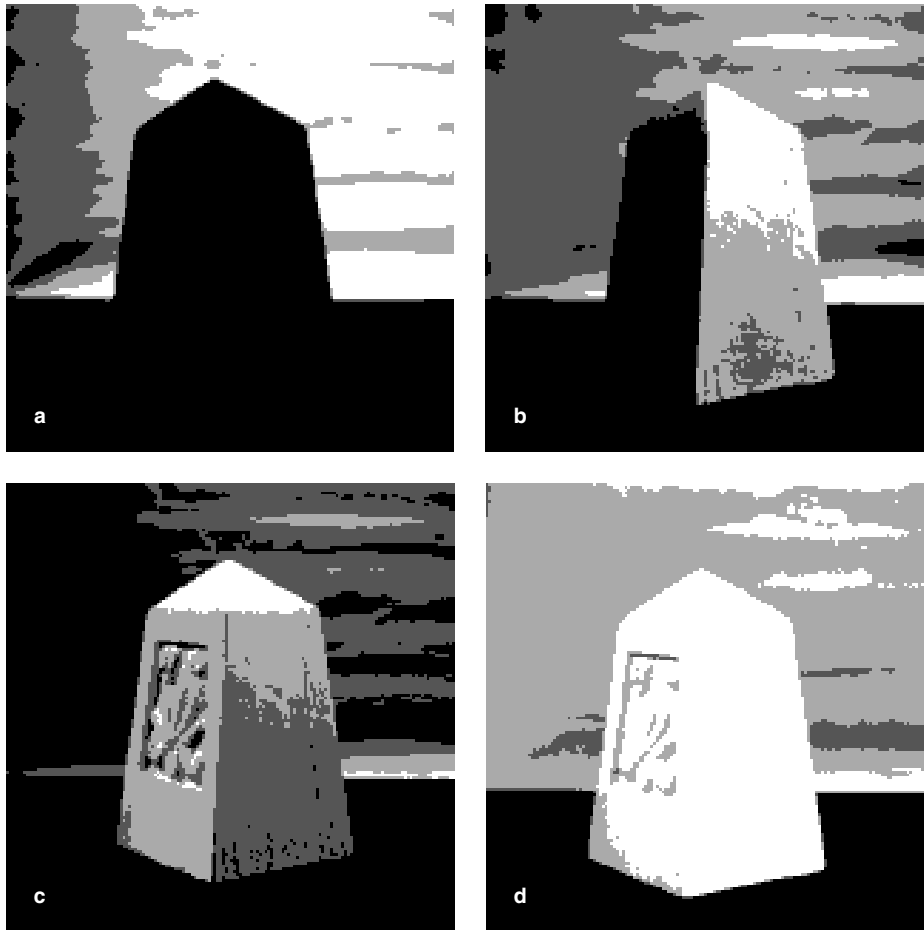
- a** Stage composition is enhanced by the lighting in this production of Shakespeare's *Edward II*. Scenery design by Robert Darling; costumes, Zelma Weisfeld; lighting, R. Craig Wolf.
- b** Both composition and focus are achieved by the lighting in this production photograph from *King Lear* at the Old Globe Theatre. Directed by Adrian Noble; scenery, Ralph Funicello; costumes, Clancy Steer; lighting, Alan Burrett.



COURTESY OF THE AUTHORS



COURTESY RALPH FUNICELLO



14-11 Revelation of Form Here lighting provides stunning effect through four different kinds of visibility.

- a** An object lit from behind is visible in silhouette only.
- b** With front-light added, the object is visible as a three-dimensional form.
- c** With the addition of another direction of light, the object's detail becomes visible.
- d** Detail and form can become less visible with too much light.

a-d COURTESY OF THE AUTHORS

a consistent and predictable manner while moving through space—something best not left to chance. Even in the proscenium theatre, with the audience viewing principally from the front, light is focused on the sides and backs of actors in order to enhance their dimensionality. However, form is often best revealed if the various sources of light playing on it have some degree of contrast—either in intensity or color. Altering form is one of light's greatest powers.

Establishing the Mood

After reading the script, researching, and talking with the collaborative team, the lighting designer begins to get a feeling for the overall mood of the play. A color impression comes from the mood, as does a suggestion of the intensity and the distribution of light. While color often is equated with mood, the other three qualities of light also have great influence. Bright light supports comedy and a happy mood; high angled distribution, creating long shadows and deep eye sockets suggests tragedy; and movement influences the pace of action (Figure 14-12).

Occasionally, a lighting designer allows concern for mood or atmosphere to override all else, sacrificing other functions, including visibility. It should be remembered that mood is only one of five equally important light functions; to slight any one for another must be a conscious decision made by the entire design team and director.

Although an abstract mood or a dramatic mood is more impressive and eye-catching than is the realistic visibility of a conventional interior setting, realism is far more difficult to accomplish with light.

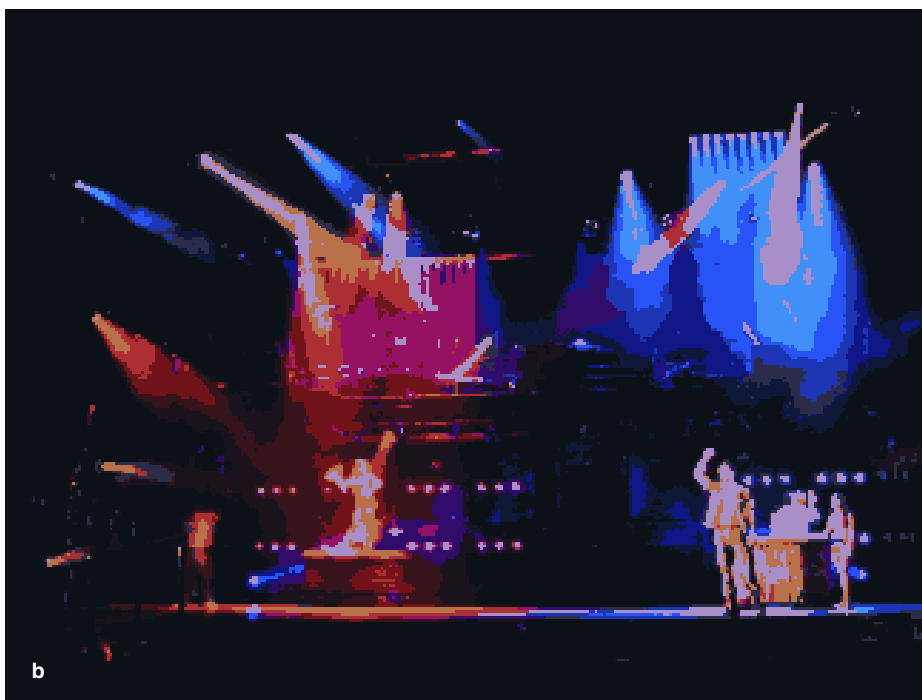
14-12 Mood Created Through Lighting

- a** *Talley's Folly* by Lanford Wilson at Madison Repertory Theatre. Directed by Richard Corley; scenery, Joseph Varga; costumes, Mary Waldhart; lighting, Ann Archbold.
- b** Broadway production of *Movin' Out*. Directed and choreographed by Twyla Tharp; scenery, Santo Loquasto; costumes, Suzy Benzinger; lighting, Donald Holder.

COURTESY ANN ARCHBOLD



PHOTO BY JEANNE KOENIG, COURTESY DONALD HOLDER



Reinforcing the Theme

The lighting of a scene must reinforce, or support, the action. The visual expression of theme depends on the collaborative team's interpretation of the script. To tell the story most effectively, the lighting designer must always keep the playwright's message foremost in mind. As always, lighting the actor is key, but thematic lighting requires a concern with compositional revelation of the thematic forms of the setting as well.

In the more extreme theme-oriented or documentary plays of Bertolt Brecht, the theme is often stressed by showing the play under a clear, uncolored wash of light, thereby eliminating the theatricality of stage lighting. Projections that take the form of propaganda pictures or subtitles reinforce the theme visually.



LIGHTING DESIGN BASICS

Light Functions

- Selective visibility
- Composition
- Revelation of form
- Establishing mood
- Reinforcement of theme

The Design Process

It has been made clear that *all* designers are involved in the creative development of an approach to the production. This collaborative process is the only time when the production team shares ideas. It is the time when the lighting and scenic designers work closely together in order to anticipate any lighting requirements that may affect scenery (attempting to add an onstage follow spot position after the scenery drawings have gone into the shops is terribly expensive if not impossible). It is the time when the style of the production is determined and critical design choices are made. It is the time when all of the designers can discuss color palette and the desired “look” of the show.

The Role of the Lighting Designer

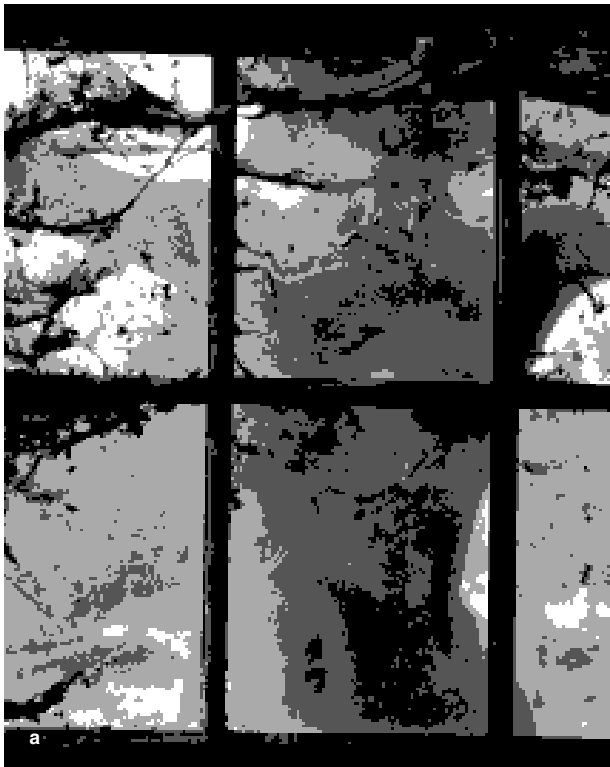
Each designer in the production team functions differently according to the demands of his or her specialty. The scenic and costume designers must begin their work well in advance of the production in order to allow sufficient time to purchase materials and build the show. Lighting, sound, and projection designers have the advantage of more time to assimilate and observe the production process as it unfolds, but they also have the added responsibilities implicit in that knowledge.

Preparation Designers must first and foremost know the script. The number of readings depends on the individual designer as well as the script; however, at least three readings are necessary. In the first, designers simply enjoy the play as a piece of literature, reading it like a novel. This highly significant reading elicits the designer’s initial emotional response to the script. This first response plays an important role in guiding later design decisions. This reading must be completed before the first design meeting. The second reading is used to identify period and locations as well as specific lighting concerns such as time of day, environmental conditions, and effects. These observations should be noted for future reference. This reading often happens after the first design meeting and before the second one. The third reading is done for characterization and thematic elements as well as more specifics concerning possible lighting “looks.”

In reading a script other than an original, note that there is an important distinction between a playwright’s notes and stage directions. Stage directions are usually based on the design of the original production of the play and are often taken from the stage manager’s book. Actual playwright’s notes reflect the viewpoint of the author and should be given utmost consideration.

Solid research is as important to the lighting designer as it is to the rest of the production team. He or she should study the various works of the playwright, as well as critical reviews, in order to discover more about point of view and style of working. The play’s time period and locale must be carefully researched—primarily for atmosphere but also for technical details. Visual research reflecting mood and/or environment should be shared with the director and design team (Figure 14-13). Any music involved in the production should be investigated for style and mood qualities. Knowledge and appreciation of music as well as art of the period will greatly enhance the lighting designer’s creative work. Simply put, good research results in a superior creative product—every time.

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a



b

ERICH LESSING/ART RESOURCE, NY

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d

BPK, BERLIN/JOERG P. ANDERS/ART RESOURCE, NY

14-13 Lighting Research Visual research for the play *Spring Awakening* by Frank Wedekind. Research by Maureen Hanratty.

- a *Nude Behind Cobwebbed Window*—research for overall mood or theme.
- b *Lady Tearing Up a Letter*—research for parents.
- c *The Beeches*—research for idyllic quality.
- d *Abbey in an Oak Forest*—research for Act III.7 Churchyard.

Finally, lighting designers must study the set and costume designs. In particular, they must carefully analyze the scenic ground plan and section, paying particular attention to lighting positions. They must look at masking in relationship to overstage lighting positions and examine the scenery itself for potential lighting positions. Of course, costume and scenery color must also be reviewed.

Rehearsals Attending rehearsals is richly rewarding for the lighting designer and must be taken advantage of if at all possible, for here the true depth and dimensions of a production are discovered through the interaction of the director and actors. To witness the development of characters, designers should attend rehearsals early on as well as later to study timing and movement patterns. Designers should speak with the director beforehand about attending rehearsals, if for no other reason than as a courtesy.

The various reasons for attending rehearsals may seem obvious, but many directors believe that blocking is the lighting designer's only concern. Although blocking and space usage are important, other benefits include increased awareness of the director's intent and how he or she works, deeper understanding of characterization, and a feeling for mood and pace. Planning for compositional lighting is extremely difficult without previous knowledge of blocking; however, every rehearsal need not be a run-through to satisfy other equally important lighting needs.

Preproduction The light plot, which has been developing in the designer's head from the start, is usually drafted one or two weeks before the lighting move-in day (assuming that a large rental is not required). Although every designer has individual ways of working, most create to some degree while they are drafting. If scaled plan and section drawings of the theatre do not already exist (one hopes, as electronic files), they must be copied from some other source. After necessary scenic elements are drawn in, lighting areas can be determined. Next, specific instrumentation and distribution methods are chosen. Finally, color is solidified and control choices are made.

Good and thorough planning is of the utmost importance. Lighting cues are written and conveyed to the stage manager, who will call them during performances. The designer or an assistant is present to answer questions during the hanging of equipment (the "hang"), but crews are supervised by a master electrician who is well-acquainted with the theatre facilities and equipment. A focus session follows the load-in, and, if lucky, the designer and crew will have the theatre to themselves for the several hours required to aim and adjust the beams of light from the various fixtures.

Production Before technical rehearsals begin, the designer should write dimmer readings for each lighting cue. This can be done on paper or, if the control system allows, remotely recorded using an off-line editor. In this way, cues can be entered into the light board well in advance. It is wise to adjust these levels visually during the acting rehearsal prior to technical rehearsals. This procedure allows the technical rehearsal to be just that—a *technical* rehearsal rather than a *lighting* rehearsal. If the designer prefers to build the show visually or if the production is complex enough to require a separate lighting rehearsal, it should be scheduled to take place before the technical rehearsal. During subsequent dress rehearsals, the lighting designer watches from the auditorium and makes level and timing changes, a procedure that may continue through previews.

The Assistant Lighting Designer

As the art of lighting has become more complex, many designers have turned to young people interested in the craft to act as their assistants. Both parties benefit, as novice lighting designers learn by observing the work of those more experienced and established than they.

Although the assistant's duties vary by designer and situation, paperwork is nearly always the responsibility of the assistant. Some designers hire an assistant to draft the light plot, in which case a solid working knowledge of AutoCAD® and/or VectorWorks® is imperative; some place their assistants in charge of paperwork such as shop orders, fixture schedules, focus charts, hookups, and the like, requiring familiarity with software such as Lightwright® and FileMaker Pro®; and some designers expect an assistant to call channels during the focus and take notes during technical rehearsals. VectorWorks® seems to be

the choice among most theatrical lighting designers; however, be aware that several different drafting programs are in use. Prospective assistants need to make sure they know which program is preferred. No matter what their duties, assistants can closely observe the designer's work as well as that of the entire production machine.

Every beginning designer should seek work as an assistant. It is advisable to assist several different designers, in a variety of theatres, in order to meet different people and learn various ways of working. A good assistant is a mostly silent observer who is not afraid to ask questions when necessary. In this way, the assistant learns what to expect and how to be flexible. As an assistant, you should not be intimidated by the designer—he or she will enjoy and appreciate your contribution. The proper way to obtain an assistant position is to submit a résumé to the designer, along with a cover letter indicating your availability.

The Lighting Laboratory

More and more institutions that are genuinely committed to training lighting designers are seeking and finding the space and equipment for lighting labs. The light lab comes in various sizes and forms; many exist in found spaces that have been equipped by students and faculty with a limited budget. The available equipment is often ancient and may be less than useful in an actual production. However, the lab is also the place for experimentation with state-of-the-art instrumentation; many facilities select for purchase one or two new pieces of equipment each year to be used in the lab.

Ideally, the light lab will be on a human scale, with a grid somewhere between 12 and 15 feet high. It should have its own control system and circuitry, although neither need be elaborate. If space is an issue, an intelligent arrangement is to combine the lighting lab with a makeup classroom if the ceiling is high enough. Lab exercises vary from reproduction of light in a painting to demonstrations of color, angle, and quality of light. A variety of laboratory exercises is available in a publication by the United States Institute for Theatre Technology (USITT) titled *Practical Projects for Teaching Lighting Design: A Compendium* (2nd ed.).

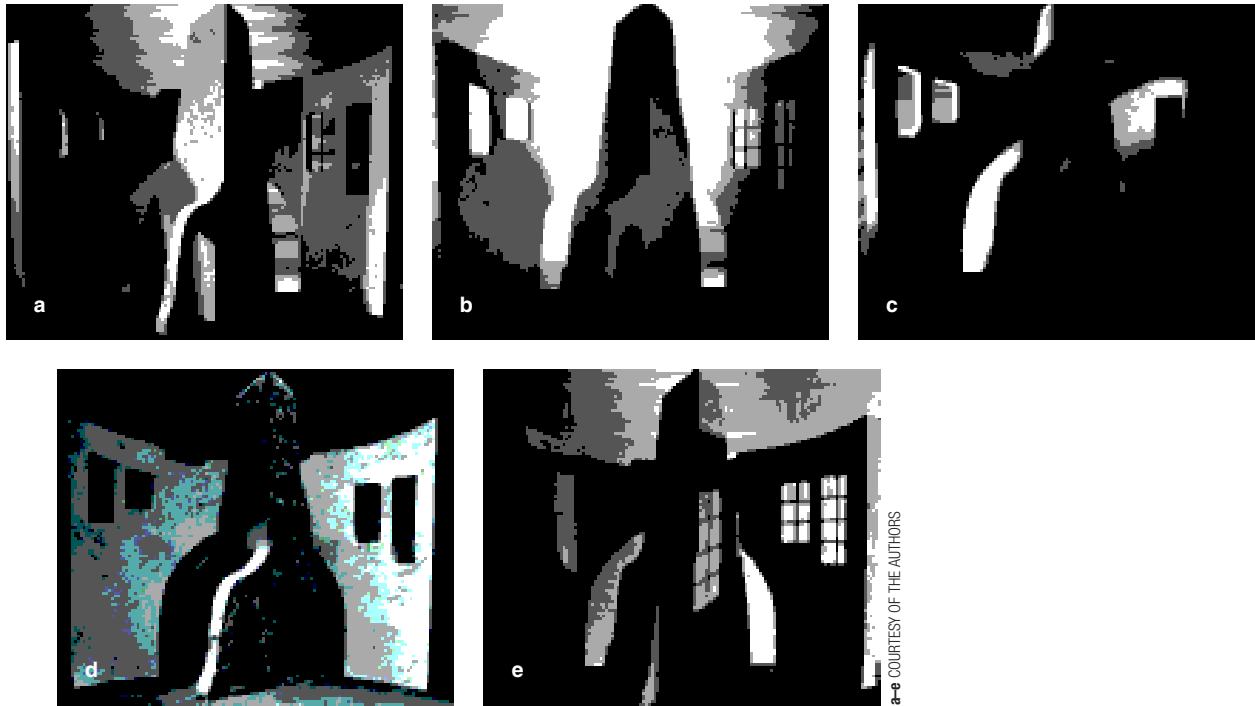
It is an observable fact that today's student learns better in a lighting laboratory than in any other environment. The student is less intimidated by scale and equipment when working in the lab as opposed to the theatre. The hands-on experience of laboratory work accelerates learning and solidifies conceptual material received in the classroom. Further, if students have free access to the lab, they can learn at their own pace.

Figure 14-14 offers an excellent example of the use of a large-scale model for demonstration in the lighting lab. Note the various uses of light angle for texture and composition.

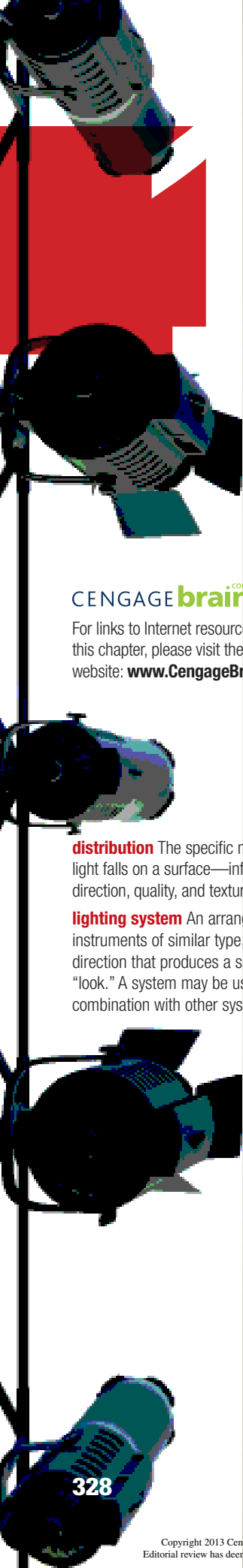
Development of a Lighting Designer

Designing for the theatre requires a great deal from an individual. Designers must have not only artistic talent and technical know-how but also good communication skills. The next few chapters discuss the nuts and bolts of lighting—information necessary for the lighting designer. But always keep in mind the importance of “learning to see”—of establishing a visual memory. Experimentation is essential: lighting instruments should be examined, control systems operated, and colors mixed. The lighting designer can learn only so much from theory and example; he or she must have opportunities to put theory into practice. Because production space is always in great demand, a lighting laboratory becomes a tremendous aid to practical training.

Perhaps most important: always remember, while wandering through the maze of technical information, to pause now and then—and *look*.



14-14 Compositional Lighting in the Lighting Lab With a large-scale model in the lighting lab, the student lighting designer can reconstruct lighting angles and direction for any stage form—proscenium, arena, or thrust—and experiment with compositional properties of light. In this example, the scenic form purposely contains a variety of surfaces. Sweeping curves, sharp corners, openings, and texture lend interest. The photographs show some of the effects.



5 Distribution

CENGAGE **brain**.com

For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

The four properties of light, as mentioned in the previous chapter, are color, distribution, intensity, and movement. **Distribution** refers to where a lighting instrument is placed, what type of fixture it is, and how it is focused. It is one of the most critical and complex choices the lighting designer makes. Distribution determines how the actor is seen and the scenery is revealed. It involves choices of direction, angle, and quality of light. Direction refers to whether the light is coming from the front, the side, or the back. Angle relates to the height of the light source (for example, is the light coming from low on the horizon, or is it high, like noonday sun?). Quality centers on the diffusion and texture of the light (for example, is it harsh or soft, broken up or smooth?).

distribution The specific manner in which light falls on a surface—influenced by the direction, quality, and texture of the light itself.

lighting system An arrangement of lighting instruments of similar type, color, and/or direction that produces a specific lighting “look.” A system may be used alone or in combination with other systems.

Advances in technology have gone hand-in-hand with increased demands on lighting in the theatre. Designers have responded in a variety of ways, but by far the most significant has been in the area of distribution. More equipment is being used to provide greater flexibility regarding angle and direction of light. At one time it was common for designers to have two or three **lighting systems** at their disposal in a given production. Today, a moderately complex show may call for a dozen systems, resulting in greatly improved variety of distribution.

Before the designer can decide where to locate an instrument, he or she must understand the effects of angle and direction on scenery and, more importantly, the actor.

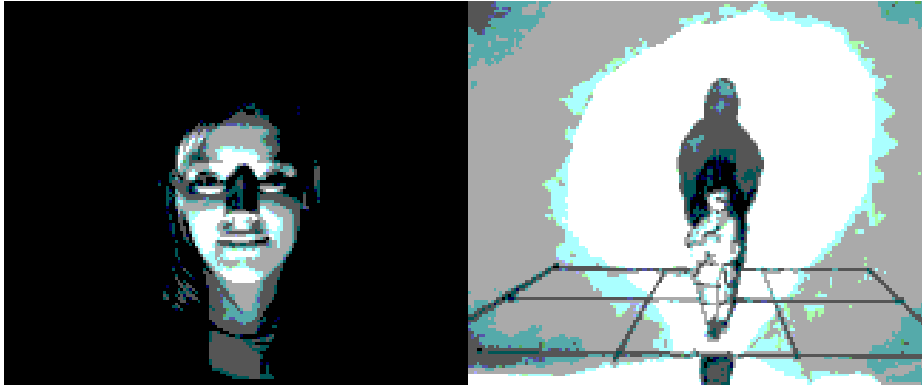
Lighting the Actor

The primary concern of a stage-lighting designer is lighting the actor. The actor must be as easy to see as the moment calls for, be lit in a manner appropriate to the play, and be seen in proper relationship to the background. Distribution is of primary importance because it involves the angle, direction, and quality of light that reveals the actors, especially their faces, in natural form.

Natural Lighting

Under normal circumstances, an actor's face should be lit as it would appear under natural lighting. In imitating nature, theatre uses reality as a basis from which to deviate. Accordingly, the lighting designer must be keenly aware of the various attributes of natural light.

Our eyes have been schooled by a lifetime of seeing people under sunlight or interior light coming from above. We are so accustomed to seeing the features of a face



15-1 Lighting the Actor: Light from Below Upward angle from the footlight position or apron; an unnatural, though dramatic, angle.

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disclosed by light from an overhead direction that to light it from below, for example, produces an unnatural look (Figure 15-1).

Artists and architects have long rendered their drawings as though light were falling on the subject from over the artist's shoulder at an angle of roughly 45 degrees (Figure 15-2). Following the lead of Stanley McCandless, a man who more than any other person might be considered the founder of lighting design in the United States, theatre-lighting designers have adopted this same practice. Light at a 45-degree angle enhances visibility and appears natural. At the same time, this angle of light creates interesting highlights and shadows on the actor's face. Intentional deviation from this angle in order to heighten an effect or create a particular mood is also common design practice in today's theatre.

Highlight and Shadow

The primary way to determine the angle and the direction of a light source is to observe the *highlight* and the *shadow* created. Time of day is related to the position of the sun and subsequently the length of shadows cast by objects such as trees and buildings. The shadow of an object lit at an angle of 45 degrees is the same length as the height of the object.

The shadows in Figure 15-1 are what make the subject look unnatural. Highlight and shadow, which give dimension to a form, are controlled by the angle and direction of the light source. Figure 15-3 further illustrates the relationship of highlight and shadow to perception. We are so accustomed to seeing light from above that changing this angle has the power to alter appearances.

Highlight and shadow offer interest to scenic objects as well as to an actor's face. In addition, highlight and shadow often become important aspects of the stage composition. Shadowless illumination is uninteresting and actually reduces visibility.

Angles and Direction of Light

Angle of light is commonly measured in degrees. The horizon (normally at the height of an actor's head—5 to 6 feet) is considered to be at 0 degrees, and light from directly above is at 90 degrees. *Direction* of light can also be measured in degrees but is most often referred to as front-, side-, or back-lighting. Each direction of light possesses its own

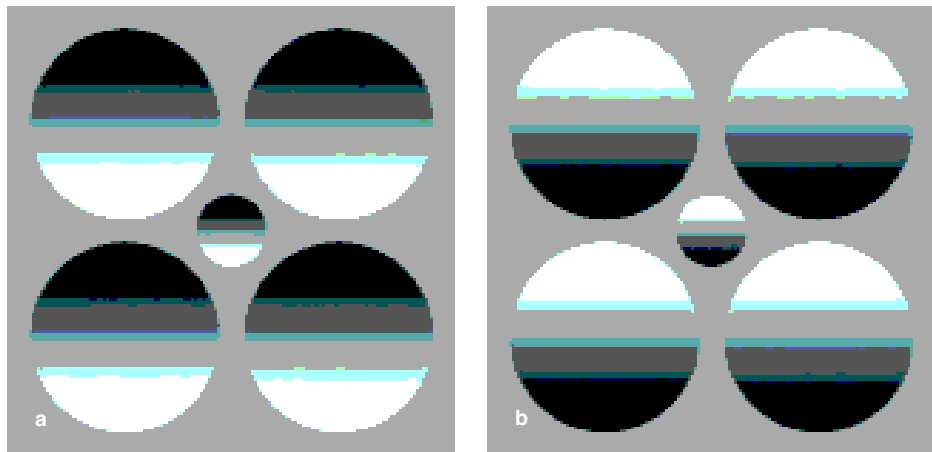


15-2 45-Degree Front-light Portrait artists often paint light as if it is hitting their subject from the front-side at a 45-degree angle, as illustrated in *Portrait of a Young Woman* by Johannes Vermeer.

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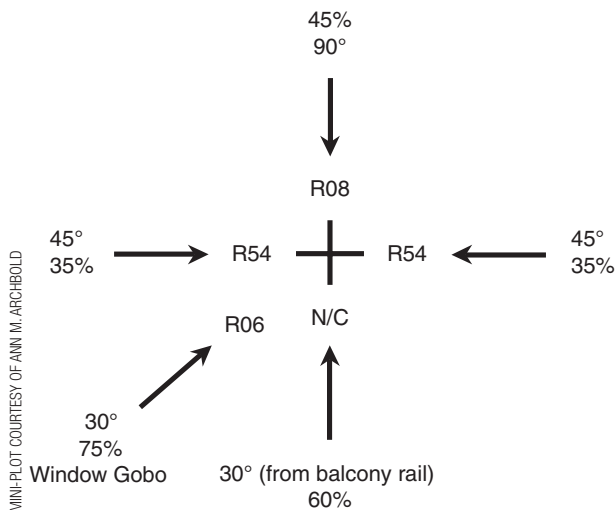
15-3 Perception as Influenced by Lighting Angle An illustration of how we assume the direction of light to be from above. Figures (a) and (b) are identical rectangles, each containing five convex domes.

- a Lighting from below—the domes appear to be concave.
- b Lighting from above—the domes appear convex.



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Lighting Mini-Plot for *Moonlight & Magnolias* “Three Men & A Couch”
Lighting Design by Ann Archbold



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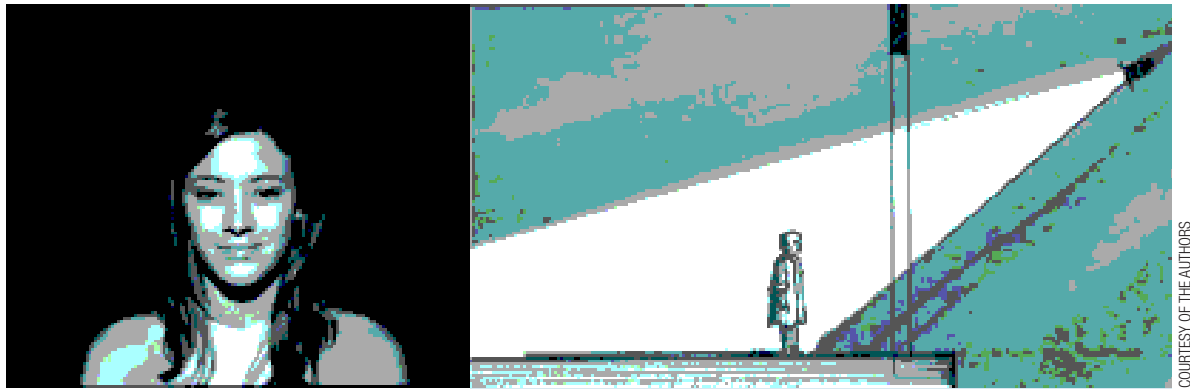
15-4 Mini-Plot The mini-plot illustrates lighting direction, color, angle, and intensity in this production photo from *Moonlight and Magnolias*. Produced by Forward Theatre Company; director, Jen Uphoff Gray; costumes, Gail Brassard; lighting, Ann M. Archbold.

mini-plot A very abbreviated light plot showing one typical lighting area for a given look in the production.

attributes, with visibility being the most important attribute of front-light. The color key or “mini-plot” shown in Figure 15-4 indicates distribution, color, and intensity of the light in the photograph.

Front-Light

There must be front-light for an audience to see an actor well. However, theatrical front-lighting is seldom directly front-on to the performer. Such light, especially if it is low-angled, flattens facial features and lacks interest (Figure 15-5). Moving the light to one side of the performer creates a much more interesting sense of directionality. Shadows are produced, and the actor’s face suddenly has dimension. However, although highly theatrical, a deep shadow on the opposite side of the face reduces visibility (Figure 15-6). A second light from the opposite side is often desirable to fill in this shadow.



15-5 Lighting the Actor: Low-Angle Front Low-angle, straight front-light. Note the lack of definition.



15-6 Lighting the Actor: Stage-Left Front Front-light from stage left only at a 45-degree angle. Note the lack of visibility on the dark side of the face.

45-Degree/45-Degree Front-Light We have come a long way since McCandless espoused his “method” in the 1930s. However, many designers still use his teachings as a basis from which to deviate. McCandless taught that two front-lights were desirable, one with its beam shining from 45 degrees above and to the right of the actor, and the second fixture shining from 45 degrees above and to the left of the actor (a total of 90 degrees horizontal between lights). In addition, placing a warm tint in one light and a cool tint in the other creates contrast and has a pleasing, natural effect. Further varying the color or intensity of these lights increases the sense of directionality. The primary source, or **key-light**, comes from the warmer or more intense light, and the shadow, or **fill-light**, comes from the cooler or dimmer light (Figure 15-7). McCandless felt that this was the most natural way to light an actor with good visibility—and it was.

Jewel Lighting In the early days of Broadway, New York theatres were not equipped to place lighting fixtures at an angle of 45 degrees to the performer. Lights could be hung off a pipe running along the front of the balcony (balcony rail), but the angle was terribly low. Lights could be hung on pipes overstage, but that angle was too steep. So Broadway designers convinced their producers to let them use the closest audience box on both sides of the auditorium as a lighting position, and the **box boom** was born. While these seats offered poor visibility for patrons, the lighting angle to the stage was fairly good. However, the direction was much more side than front.

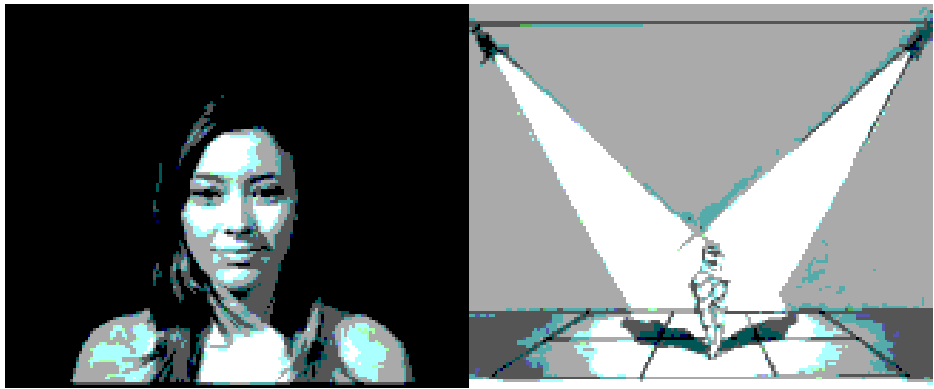
The performers acting downstage are lit with three lights: one from each box boom, creating good highlight and shadow, and one from the balcony rail, filling shadows and

key-light The primary source of light in a composition—normally the brightest. Key-light may imitate a motivational source.

fill-light The secondary source of light in a composition. An important factor in visibility, fill-light is often thought of as bounce light or shadow.

box boom A vertical hanging position for lighting equipment, located in the side walls of the auditorium close to the stage. Named after the placement of light booms in audience side boxes, these positions create a low to medium side angle a bit to the front of the performer.

15-7 Lighting the Actor: Front-Light from Both Sides Front-light from the left and right at a 45-degree angle. The stage-right side of the face has a higher-intensity light, suggesting the direction of the motivating or “key” source.



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jewel lighting An early Broadway technique of lighting involving the use of a low-angled source from the balcony rail in combination with lights from each box boom.

footlight Low-angled light sources often placed at the front edge of the stage apron—at the “feet” of the actors.

making eyes sparkle (hence, the term **jewel lighting**) (Figure 15-8). Although lighting positions have improved, one can still see the roots of this system in the work of today’s Broadway designers.

Front-Lighting from Below In nineteenth-century theatres, lighting positions located along the edge of the stage’s apron were permanent installations. These **footlights** consisted of a row of lights used to wash the scenery with light and color, as well as fill in shadows on the actor’s faces created by harsh, high-angle front-light. When lighting became more sophisticated, footlighting went out of vogue, considered old-fashioned and incapable of producing anything but unsightly shadows. Ironically, today’s designers are again using lighting from the apron position for many of the same reasons that it was originally developed. It can color-tone actors and scenery, it can fill shadows on actors’ faces, and, at a higher intensity, it can be used to create unusual effects. If a source from the footlight position is strong enough, it can create wonderful special effects—much like a spotlight from below. Small MR16 fixtures (often called “birdies”) can be placed in this position for just such an effect (Figure 15-9).

Follow-Spotting Traditional Broadway follow-spotting is done with a high-intensity fixture at a low front angle. The effect is blatant, with the light carrying far upstage. A more subtle approach can be achieved by using follow spots from higher angles (45 to 60 degrees) and at lower intensities.

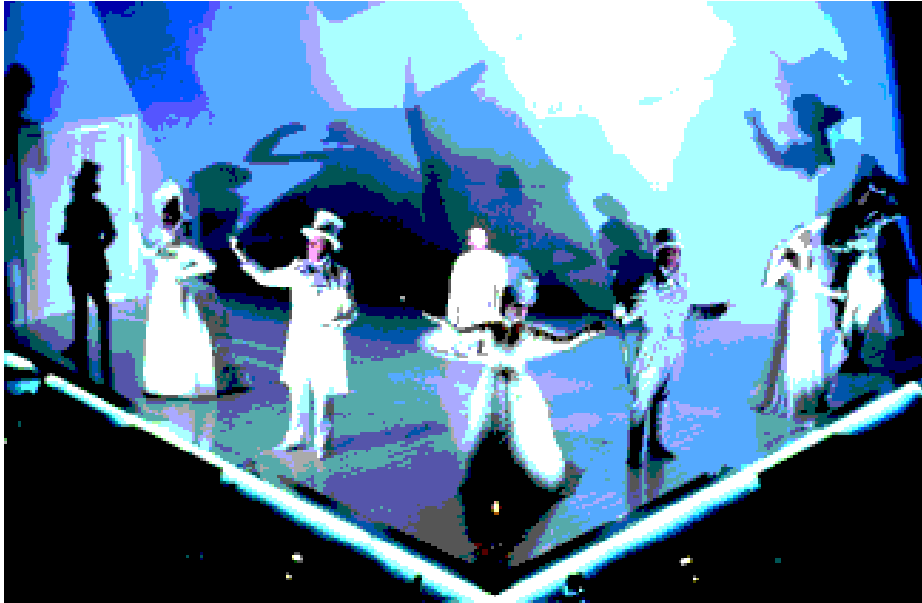
Varying Angle and Direction The most interesting kind of stage lighting employs varied angles and directions of light. The only rule of visibility lighting is that there be at least one source somewhere from the front. It can be filled by a source from the side or by a second front-light. Desired mood and degree of visibility determine angle and direction of the light.

As noted earlier, if a natural effect is desired, a 45-degree angle with a direction somewhat to the side of the performer might be chosen for the key-light. If a harsher

15-8 Jewel Lighting High angle (45- to 60-degree) light from each side (box boom positions) with a low angle front fill (balcony rail) creates “sparkle.”



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15-9 Front-Lighting from Below
“Footlight” from the stage edge creates a dramatic picture in this scene from *The Gambler* at the Milwaukee Repertory Theatre. Lighting, Chris Parry.

effect seems appropriate, the angle might be increased to 60 degrees or the direction moved more to the side. If a softer, less angular feeling is the goal, the angle might be lowered to 30 degrees or the direction changed more to the front.

Back-Light

Light coming from behind an actor creates dimensionality. It also separates performer from background. It can color-tone the stage floor and add contrast to the scene. Compare Figures 15-7 and 15-10; the difference results from back-light.

The use of back-light adds three-dimensionality to scenery and especially actors. In separating actors from their background, it allows the lighting designer to put a brighter light on the background than would otherwise be possible. Additionally, it permits scenic and costume designers to use colors without fear of the actor blending into the background. Because the color of back-light does not affect an actor’s skin tone or costume, stronger colors than those used in front-lighting may be considered. Creative use of back-light color can help to establish an overhead motivational source or simply color and texture the stage floor for a specific mood or effect.

Angle and Direction Just as with front-light, back-light need not be directly behind the performer. Light from the back and to the side strikes more visible surface area and



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15-10 Lighting the Actor: Front- with Back-Light Three directions of light: right and left front-light, each at 45 degrees, and back-light. Note the superior revelation of form.

15-11 Lighting the Actor: Back-Light

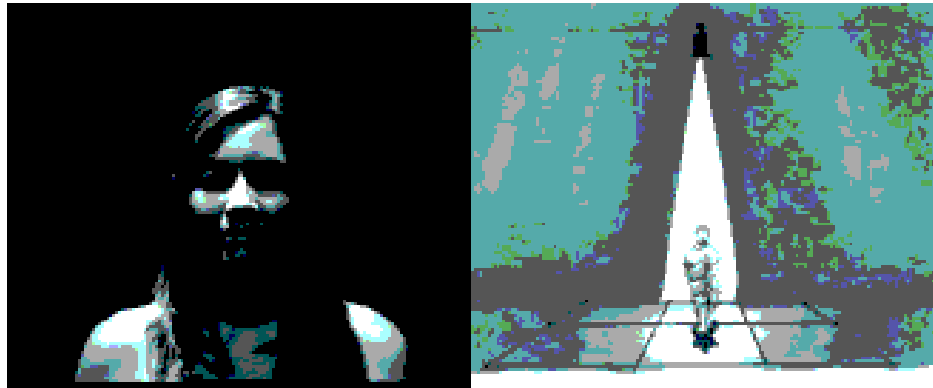
Back-light providing a halo, or “rim,” effect.

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**15-12 Lighting the Actor: Top-Light**

Down-light or top-light at a 90-degree angle (straight-top). Normally not a complimentary angle.

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becomes more apparent. Two back-lights, one from each side, offer a greater degree of visible light and more intensity than does a single light shining directly behind an actor.

The ideal angle for back-light is between 45 and 60 degrees (Figure 15-11). An angle steeper than 60 degrees appears more like top-light (Figure 15-12). In many situations, care must be taken to prevent back-light from shining into the audience. The temptation is to increase the back angle, creating more of a top- or down-light, but the designer must remember that top-light is not at all the same as back-light, for it tends to “squash” rather than “edge” an actor.

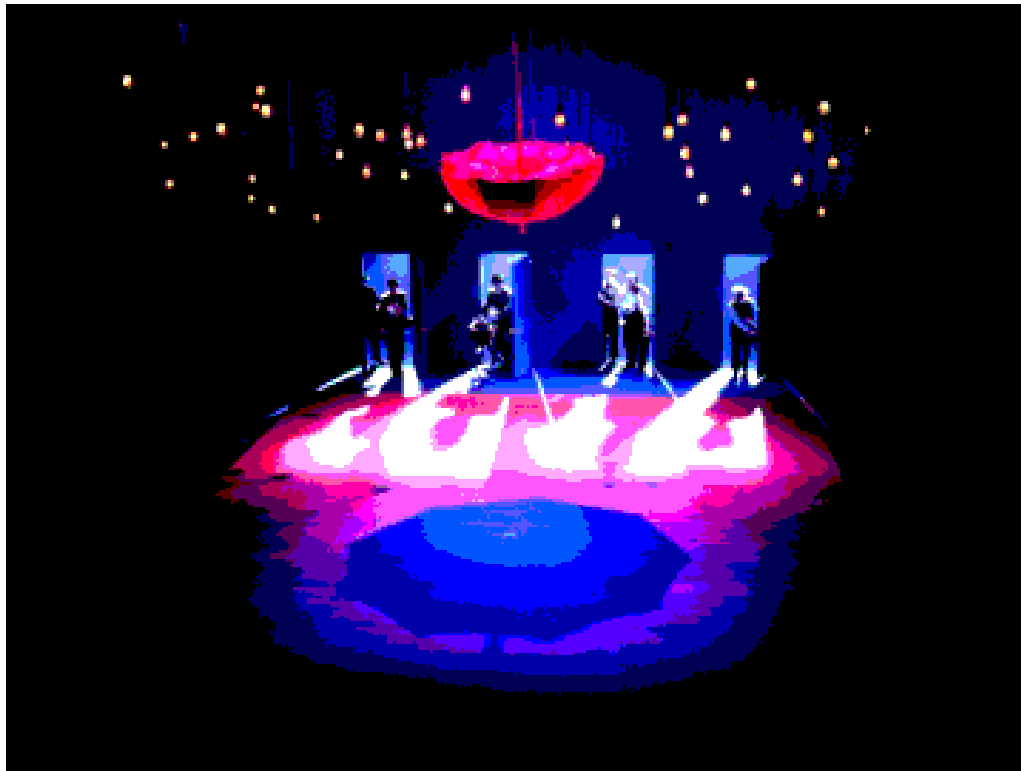
Intensity Because back-light on the actor strikes so little visible surface, its intensity normally needs to be roughly one and a half times that of front-light. If it is too bright, however, a halo effect is created on the head and shoulders of the performer, and the stage floor may glow too brightly. When back-lighting is kept in proper balance with front-lighting, the actor is etched clearly against the background.

Back-light is reflected off the stage floor toward the audience more than light from any other direction. Therefore, it must be realized that the color or texture of back-light will dominate. A lighting designer uses this knowledge to create mood or composition if the stage floor is visible from the majority of the auditorium (Figure 15-13).

Side-Light

The most important attribute of side-light is revelation of form. Side-lighting gives the designer additional flexibility in defining form. Both color and angle add variety as side-lighting is used in combination with front-lighting. Using side-light as a key source is a highly dramatic and effective technique. Like back-light, side-light can be used to establish a motivational source through color, angle, and intensity. The amount of visible surface lit by side-lighting is considerably greater than that lit by back-lighting.

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15-13 Back-Light Creating Composition Composition is created by strong use of back-light and shadow in this production of *A Midsummer Night's Dream* by the Royal Shakespeare Company. Lighting design, Chris Parry.

Low Side Dance lighting designers like to use side-light coming from a low angle to sculpt the figures of the dancers. Such light is hung on floor stands called **booms** located in the **wings**. Low side is angled from 0 degrees (the horizon) to about 30 degrees (Figure 15-14). The best direction for dance side-light is nearly straight to the side, a bit in front of the performer (Figure 15-15).

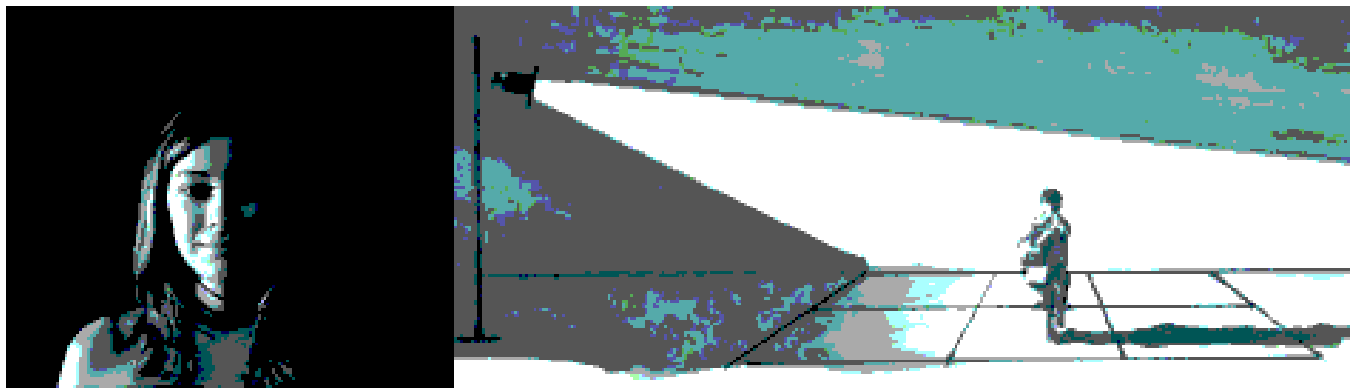
Although low side used in a stage play can create dramatic effects, it must be used with caution. Assuming that an adequate hanging position is available, the designer must be concerned with the light striking scenery in an undesirable manner. In addition, two actors lit with low side-light and standing opposite each other on the same plane will cast shadows on each other's faces.

High Side A more practical angle for dramatic productions, high side is usually angled between 45 and 60 degrees (Figure 15-16). As with back-light, an angle higher than 60 degrees begins to act like top-light, beating down on the performers. High side

booms Vertical hanging positions for lighting instruments. Portable types often consist of 1½-inch black pipe screwed into a heavy base. Also called *lighting trees*.

wings Vertical masking pieces on the sides of a proscenium stage. The name is derived from "wing and border" scenery. Wings also refer to the offstage right and left spaces in the proscenium theatre.

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15-14 Lighting the Actor: Straight Side This angle, accenting the verticality of the actor, is commonly used for dance lighting.

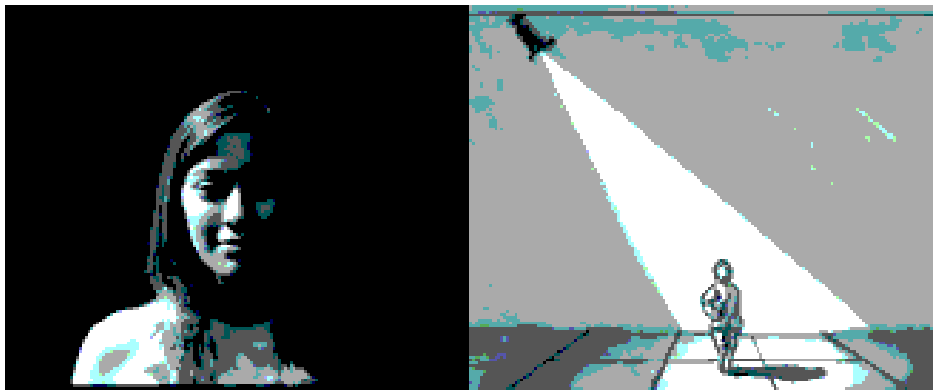
15-15 Dance Side-Light Side lighting in a dance production by San Diego Dance Theatre. *Hunter's Trilogy*, choreographed by Jean Isaacs, Zen paintings and costumes by Rosemary KimBal, lighting by Luke Olson.

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15-16 Lighting the Actor: High-Side A higher side-light (45 to 60 degrees) is normally most practical for theatre production.

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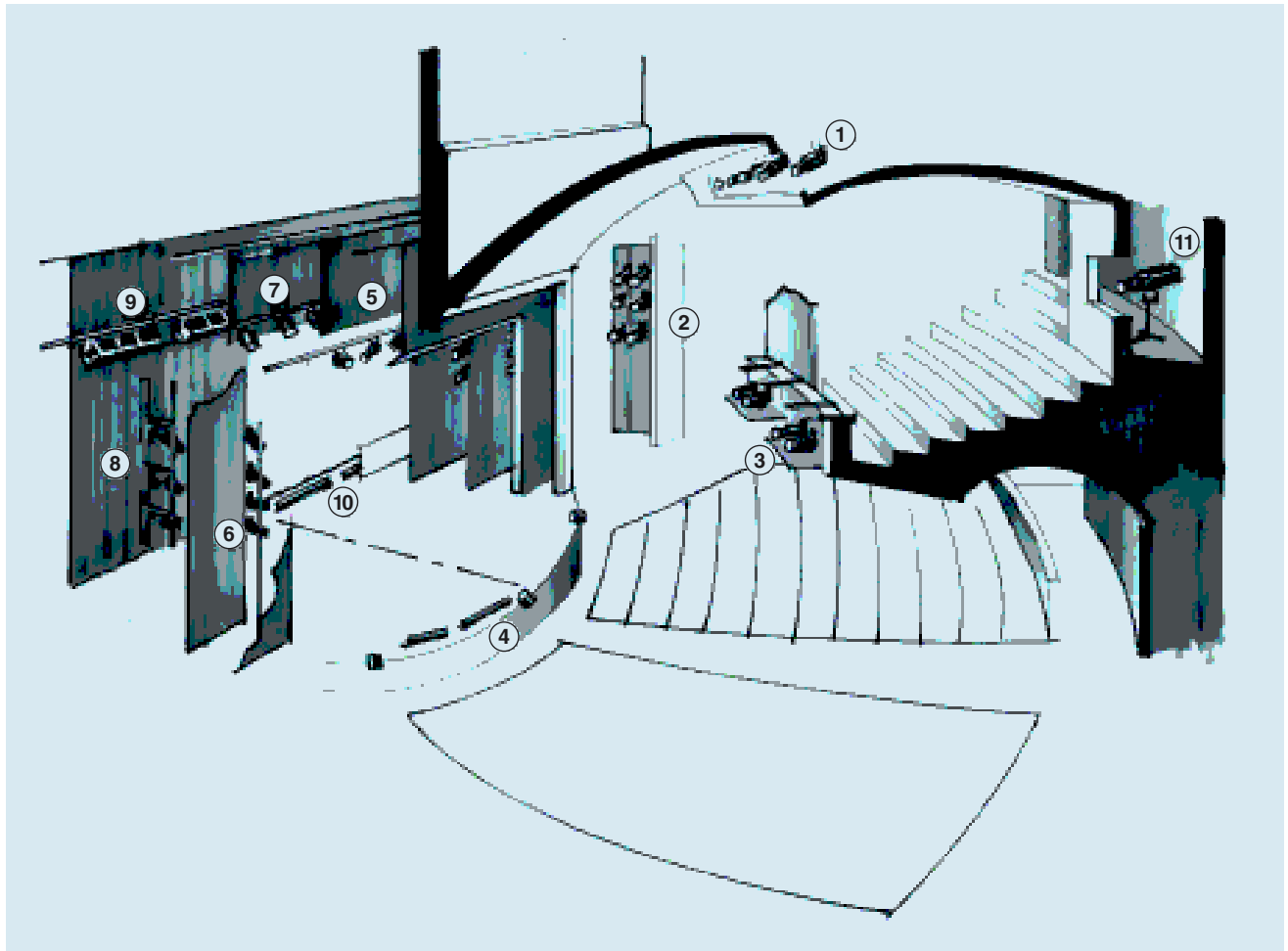
ladders Hanging positions for lighting instruments that derive their name from the fact that, with vertical uprights and horizontal “rungs,” they look like ladders. They may be permanently fixed or, more likely, able to be hung in a variety of positions.

is as common as front-light in today’s theatre. Its effect is *sculptural*, revealing the actors and scenic elements in a sharp, dramatic angle of light. When used with no color or a cool tint, high side is at its harshest; when used with color, it creates a strong directional quality without tampering too much with costume color. It can be hung from the top of booms, from lighting **ladders** located in the wings, or from the ends of overstage pipes. It can face any direction, from front-side to straight-side to back-side, depending on the desired effect.

Lighting Positions

A well-designed theatre offers numerous possibilities for varying the angle and direction of light sources. However, each theatre form has unique lighting requirements that are in part dictated by audience viewing angle.

The Proscenium Theatre The proscenium form situates the audience to see the stage primarily from the front. Figure 15-17 shows various standard positions available in a simplified proscenium house. Those positions on the audience side of the proscenium arch—referred to as “front-of-house” (FOH)—present the designer with a good variety of angles from the front. The overstage positions offer even greater variety, including lights from the side, top, and back as well as the front. Most of these hanging positions are equipped with electrical circuits for conveniently plugging in equipment.



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15-17 Lighting Positions in the Proscenium Theatre

- | | |
|---|---|
| 1 Ceiling beams or ports. | 7 Second electric pipe (midstage back-light position). |
| 2 Box booms or side coves. | 8 Ladder. |
| 3 Balcony front or balcony rail. | 9 Third electric (back-light, backdrop, or cyclorama lighting). |
| 4 Apron or footlights. | 10 Ground row (backdrop or cyclorama lighting). |
| 5 First electric pipe or bridge (upstage front-light position). | 11 Follow spot. |
| 6 Floor stand or boom. | |

Position 1 in Figure 15-17 is the **ceiling beam** or **port**. This is a primary position for front-light visibility. Well-equipped theatres have multiple ceiling positions to allow for a variety of lighting angles. A close position such as the one illustrated might be used to light midstage at about a 45-degree angle. A position farther back in the auditorium would light downstage areas at roughly a 45-degree angle, and a position even farther back would provide low-angle front-light. The first electric (position 5) could light an actor upstage at a 45-degree angle. High-angle follow spots can be used with good results from most ceiling positions.

Position 2 is the **box boom** or **side cove** position. As mentioned earlier, the box boom position offers a good front side-light that can be used in conjunction with front sources. It can also sculpt actors downstage with side-light. The side cove is a vertical hanging position located in the side walls of the auditorium. It provides a more frontal and lower-angle light than the box booms do. A large theatre may have several cove positions in each side wall.

ceiling beam or **port** A slot cut in the auditorium ceiling, providing a position for hanging and focusing front-lights.

side cove A vertical slot cut in the side wall of the auditorium to provide a hanging location for side-front light.

Position 3 is the *balcony rail*. Although a low angle, it can be valuable when used in conjunction with more extreme angles. Projections and color washes work well from this position.

Position 4 is the *footlight* position. As noted earlier, low-angle effect lighting can be done from the footlight position. Color washing from this position is also possible. It offers a unique angle that is sometimes quite useful.

Position 5 is the *first electric pipe*, farthest downstage of the three overstage pipes. As such, it is usually heavily hung with front-lights aimed upstage, back-lights aimed downstage onto the apron, and high sides shooting across the stage. Occasionally, a focusing bridge hangs in this position, making it valuable for high-angle follow-spotting.

Position 6, the *side-lighting boom*, is a floor stand that can go as high as 16 feet. Such a boom provides hanging positions for both low and high side-lights. Lights from booms may be part of a high-side system, combining with lights on the electric pipes to maintain a consistent angle across the stage. The boom position is especially valuable for dance lighting, where low side-lighting booms may be located in each of the side wings.

Position 7 is the *second electric pipe*. It provides a good back-light angle to downstage areas as well as a location for midstage high side-lights. Top-light may also be hung in this position.

Position 8 is a *ladder* located in the wing. This is usually hung from the end of an overstage pipe, but it may also be suspended from the grid. Ladders are used for high side-light and have an advantage over booms in that they do not take up valuable floor space. A ladder can also **trim** higher than a boom reaches.

trim To hang pipes or scenery above the stage floor.

Position 9 is the *third electric pipe*, located the farthest upstage of the three overstage pipes. One pipe in this position is used for upstage back-lighting and a second to light the cyclorama or backdrop. Three electric pipes are a minimum, with larger theatres having as many as seven or eight.

Position 10 is called the **ground row**. It is used to light the cyclorama or backdrop from the bottom. Sunsets and special sky effects are created from this position.

ground row A row of striplights located upstage and used to illuminate the background from the bottom. A *scenery ground row* is a horizontal masking device used to hide the lighting ground row.

Position 11 returns front-of-house to the traditional *follow-spot* position. This position provides the low-angle light that is the trademark of traditional musical theatre. If subtlety is desired, a higher angle should be chosen.

The Thrust Stage The thrust form provides audience viewing from three sides. It also typically has a steep audience rake. Lighting angles are normally higher than in other theatre forms because of the audience orientation. Angles closer to 60 degrees, rather than 45 degrees, allow the designer to keep light from spilling into the audience, while still providing visibility. As mentioned earlier, flexibility of lighting positions is imperative in the thrust theatre.

Black Box and Arena Stages Lighting angles for these theatre spaces normally need to be lower than those in the thrust. The audience is seated close to and on all sides of the performers. If lighting angles are too steep, visibility is impaired. As in the thrust, concern for keeping light off the audience is important. Again, owing to the necessity of lighting from all directions, flexibility of hanging positions is critical to good arena lighting.

Distribution and Design

Over the years, designers have demanded an ever greater number of lighting instruments for their productions. The total number of units in a light plot has doubled and tripled. The principal motive behind this increase has been the desire for a greater

variety of angles and directions of light. The use of automated fixtures in the theatre has further increased the possibilities of variable lighting angles and directions.

Angle and Direction As we have seen, angle and direction are primary indicators of a motivated light source. In addition, variation in angle and direction is critical to changing mood in a production as well as maintaining visual interest. A good way for a lighting designer to work is to first consider each lighting look as its own entity. In this way, compromises of angle and direction are not made too early in the design process. When creating the final design, the designer simplifies and combines looks into a finished light plot.

6

Color and Light

Color, one of the four primary tools of theatre lighting, is a powerful force in stage composition. It can be subtle or dramatic, decorative or atmospheric, symbolic or realistic. Color in light animates the scene. The energy of light reveals, brightens, and adds color to actors and scenery, thereby increasing their vitality. The history of the use of color in the theatre goes back well before electric light and plastic color filters. Designers have always known that colored light conveys a sense of mood or atmosphere in a way unlike that of any other medium.

Of the design elements, color often seems to be the most complex; costume, scene, and lighting designers must pay attention to color in dye and pigment as well as in light because they always interact. Although mastering the subject of color usage takes time and experience, the beginning lighting designer will benefit from understanding basic principles of color physics, physiology, and psychology:

- An object has a particular color of its own—its surface color.
- Light is always colored—even if its color is white.
- The color of light affects the color of objects.
- Certain perceptual factors influence how we see color.

Color Is Light

Color would not exist without light. As anyone who has used a prism knows, white light is actually made up of a variety of colors or hues. If we perceive a light as white, the receptors in our eyes are actually receiving a mixture of colors that our brain interprets as white. The color receptors in our eyes are most sensitive to three color wavelengths: red, green, and blue (RGB). The combination of these **primary hues** creates white light. Note that the primaries of light (red, green, and blue) are different from those of pigment (red, blue, and yellow).

The Visible Spectrum

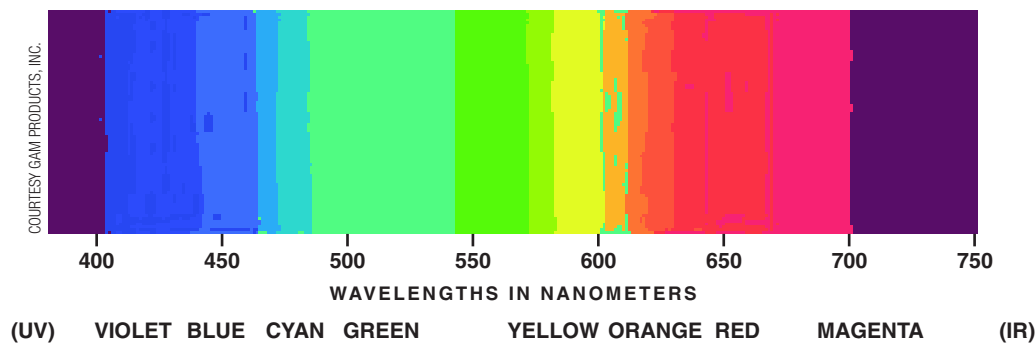
The visible wavelengths of the electromagnetic spectrum provide color and light (Figure 16-1). Every color has a different spectral wavelength. These wavelengths are measured in **nanometers**, with 1 nanometer equal to one-billionth of a meter. The visible portion of the spectrum is a minute section with wavelengths of roughly 400 to 750 nanometers. The shortest wavelengths in the visible spectrum, 390 to 430 nanometers, produce what we call violet light. The next length is blue, followed

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primary hue One of three hues that are used to mix all other hues; in pigment, the primary hues are red, yellow, and blue; in light, they are red, green, and blue.

nanometer A measurement in billionths of a meter used to define certain wavelengths (colors) of light.



16-1 The Color Spectrum
Visible wavelengths are between 390 and 750 nanometers (billionths of a meter) in length. Ultraviolet (UV) light is at the short end and infrared (IR) at the long end.

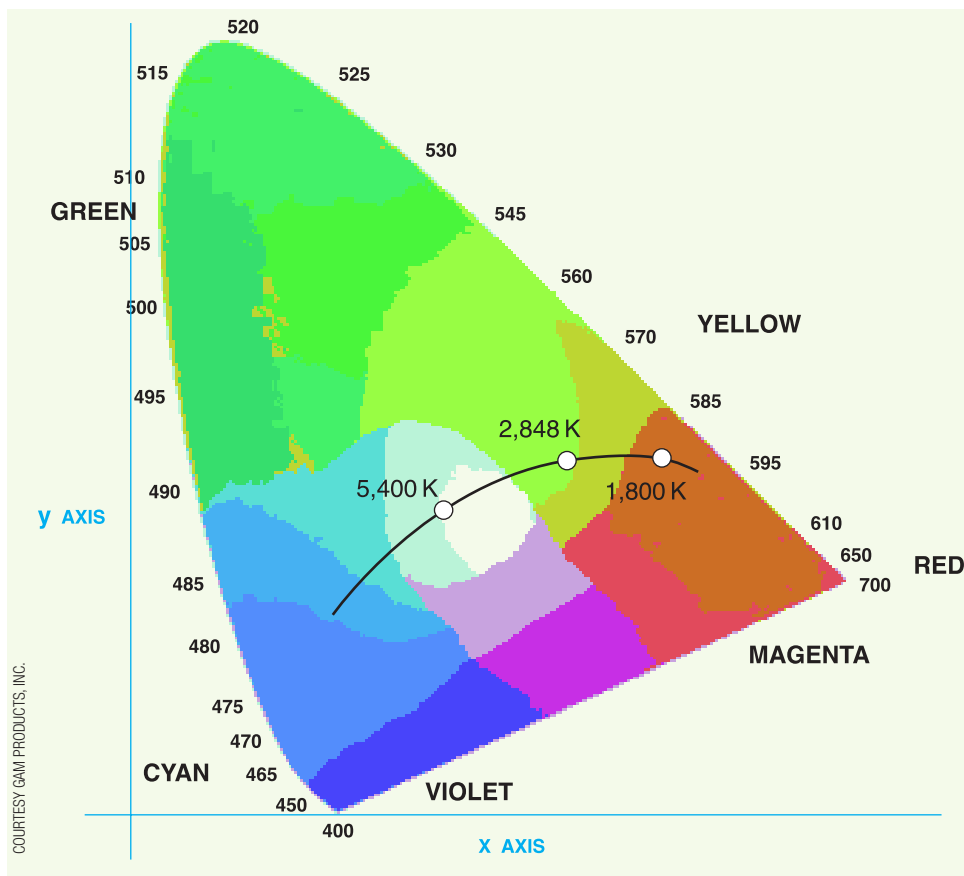
by green, yellow, orange, red, and finally magenta light (at 720 to 750 nanometers). The wavelengths shorter than 390 nanometers are called **ultraviolet** (beyond violet), and those longer than 750 nanometers are **infrared** (below red).

ultraviolet Light energy with wavelengths just shorter than the shortest visible wavelengths (violet)—literally “beyond violet.”

infrared Light energy with wavelengths just longer than the longest visible wavelengths (red)—literally “below red.”

CIE Chromaticity Chart

The color chart shown in Figure 16-2 was developed by The International Commission on Illumination (CIE) to indicate visually the relationship of any color with another. It shows color mixing quite clearly—specifically, how various colors are derived from the mixing of the three primaries. Saturated colors are located at the perimeter of the chart and become less saturated as they mix, moving toward the white center. The curved black line (called the *black body locus*) indicates the exact color emitted by a light source at any given color temperature.



16-2 CIE Chromaticity Chart A commonly used color chart developed by the International Commission on Illumination. The black line indicates colors emitted by an incandescent light source at various Kelvin temperatures.

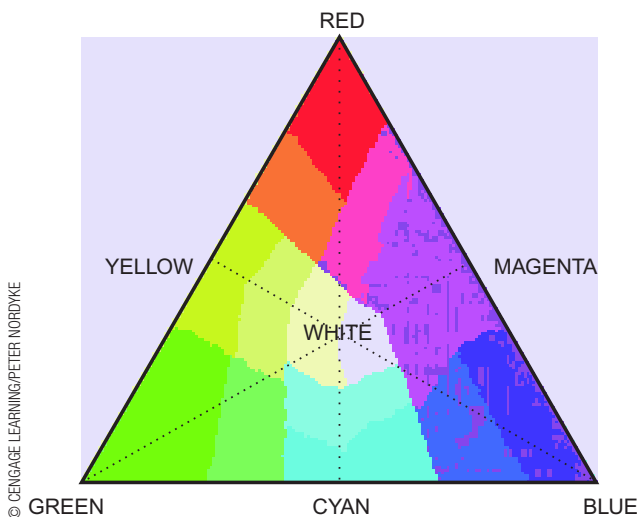
The Language of Color

In describing a color, lighting designers need to use a common language that will be understood by other designers and coworkers. The three variants of color in pigments and dyes are hue, chroma, and value (discussed in Chapter 8). The lighting designer begins with these variants as a basis of color terminology. In light, color can be described in simple terms by referring to its hue or its dominant wavelength (blue, yellow, and so on) and its chroma or saturation (purity).

Hue or Dominant Wavelength The position of a color in the spectrum determines its hue. Recall that hue is what allows us to differentiate one color from another or from a gray of the same value (brightness). Eight easily identified hues are magenta, red, orange, yellow, green, cyan, blue, and violet. As mentioned earlier, our eyes respond most strongly to the three primary hues: red, green, and blue. The lighting designer often finds it useful to think of any hue as a mixture of these three primary colors in light.

Chroma or Saturation In the context of lighting, the term *saturation* is preferred to that of *chroma*. *Saturation* refers to the amount of pure spectral hue present in a color. Primary blue, for example, is a highly saturated color. LEE Filters No. 075, evening blue, is more saturated than LEE No. 063, pale blue. When the purity of a spectral hue is modified by mixing, the result is a difference in saturation. Colors low in saturation, referred to as **tints**, are created by adding white to the spectral hue.

tint Lighter value of a hue.



Color Interaction

Color in light and pigment can be varied by mixing. When two lights of different colors strike a white surface, the result is an admixture of those colors. If the surface itself is colored, mixing still takes place, but the surface color interacts with the light to produce a particular reflected color. This is called *color modification*.

The Color Triangle

A good way to illustrate color mixing is by using a color triangle such as Figure 16-3. Each of the three primary colors is located at one of the points of the triangle. The center of the triangle represents the mixture of all three primaries to create white light.

16-3 The Color Triangle The color triangle illustrates how the three primary colors (RGB) mix to secondary colors (CYM) and to white.

secondary hue One of three hues produced by mixing any two primaries; The three secondaries are cyan, yellow, and magenta (CYM).

complementary hue One of two hues directly opposite each other on the color triangle.

Secondary Hues If any two of the primary colors are mixed along the edge of the triangle, a **secondary hue** is the result. Mixing primary green and primary blue results in cyan. Mixing primary red and primary green results in yellow. Mixing primary red and primary blue results in magenta. Like the primaries, these three secondary hues (CYM), if mixed together, create white light.

Complementary Hues Directly across the triangle from any color is that color's **complement**. Magenta is the complement of green; cyan is the complement of red; and yellow is the complement of blue. As the triangle indicates, mixing a color with its complement results in white light.

Color Mixing

Mixing colored light is common practice in the theatre. Overlapping beams of light combine in a variety of ways, filling each other's shadows with rich and vibrant colors that enliven a scene. By thinking in terms of the primary colors and keeping the color triangle in mind, designers can easily predict the results of mixing (Figure 16-4).

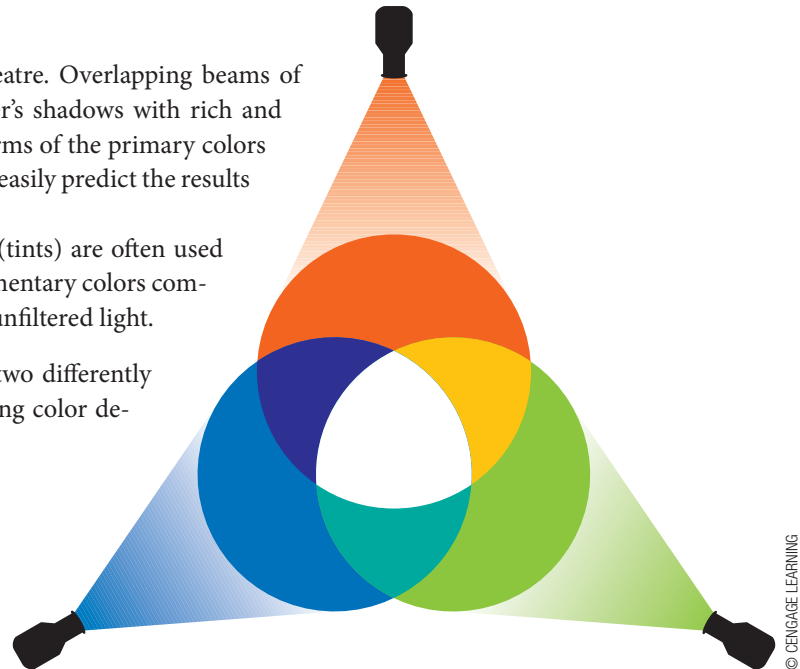
Primary and secondary colors in lighter values (tints) are often used to front-light the actor. When mixed, tints of complementary colors combine to create a white light that is more vibrant than unfiltered light.

Mixing on a Surface Mixing occurs any time two differently colored lights are used on the same area. The resulting color depends on several things:

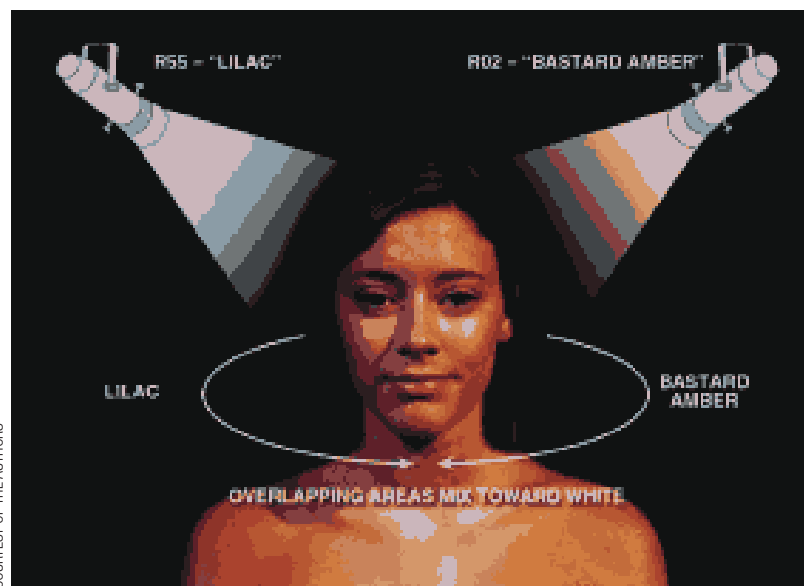
- Colors of the light sources
- Direction of the light sources
- Contour of the surface being lit
- Natural color of the surface being lit

If two light sources strike a surface from different directions, and if the surface is three-dimensional and sculpted (an actor's face, for example), several things happen. First of all, one source will cast shadows that are filled or partially filled by the other source's light and color. Second, an overall even color mix will not be achieved because the sources are coming from different directions. What will be seen instead is a heavy coloration from one source that merges gradually to an even mix with the second color and finally moves into the color of the second source. Such coloration adds three-dimensionality to a figure onstage and can help establish a direction of light (Figure 16-5).

Mixing in the Air Another form of color mixing involves placing two or more light sources very close to one another, effectively acting as a single source. Common



16-4 Color Mixing When the three primary colors of light are mixed, white light is the result. Any two primaries mix to form secondary colors.

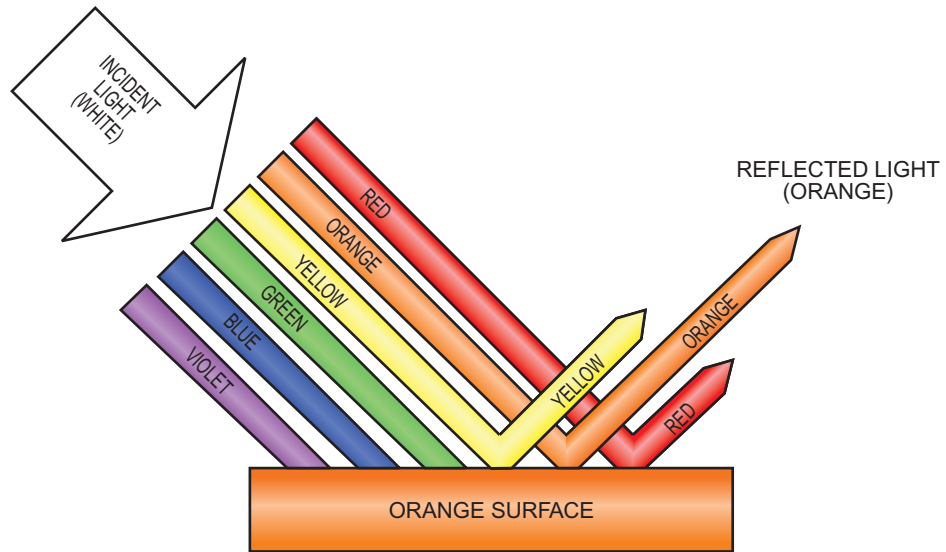


16-5 Color Mixing on the Actor Two complementary colors striking a three-dimensional object (such as an actor's face) from different directions will gradually mix toward white.

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16-6 Selective Color Reflection The horizontal orange strip represents an orange-colored surface (a costume, for instance). It appears orange under white light because only the red, yellow, and orange hues of the spectrum are reflected. The other hues are absorbed by the surface.



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examples of such mixing in the theatre are the use of striplights or cyc lights on a backdrop or color-mixing LED fixtures. Designers can also employ this technique for lighting the actor by using spotlights placed very close to one another (double- or triple-hanging). This provides a large range of color options through mixing while using only two or three lighting fixtures.

Color Reflection

We see the color of a surface by means of *reflection*. Specifically, a colored surface lit by white light reflects its own color while absorbing all others (Figure 16-6). So, a colored surface acts somewhat like a color filter except that it selectively reflects color rather than allowing it to pass through. For example, if an actor wearing a blue costume is lit by unfiltered white light, the costume absorbs most of the red and green wavelengths while reflecting primarily the blue. This is why it is cooler to wear white clothing than black; black absorbs all color, turning the light energy into heat.

color modification The alteration of a surface's color by colored light.

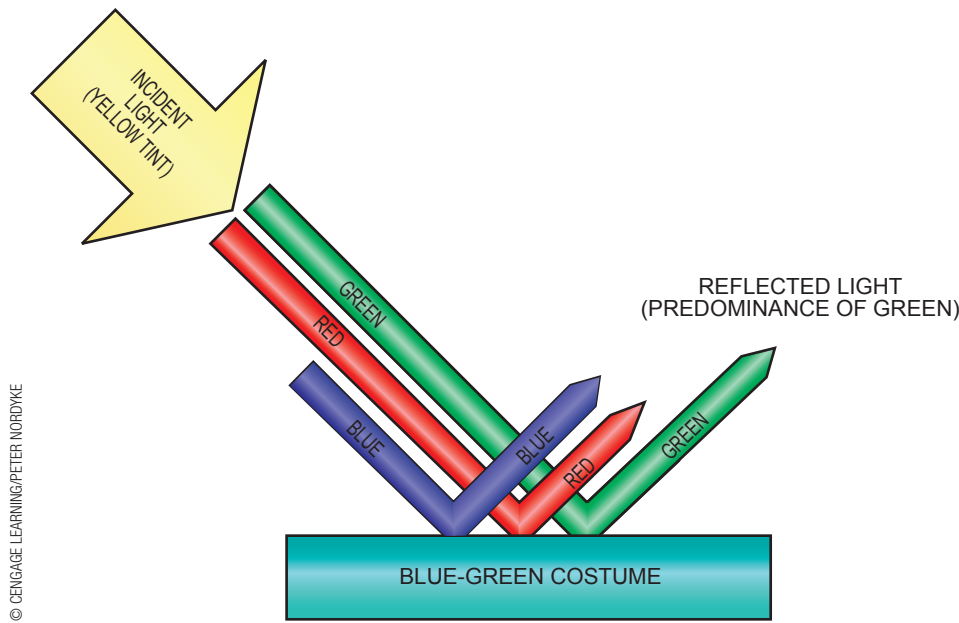
When colored light strikes a differently colored surface, **color modification** takes place. This means that the surface color of the object being lit is altered to some degree. Ideally, lighting designers use color modification to their advantage. For instance, it is common practice to use certain warm tints that are complementary to skin tones to make an actor's face appear pink and healthy.

Using the example of a blue costume again, picture what happens when it is lit with yellow or amber light. If the fabric is any hue other than primary blue, it contains some amount of red or green or both. Let us assume that the blue is actually a cool blue, containing more green than red. Yellow light is made up of red and green. Therefore, under yellow light, the cool blue costume will appear greener than it would under white light (Figure 16-7).

Color modification of scenery or costumes can present a problem, or it can be used to the designer's benefit. It is simply a matter of knowing how colored light will react on a colored surface. Once again, thinking in terms of the primaries is beneficial.

Color Perception

Knowledge of *how* we see color is perhaps of greater interest to the lighting designer than to other designers in the theatre. Understanding the physiology of the eye as it relates to color vision gives the designer some indication of how an audience may react to both intensity and color.



16-7 Surface Color Modification The horizontal strip represents a blue-green costume. Yellow light (made up of red and green) shining on the costume makes it appear more green than it would under white light.

Color Physiology

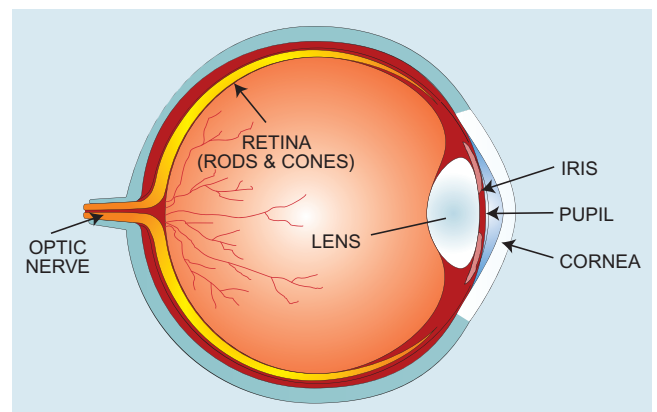
The lens of the eye is capable of focusing on objects between distances of approximately 8 inches and infinity by changing the curvature of its surface—in effect, changing its own focal length. The iris contains the pupil, located just in front of the lens, which opens or closes to allow more or less light into the eye (Figure 16-8). As a protective device, it can close quite a bit faster than it opens.

Two types of nerve endings located in the retinal area of the eye detect light intensity and color, respectively: the rods and the cones (Figure 16-8). **Rods** are sensitive only to intensity or brightness. The color-sensitive **cones** are of three types: the first is most sensitive to colored light in the red range; the second to blue; and the third to green. Rods and cones send an electrochemical signal to the brain that varies in frequency with the intensity and color of the light. The brain then *interprets* the signal. This interpretation is affected by many factors including viewer expectation and need.

Intensity and Color The eye’s sensitivity to high or low levels of illumination affects the color we see. The rods of the retina, which produce most low-intensity or night vision, are most sensitive to wavelengths in the green-blue range. This sensitivity adds a greenish-blue cast to all hues seen under low levels of illumination. Moonlight appears to have a blue tint, even though it is the reflection of the sun, greatly reduced in intensity. For this reason, theatrical tradition calls for indicating nighttime with a blue tint of light (Figure 16-9).

Color-receptive cones function best under moderate to high levels of illumination. This accounts for our reduced color vision at night. At high levels of illumination, the cones are more sensitive to red and green wavelengths of light. The sun at noon, although a brilliant white, appears to have a yellowish tint (a combination of red and green). The stage convention that sunlight is yellow is based on this audience expectation.

rods Light receptors located in the retina that are sensitive to intensity.
cones Light receptors located in the retina that are sensitive to color.



16-8 The Eye The rods located in the retina are sensitive to brightness. The cones are most sensitive to the primary colors in light (red, green, and blue).

16-9 Blue and Night A fine example of the use of color to create a feeling of night is seen in this photograph from a production of *A Streetcar Named Desire* at San Francisco's American Conservatory Theatre. Directed by Richard Seyd; scenery, John Iacovelli; costumes, Anne Bruce; lighting, York Kennedy.



PHOTO BY KEN FRIEDMAN, COURTESY YORK KENNEDY

Retinal Fatigue

The retina of the eye receives and assimilates light energy. Like a microphone, it is a transducer in that it changes energy from one form to another. When it becomes saturated, the effect is twofold: (1) color impressions become weaker (less saturated); and (2) intensity appears to be lower. Regeneration takes place over a noticeable period. Intensity-sensitive rods take roughly one and a half minutes to return to normal. The color-sensitive cones may take as long as five minutes to regenerate.

Intensity Fatigue Visual fatigue becomes a factor when stage pictures remain static for long stretches of time. For example, if a scene offers little physical action or visual contrast for 10 minutes, fatigue may cause viewer discomfort. Seeing well becomes difficult. Light levels appear to be low. The lighting designer may be required to slowly boost intensity levels in order to achieve visual parity with the earlier scene.

Color Fatigue The classic example of color fatigue as it occurs in the theatre is the annoying predominance of yellow light in a day scene that has immediately followed a night scene. The night scene, lit with an abundance of blue light, causes the retina's blue receptors to fatigue. The "white" day scene then appears too yellow, because the red and the green cones are much more responsive than the blue ones are. Color contrast in the blue scene can help to reduce the effects of retinal fatigue. Likewise, shifting the color of the daylight toward blue can cause that scene to look more natural.

Interaction of Colors

How we perceive a color in relationship to an adjacent hue or to its background is known as **color interaction**. A working knowledge of color interaction is a basic element of color selection. Knowing how to use contrasting colors in particular is a valuable tool for the lighting designer. For example, hue opposites such as blue-green and red-orange seem to vibrate when right next to each other, creating a sense of tension. Such colors might be considered when a strong separation between actor and background is desired.

color interaction How the perception of a color is influenced by the presence of another color.

Because of differences in wavelength, certain colors appear to recede whereas others come forward. When viewed next to each other, cool colors such as blue and green seem to be more distant than warmer colors such as red and yellow. A designer may choose to create an artificial sense of depth by subtly layering colors from warm to cool.

Color Psychology

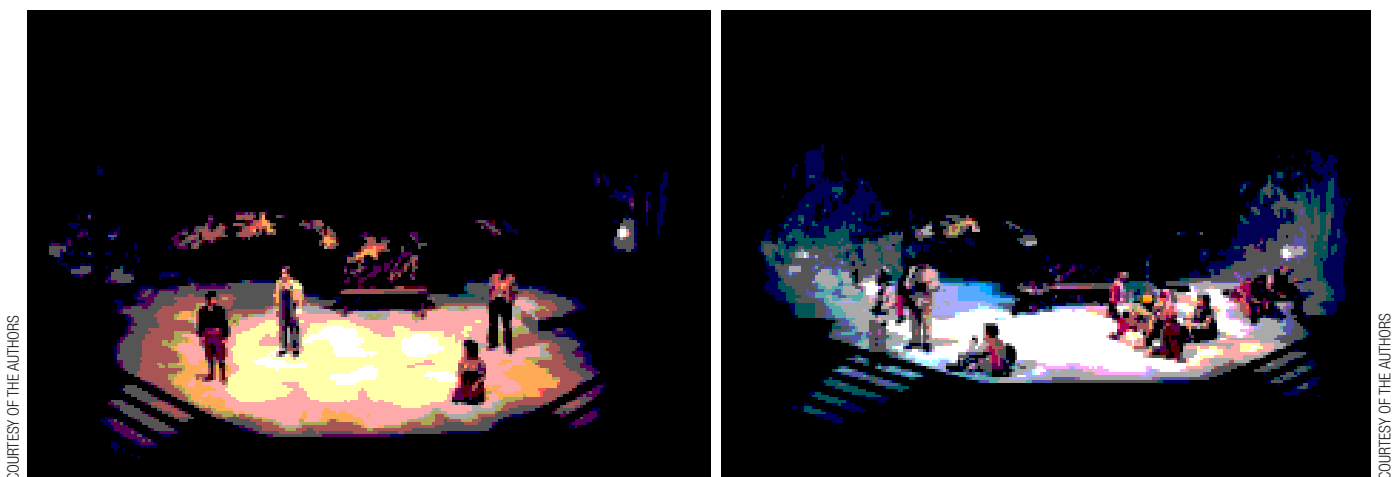
Typical Associations Most people view the color red to represent violence, anger, and perhaps war. Amber is likely to be perceived as sunlight, warm and comfortable. Blue signifies restraint and coolness, whereas green may be seen as restful. When selecting stage colors, designers take these and similar audience associations into consideration. However, placing too much emphasis on the psychological effects of color is a mistake. Cultural differences as well as the personal nature of color perception cause color symbolism to be fraught with conflicting theories.

Warm and Cool Colors There is one psychological effect, however, that should not be ignored: the relative warmth and coolness of colors. Few people would deny that bright red-orange suggests warmth; most would agree that brittle blue-white gives an impression of coolness. Figure 16-10 is a good example of the warmth and coolness of colors used in a literal manner to convey temperature. Color warmth and coolness used in a more abstract manner can also have a strong effect on the mood of a scene.

Given samples of twenty different tints and shades, two people rarely will list them in exactly the same order from warm to cool. But in general, the reds, oranges, and ambers are considered in the warm group, whereas the cool group consists of blues, violets, and greens. Some mixtures of hues from the opposing groups seem to be on the borderline. The particular effect they give at any moment depends on which color is viewed in relationship to them (color interaction and contrast).

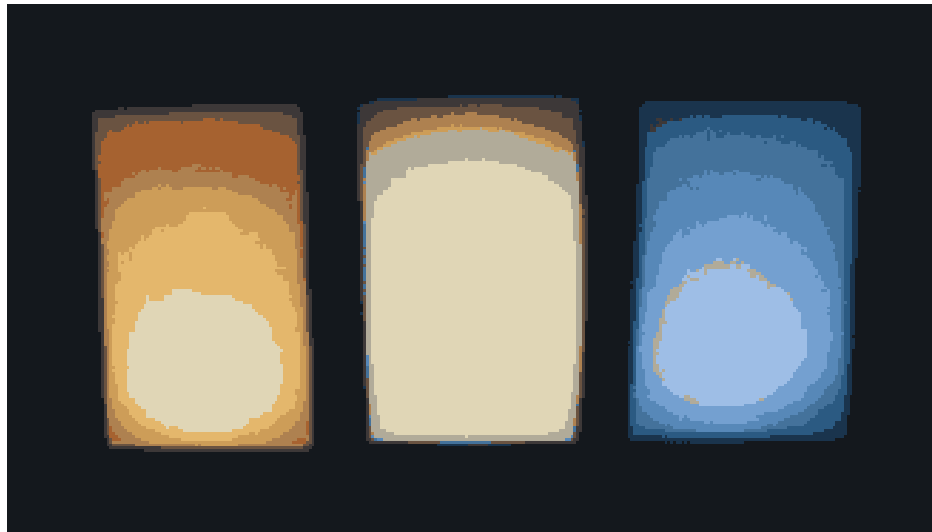
White Light Variables

Color Temperature The lighting designer has yet another concern: the color of the light source itself. We tend to think of light emitted from the sun and almost any arc or incandescent lamp as white. In reality, the actual color of light from one white source can be quite different from that of another. One method of identifying the exact color makeup of most common light sources is called *color temperature*, a measurement using the Kelvin scale (after the British physicist, William Lord Kelvin).



16-10 Color on a Scene These examples from *As You Like It* illustrate the strong effect of color on a scene.

16-11 Kelvin Temperature These three light boxes illustrate the visual difference (recorded on tungsten film from left to right) among a source at 1,800 K, such as candlelight; a source at 3,200 K, such as stage lighting; and a source at 5,700 K, such as daylight.



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Unlike literal temperature, a higher Kelvin temperature indicates a cooler-colored source—that is, one that has more blue in it. A source with low Kelvin temperature is rich in warmer colors such as red and amber. Candlelight, which tends to be a warm yellow-red, is rated at 1,800 Kelvin (K); light from a standard incandescent household lamp is close to 3,000 K; and daylight is surprisingly blue at a cool 5,700 K. Standard incandescent stage fixtures produce light that is around 3,200 K whereas arc sources are usually around 6,000 K—a huge visual difference. Figure 16-11 compares the approximate color of each of these sources. (More information about Kelvin measurement is in Chapter 23.)

spectral distribution The radiant power emitted by a light source at each wavelength over the visible spectrum—normally shown in graph form.

color rendering index (CRI) A measure on a scale of 0 to 100 of how accurately a light source reveals the color of an object.

Color Rendering Index (CRI) As indicated previously, the **spectral distribution** of any light source is unique to that particular source. In fact, such distribution may vary greatly from one source type to another. This is indeed the case when comparing three commonly used theatrical light sources: incandescent, arc, and LED. Although we view the light emitted from each of these sources as white, the way each of them renders color is totally another matter. To measure this color rendition, the International Commission on Illumination (CIE) has established a standard referred to as **color rendering index (CRI)**. Figure 16-12 shows color rendering from various light sources. In the past, this

16-12 Color Rendering This image illustrates the effect of color rendering from various light sources on human skin.

<p>Fair 50-60 CRI Standard Warm White Fluorescent Standard Cool White Fluorescent</p>	
<p>60-70 CRI Premium High Pressure Sodium Conventional Metal Halide</p>	
<p>Better 70 - 80 CRI 5600 K Arc White LED</p>	
<p>Best 80 - 100 CRI Natural Daylight 3200 K Tungsten</p>	

PHOTO COURTESY MICHELLE CARON

has not been a major concern for theatrical designers because all incandescent sources and most arc sources in use render color very well. However, many LED sources do not. As a result, designers must take care when choosing either color-mixing or white LED light sources when lighting colored objects. More detailed information on spectral distribution and color rendering will be found in Chapter 23.

Color Filtering

Most stage-lighting fixtures produce a light that we perceive as “white,” rated at approximately 3,200 K. One way to alter this color is by interrupting the beam of light with a filter. Placed in front of candles, clear glass vessels containing red wine and other colored liquids were once employed as filters. Modern stage lighting uses the same technique with filters of colored plastic or dichroic glass.

As the name implies, a filter placed in front of a light source causes selected colors to be filtered or blocked from passing through. This is an important concept to understand. When white light is shone through a blue filter, the red and green wavelengths are either absorbed or redirected by the filter; only the blue wavelengths are allowed to pass. In theory, if a pure red light is shone through a pure blue filter, no light at all will pass through (Figure 16-13).

Color Media

It is common in the theatre to refer to plastic color filters as **gels**, short for *gelatin*, the first material to be manufactured as a color medium. Designers can choose from three main types of color media: plastic, colored glass, and dichroic glass.

gels A short name for color filters; derived from the word *gelatin*.

Plastic Media

Plastic filters made of polyester or polycarbonate are available by the roll or in 20-by-24-inch sheets. Frame-size cuts can be catalogued and stored for future use. The three major suppliers of stage filters in the United States are: GAM (GamColor), LEE (LEE Filters), and Rosco (Roscolux). A huge range of colors is available, as indicated by the swatch or sample books shown in Figure 16-14.

Swatch Books Color sample books (swatch books) are available from color manufacturers or theatrical distributors. They contain a small sample of color filters along with their name and number as well as a spectral distribution curve and transmission percentage.

The transmission percentage indicates how much of the original white light from the source is allowed to pass through the filter. This information is helpful to the designer in determining how much light will get onto the stage, and at times, it is quite alarming. For instance, although Rosco’s No. R13—Straw Tint—has a transmission of 78 percent, its No. R42—Deep Salmon—will only allow 8 percent of the light to pass through!

The spectral distribution curve of the filter is placed on a graph of the visible spectrum. It shows what percentage of any spectral wavelength is passing through the filter.

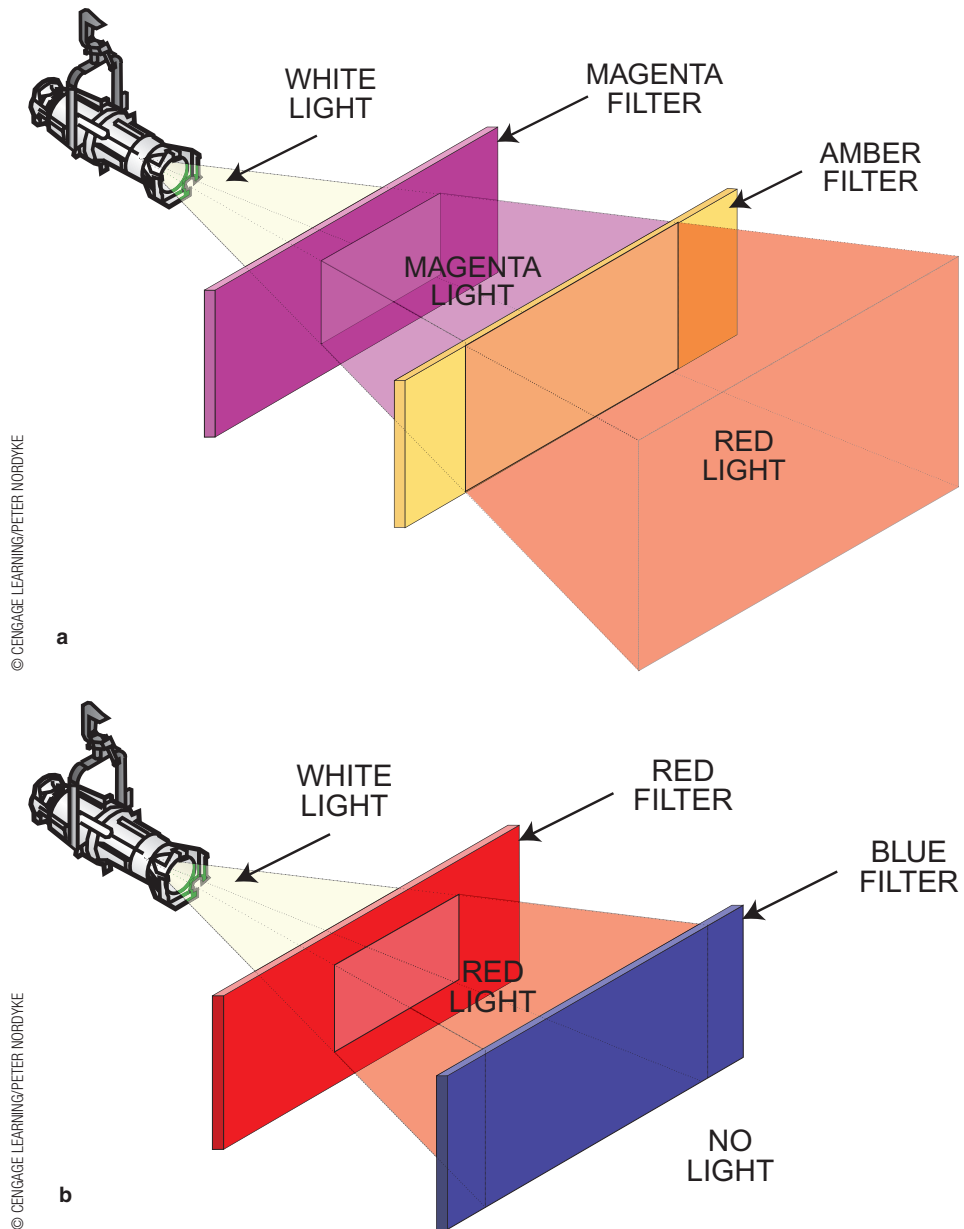
To avoid confusion caused by different manufacturers using the same numbers, the following practices can help designers designate a color clearly:

- Use a “G” prefix before GamColor numbers
- Use an “L” prefix before LEE Filter numbers
- Use an “R” or “X” prefix before Roscolux numbers

It is good practice to replace swatch books every two or three years, keeping abreast of newly added colors. Never trust the names that the various manufacturers assign to

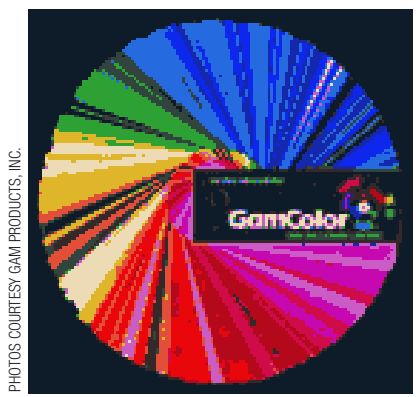
16-13 Color Filtering

- a White light, when filtered through two secondaries such as magenta (made up of blue and red) and amber (made up of red and green), results in red, the secondaries' common primary.
- b White light, when filtered by two primaries, is completely absorbed so that no light emerges.



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PHOTOS COURTESY GAM PRODUCTS, INC.

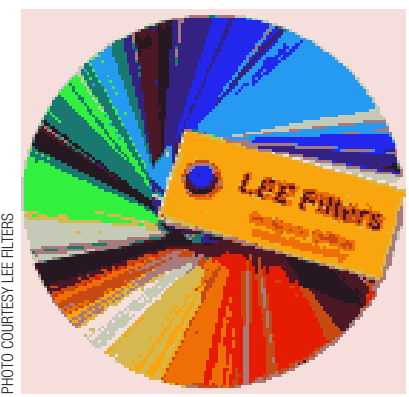


PHOTO COURTESY LEE FILTERS



PHOTO COURTESY ROSCO LABORATORIES

16-14 Color Swatch Books Color sample books, called *swatch books*, are available from the three major manufacturers.

their colors. Names are given to individualize the color, making it easier to remember. However, their descriptive accuracy is suspect. One need only compare GAM’s “light steel blue” (G720) with Roscolux’s color of the same name (R64) to see why such labels are meaningless.

Color Correction Initially developed for the film industry, color-correction filters adjust the color temperature of a light source. Anyone who is familiar with film is aware that the proper type must be used in order to achieve accurate color rendition. This is due to the large color disparity between incandescent and daylight sources. If a cinematographer needs an incandescent source to be the color of sunlight, a color-correction filter such as LEE No. 201 may be used to correct the color temperature from 3,200 K to 5,700 K. Theatrical designers frequently use color correction filters to balance sources. For instance, if a designer wants to match the color temperature of a 6,000 K arc source with that of a 3,200 K incandescent source, LEE No. L204—Full C.T. Orange—can be used on the arc source.

Diffusion Diffusion material, often called **frost**, diffuses light from a fixture and softens or even eliminates a shutter cut or beam edge. Although not a color medium, it is manufactured by the same companies that produce color media. Frosts are listed in the color swatch books and are commercially supplied in sheets.

A wide range of diffusers is available—from a very light frost, which barely takes the edge off a sharply focused ERS, to a heavy frost, which makes a beam edge all but disappear. In addition, several densities of “silk” are available, which cause the beam of light to spread in only two directions (Figure 16-15).

An electrician is able to soften the beam edge of an ellipsoidal reflector spotlight by sliding its barrel a bit out of focus. However, newer ellipsoidals such as the Source Four don’t soften as nicely as the older types. Light frosts such as R119 (Light Hamburg Frost) and R132 (Quarter Hamburg Frost) help solve the problem.

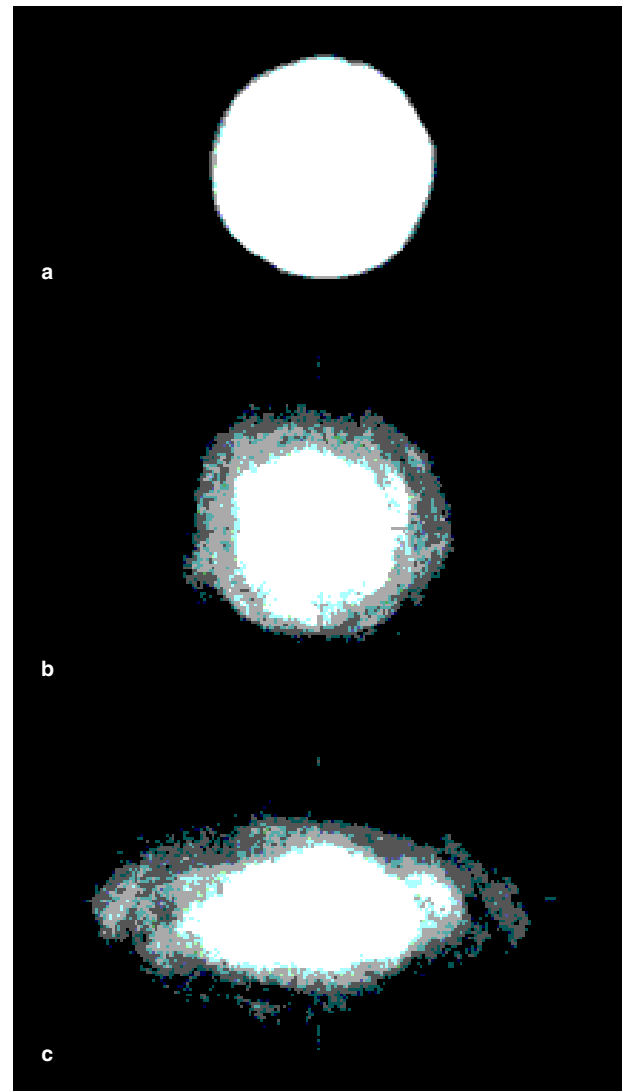
Most diffusion material has limited application in front-of-house positions because of the amount of unwanted spill light that is produced. Although any use of frost reduces light intensity to some degree, some heavy frosts cause nearly as much light to come out of the side of the filter as the front. The variety of frost media available provides a lighting designer with many options and is an important tool of the trade.

Handling Plastic Media It is easy to cut sheets of color media down to size by using a large paper cutter. The color-frame size of newer ellipsoidal reflector spotlights is 6¼ by 6¼ inches. The color-frame size for 6-inch lighting fixtures is 7½ by 7½ inches, and for an 8-inch fixture it is 10 by 10 inches. Electricians should always check for the proper frame size before cutting.

Colored Glass

Colored glass filters are expensive and break when dropped. Whereas plastic may be cut to any size or shape desired, glass must be ordered for exactly the purpose required. It comes in few colors, is heavy, and is bulky to store. Glass does offer three advantages, however: it never fades, it resists heat, and it can be molded like a lens in order to spread light.

frost A plastic light-diffusion medium.



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16-15 Diffusion Material The effects of three different diffusion materials.

- a** A light frost such as Rosco’s “Light Hamburg Frost” — R119.
- b** A heavy frost that keeps a hot center similar to Rosco’s “Tough Frost” —R103.
- c** A spread frost such as Rosco’s “Tough Silk” —R104.



TOOLS OF THE TRADE ■ Obtaining Color Samples

To obtain color swatch books, go to your local theatrical supply house or contact the following manufacturers:

GamColor

GAM
4975 W. Pico Blvd.
Los Angeles, CA 90019
www.gamonline.com

LEE

LEE Filters
2237 North Hollywood Way
Burbank, CA 91505
www.LeeFilters.com

Rosco

Rosco Laboratories, Inc.
52 Harbor View Avenue
Stamford, CT 06902
www.rosco.com

GAM's Web site contains a great deal of valuable information on color use and terminology, including a wonderful section on "split gels."

roundel Round glass color filters made to fit into striplights.

Roundels Colored glass **roundels** can be obtained with the following features:

- *Plain.* For color filtering only
- *Stippled.* For color and also to diffuse the beam
- *Spread.* For color and also to spread the beam laterally, so that the various colors blend more readily
- *Stripped.* Very thin glass in narrow strips to color the light from fixtures with extremely hot beams

Variiegated Glass Filters Rosco manufactures a line of glass filters that fits into the gobo slot of an ellipsoidal reflector spotlight. There are four types: Colorizers, Image Glass, Prismatic, and ColorWaves. The Colorizers offer rather subtle variegated multi-color effects (Figure 16-16). The Prismatic are made up of broken chips of dichroic glass and produce a stronger texture and shape than the Colorizers do. The ColorWaves produce a more distinctive multicolored pattern than either of the other two does. Any one of the types can be used in conjunction with a gobo pattern. Although they cost about \$50 each, they produce a unique and interesting effect.

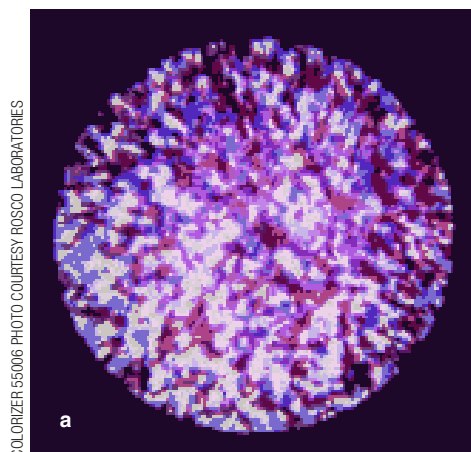
Dichroic Glass

Thin pieces of glass treated with a dichroic coating can act as superb color filters. Whereas plastic filters absorb the unwanted color wavelengths, turning their energy into heat, **dichroics** reflect the unwanted color to the sides and back toward the source. The dichroic reflection process provides colors that exhibit a greater purity, richness, and saturation

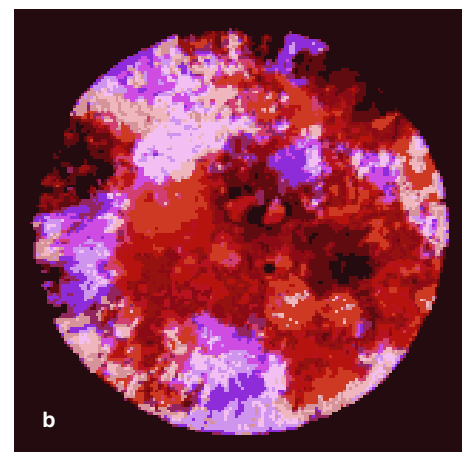
dichroics Glass color filters that reflect rather than absorb unwanted wavelengths.

16-16 Rosco Colorizers Two of the various glass Colorizers available from Rosco Laboratories.

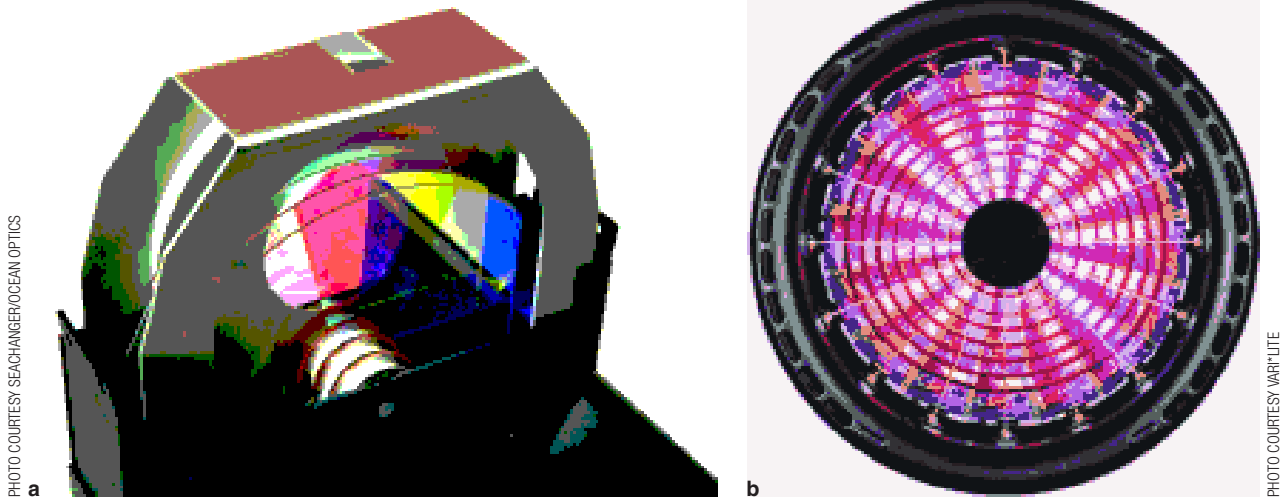
- a Stippled—red, blue, lavender.
- b Warm free flow.



COLORIZER 55006 PHOTO COURTESY ROSCO LABORATORIES



COLORIZER 56102 PHOTO COURTESY ROSCO LABORATORIES



16-17 Dichroic Glass Filters

- a The SeaChanger color engine uses four dichroic glass filters for mixing.
- b Dichroic color-mixing system in the Vari*Lite VL550 Wash Luminaire.

than do the colors produced by plastic. Commonly used in automated fixture color mixing and color wheels, a vast array of colors can be produced (Figure 16-17).

Remarkable for its purity, the color from dichroics is unobtainable with standard colored glass or plastic. The major drawback of dichroic filters is their expense. The cost of a 6-inch filter is prohibitive except for theme parks and architectural applications where alternatives are equally expensive.

Automated Color Changers

Remote control of the color projected by a stage-lighting fixture is a valuable design tool. The theatrical use of automated color changers has become widespread because one lighting fixture can serve as several.

There are three basic types of color-changing accessories available today:

- Units commonly called *scrollers*, which use **gelstrings**: a series of plastic colors taped together and rolled to form a scroll
- Subtractive color mixers, which use two scrolls mixing together to form a unique color
- Dichroic color mixers

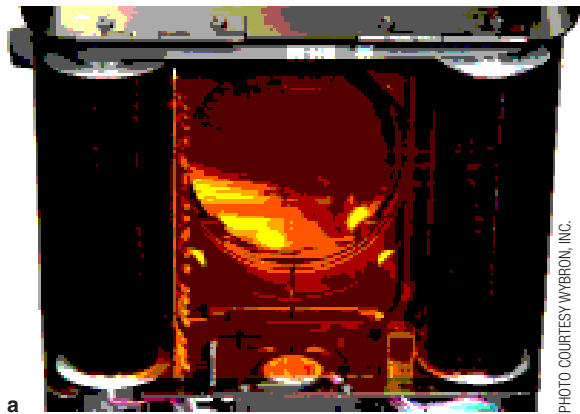
gelstring A series of plastic color filters taped together and rolled to form the scroll of a color changer.

Scrollers Least expensive of the color mixing accessories, scrollers allow the designer to select from 12 to 30 different colors depending on the model. A metal box, containing the color, two rollers, a fan, and a motor, slides into the lighting fixture's color holder. A DMX signal is sent from the lighting control console to the changer, instructing the motor what to do. They require one or two channels of DMX—the fan cools the filters (Figure 16-18).

Subtractive Color Mixers Mixing offers a wider range of color choices than is available from standard scrollers. Wybron claims that 432 distinct colors are achievable from their CXI IT unit, which uses two CYM color scrolls. The CXI IT uses two or three DMX control channels and a fan for cooling.

Apollo's MXR 2 also uses two scrolls for subtractive mixing. In addition, the primary colors have been added at the end of each string. It requires three DMX channels (Figure 16-19).

Dichroic Color Mixers Ocean Optics manufactures the SeaChanger Color Engine, which fits between the lamp and the lens module of a Source Four ellipsoidal reflector



16-18 Remotely Controlled Color Scrollers

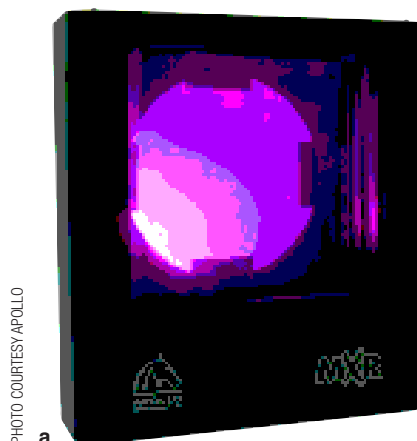
- a Interior view of a Wybron Scroller showing the gelstring, fan, and rollers.
- b The Smart Color PRO Scroller from Apollo offers variable speed and 16 frames of color.
- c Coloram IT from Wybron has variable speed and 32 frames of color on the gel string.

spotlight. It uses cyan, yellow, and magenta dichroic filters plus a fourth “extreme green” tri-chromatic RGB (red, green, blue) filter. Four DMX control channels are required. It is the most expensive of the changers, but the filters never fade, and the operation is silent (Figure 16-20).

Using Color Changers Use of scroller fans increase the life of the filters, but the noise can be distracting in small spaces. Quickly moving several color scrolls in unison is to be avoided, owing to the noise.

In using color changers, designers must alter the way light cues are normally written. As noted, up to four control channels are necessary to operate each changer independently. Color changes are written as cues. However, in order to imperceptibly change from one color to another, the fixture must dim out, change color, and dim up again. Dimming out in order to change color is referred to as a **dark set**.

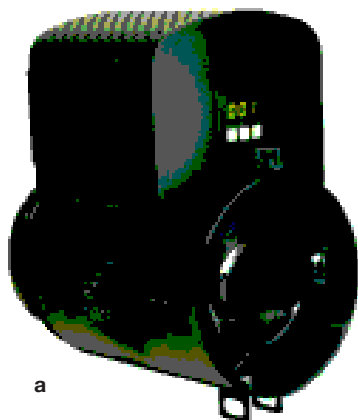
dark set Special lighting cue written and inserted into the cue list to cause color changers or automated fixtures to change their color or focus without being seen.



16-19 Remotely Controlled Subtractive Color Mixers

- a MXR 2-scroll mixer from Apollo.
- b Wybron's CXI IT color-mixing scroller.

PHOTO COURTESY OCEAN THIN FILMS



a



b

PHOTO COURTESY OCEAN THIN FILMS

16-20 Remotely Controlled Dichroic Color Mixers

- a The SeaChanger color engine uses CYMG dichroic filters to mix nearly any color. It contains no fan and fits into any Source Four ellipsoidal.
- b SeaChanger color engine mounted in a Source Four.

Color-Mixing LEDs

Creating color by filtering white light is extremely inefficient. How wonderful it is to finally have a source of light that actually emits colored light—the **LED**. Although LEDs are explained in detail in Chapter 23, let it be said here that an LED is a diode which gives off light; the light is produced by applying a small current to two different materials separated by a slight gap or *junction*; the specific color that is produced is determined by the type of material systems used.

LED Light-emitting diode; a special diode that can be designed to produce light of various colors.

Color Properties

The color produced by an LED has a vibrancy that is unusual in stage lighting. It is similar to the light emitted by neon sources. The designer needs to be aware that color from filtered light and from an LED are really very different in quality. As mentioned in the earlier discussion on spectral distribution and color rendering, LEDs are not great color renderers. They produce their color as narrow spikes in the spectrum rather than the gentle curve we see from filtered incandescent light. This isn't a problem in reproducing color within the narrow range of the spike, but a surface color outside that range could be considerably altered. For this reason, LED fixture manufacturers have increased the number of colors in a mixing fixture from three (RGB) to five or seven. The Philips Color Kinetics ColorBlast TRX fixture has five LED color emitters: red, green, blue, amber, and white (RGBAW). ETCs Lustr fixture uses a ×7 color mixing system: red, red-orange, amber, green, cyan, blue, and indigo (Figure 16-21).

Using LEDs

Other than their unique color quality, LEDs exhibit several design characteristics that set them apart from incandescent sources. First of all, LED fixtures have on-board

COURTESY PHILIPS COLOR KINETICS



a



b

PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)

16-21 Color-mixing LED Fixtures

- a ColorBlast TRX from Philips Color Kinetics.
- b ETC Selador® Lustr+™ LED luminaire 11".

dimmers—they don't require anything more than a power supply and a DMX signal from the control board. Secondly, LEDs do not change color temperature when dimmed—they maintain their original color throughout the dimming curve. Finally, unmixed colored light from several LEDs creates multiple shadows—each LED is a single source. Some manufacturers have solved this issue by premixing the light before it leaves the lens of a fixture.

The use of LED color on the stage is in its infancy. Designers appreciate the color's uniqueness and great variety obtainable through mixing. As LED fixtures become more available and less expensive, their use will increase. At this point, designers are using LEDs to color wash surfaces as well as to create general stage color washes. Figure 16-22a illustrates the use of color-mixing LEDs for a performance in San Francisco's Grace Cathedral. Side walls are up-lit in lavender using narrow-beam



PHOTO COURTESY YORK KENNEDY



PHOTO COURTESY MOUNTAIN LIGHT COMPANY, DENVER CO. PHOTOGRAPHER JOHN W. FULLER



PHOTO COURTESY FLORI SCHUTZTER

16-22 LED Color Mixing

- a** *On Grace* at San Francisco's Grace Cathedral. Performed and Created by Anna Deavere Smith. Lighting design by York Kennedy.
- b** *Wings Gala* at Wings Over the Rockies Museum, Denver, Colorado. Lighting by Mountain Light Company, design by Craig Wolf.
- c** "ColorBlast" fixtures by Color Kinetics are used to light the background sculpture in this production of *Stone Heart*, produced by Native Voices at the Autry National Center in Los Angeles. Directed by Randy Reinholz; scenery, Susan Scharpf; costumes, Christina Wright; lighting, Craig Wolf.

Color Kinetics ColorBlasts. The audience is washed in a similar lavender light by Martin MAC 301 Wash fixtures, while the apse is toned deep blue, again using ColorBlasts. Figure 16-22b is a fund-raising event at Wings Over the Rockies Museum in Denver. The entire space is lit with LEDs: walls and ceiling are washed with ColorBlazes, and the audience, stage, and aircraft are washed using ColorReaches and ColorBlasts. Figure 16-22c shows a production of *Stone Heart* which used ColorBlasts to side-light the background sculpture.

Designing with Color

Experimenting with color mixing is especially important for the beginning lighting designer. Colors projected by stage-lighting fixtures can be examined in the theatre or in a lighting laboratory—in fact, any place that has dimmers.

A particularly useful tool for color experimentation outside the theatre is the *mix-box*. Three-inch Fresnels and three common household dimmers are all that is necessary. The box is portable and can be plugged into any household circuit. To make best use of a mix-box, a designer should have available a file box of color media that contains a frame-size cut of every color the designer may need.

With a basic understanding of color and the media that produce it, the beginning lighting designer can start to learn through experience the more subtle aspects of stage lighting. The next chapter presents yet another important tool of lighting—the lighting fixture itself.



Lighting Fixtures

A stage-lighting fixture must be capable of delivering light controlled enough to illuminate only that which is intended. In addition, the stage-lighting designer looks to other features of a fixture such as intensity, beam shaping, and quality of light; matching its properties and capabilities with the specific design requirements of a production. To do this effectively, the designer must be familiar with the sometimes subtle differences among stage-lighting fixtures.

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For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

Choosing the Right Fixture

When the designer has a visual image of what is desired, the next step is to determine which fixture will best produce the light quality. Several factors affect this determination:

- Fixture inventory and budget
- Physical restrictions
- Quality of light
- Source intensity and color temperature
- Beam shaping and control

Fixture Inventory and Budget

If a production's lighting equipment is rented, the designer has free choice of fixture within the allocated budget.

However, many designers work with a fixed instrument inventory. Such inventories can vary from all new equipment to a variety of types and styles purchased over the years when funds were available. Designers are wise to confirm the accuracy of an equipment list, particularly when working with older inventories. Because a venue's inventory seldom provides everything a designer desires, compromises must often be made. The success of mixing and matching various pieces of equipment depends on familiarity with the fixtures and begins with a basic knowledge of the types. While the information that follows provides a solid foundation for the young designer, hands-on experience working with the fixtures is equally important.

Physical Restrictions

The physical features of a theatre invariably affect lighting possibilities. Throw distances (distance from lighting fixture to target) vary greatly from venue to venue.

The type and the amount of offstage space for side-lighting positions may influence design decisions. Space limitations in front-of-house ceiling and side-cove positions dictate maximum fixture size as well as the number of fixtures. The number of hanging positions front-of-house and overstage matters significantly as well. Finally, control and circuit limitations may be a factor in fixture usage and selection.

Quality of Light

Because this factor greatly influences mood, a designer always considers the quality of light provided by a specific type of fixture. It is possible to alter the quality of light from profile spots (ERS), but not from Fresnels or PAR fixtures.

A Fresnel delivers a soft beam of light with fuzzy edges and an even field. The beam from a PAR has fuzzy edges, but the light itself is harsh and the field is uneven. The beam from a profile spot has hard edges that can be softened by various means. It is harsher than a Fresnel but less harsh than a PAR. Profile fixtures such as ellipsoidal reflector spotlights are the only conventional fixtures that can take gobos or patterns that alter the texture of the light.

Source Intensity and Color Temperature

The designer must constantly consider whether a chosen fixture can deliver the appropriate amount of brightness for the task involved. Many lighting fixtures can take lamps of varying intensities, but facilities with fixed inventories normally have chosen a specific lamp to be used in each fixture type. Designers need to know not only what fixture is in an inventory but also what lamp it is using. Besides the lamp, the beam spread of a fixture also greatly affects how bright the light will be. A wide-angle 50-degree ellipsoidal spreads the light over a much greater area than does a narrower 19-degree one.

The color temperature of a light source has become an important design tool in the theatre. Theatrical light sources vary in color temperature from a warm 2,800 K to a harsh and crisp 5,600 K. The visual difference is huge. In addition, modern LED fixtures may offer color temperature variability in a single source. Using differences in color temperature in a design can be very effective; ignoring variations in color temperature can be equally detrimental. Recall that higher color temperature sources are perceived as being brighter, harsher, and cooler than are lower ones.

Beam Shaping and Control

The ability to alter the shape and the size of a light beam is an important design tool. Each type of stage-lighting fixture is very different in this respect.

Profile spotlights are the most versatile in terms of beam shaping and control. To a lesser extent, the beams from a Fresnel and some automated wash fixtures can be altered as well. The beam of a PAR is oval and nearly impossible to alter.

Stage-Lighting Optics

The quality of light from a fixture is determined by two things: (1) the light source itself and (2) how the light is manipulated after it leaves the source. The latter factor is controlled by the **optics** of the fixture.

Most stage-lighting fixtures use reflectors to increase the efficiency of their light sources. Most also use lenses to gather and redirect the light, focusing it into a usable beam.

optics Reference to the optical features of a stage-lighting fixture—most significantly, the reflector and lens or lenses.

Reflectors

The most important law of reflection for a lighting designer to remember is that the angle of incidence is equal to the angle of reflection. Early stage-lighting reflectors were molded-glass mirrors. In the 1950s, reflectors began to be constructed of a lightweight spun metal. This metal shell was given a highly reflective and durable surface treatment referred to as *Alzak processing*. The Alzak reflector became an industry standard.

dichroic reflector In a theatrical spotlight, a glass reflector with a dichroic coating, which allows some wavelengths of light to pass through while reflecting others.

Today, the metal reflector has, in many cases, been replaced by dichroic-coated glass reflectors (Figure 17-1). The advantage of a **dichroic reflector** is that it can be designed to allow ultraviolet and infrared light rays to pass through the back, so that only visible light is reflected. This produces a light beam of significantly cooler temperature. As a result, the internal parts of the fixture function better and last longer, color filters do not fade as quickly, and metal gobos last considerably longer.

The new LED stage-lighting fixtures generally do not require reflectors, for their light is emitted off the face of the LED in one direction. Other fixtures use one or a combination of the following three reflector shapes:

1. *Spherical*. Used in Fresnels, follow spots, and many automated wash fixtures
2. *Parabolic*. Used in beam projectors and PAR-, MR-, and R-type lamps
3. *Ellipsoidal*. Used in ellipsoidal reflector spotlights and automated spot fixtures

By redirecting light coming out of the back of a lamp, a reflector increases the amount of usable light from any source. The shape of a reflector determines how the light is redirected. Every reflector has a specific point where a light source must be placed in order to achieve the desired reflective pattern. This location is called the reflector's **focal point**.

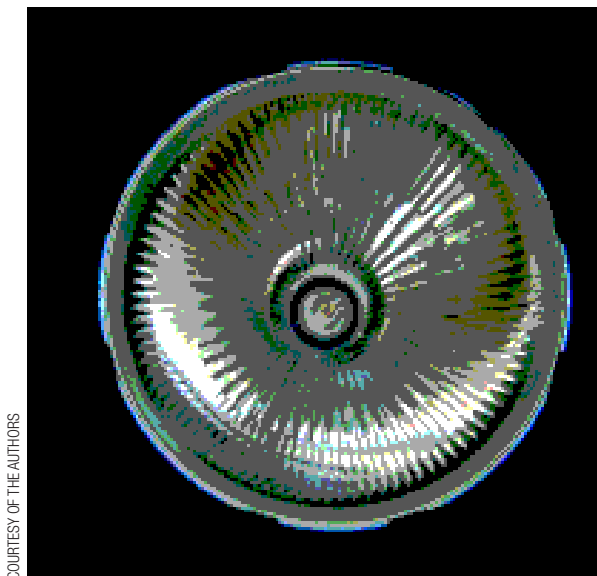
focal point of reflectors The specific point at which a light source must be placed in relationship to the reflector in order to achieve the desired reflective pattern.

spherical reflector A reflector cast in the shape of part of a sphere, which returns light back to its focal point; found in Fresnel spotlights.

parabolic reflector A reflector cast in the shape of part of a parabola, which reflects light in parallel rays; found in PAR fixtures.

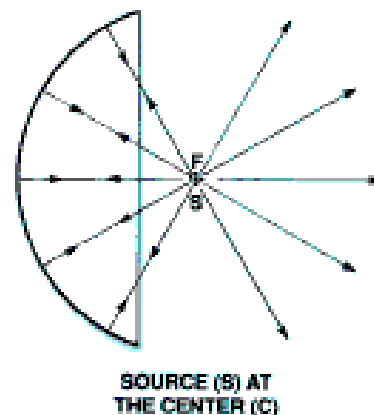
Spherical Reflectors As its name implies, the **spherical reflector** is constructed in the shape of part of a sphere. The exact center of the imaginary sphere is its focal point. If a light source is placed at this point, its rays are reflected squarely off the surface. The reflected light rays bounce directly back to the source itself and continue to spread from there (Figure 17-2). Light output from a lamp is nearly doubled.

Parabolic Reflectors A **parabolic reflector**, constructed in the shape of part of a parabola, is unique in that it produces parallel rays of light. If the light source is placed at the parabola's focal point, rays striking the reflector bounce off parallel to one



COURTESY OF THE AUTHORS

17-1 Dichroic Reflector Glass dichroic-coated reflector of an ETC Source Four ellipsoidal reflector spotlight.

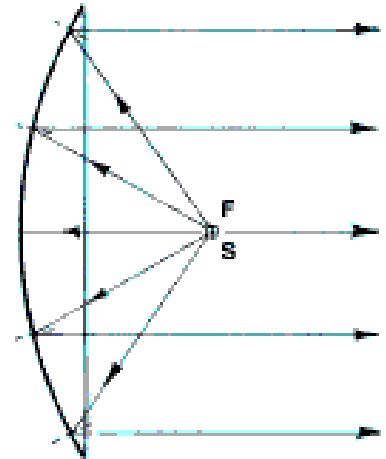


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17-2 The Spherical Reflector If a light source (S) is placed at the focal point (F) of a spherical reflector, the reflected rays are returned directly to that focal point.

another (Figure 17-3). The result is a concentrated and harsh beam of light. Moving the source away from the focal point toward the reflector spreads the light. Moving it away from the focal point farther from the reflector causes the light rays to converge.

Ellipsoidal Reflectors Constructed in the form of half of an ellipsoid, an **ellipsoidal reflector** is more efficient than either the spherical or the parabolic because it wraps farther around the source. By mathematical definition, an ellipsoid has two focal points. The focal point nearest the reflector and where the source is placed is called the *primary focal point*. The more distant focal point is called the *conjugate focal point*. If a light source is positioned at the primary focal point, the rays striking the reflector are redirected to converge through the conjugate focal point (Figure 17-4). A large percentage of the light from the source is thus gathered into a concentrated beam.



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17-3 The Parabolic Reflector If a light source (S) is placed at the focal point (F) of a parabolic reflector, the reflected rays are parallel. Note that nonreflected rays from the front of the source are not parallel—they diverge.

Refraction of Light

Refraction refers to the bending of light. The law of refraction states that when a ray of light passes into a denser medium (for example, from air into glass) it is bent toward a perpendicular drawn to the surface at the point of entry. When it reemerges into the less dense medium, it is bent away from a perpendicular drawn at that point (Figure 17-5).

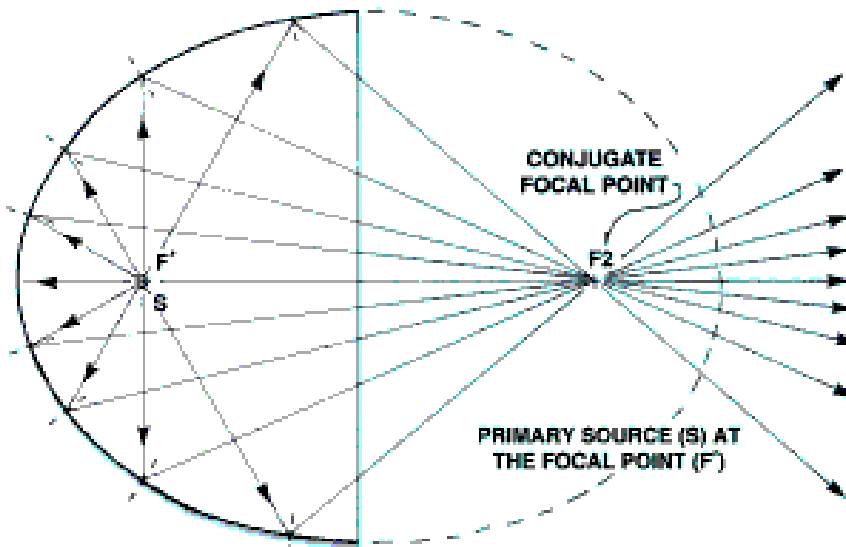
The two surfaces of the piece of glass illustrated in Figure 17-5 are parallel. In such an instance, the emerging ray of light is slightly offset but continues parallel to its original course. Lenses have nonparallel surfaces, causing light to bend in a different, though equally predictable, manner.

The Plano-Convex Lens Light from a theatre spotlight must be intensely concentrated in the shape of a cone. A lens is used to redirect the spreading rays of light coming from the source and the reflector. A lens is categorized according to the shape or curvature of each of its two surfaces. For instance, the **plano-convex** lens is important in stage lighting. It has a flat (plano) surface on one side and an outwardly curved (convex) surface on the other. It is the simplest and least expensive lens for concentrating spreading rays into a compact and bright beam of light (Figure 17-6).

ellipsoidal reflector A reflector cast in the shape of part of an ellipsoid, which reflects light back to its secondary focal point; found in ellipsoidal reflector spotlights.

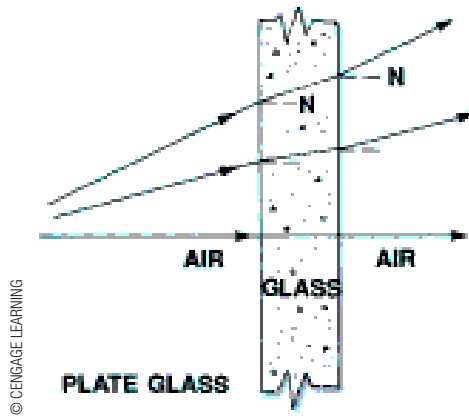
refraction The bending of light rays as they pass through mediums with different densities, as in a light beam traveling through air bending from its original track when it goes through glass.

plano-convex lens A lens with one flat (plano) side and one outwardly curved (convex) side; found in ellipsoidal reflector spotlights.

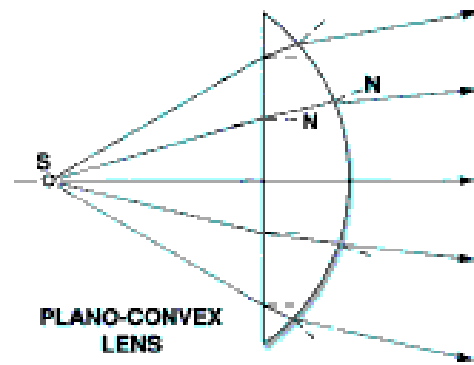


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17-4 The Ellipsoidal Reflector If a light source (S) is placed at the primary focal point (F) of an ellipsoidal reflector, the rays converge at the conjugate or secondary focal point (F2).



17-5 Refraction of Light This drawing illustrates the refraction (bending) of rays of light passing through a medium denser than air, in this case a sheet of glass. N = the normal (a perpendicular drawn to the surface).



17-6 The Plano-Convex Lens This diagram shows the refraction of diverging light rays as they pass through a plano-convex lens.

focal point of lenses The point at which parallel rays of light converge after passing through a lens.

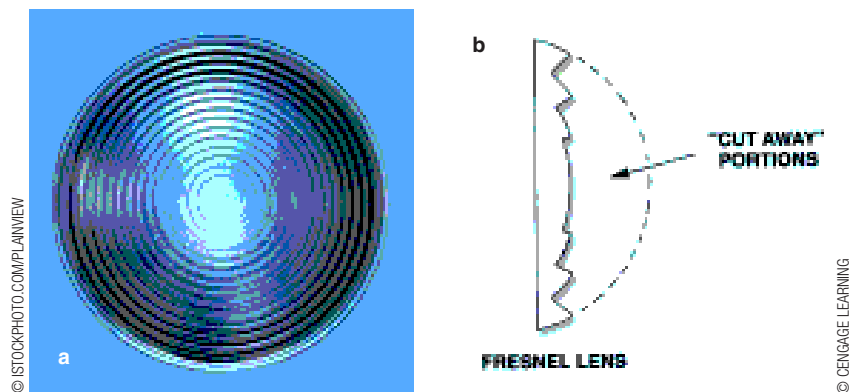
focal length The distance between the center of a lens and its focal point.

The Fresnel Lens The Fresnel lens shown in Figure 17-7a was developed in order to save weight and lessen the chance of cracking due to excessive heat. The curved surface of a plano-convex lens is retained while “steps” are cut into the glass to reduce its thickness (Figure 17-7b). In order to eliminate ring patterns projected by the steps, the flat surface is broken up either by a light frosting or by a series of dimples molded into the glass. This slight diffraction results in the Fresnel fixture’s distinctive smooth and soft illumination.

Other Lens Shapes Automated fixtures, profile spotlights, and follow spots use different lens configurations depending on the refraction needs. In addition to the plano-convex lens, bi-convex and concave-convex lenses are common (Figure 17-8).

Focal Point and Focal Length Like reflectors, lenses have a **focal point**. If parallel light rays (such as those from the sun) strike a converging (convex) lens, they will be bent to cross at the focal point. Conversely, if a source of light is placed at the focal point of that lens, all the rays of light that emerge will be parallel to one another (Figure 17-9). The distance from the focal point to the center of the lens(es) is called its **focal length** and is measured in inches or millimeters.

Lenses are traditionally identified by two numbers. The first indicates the diameter of the lens and the second the focal length. Thus, a 6-by-9-inch lens (6 × 9) has a diameter



17-7 The Fresnel Lens

a A large Fresnel lens.

b This simplified diagram illustrates how the Fresnel lens is derived from the plano-convex lens.

of 6 inches and a focal length of 9 inches. The greater the curvature of the convex face, the greater the bending power of the lens.

The Profile Spotlight

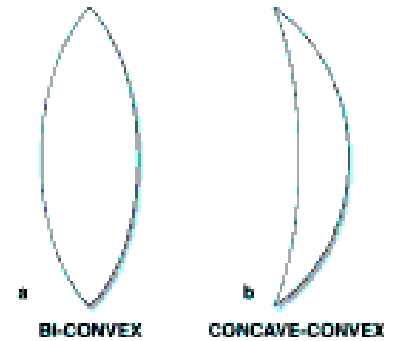
The first profile spotlight was developed in the 1930s, the American version being an **ellipsoidal reflector spotlight (ERS)** and bearing the name “Klieglight” or “LeKo.” It is a high-intensity spotlight which may or may not use a reflector depending on the type of light source (incandescent, arc, or LED). Light from the source is typically passed through a circular aperture, then captured and redirected into a smaller cone by a lens or series of lenses. It is possible to introduce a metal pattern (called a “gobo”) into the beam, turning this versatile fixture into a pattern projector. Interchangeable lens barrels are available that alter the spread of the light beam leaving the fixture, providing for longer or shorter throw distances.

Figure 17-10 illustrates several features of the profile spot that are common to all stage-lighting fixtures. The fixture is attached to a lighting batten by means of a **C-clamp**. The C-clamp is bolted to the fixture’s **yoke**. Loosening the C-clamp’s bolt allows the fixture to be turned from side to side (to *pan*). The yoke is attached to the fixture’s *housing* by means of a handle that can be loosened to allow for tilt adjustment. At the front of the fixture, holders can accommodate a color frame or other accessories.

A cutaway view of an ellipsoidal reflector spotlight, Figure 17-11a shows how the reflector receives light from the source and redirects it to the conjugate focal point. At this point sits a metal baffle that has a circular opening called the *aperture*, or **gate**. This baffle cuts off stray rays, allowing only the useful light to continue on to the lens(es). The sharp, round beam typical of a profile spot is actually an image of the gate. Four beam-shaping **shutters** are positioned immediately adjacent to the gate. The fixture and lens barrel illustrated is an example of a fixed-lens system, meaning that the diameter of the beam of light cannot be significantly changed without changing the lens tube. The barrel can move back and forth only enough to soften or sharpen the beam edge. A **zoom profile** offers variable focus lenses that allow for a range of beam sizes.

Beam Size and Shaping

The profile spot is a unique and valuable stage-lighting fixture partly because of its built-in beam-shaping capability. As we have seen, the beam of light is naturally round, but its size can be changed by using an **iris** and its shape can be altered by means of shutters or a gobo.



17-8 Other Stage-Lighting Lens Shapes

- a Bi-convex.
- b Concave-convex.

ellipsoidal reflector spotlight (ERS)

Stage-lighting fixture that uses an ellipsoidal reflector. The ERS is the most efficient and versatile fixture in use today. It creates a concentrated, sharp light and has a built-in beam-shaping capability.

C-clamp A clamp, shaped like a C, that is used to attach a lighting fixture to a pipe batten.

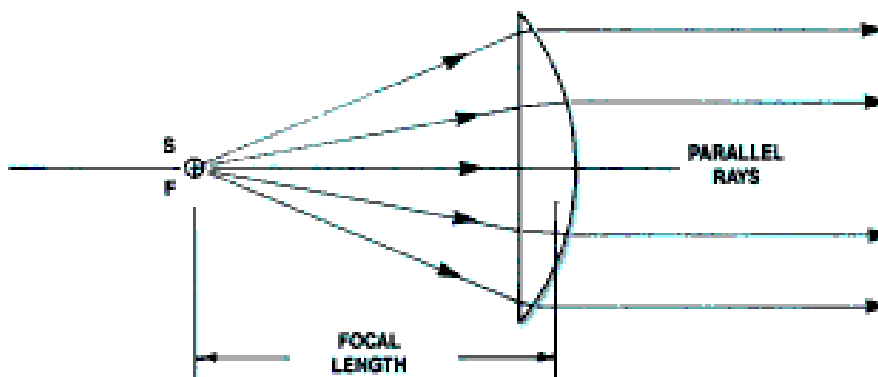
yoke On a lighting fixture, the U-shaped part that holds the C-clamp and allows the fixture to tilt.

gate In an ellipsoidal reflector spotlight, the position at which shutters, iris, and gobos are located. The gate is also close to the reflector’s secondary focal point, where the light rays cross.

shutters Moveable metal plates, inserted at the gate of an ellipsoidal reflector spotlight, that allow the beam to be shaped in a linear manner from any of four directions.

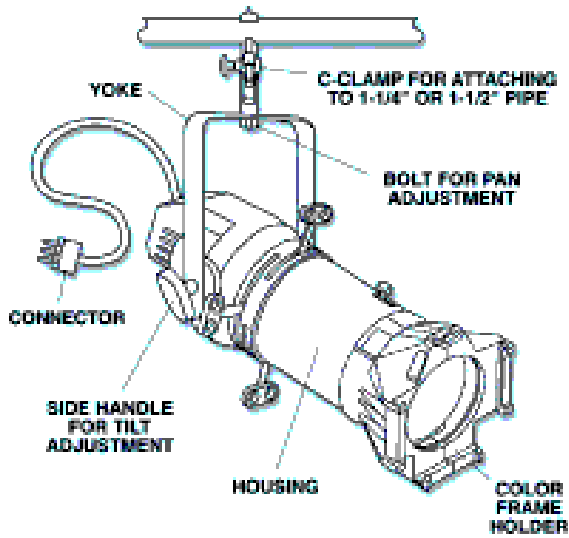
zoom profile A profile spotlight with movable lenses that provide an adjustable beam diameter.

iris A device, located at the gate of an ellipsoidal reflector spotlight, that makes the beam’s circumference larger or smaller.



17-9 Focal Length Source (S) at the focal point (F) of the lens. Note the focal length of the lens.

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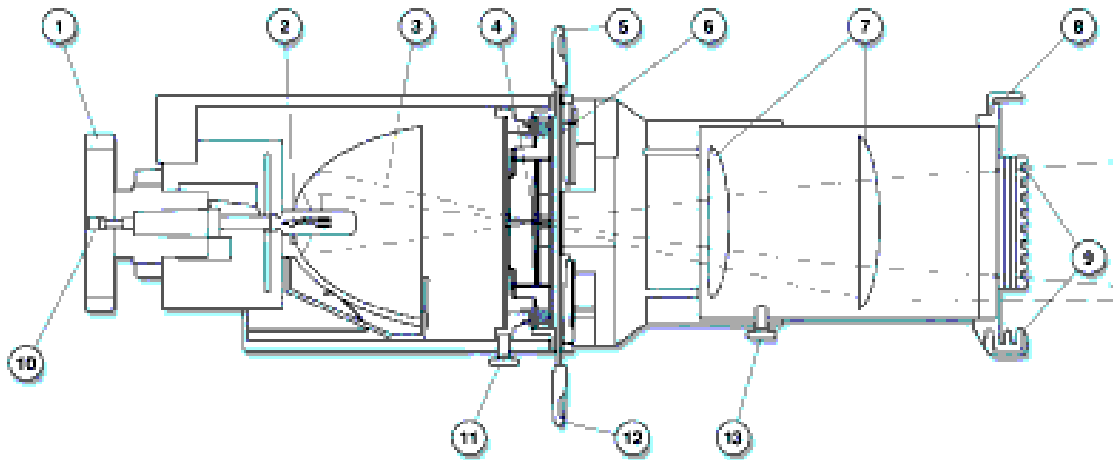


17-10 Lighting Fixture Parts Parts common to all types of lighting fixtures.

Iris An iris is an optional feature of a profile spot. Its metal, leaf-like fingers act to reduce the diameter of the beam in a circular manner. Most profile spots provide a drop-in slot at the top of the fixture for an iris assembly. An iris is a necessity if the fixture is being used as a follow spot.

Shutters The profile's four shutters are standard equipment. These metal plates have heat-insulated tabs or rings attached to the part extending out of the housing. One or more shutters can be pushed into the aperture, cutting into the beam of light in a linear fashion. In ellipsoidal reflector spotlights, the shutter action is reversed because the light beams cross at the aperture—that is, the bottom shutter creates the top cut. Many fixtures are equipped with a rotating shutter assembly that allows virtually any angle of cut to be achieved. In older fixtures without dichroic reflectors, beams of light crossing at the gate create high temperatures that cause even the best shutters to bend and warp over time.

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a

17-11 Ellipsoidal Reflector Spotlight

a The parts of an ERS:

- 1 Protective rear ring handle.
- 2 High-performance lamp.
- 3 Dichroic glass or metal-coated ellipsoidal reflector.
- 4 Aperture, or gate, with reflected rays crossing at the conjugal focal point.
- 5 Top shutter, which shapes the bottom of the beam.
- 6 Gobo/Iris slot.
- 7 Dual plano-convex lenses.
- 8 Gel frame retainer.
- 9 Two-slot gel frame holder.
- 10 Lamp focus control.
- 11 Lens barrel rotation knob.
- 12 Bottom shutter.
- 13 Retaining screw for barrel focus.

b ETC Source Four® ellipsoidal reflector spotlight.

PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)



b

Gobos Profile spotlights have a slot in the top of their housing that is made to receive a template commonly called a *gobo*. This template is a metal plate with a pattern cut in it (Figure 17-12). It fits into a holder that positions the pattern near the gate and squarely in the center of the light beam. Images of an endless variety of words or patterns can be projected onto scenery, actors, or the stage floor. By sliding the lens barrel slightly, electricians can sharply focus the pattern or turn it into soft, indistinguishable texture. Fixtures equipped with a slot big enough for a drop-in iris can accommodate a gobo rotator capable of spinning a standard pattern. In using gobos, electricians must remember that the pattern image is inverted because of the crossing light rays. Consequently, the gobo should be placed upside down in its holder.

Lenses

There are two types of profile spot lens systems:

1. *Fixed lens/Interchangeable barrel.* Allows an adjustment in beam edge but not in spread unless barrel is changed.
2. *Zoom lens.* Provides a variable beam spread within a fixed range.

Both systems use a combination of plano-convex, bi-convex, or concave-convex lenses, each having its own distinct advantages.

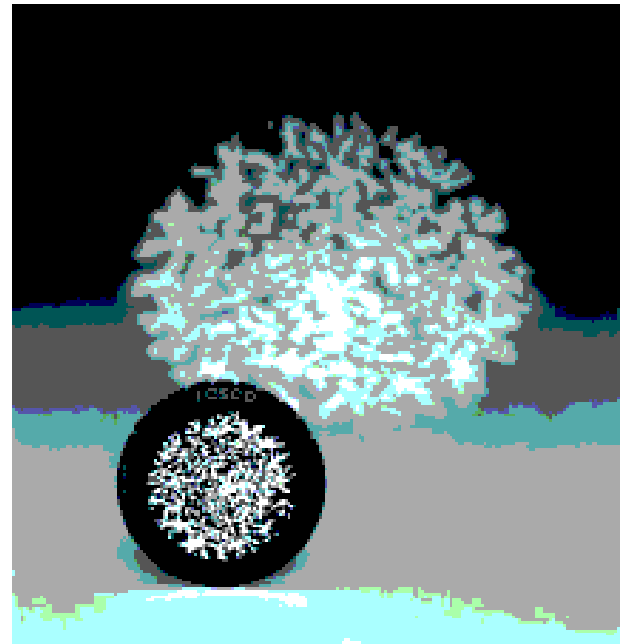
Fixed Lenses/Interchangeable Lens Barrels Older profile spots use two plano-convex lenses mounted belly to belly in a barrel. As noted previously, modern fixtures use a unique combination of lens shapes depending on the desired beam spread. Most fixtures allow for interchangeable lens barrels within a range of beam spreads. For instance, 5-, 10-, 19-, 26-, 36-, and 50-degree lens barrels all fit and work in the same fixture. It is worth noting that Electronic Theatre Controls (ETC) offers an enhanced definition lens tube that fits all its fixtures and is recommended for Source Four LED fixtures. These new lenses increase light output and project sharper and higher-contrast gobo patterns.

Zoom Lenses The example shown in Figure 17-13 is a Source Four Zoom ERS. Rated up to 750 watts, it has a field spread from 25 to 50 degrees with a single knob for moving the lenses. The rear plano-convex and the front bi-convex lenses slide toward or away from each other allowing for a continuously variable size beam of light. For longer throws, a 15- to 30-degree zoom fixture is also available from ETC. Zooms are slightly less efficient than fixed-lens fixtures and more expensive. In certain applications, however, the convenience and flexibility is well worth the extra expense.

Beam Characteristics

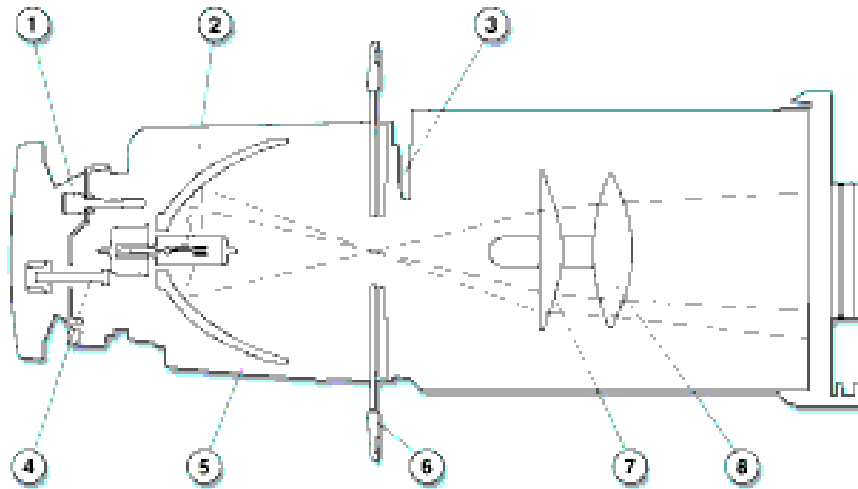
The profile spotlight throws a powerful beam of light capable of creating harsh and sharp shadows. Yet, this fixture offers the flexibility of altering the quality of light in nearly any manner.

Stage lighting requires tight control over light beams for composition and focus. In addition, stray light illuminating the architecture of the theatre or unintended scenery is both distracting and unacceptable. The profile spot is by far the most successful of conventional fixtures in controlling light. The precision of the fixture's optics accounts for this control. The addition of gobos can texture the light in endless ways. Frost diffusion placed in the color frame can achieve a variety of softening effects. There is no better fixture for providing flexibility as well as control of light.



17-12 Gobo Rosco's "Realistic Leaves" gobo and the image it projects.

PHOTO COURTESY ROSCO LABORATORIES, INC.



a

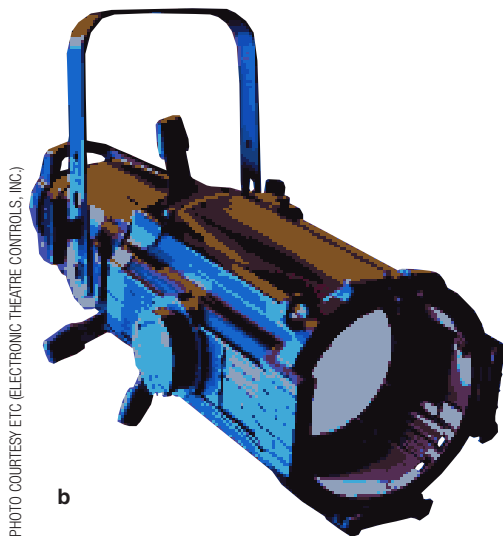


PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)

b

17-13 The Zoom Ellipsoidal

a Parts of the Source Four Zoom.

- 1 Bolt allowing access to lamp.
- 2 HPL lamp.
- 3 Iris, gobo, and gobo rotator slot.
- 4 Lamp adjustment mechanism.
- 5 Dichroic reflector.
- 6 Shutter.
- 7 Plano-convex lens.
- 8 Bi-convex lens.

b The ETC Source Four® zoom provides adjustable beam spreads from 15 to 30 degrees or 25 to 50 degrees.

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Beam and Field

When a profile spotlight is properly aligned, its cone-shaped beam of light is most intense along the center-line of the beam. Intensity drops off evenly from the center to the edge of the beam. The point at which the light's intensity drops to 50 percent of maximum is called the **beam edge**. Farther outward, the place where light intensity drops to 10 percent is called the **field edge**.

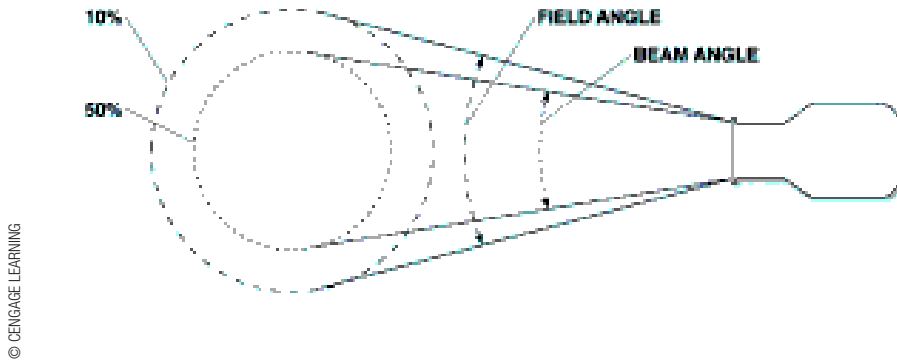
As noted earlier, lenses are traditionally identified by two numbers: diameter and focal length in inches or millimeters. In the theatre, it is most convenient to classify spotlights by the diameter of the light beam, measured in degrees. The figure used is technically the angle of the *field* rather than the *beam* (Figure 17-14). For example, a 6-by-12 ellipsoidal is called a “30 degree,” referring to the fixture's nominal field angle of 30 degrees.

The table in the box on the next page lists typical beam and field angles as well as appropriate throw distances for profile spots with various lens systems. Note that these figures are approximate and may not correspond exactly to the performance of any specific fixture. Consult manufacturer specifications before using.

Flattening the Field The box on the next page indicates beam and field angles that allow for good, smooth overlapping of two light beams. Ellipsoidal reflector spotlights

beam edge In a spotlight beam, the point where the light drops off to 50 percent of maximum intensity.

field edge In a spotlight beam, the point where the light drops off to 10 percent of maximum intensity.



17-14 Beam and Field Angles In a typical ellipsoidal reflector spotlight, 100-percent intensity is found at beam center. The beam and field angles are designated in degrees.

allow an electrician to change this by adjusting the light source in respect to the focal point of the reflector. By moving the lamp either in or out, an electrician can change the distribution of light from an extremely “hot center” to a “flat field.” The hot center concentrates a greater amount of light into the center of the beam. The flat field creates even intensity throughout the beam. This adjustment does not alter the effective field angle but does change the beam angle considerably

Ellipsoidal Reflector Spotlights

The Source Four line of enhanced ellipsoidals from ETC had a huge impact on the theatre lighting world. The Source Four was designed around a new high-intensity 575-watt lamp comparable in brightness to a standard 1,000-watt quartz lamp. The energy efficiency alone made the development of this fixture significant, but it also introduced the innovative “cool mirror” dichroic reflector and a rotating shutter assembly. A higher-intensity 750-watt lamp is also available. Altman, Philips Selecon, Robert Juliat, and other manufacturers have followed suit. Ellipsoidal reflector spotlights are available in several sizes for different applications. In general, the smaller fixtures use lower-wattage lamps and are designed for short-throw applications. For instance, Altman makes a 3½-inch fixture that takes a 500-watt lamp and is available with interchangeable lens barrels in 18-, 23-, 28-, 38-, and 48-degree field spreads. The Source Four jr™ (Figure 17-15a) uses the popular 575-watt HPL lamp and has options for spreads of 26, 36, and 50 degrees as well as a 25- to 50-degree zoom.



TOOLS OF THE TRADE ■ ERS Beam and Field Angles

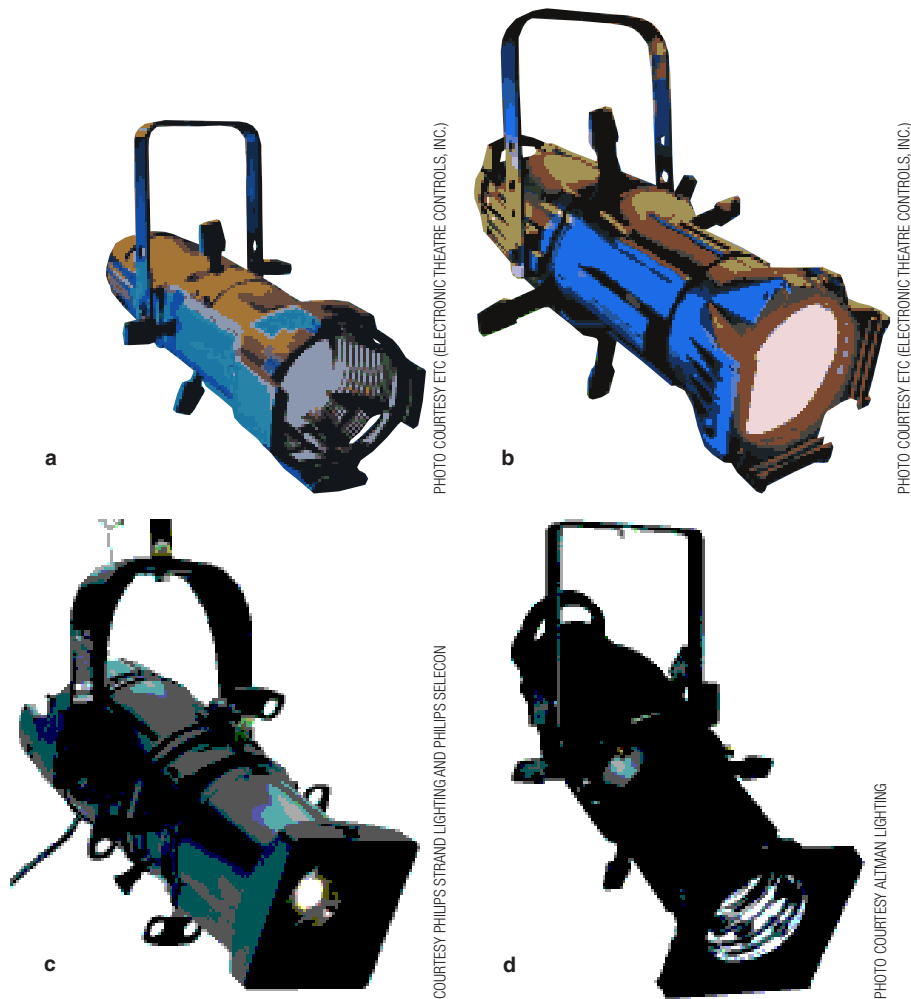
If the intensity of light from an ellipsoidal is considered in terms of percentages, and the beam's illumination along the center-line is 100 percent, the beam and field angles are defined as follows:

- *Beam angle* is the point where the illumination falls off to 50 percent.
- *Field angle* is the point where illumination falls off to 10 percent.

Fixture	Beam Angle	Field Angle	Throw
50-degree	33°	51°	12–20 feet
36-degree	25°	35°	15–25 feet
26-degree	17°	25°	25–35 feet
19-degree	15°	18°	30–45 feet
10-degree	9°	11°	40–60 feet

17-15 Modern Ellipsoidal Reflector Spotlights

- a** ETC Source Four jr™ spotlight. Smaller than the standard Source Four. Available in 26-, 36-, and 50-degree field spreads; takes a 575-watt lamp and an “M” size gobo.
- b** ETC Source Four® spotlight. Takes a 575- or 750-watt lamp and has a dichroic reflector and rotating shutters. Interchangeable lens tubes provide field angles of 5, 10, 19, 26, 36, 50, 70, and 90 degrees.
- c** Philips Selecon SPX. Available in 14-, 19-, 26-, 36-, and 50-degree field spreads; takes a 575- or 750-watt lamp.
- d** Altman Phoenix. Available in 5-, 10-, 19-, 26-, 36-, and 50-degree field spreads; takes a 575- or 750-watt HPL lamp.



By far the most popular size is the 6-inch ellipsoidal. As the box on ERS Beam and Field Angles indicates, field spreads range from a narrow 10 degrees up to a wide 50 degrees. ETC also makes lenses that provide 5-, 14-, 70-, and 90-degree field spreads. The 575- or 750-watt HPL (High-Performance Lamp) developed by ETC has become an industry standard (Figure 17-15). Larger 8- and 10-inch ellipsoidals have been replaced by 6-inch ellipsoidals with special lenses that can produce narrow field spreads of 5 and 10 degrees. These fixtures allow throw distances up to 100 feet (Figure 17-16).

The LED Profile Spotlight

Our prediction in the ninth edition of this text that the theatre industry was on the verge of a lighting revolution with the introduction of the LED light source has come to fruition in an amazingly short span of time. In the previous edition, we were able to point to a handful of LED wash fixtures that offered reasonably good color mixing but were not very bright. Today, we introduce the first of several LED profile spots which actually do compete with incandescent spotlights in terms of intensity.

In 2010, Robert Juliat introduced the first practical LED profile spot, the Aledin, which has now been replaced with the output-improved Zep Profile. Strong Entertainment Lighting followed with its Neeva LED profile and in 2012 ETC introduced its Source Four LED profile spot. As we go to press, Philips Selecon is introducing their version, the PL4 Profile (Figure 17-17).



PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)



PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)

17-16 Narrow Beam Ellipsoidal Reflector Spotlights

- a ETC Source Four® 10 degree spotlight.
- b ETC Source Four® 5 degree spotlight. Has all the features of a standard Source Four, with a long lens providing a 5-degree field angle.

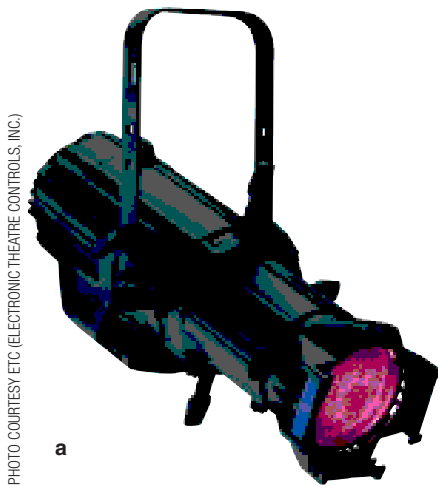
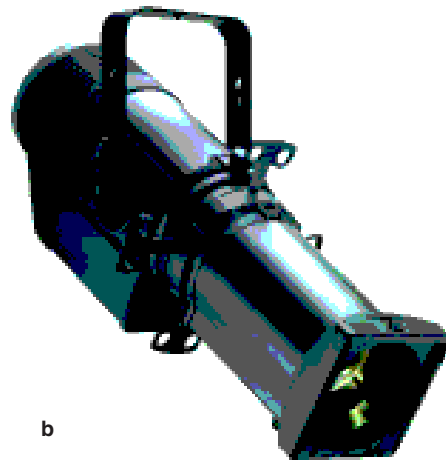


PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)



COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON

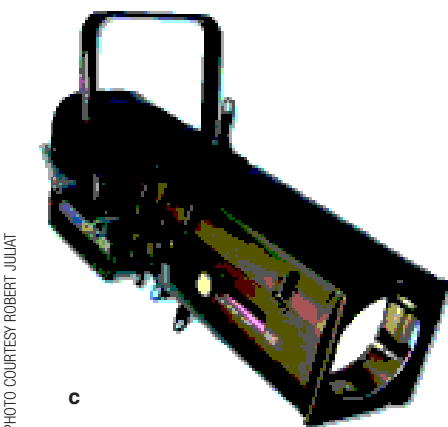


PHOTO COURTESY ROBERT JULIAT

17-17 Modern LED Profile Spots

- a ETC Source Four LED™ spotlight. Uses same lenses as the standard Source Four ERS and is available in three models: seven-color mixing Lustr+, 3,000 K Tungsten, and 5,600 K Daylight.
- b Philips Selecon PL4 Profile. Interchangeable lens barrels and two zoom models, three-color plus white LEDs.
- c Robert Juliat's Zep Series LED Profile Spotlight. Available in 3,000 K and 6,000 K color temperatures and three zoom lens systems: 11–26 degree, 16–35 degree, and 28–54 degree.

These new fixtures do not require dimmers, can be color-mixing, and consume so little power that up to ten fixtures can be connected to one 15-amp circuit.

Features Standard Source Four ERS lenses are compatible with their new LED profiles, the Philips Selecon PL4 Profile offers a similar full range of lenses plus two zoom-lens models, and the Robert Julian Zep Profile has three zoom-lens options. LED profile shutters and gobos work exactly like those in standard fixtures. The Source Four LED

daylight profile spot has a color temperature of 5,600 K while the LED tungsten fixture is 3,000 K. The PL4 Profile provides RGBW color-mixing as well as three white presets (3,200 K; 4,200 K; and 5,600 K). The Zep Profile is available in 3,000 K and 6,000 K.

Dimming The LED sources have built-in dimming capability controlled by a single DMX channel per color. Fixtures can be “daisy-chained” by in/thru XLR connectors and, when dimmed, the LED source exhibits no amber drift—the color stays true throughout the dim.

Power A new era in power consumption and distribution is upon us with the use of LED sources. The ETC Lustr+ color-mixing LED profile requires 128 watts of power while the Source Four LED tungsten and daylight use approximately 150 watts. Of course, this means that up to nine fixtures can be powered by a single 15-amp circuit. The Zep Profile consumes 185 watts, and the higher-powered PL4 Profile consumes up to 316 watts in the tungsten white setting. Power requirements are going to change from conventional 20-amp dimming circuits to simple 15- or 20-amp power circuits distributed throughout the theatre.

Color While the ETC Lustr+ isn't as bright as either the tungsten or daylight versions (3,825 lumens compared to 5,290 and 6,410 respectively at 26 degrees), it provides wonderful color variability by means of six colored LEDs plus white. The array of six colors (red, amber, green, cyan, blue, and indigo) can achieve nearly any spectral hue and produce good-quality color rendering.

Wash Fixtures

Wash fixtures are designed to do exactly what the name implies: wash the stage in light. The familiar Fresnel fixture is our traditional wash light with its soft beam which blends so well. Color-mixing LEDs have become extremely popular as a light source for wash fixtures due to their color versatility.

The Fresnel

Fresnel fixture Named after the inventor of its lens, the Fresnel is a theatrical fixture with a spherical reflector and the ability to change beam size. It produces a soft, even field of light.

flood focus The largest of the variable beam sizes of a Fresnel spotlight.

spot focus The smallest of the variable beam sizes of a Fresnel spotlight.

barn door An accessory for the Fresnel spotlight that attaches at the color-frame holder and allows for linear beam-shaping from four sides.

The **Fresnel** (pronounced Fra-*nel*) **fixture** gets its name from the inventor of its unique lens, Augustin-Jean Fresnel (1788–1827). This spotlight is simpler than a profile spot, consisting of only a spherical reflector, a lamp, and the Fresnel lens. As shown in Figure 17-18a, the Fresnel's spherical reflector returns the light back to the filament of the lamp. The light then travels on to the lens, where it is redirected into the cone-shaped beam typical of spotlights.

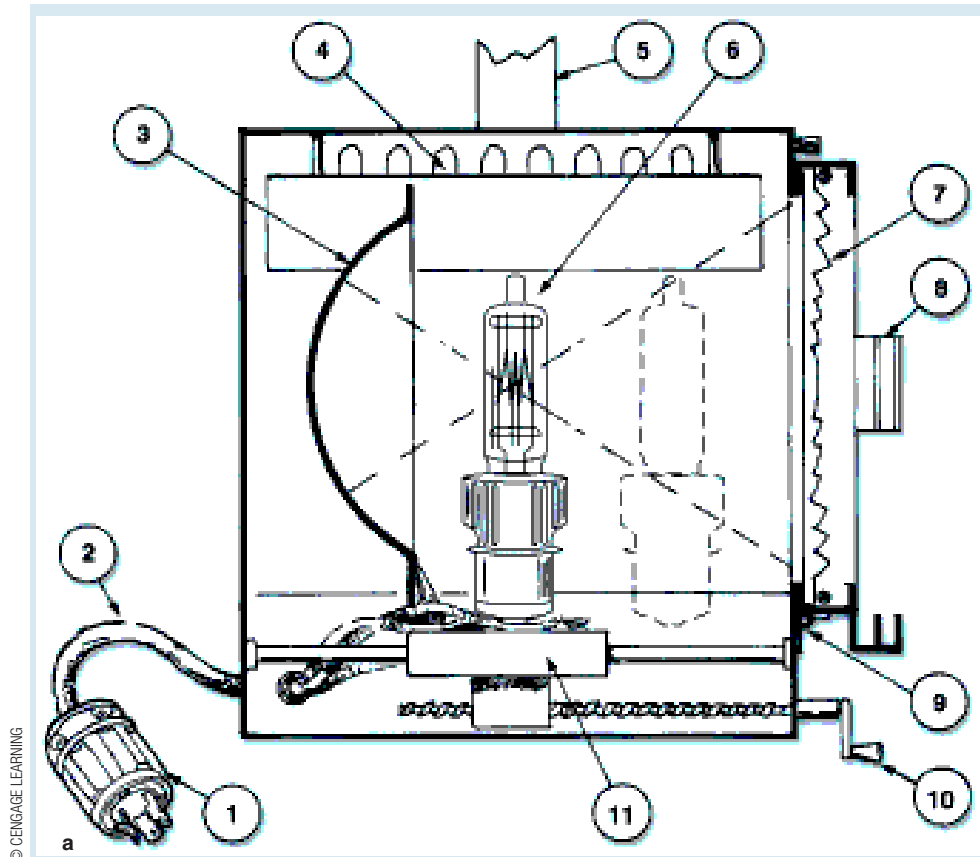
Spot and Flood Focus The Fresnel has variable beam-spread capability. As shown in Figure 17-18a, the lamp and the reflector are both mounted on a sliding carriage that can be moved closer to or farther from the lens. When the lamp is moved all the way forward, the light beam achieves its largest diameter, or **flood focus**. As the lamp is slid back away from the lens, the light beam becomes narrower. All the way back is called **spot focus**. Movement of the carriage is accomplished by means of a worm screw or a simple thumbscrew extending from the bottom of the fixture. The box lists field angles for typical 6- and 8-inch Fresnels at both spot and flood focus.



TOOLS OF THE TRADE Fresnel Field Angles

	Spot Field Angle	Flood Field Angle
6-inch Fresnel	15°	60°
8-inch Fresnel	10°	50°

Beam Shaping Although internal beam shaping is not possible, an accessory called a **barn door** can be added. Placed in the color frame holder of the fixture, a barn door effectively shapes the beam by cutting it in a linear manner from any of four sides (Figure 17-19a). Most barn doors can be rotated to allow cuts of any angle. The well-equipped theatre has barn doors for every Fresnel in its inventory.



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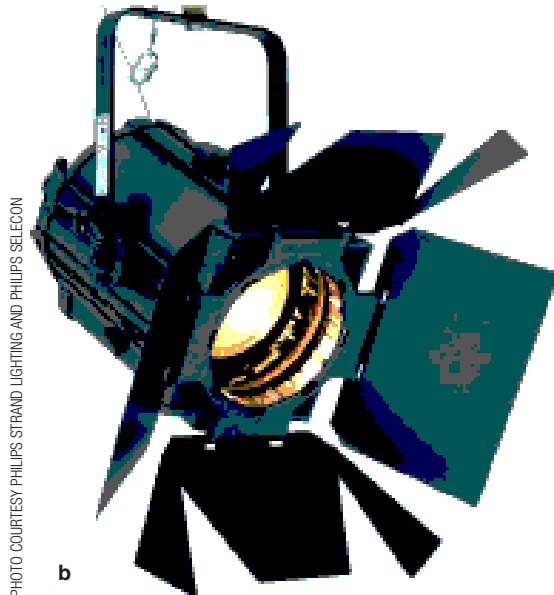


PHOTO COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON

17-18 Fresnel Fixture**a** Cutaway view of a typical Fresnel:

- 1 Twist-lock connector.
- 2 Rubber-coated lead wires.
- 3 Spherical reflector.
- 4 Ventilation holes.
- 5 Yoke.
- 6 Quartz lamp with a prefocus base.
- 7 Fresnel lens.
- 8 Color-frame holder.
- 9 Hinged lens front for interior access.
- 10 Worm-screw drive for moving the lamp and reflector carriage.
- 11 Movable carriage.

b 575- to 1,000-watt 6-inch Rama 7- to 50-degree Fresnel from Philips Selecon.

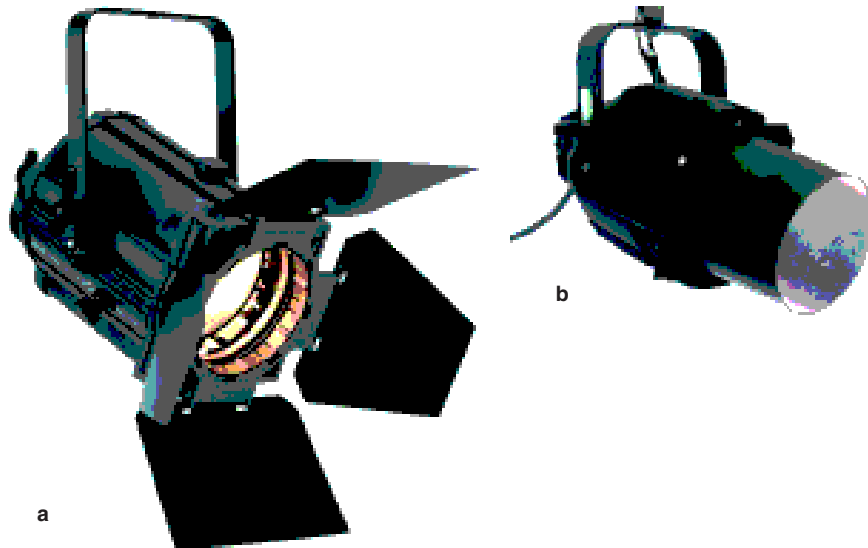
Many newer Fresnels are provided with a top locking device as part of the color frame holder. Even so, it is wise to “safety” a barn door to the pipe or yoke of the fixture by means of a small chain or wire rope. This is particularly important for larger Fresnels, whose barn doors are heavy and easily dislodged by scenery flying on an adjacent batten.

Another accessory, useful for any fixture but particularly valuable with a Fresnel, is the **top hat**, or *snoot* (Figure 17-19b). Painted flat black inside and out, the top hat controls lens flare by absorbing stray light refracted by the risers of the Fresnel lens. If a lens is in audience sight, light flare from it can be quite distracting; therefore, top hats are most often used in backlight and box boom positions.

top hat An accessory particularly useful with the Fresnel spotlight that attaches to the color-frame holder and reduces spill and glare from the fixture’s lens.

17-19 Fresnel Barn Doors and Top Hat

- a The four-way barn doors at the front of the fixture slide into the color-frame holder and allow for beam shaping.
- b A top hat reduces flare from the Fresnel lens.



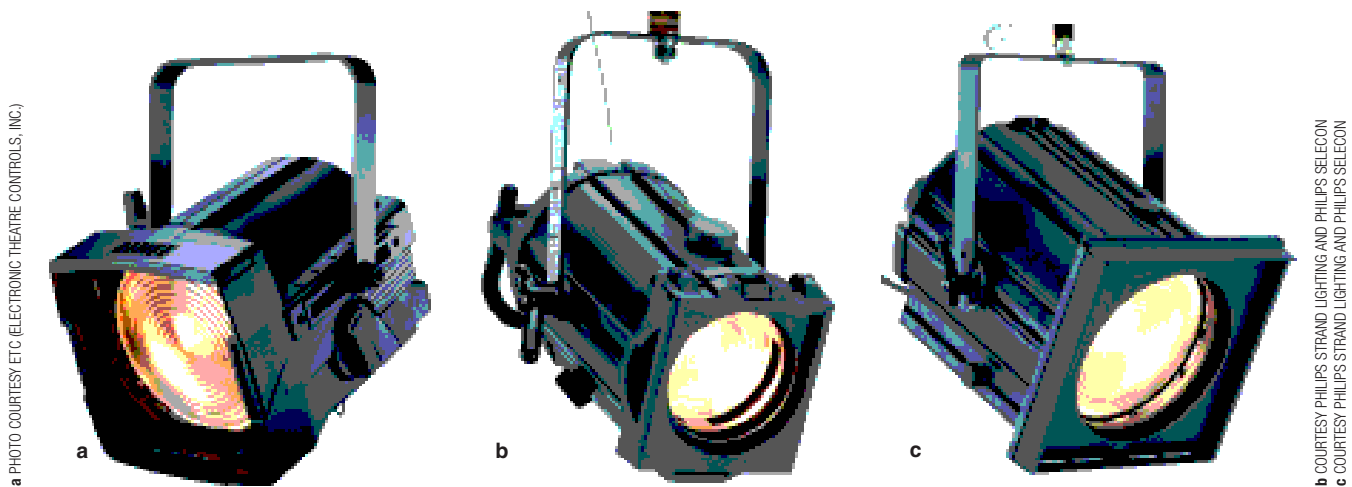
a COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON
b DRAXLIGHTING.COM AND BLISSIMAGING.COM

Fresnel Beam Characteristics The beam of light from a Fresnel is soft in quality with a smooth, even field. Its light appears to wrap around a figure; shadows are soft-edged, not harsh. The Fresnel is useful for “washing” walls and drops with smooth and even coverage. It is excellent in short-throw applications, blending one acting area with another.

The light from a Fresnel exhibits a good sense of direction. It can be used to simulate the soft quality of candlelight, an overcast sky, or any other diffuse source. In a proscenium theatre, the Fresnel’s usefulness is generally limited to overstage positions because its scattered beam characteristics cause too much illumination in the auditorium.

Fresnel Sizes Fresnel fixtures come in several sizes, the smallest of which has a 3-inch lens and takes up to a 150-watt lamp. Fondly called an “inky,” this little fixture does not possess much punch but is handy for tucking into small corners.

The most common Fresnel is the 6-inch, which uses 500- to 1,000-watt incandescent lamps. Short- to medium-throw distances of 15 to 25 feet are best suited to the 6-inch fixture. It is especially valuable for lighting upstage acting areas, where its soft-edged beam fades away on scenery (Figure 17-20).



a PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)

b COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON
c COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON

17-20 Modern Fresnels

- a ETC Source Four Fresnel™. Takes lamps ranging from 375 to 750 watts and has a beam angle range from 9 to 52 degrees.
- b Philips Selecon Acclaim. Has a 4 ¼-inch lens and takes a 575- or 650-watt lamp. Has a beam angle range from 6 to 60 degrees.
- c Philips Selecon Arena. Has an 8-inch lens, 2,000-watt lamp, and beam angle range from 7 to 60 degrees.

For larger stages and longer throw distances, the 8-inch Fresnel is recommended. It takes up to a 2,000-watt incandescent lamp and delivers a powerful beam with the typical smooth Fresnel pattern. Fresnel fixtures are also available with lenses from 10 to 20 inches in diameter and lamps of 5,000 or even 10,000 watts. Primarily found on a film location or in a television studio, these lights deliver a vast amount of soft illumination.

LED Wash Fixtures

White and color-mixing LEDs, discussed in the previous chapter, have formed the basis for numerous new theatrical fixtures. The primary attraction of LED wash fixtures is in their color-mixing. Color Kinetics, a leader in LED research and development and now a subgroup of Philips Lighting, developed the first practical color-mixing LED fixture for theatre use: the ColorBlast (Figure 17-21a). Today, many of the new LED fixtures are using the Luxeon Rebel LED emitters developed by Philips Color Kinetics.

Color-mixing The early ColorBlast used a three-color mixing system comprised of the primary colors (RGB) and could recreate many spectral hues, but was a bit weak



17-21 Philips Color Kinetics LED Wash Fixtures

- a** The Color Kinetics ColorBlast 12 TR contains 30 RGB light-emitting diodes and is DMX controllable.
- b** ColorReach TR Powercore. Available lenses: 8, 13, 23, 40, and 60 degrees. Size: approximately 29 × 20 inches. Weight: 75 pounds.

COURTESY PHILIPS COLOR KINETICS



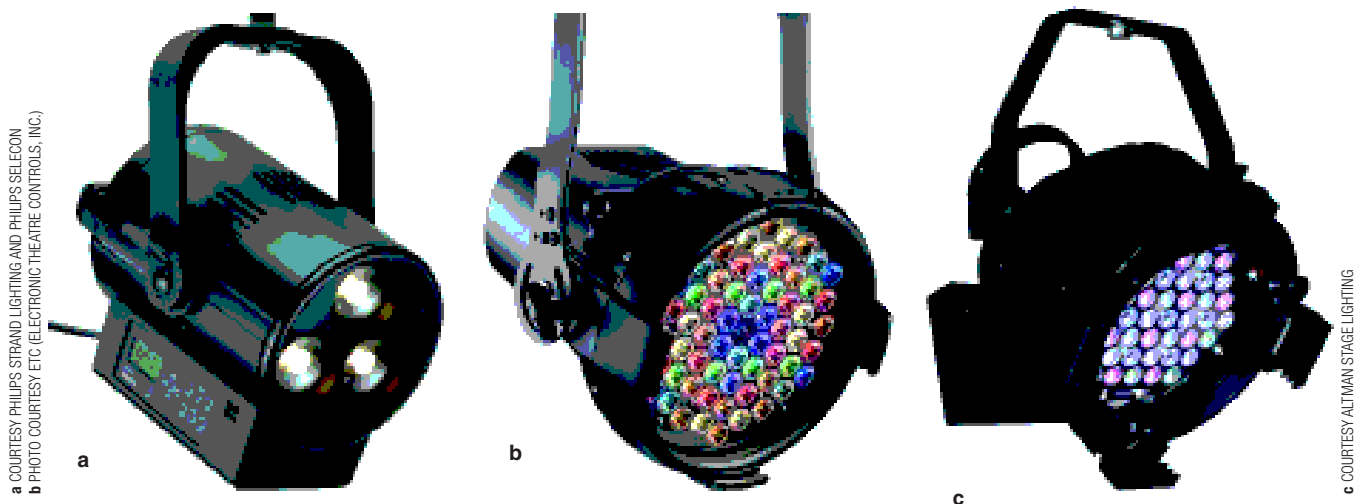
COURTESY PHILIPS COLOR KINETICS

in the amber range and some of the more subtle warm tints. Nonetheless, it was a great breakthrough in LED color mixing technology and was welcomed with open arms by theatrical lighting designers. Some LED fixtures still use a simple three-color mixing system, but many have added additional colors and/or white to allow greater color possibilities. The Philips Selecon PL3 LED is a RGBW fixture while ETC has decided to use what they call the $\times 7$ Color System (a seven-color LED array). The choice of which system to use is mostly dependent upon application. For instance, if front light and subtle toning is required, a larger array of colors would be preferable; if color washing or toning white light with color is the objective, a simple RGB system may suffice.

Features Just a casual stroll through a theatrical lighting trade show floor proves that there are numerous LED color-mixing wash fixtures on the market. Some are functionally similar to a Fresnel with a variable beam-spread and some act more like a PAR fixture, requiring a lens change to alter the beam size. However, the greatest disparity among today's fixtures is intensity—only a handful are bright enough to function well as color-wash fixtures in a theatre environment.

The ColorBlast Grown Up Not long ago, Philips Color Kinetics introduced two new LED color-mixing fixtures: the ColorBlast TRX and the ColorReach TR Powercore (Figure 17-21b). The ColorBlast TRX can be operated as a three-channel RGB or a five-channel RGB plus Amber (A) and White (W) fixture. It allows for far greater variation in color than the earlier ColorBlast TR and has an intensity of 1,577 lumens at its natural 10-degree spread. Its drawback as a theatre fixture is the rather convoluted mounting plate and hinge arrangement. The ColorReach mixes only the three primary colors but has a light output of 5,200 lumens at its 5-degree native beam angle. Its drawback is size and weight.

Philips Selecon PL3 LED This LED wash fixture acts very much like a theatre Fresnel. It offers a motorized variable beam spread from 15 to 55 degrees, has three RGBW color engines, and delivers a white light output of over 6,000 lumens. And it draws only 4.6 amps of power! Disadvantages: it requires a molded-yoke (long bolt) C-Clamp; the color frame holder is an optional accessory; and, while it provides for DMX pass-through, it does not provide an AC-out for daisy-chaining fixtures (Figure 17-22a).



17-22 LED Wash Fixtures

- a Philips Selecon PL3 LED, showing the 3 lenses. Bright, RGBW color-mixing, and remotely-controlled variable beam spread.
- b ETC Selador® Desire™ D60 LED luminaire. Wide range of color selection in four models with interchangeable lenses.
- c Altman Spectra Star PAR. Four models offer RGBA, RGBW, variable color temperature, and white light. Available with four PAR-like lenses.

ETC Selador® Desire D60™ ETC offers several color-mixing LED fixtures in the Desire line with the D60 being the brightest. Four color arrays are available: “Vivid”—using RGB plus orange, amber, cyan, and indigo LEDs for the most vibrant color range; “Lustr +”—with RGB plus amber, cyan, indigo, and white LEDs for more subtle tints; “Fire”—red, orange, amber, green, and indigo LEDs for higher output of warm colors; and “Ice”—RGB plus red, orange, cyan, and indigo LEDs for brighter colors in the cool range. The D60’s native beam is round with a field angle of 17 degrees. Lenses are available with a wide range of spreads and three different beam shapes: round, oblong (oval, similar to a PAR), and narrow linear (a very narrow oval). The D60 delivers up to 5,000 lumens depending on the model (Figure 17-22b).

Altman Spectra Star PAR As its name implies, the Spectra fixture was modeled after a PAR. It offers a choice of four lenses: very narrow, narrow, medium, and wide. It is available in four models: RGB plus amber, RGB plus white, 3K–6K variable color temperature, and white. At 100 watts it can achieve up to 1,000 lumens (Figure 17-22c).

Other Theatre Fixtures

In addition to profile spots and wash fixtures, theatre lighting uses various other fixtures for more specialized needs. These include:

- PAR and other parabolic reflector fixtures
- High-intensity discharge (HID) fixtures
- Follow spots
- Cyclorama and backdrop lighting fixtures
- Floodlights

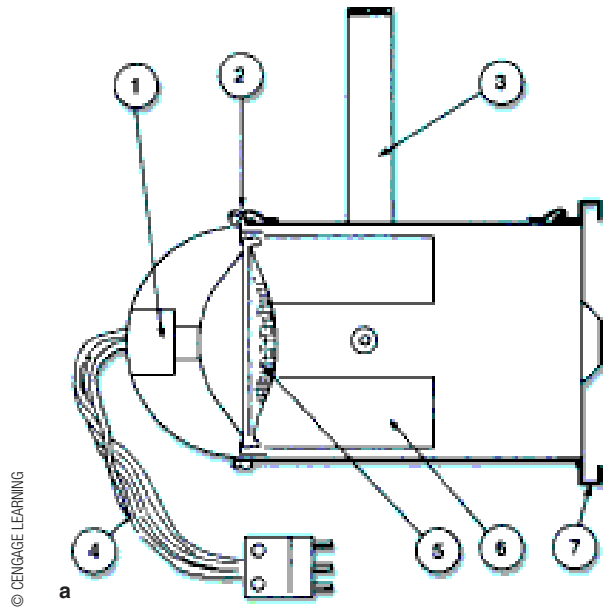
The PAR Fixture

The heart of a conventional **PAR fixture** is the parabolic aluminized reflector lamp, which was invented by Clarence Birdseye, the pioneer of frozen foods. The 1,000-watt PAR-64 version of this lamp soon became the mainstay of concert lighting. The PAR lamp is a self-contained fixture, lacking only a housing and a conventional plug. The PAR fixture’s extruded-metal housing, sometimes called a “PAR can,” secures the PAR-64 lamp in place by means of a large spring ring. It also acts like a top hat, absorbing some of the abundant flare caused by the built-in lens of the lamp (Figure 17-23). The butt of the housing hinges open to allow access to the lamp and socket. Color-frame holders, including a top safety clip, are fixed to the front of the fixture.

PAR fixture A lighting fixture using the parabolic aluminized reflector lamp. It produces a strong and harsh beam of light that is oval with soft edges. Its field is rather uneven.

The PAR-64 Lamp Incandescent PAR-type lamps are available in many sizes, but the 8-inch PAR-64 is the theatrical standard. The lamp’s parabolic reflector causes reflected light to leave the lamp in parallel rays. The lens serves only to redirect those nonparallel rays of light emanating from the front of the filament. A unique feature of the PAR-64 lamp is its oval beam, which is more than twice as long as it is wide. PAR-64 lamps are available with four different beam sizes, as shown in the box on page 377.

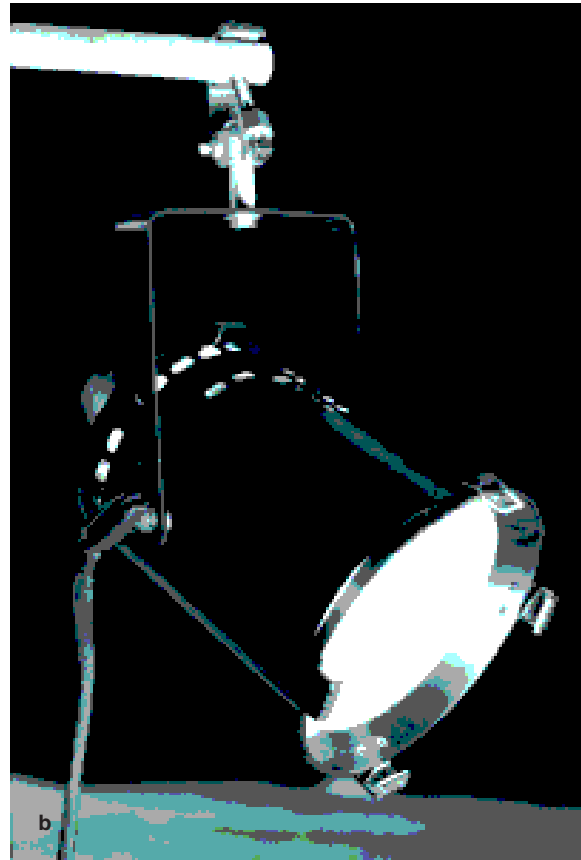
The Source Four PAR ETC developed a PAR-type fixture based on Source Four technology. It takes the Source Four HPL lamp, is more compact than a traditional PAR, and the 750-watt version is considerably brighter than a standard PAR-64. The fixture comes with four interchangeable lenses that mimic the beam spreads of a PAR-64 lamp. The beam is oval, and the lenses can be rotated (Figure 17-24).



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17-23 The PAR-64 Fixture**a** Illustration of the PAR fixture:

- 1 Lamp socket.
- 2 Rear latch allowing access to lamp.
- 3 Yoke.
- 4 Three-wire cord and pin connector.
- 5 1,000-watt PAR-64 lamp.
- 6 Light baffle.
- 7 Color-frame holder.

b An actual PAR-64 fixture. Note flare from the lamp on the inside of the housing.

b COURTESY OF THE AUTHORS

PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)



17-24 ETC Source Four PAR™ ETC Source Four PAR uses a 575- or 750-watt HPL lamp instead of the common PAR-64 lamp. Interchangeable lenses adjust the beam spread in a fashion similar to a standard PAR.

Because the Source Four PAR housing does not extend very far beyond the lens, flare can be a problem. If this is the case or if the lens is visible to the audience, it is best to add a top hat to the front of the fixture to cut down on the typical PAR lens flare. Standard 6-inch top hats and barn doors fit the Source Four PAR.

PAR Beam Characteristics The oval beam of light from a PAR fixture cannot be effectively altered or adequately controlled. The use of barn doors tends to dim rather than shape the beam of light. However, the direction of the oval can be changed by simply rotating the lamp within its housing or rotating the lens in the case of a Source Four PAR.

Because of the PAR fixture's parabolic reflector, the quality of its light is harsh. In contrast, the beam edge remains quite diffuse because of the lens. Because PAR fixtures deliver a very bright light, they make good back-lights. However, the field is uneven and of poor quality, and blending several PARs with one another is difficult. Like the Fresnel, the use of PAR fixtures is normally limited to overstage.

Relative to other stage fixtures, the PAR-64 fixture is nearly indestructible, making it ideal for touring. Its fairly inexpensive lamp lasts a long time as well.

Smaller PAR Fixtures PAR fixtures and their lamps are extremely economical and come in a variety of sizes:

- The 500-watt PAR-56 is useful for short-throw applications. It is available in three beam spreads.
- The 200-watt PAR-46 is smaller yet and is also available in three beam spreads.
- The 250-watt PAR-38 is 3¾ inches in diameter and is available in spot or flood.



TOOLS OF THE TRADE ■ PAR-64 Beam Sizes and Spreads

The Incandescent PAR-64 lamp is rated at 1,000 watts and is available in the following beam spreads:

Beam Size	ANSI Code	Beam Angle	Field Angle
Very Narrow	FFN	6° × 12°	10° × 24°
Narrow	FFP	7° × 14°	14° × 26°
Medium	FFR	12° × 28°	21° × 44°
Wide	FFS	24° × 48°	45° × 71°

However, the really useful small PAR is the PAR-16, which is only 2 inches in diameter (Figure 17-25). Sometimes called a “birdie,” it is used in television and film lighting and in the theatre for special applications. As small as it is, it can be mounted almost anywhere: on a piece of scenery, under the floor, or at the front of the stage (Figure 17-25). It is available with two different lamps: low-voltage MR-16 or standard voltage PAR-16. Either lamp provides three different beam spreads, but the MR-16 requires a voltage transformer and is more fragile than the PAR-16.

Other Parabolic Reflector Fixtures

The parallel rays of light produced by a parabolic reflector serve well as a harsh theatrical source of light. However, designers who use parabolic reflector fixtures have always had to contend with the diverging light rays that come out the front of the lamp.

The Beam Projector The *beam projector* is a parabolic reflector fixture without a lens. Pani’s P 1001 Parabolic Spotlight uses a 1,000-watt, 24-volt lamp, which has a very small filament, allowing superior control of its light. (Pani also makes a 250- and 500-watt version.) This is a bright, harsh source that has been used successfully as a short-range follow spot (Figure 17-26).

High Intensity Discharge (HID) Fixtures

HID lamps are arc sources that provide great intensity and light with a high color temperature. However, arc sources vary a great deal in terms of the color makeup of their light and, therefore, how they render color onstage. Some of the better arc sources are HMI (heavy metal iodine), metal halide, and xenon. Generally, xenon is too unstable for small lighting applications, but HMI and metal halide sources are common in automated fixtures and follow spots. In its quest for new and brighter sources, the theatre has begun to put HID fixtures to use. They have been available for several years in the form of PAR lamps and in Fresnel fixtures (Figures 17-27a and b). Both Strand and ETC manufacture a line of HID fixtures intended primarily for architectural use (Figure 17-27c).

Being arc sources, HID lamps require heavy, bulky ballasts and cannot be electronically dimmed. Use in the theatre requires the addition of a mechanical dimmer or **douser**, such as the Eclipse from Wybron (Figure 17-28).

Follow Spots

The traditional follow spot is a specialty fixture intended to produce a bright and concentrated beam of light over a long throw distance (Figure 17-29). Required for



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17-25 Shown is a MR-16 “birdie” capable of hiding in small places.

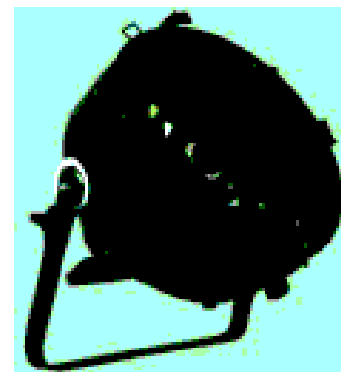
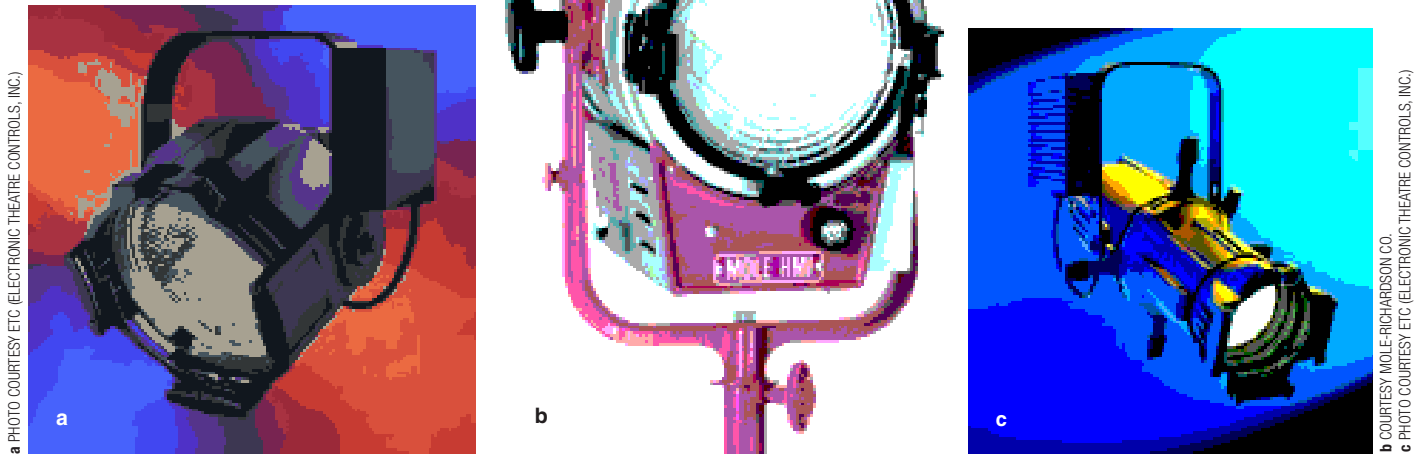


PHOTO COURTESY PANI PROJECTION AND LIGHTING

17-26 Beam Projector Pani’s P 1001 parabolic spotlight uses a 1,000-watt, 24-volt lamp and produces a highly concentrated beam of light.

douser A mechanical device, commonly found in follow spots, used to dim the light. Sometimes spelled *dowser*.



17-27 High-Intensity Discharge Arc Fixtures

- a** ETC Source Four HID PAR™ comes with a 150-watt metal halide lamp and four lenses, as does the standard Source Four PAR.
- b** Mole-Richardson's 8" HMI Solarspot Fresnel Type 6321 – 1,200-watts – 11- to 46-degree field.
- c** ETC Source Four HID™ 150w—all the features of a Source Four ERS, with an arc light source added.

a certain style of Broadway musical, the fixtures and their operators are most often situated at the very rear of the auditorium in the uppermost balcony. In concerts, multiple follow spots are used to highlight lead singers and musicians. In large venues, with some audience members several hundred feet away from the performers, extremely high levels of illumination are required for visibility. Sometimes as many as six or eight follow spots are concentrated on one performer.

An ellipsoidal reflector is used to help direct the light to an aperture similar to that of the ERS. An iris and a douser are located near the aperture. Also in this vicinity is a mechanism variously called a “damper” or a “clipper” or “curtain shutters” that chops the beam of light in a horizontal manner. Mounted in a long barrel in front of the aperture are lenses that can be moved to adjust beam size and sharpness. A device called a **color boomerang**, which normally holds six color filters, allows for rapid changes.

Truss-Mount Follow Spots The design of a follow spot depends on its function and throw distance. Some follow spots such as the Strong Truss Trouper, Lycian's M2 Short-throw, and Robert Juliat's LUCY 1449 are designed for truss mounting (Figure 17-30). They are used primarily in concert situations where the fixture and an operator work from a **lighting truss** located above the performance space. They also serve well for high-angle theatrical follow-spotting from overstage or ceiling positions:

- Strong's Truss Trouper uses a 1,200-watt HMI arc lamp and has interchangeable lens assemblies for short, medium, or long throws. The unit is only 29 inches long with the short-throw lens and weighs about 80 pounds.
- The Lycian M2 Short-throw can use either a 1,200- or 2,500-watt HMI arc lamp.
- The LUCY 1449 uses a 1,000-watt HMI lamp, is roughly 40 inches long, and weighs about 70 pounds.

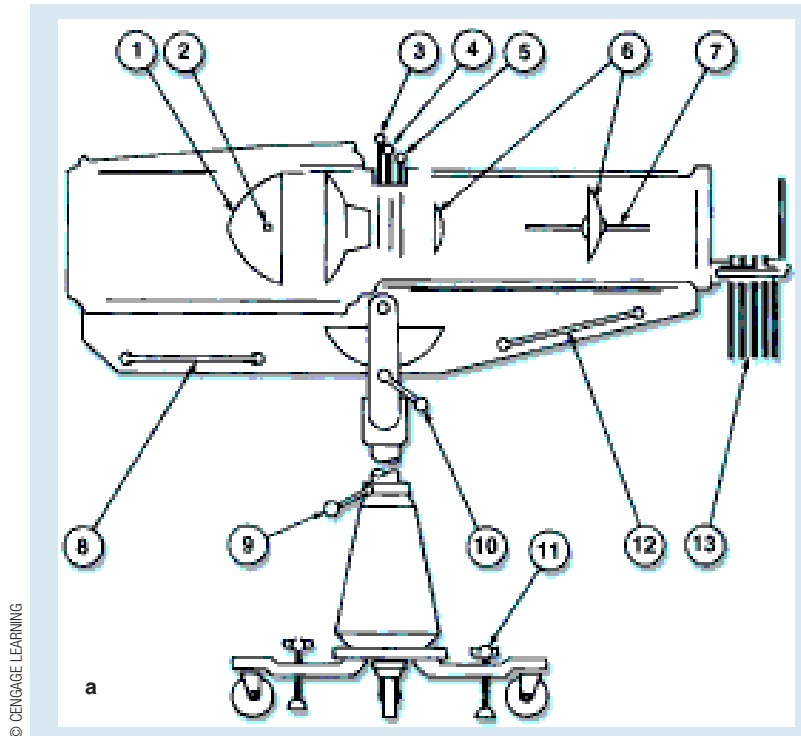
Long-Throw Follow Spots Long-throw follow spots must deliver a high-intensity light. Carbon arc, the original source, has been replaced by metal halide or xenon arc



17-28 Remotely Controlled Mechanical Shutter/Douser Wybron's LF Eclipse IT Shutter offers cross-fades up to 60 seconds long and 5 “fast cuts” per second.

color boomerang A device, located in the front of the barrel of a follow spot, that holds several color filters, allowing for quick color changes.

lighting truss Metal tubing, often aluminum, welded together in a crossing pattern for strength; used to support lighting equipment.



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PHOTO COURTESY STRONG ENTERTAINMENT INC.

17-29 The Follow Spot

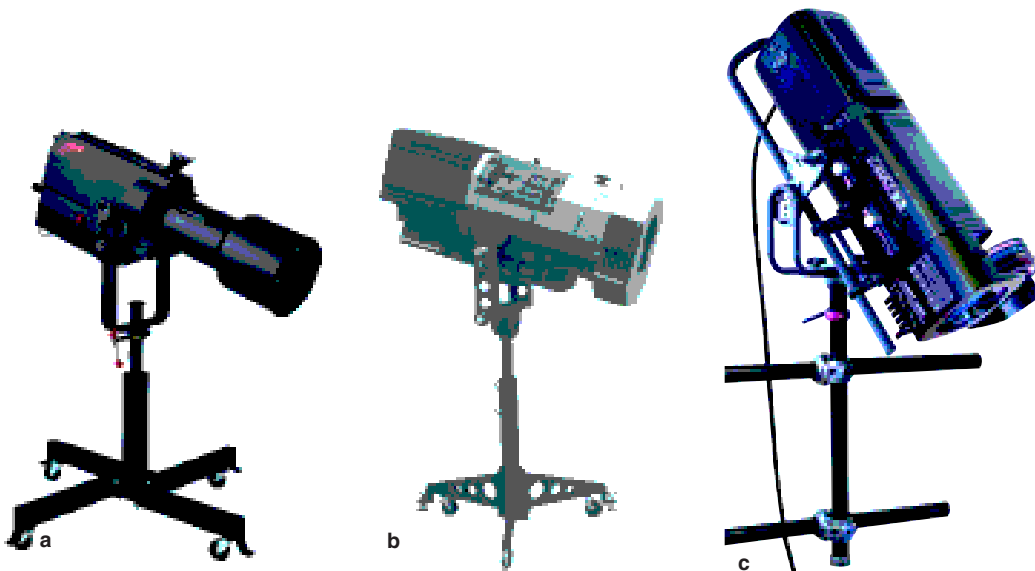
a The major components of a long-throw follow spot:

- | | |
|-------------------------------|---------------------------|
| 1 Reflector. | 8 Rear pan/tilt handle. |
| 2 Arc lamp source. | 9 Pan lock. |
| 3 Dimming control (douser). | 10 Tilt lock. |
| 4 Horizontal shutter control. | 11 Lock-down stabilizer. |
| 5 Iris control. | 12 Front pan/tilt handle. |
| 6 Lens system. | 13 Six-color boomerang. |
| 7 Zoom track. | |

b Strong Super Trouper with a xenon arc lamp.

lamps. Several companies manufacture theatrical follow spots including Strong, Lycian, Altman, and Robert Juliat.

- Strong’s Super Trouper II (Figure 17-31a) is intended for touring. It is smaller, lighter, and brighter than previous Super Troupers. It can take up to a 2,000-watt xenon lamp, has a beam angle of 4 to 12 degrees, and throws up to 400 feet.



a PHOTO COURTESY STRONG ENTERTAINMENT LIGHTING
b PHOTO COURTESY LYCIAN STAGE LIGHTING

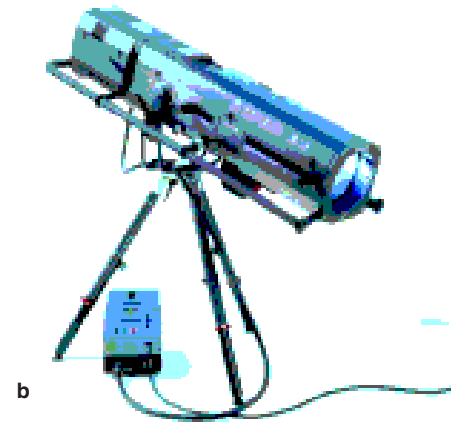
c COURTESY OF ROBERT JULIAT

17-30 Truss-Mount Short-Throw Follow Spots

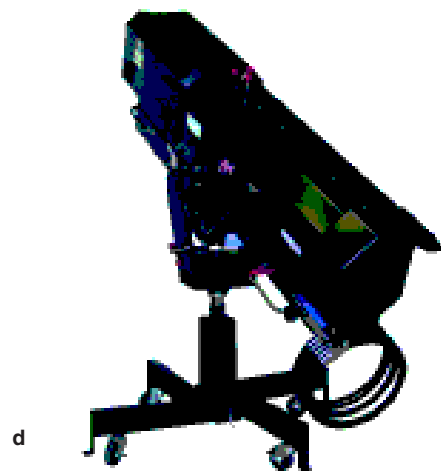
- a Strong Truss Trouper.
- b Lycian M2 Short-throw.
- c Robert Juliat LUCY 1449.

17-31 Long-Throw Follow Spots

- a Strong Super Trouper II.
- b Robert Juliat CYRANO 1015.
- c Lycian Super Star 2.5.
- d Strong Gladiator IV.



a PHOTO COURTESY STRONG ENTERTAINMENT LIGHTING
b COURTESY OF ROBERT JULIAT



c PHOTO COURTESY LYCIAN STAGE LIGHTING
d PHOTO COURTESY STRONG ENTERTAINMENT LIGHTING

- The CYRANO 1015 follow spot from Robert Juliat uses a 2,500-watt HMI lamp and has a beam angle of 3 to 8 degrees (Figure 17-31b).
- Lycian Stage Lighting's Super Star 2.5 (Figure 17-31c) uses a 2,500-watt metal halide lamp. It has a template and effects slot and is recommended for throws up to 400 feet.
- Strong's Gladiator IV (Figure 17-31d) uses an extremely bright 4,500-watt xenon lamp. It weighs in at a hefty 310 pounds (without the power supply) and is recommended for throws up to 550 feet.

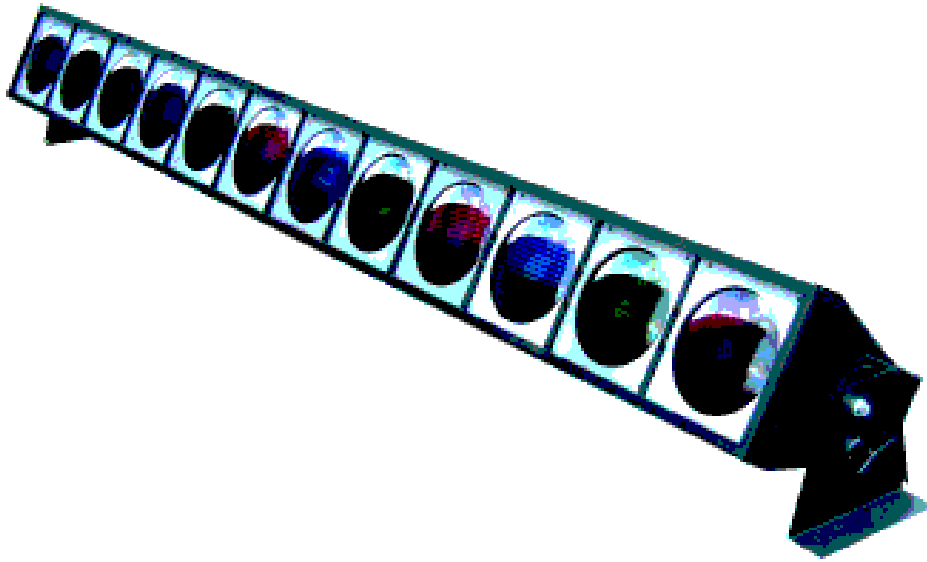
Cyclorama and Backdrop Lighting Fixtures

Lighting large surfaces such as cycloramas or scenic drops requires specialized equipment. The lighting fixture must be able to project a “wall” of light over a considerable distance while maintaining a smooth and even field. Drops are most often lit from above, although occasionally from below also.

Conventional Striplights One form of stage-lighting fixture that predates electricity is the **striplight**, which is a line of light created by multiple sources—formerly candle or gas—placed adjacent to one another. Standard striplight lamps are usually wired in three or four color circuits. In a three-circuit, twelve-lamp striplight, the first, fourth, seventh, and tenth lamps operate together. A great variety of color can be attained by placing different colored filters in each circuit and mixing them by controlling their respective intensities. The lamps must be close together so that their various colored beams will blend.

striplight A row of lamps in a single housing used to create a wide and even wash of light; commonly used to illuminate backdrops.

COURTESY TIMES SQUARE STAGE LIGHTING



17-32 Reflector-Lamp Striplight A 3- or 4-circuit R-38 striplight available in 6- or 8-foot lengths from Times Square Stage Lighting.

For many years, the basic type of striplight was the 6-foot section containing twelve PAR-36 or R-40 150-watt lamps. Modern fixtures of this type take 120- or 250-watt PAR-38 spot or flood lamps (Figure 17-32). With their common screw bases and built-in reflectors, these lamps produced a broad and relatively smooth sheet of light. The PAR-38 flood is used for shorter throws and the spot for longer. Although one can still purchase striplights designed to use these or similar lamps, other light sources have proven to be more efficient.

Other conventional striplights use one of two light sources: **quartz strips** take elongated quartz lamps, and **ministrips** use low-voltage MR-16 lamps.

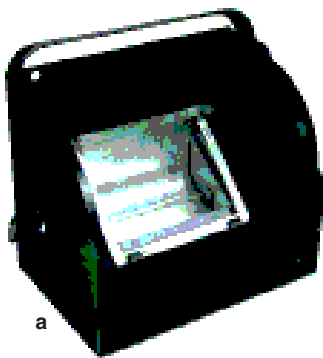
- The Series 720 Broadway Cyc uses a 1,500-watt quartz lamp and is available in 1- to 4-cell models, each 14-inches wide. It has an asymmetrical reflector which provides an even wash of light from top to bottom of the cyc (Figure 17-33a).
- The ministrip shown in Figure 17-33b takes 12-volt MR-16 lamps rated from 35 to 75 watts. They are available in narrow, medium, and wide spreads for different throw applications. The fixture itself has a very low profile and, therefore, is ideal for groundrows.

quartz strips Striplights using long quartz lamps.

ministrips Striplights using MR-16 lamps.

LED Striplights Color-mixing LED sources are a natural for theatrical striplights. With the new higher-powered LEDs, intensity is no longer an issue, and they are so easy to use that there is little reason to have anything else—they are the fixture of choice

COURTESY TIMES SQUARE STAGE LIGHTING

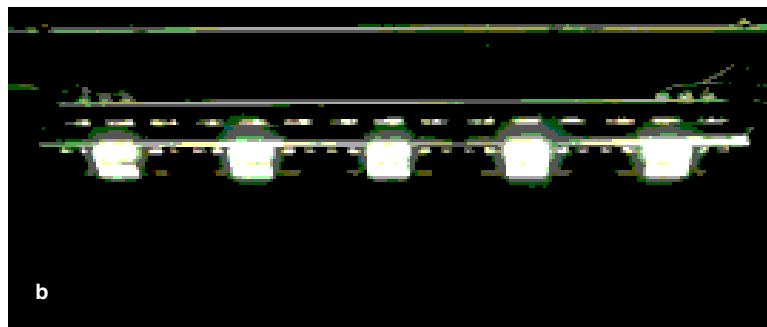


a

17-33 Conventional Striplights

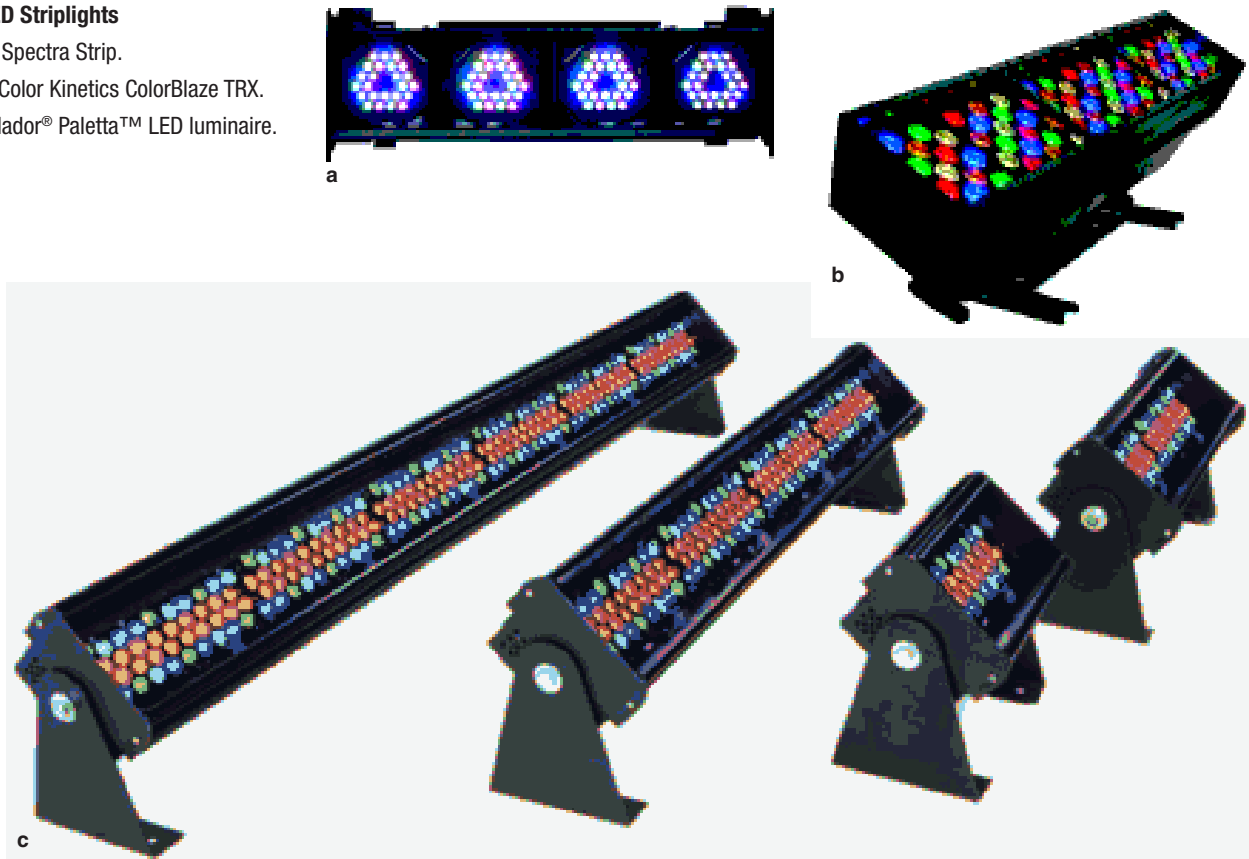
a Times Square Series 720 Broadway Cyc.

b A 3-circuit MR-16 ministrip.



b

COURTESY OF THE AUTHORS

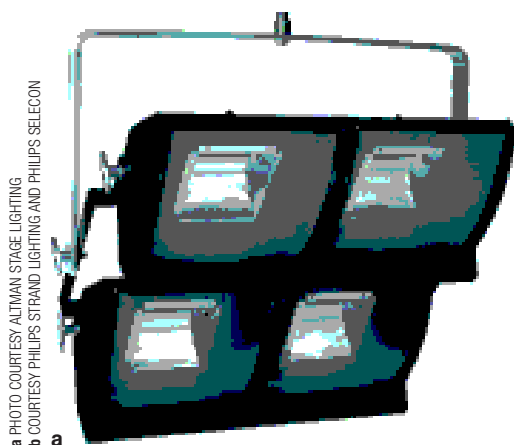
17-34 LED Striplights**a** Altman Spectra Strip.**b** Philips Color Kinetics ColorBlaze TRX.**c** ETC Selador® Paletta™ LED luminaire.

a COURTESY ALTMAN STAGE LIGHTING
b PHOTO COURTESY PHILIPS COLOR KINETICS
c PHOTO COURTESY ETC (ELECTRONIC THEATRE CONTROLS, INC.)

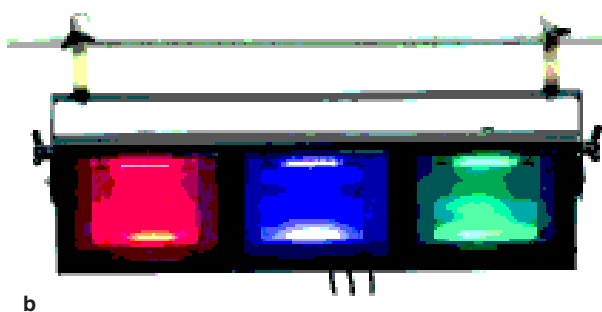
for groundrow applications. Although the initial cost of LED striplights is higher than conventional strips, they rapidly pay for themselves: lamp life is greatly increased, power consumption is greatly reduced, and there is no color filter expense. Many companies manufacture LED strips:

- The Altman Spectra Strip is a RGBA color-mixing strip available in 2-, 4-, and 6-foot lengths with 4, 8, or 12 compartments respectively. The 6-foot model is 600 watts and stands 9 1/2" high on the floor. It is available with all white LEDs also (Figure 17-34a).
- Philips Color Kinetics makes the ColorBlaze (RGB) and ColorBlaze TRX (RGB or RGBAW). The ColorBlaze is available in 4- or 6-foot lengths each controllable in 6-inch sections. Each section has a 300-lumens output with a native beam angle of 10 degrees. The TRX version is available in 2- or 6-foot lengths with a light output of 3,500 lumens per foot, also with a native 10-degree beam spread. Multiple lenses are available (Figure 17-34b).
- ETC manufactures the Selador® Paletta™ with a 40-emitter seven-color LED array per cell. Each cell is 11 inches long and fixtures are available in lengths of 11, 21, 42, and 63 inches. Its native beam spread is 26 degrees and a variety of horizontal and vertical spread lenses are available. On the floor, it stands 11 inches tall (Figure 17-34c).

Conventional Cyclights With the advent of the quartz lamp came a superior new design in cyclorama and drop lighting fixtures. Colortran was the first manufacturer to develop what they called the Far Cyc. Although each manufacturer uses a different trade name for its particular fixture, they all use 1,000- to 2,000-watt quartz lamps and are available with one to four lamp compartments per section. As can be seen in Figure 17-35, the reflector (called a “push” reflector) is curved in an inverted J shape to project more of the light to the bottom of a backdrop or cyclorama. These



a PHOTO COURTESY ALTMAN STAGE LIGHTING
b COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON



b

17-35 The Quartz Cyclight

- a Altman's Sky-Cyc takes a 1,000- or 1,500-watt lamp and is designed to throw more light to the bottom of a backdrop.
- b The Philips Selecon Hui Cyc takes a 1,000-watt lamp.

fixtures have a wide horizontal spread and can be spaced up to 12 feet apart if placed far enough away from the cyc or backdrop. However, they will typically need to be on 6- to 8-foot centers. Experience has proven that they must be hung at least 4 feet away from the cyc. For most applications, this innovative fixture is the best choice for lighting a drop from above.

LED Cyclight Philips Selecon has introduced a new RGBW LED cyclight, the PLCyc Luminaire. It has a unique reflector which will push the light down vertically and delivers over 2,000 lumens in white. Spacing is on 5-foot centers 4 feet away from the cyc. It is designed for cycs up to 16 feet high (Figure 17-36). Soon to follow will be a brighter fixture for cycs up to 30 feet high.

Floodlights

A floodlight, as its name suggests, is designed to throw a broad wash of light over a wide area. For many years, the **scoop**, an ellipsoidal reflector floodlight, has been the standard fixture for such a purpose (Figure 17-37). It has a reflector with a matte finish that distributes light smoothly and without a sharp edge to the beam. Scoops come 10 to 18 inches in diameter and take lamps up to 2,000 watts. A single fixture can light a fair-sized window backing. Banks of scoops have been used to light a drop and are especially useful for washing a curved surface.



COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON

17-36 LED Cyclight Philips Selecon PLCyc LED

scoop Ellipsoidal reflector floodlight used to create a bright, even wash of light.



SAFETY PRACTICE ■ Fixture Safety

The best way to prevent accidents from happening is to keep equipment in good operating order. Sticking shutters, bent bolts, and missing knobs or handles all frustrate an electrician and encourage mistreatment.

Almost all theatres require that lighting equipment mounted overhead be secured to the pipe with a safety chain or wire in addition to the C-clamp. Although the likelihood of a fixture falling during a performance is slim, nothing could be more unnerving for a theatre patron than to have an ERS fall from 30 feet and land nearby. To prevent accidents, the safety cable should ideally be attached to the fixture itself (as opposed to the yoke) and then around the pipe. A second cable clipped to the color frame will ensure that it stays with the fixture. Safety cables should be constructed of wire rope with rated hardware. Other theatres may require that a wire mesh separate all fixtures from the auditorium.

broad A rectangular floodlight that produces a bright and fairly even wash of light.

The **broad** is a floodlight borrowed from television and film lighting. They produce a wide field with even light distribution and take quartz lamps up to 1,500 watts.



COURTESY TIMES SQUARE LIGHTING

17-37 Floodlights An ellipsoidal reflector floodlight, often called a *scoop*, takes a 1,000- to 2,000-watt lamp and provides a soft and even wash of light.

Care and Handling

Although the care and handling of lighting fixtures naturally vary by situation and locality, certain good practices should be observed everywhere. By far the most important concern should be maintenance of equipment. Hanging, circuiting, and focusing are made much simpler if equipment is in good condition (see the box on fixture safety).

Older fixtures can be valuable if they are used properly and taken care of. Do not attempt to increase the light output of an older fixture by exceeding the recommended lamp wattage—they simply do not dissipate heat as well as newer equipment.

The single most important factor in fixture maintenance is keeping everything clean. Lenses can be washed in mild soap and water or with a good glass cleaner. Reflectors should be wiped with a soft cloth or washed with vinegar and water. Keep body parts as free of dust as possible. A clean spotlight dissipates heat better, thereby increasing lamp life and decreasing warpage. It also delivers more light.

Commonly needed spare parts such as shutters, knobs, and lenses should be kept on hand so that repair is not delayed by waiting for a parts order. Further, most fixture manufacturers require a fairly large minimum charge for parts orders and, adding insult to injury, take forever to fill the order.

Projected Effects, Practicals, and Special Effects

This chapter covers lighting and special effect elements integral in creating the magic of theatre. Lighting effects can be as subtle as a softly textured pattern spread across the stage to provide a hint of outdoors or as blatant as the brilliant flash of a lightning strike. Both effects and practicals (visual sources of light on stage) are exciting to produce, but take time and a good deal of planning.

Projected Effects

Projected effects are normally used to enhance the mood of a scene or create a sense of location. They are the responsibility of the lighting designer in collaboration with the director and scene designer.

Effects Machines

Theatrical effects are only limited by the designer's imagination. There are machines that produce specific effects such as snow, smoke, or lightning, and there are software and projectors that allow designers to create customized effects.

Projectors Effects can be achieved by using one of a variety of effects projectors or by attaching an effects module to the front of an ellipsoidal reflector spotlight.

- Rosco has the X24 X-Effects projector with a 5,000-lumen output and interchangeable lenses. It creates rippling light effects such as fire or water by means of two rotating glass gobos (Figure 18-1a).
- GAM markets the Scene Machine, which is available in three models: the 1,000- or 2,000-watt Incandescent and the 2,500-watt HMI. Lenses come in a range of focal lengths between 4 inches (50-degree beam spread) and 16 inches (12-degree beam spread). For simple slide projection, the Scene Machine takes a 4 × 5-inch glass slide. A number of effects machines that fit on the front of the lamp housing are available. A mechanical douser is necessary for dimming the HMI model. (Figure 18-1b).
- Rosco's INFINITY™ Gobo Animation Device rotator also slides into the color frame of an ERS and projects numerous effects. Available stainless steel disks are 16 ½-inches in diameter, with rotation speed and direction controlled at the unit (Figure 18-1c).

Drop-in Image Projection GAM, Rosco, and Apollo supply image projection devices that fit into the iris slot of an ERS. However, each one is quite different. GAM's Film/FX provides a continuous pattern loop motion. The unit is variable speed and a number of patterns are available from GAM (Figure 18-2a). Rosco's iPro Image Projector uses a customized plastic slide to project a still image. The slide can be created from any

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For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

PHOTO COURTESY ROSCO LABORATORIES



a



b

COURTESY GAM PRODUCTS, INC.

18-1 Effect Projectors

- a Rosco X24 X-Effects projector.
- b GAM Scene Machine.
- c Rosco INFINITY™ Gobo Animation Device.

PHOTO COURTESY ROSCO LABORATORIES



c

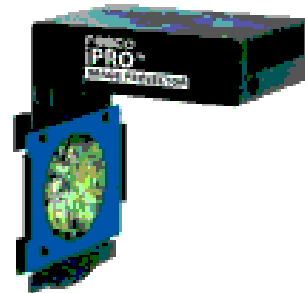
18-2 ERS Projection

- a The Film/FX unit from GAM projects a moving pattern from a metal loop dropped in the iris slot of an ERS.
- b Custom plastic patterns can be projected with an ERS using Rosco's iPro Image Projector.
- c Apollo's Smart Move® Vertical DMX projects moving text or images in a vertical plane.



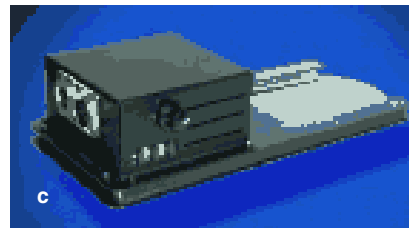
a

COURTESY GAM PRODUCTS, INC.



b

PHOTO COURTESY ROSCO LABORATORIES



c

COURTESY APOLLO

image in 24 hours by Rosco (Figure 18-2b). Apollo's Smart Move® Vertical DMX moves an image or text from side to side with adjustments for speed and dwell time. In addition, 17 pre-programmed effects are available and controlled by DMX (Figure 18-2c).

Many companies manufacture projectors that create effects. In selecting from them, pay close attention to the lumen output of the projector to make sure that it will be bright enough for theatrical applications.

More sophisticated automated projectors are discussed in Chapter 13, “Automation in the Theatre.”

Gobo Projection When a pattern is placed at the gate of an ERS, its image may be projected onto any appropriate surface. The clarity of the image can be adjusted from sharp to blurry by sliding the fixture's lens barrel. A great variety of textures and images can be achieved and projected from the numerous patterns available (Figure 18-3).

Further, gobos can be rotated at variable speeds to create moving texture. Double gobo rotation can create an astonishing array of subtle effects—experimentation is the key. All these rotators fit into the drop-in iris slot of an ellipsoidal reflector spotlight (Figure 18-4).

Custom glass gobos are becoming more popular for projected effects. The Broadway hit *The Producers* projected images of actor Matthew Broderick's face on the walls of the set using ellipsoidal reflector spotlights equipped with glass gobos. The cost is still a bit high but can be justified by the quality of the effect. These gobos can be made simply and quickly by any of the manufacturers.

Commercial equipment houses sell metal gobos in a variety of designs; some are realistic, but most are abstract patterns. Catalogs are available from Rosco, Lee, GAM, and Apollo and, of course, can be found online. Custom gobos can be made from any design at a reasonable cost. Be aware that gobos come in different sizes. Nearly all ellipsoidal



COURTESY APOLLO

18-3 Gobo Projection Several of the many templates, or “gobos,” available from Apollo.

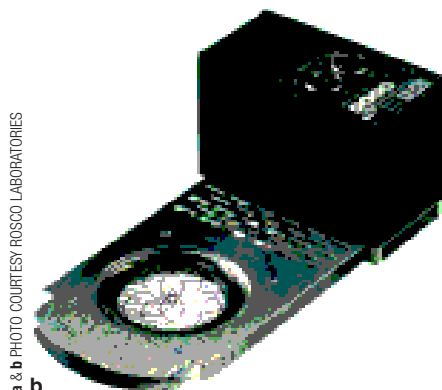


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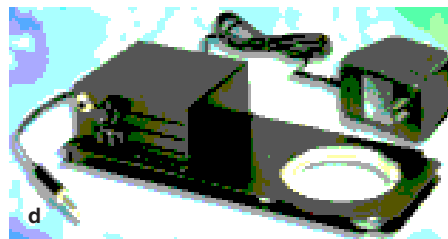
c

COURTESY GAM PRODUCTS, INC.



b

a & b PHOTO COURTESY ROSCO LABORATORIES



d

COURTESY APOLLO

18-4 Gobo Rotators

- a** Rosco's SimpleSpin™ is inexpensive. A single motor rotates two gobos in opposite directions and has variable speed control with the possibility of remote dimmer control.
- b** The Revo™ Dual Indexing rotator from Rosco allows for independent DMX control of both gobos.
- c** TwinSpin™ II from GAM allows for independent DMX control of both gobos.
- d** Apollo's Smart Move® DMX Rotator offers multi-direction rotation as well as additional motion effects.

PHOTO COURTESY X-LASER



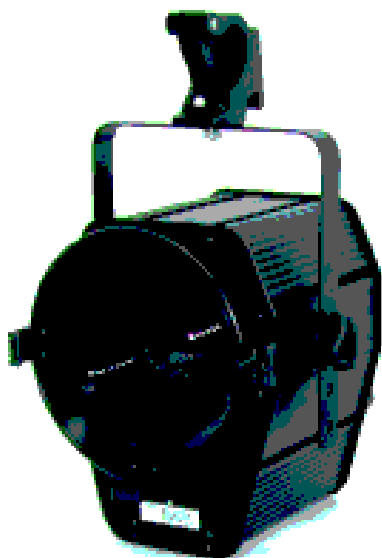
18-5 Laser Projection Shown is the Dimension 3-D laser from X-Laser. It is affordable, offers sophisticated color mixing, and is designed for touring.

reflector spotlights take a “B”-size gobo, but smaller instruments, effects projectors, and automated fixtures take smaller sizes. Refer to manufacturer catalogs.

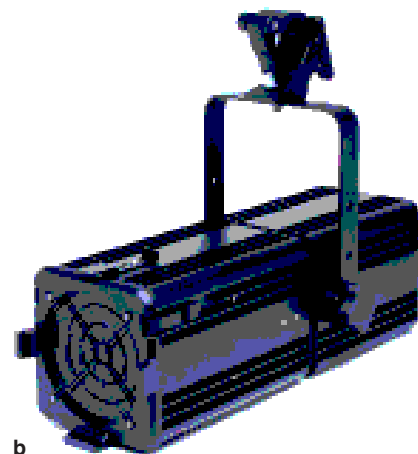
Patterns can be home-designed and cut from heavy aluminum foil or the bottom of a cheap metal pie plate. An especially useful effect is clouds cut from foil, which can be wrinkled slightly to give out-of-focus soft edges. Gobos made from such materials can last a long time in an ERS with a dichroic “cold mirror” reflector.

Laser Projection The term *laser* is an acronym of *light amplification by stimulated emission of radiation*. Laser light is unique because it consists of a single, in-phase wavelength of light. Since their development in the 1960s, lasers have appeared in hundreds of applications, ranging from surgical tools to supermarket barcode scanners. Lasers in the theatre have been used primarily for effects, one of the most popular being Tinker Bell in *Peter Pan*. Low-power lasers are harmless, but their light output is normally insufficient for stage use. Class II lasers (power up to 1 milliwatt) are usually bright enough but can cause eye damage if improperly used. Because higher-power Class III lasers can be extremely dangerous, their use is carefully regulated. *Holograms*, three-dimensional projections in space, can be achieved by laser projection. Lasers and their related control equipment are expensive to purchase or rent. One supplier of theatrical lasers is X-Laser (Figure 18-5).

Ultraviolet Projection Ultraviolet light is invisible to the human eye but causes certain materials to fluoresce, or glow brightly. Designers can create startling and exotic stage effects by using ultraviolet light and fluorescent paint or materials. For many years, the best source of ultraviolet light was the carbon arc follow spot equipped with a UV filter. Most arc lamps produce a high quantity of UV light. Therefore, placing a UV filter in front of an arc lamp creates a good projector. Several companies, such as Wildfire and StarLight, manufacture ultraviolet lighting fixtures as well as fluorescent paints and materials (Figure 18-6). Be aware that UV effects work best in the absence of any other light—even the dimmest of stage lighting will wash out



a



b

18-6 Ultraviolet Projection With special filters and lamps, fixtures can project high intensities of UV light.

- a Wildfire's 400-watt Long-Throw Spot/Flood has an adjustable beam spread from 8 to 59 degrees.
- b Wildfire's 250-watt fixtures are available as Long-Throw Flood, Spot, and Wide Spot.

a & b PHOTOS COURTESY WILDFIRE, INC.

the UV. It is important to conduct careful testing of lighting and reflective material before counting on UV as a significant effect in your production. Higher-powered UV fixtures from Wildfire or filtered arc sources are your best bet.

Practicals

Practicals are onstage, working light sources such as lanterns, lamps, fireplaces, and candles. The design of practicals is the responsibility of the scenic designer and the property department. The wiring and maintenance of such units is the responsibility of the electrics department. The lighting designer is always interested in the use of such practicals. Playwrights or scene designers specify the use of practicals for several reasons, including these:

- Enhancing the desired mood of a scene
- Indicating time of day, season, or period
- Reinforcing the reality of a scene or a location

Fire Effects

Often prohibited by fire codes, open fires on stage are rarely convincing and are difficult to control. However, all too often the demands of a script force the designer to put a fire in full view of the audience.

Hearth Fires If no flames are required from a hearth fire, a glow from lamps buried among burnt logs and scraps of color media will do nicely. A random chase or flicker effect programmed into the control console can make the hidden lamps pulse. One can also purchase flicker generators from several suppliers, such as GAM and Theatre Effects (Figure 18-7). If flames must be shown, several options are available. An old stage method that works well from a distance is to shine light on thin streamers of chiffon or China silk as they are blown upward by a small fan. A light smoke effect supports the illusion. LaMaitre makes a system called Fake Flame™ that projects colored light onto a vapor (Figure 18-8a).

Torches and Lanterns Torches are particularly difficult to simulate. If actual flame is allowed, a can of Sterno mounted in the top of a torch can be convincing. GAM makes a good, safe torch that burns solid paraffin, and Ultratec has a torch that is fueled by butane (Figures 18-8b & c). In addition, LaMaitre has a new product called Flame Paste. It is a flammable paste that burns an orange flame and can be applied nearly anywhere. Care must be taken!

Torches or lanterns burning oil or other liquid fuel must *never* be used on the stage. Their use is strictly against all fire rules and insurance regulations. They present a potentially extreme hazard. In case of an accident, the stage could become flooded with blazing oil. Fortunately, oil lanterns conventionally have glass chimneys that can be realistically smoke stained to hide a small light bulb. If the lantern needs to be carried about, a flashlight battery and lamp can be hidden in its base.

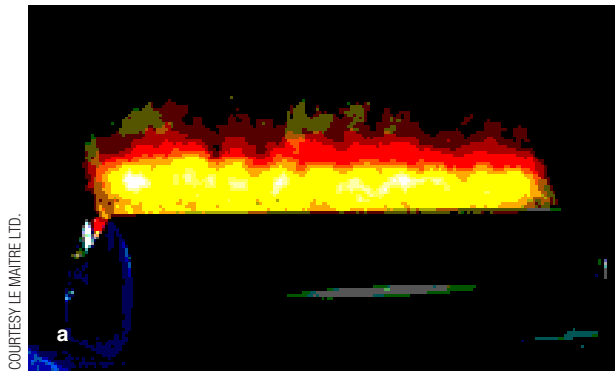
Small lamps can be colored by using Colorine, a commercial transparent dye manufactured by Rosco. Fabricators should always test the color first. Amber works well, and good results can also be achieved by mixing various colors.

Candles Unlike oil lanterns, candles, which usually extinguish themselves when dropped, are permissible on many stages if properly handled. In some locations they must be encased in transparent mica shields. Candles that self-extinguish when tipped



COURTESY GAM PRODUCTS, INC.

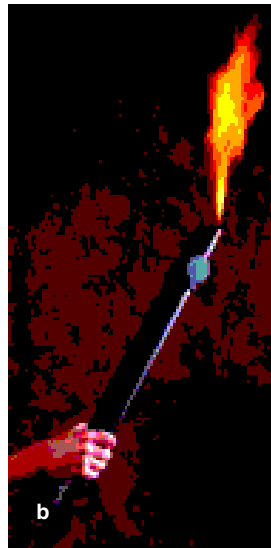
18-7 Flicker Generator Flickermaster DMX 8 from GAM can produce a random flicker or strobe effect.



COURTESY LE MAITRE LTD.

18-8 Fire Effects

- a Fake Flame™ from LeMaitre simulates a gas fire by projecting colored light on a wall of vapor.
- b GAMTORCH produces real flame using a solid fuel.
- c Le Torcia by Ultratec produces real flame using butane.



COURTESY GAM PRODUCTS, INC.

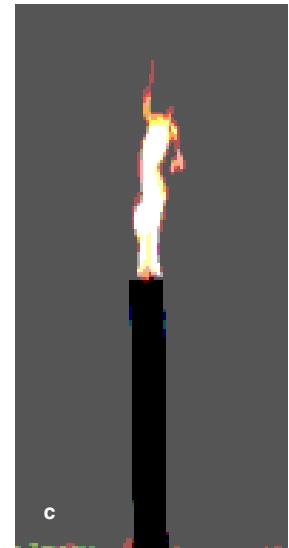


PHOTO COURTESY ULTRATEC SPECIAL EFFECTS

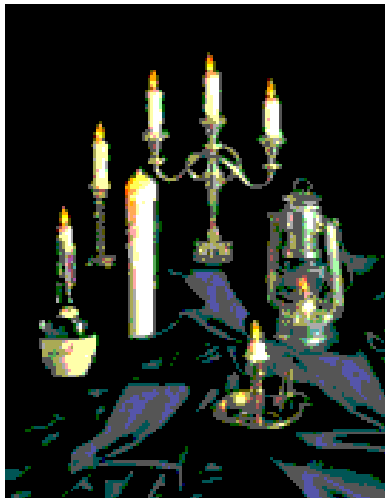


PHOTO COURTESY ROSCO LABORATORIES

18-9 Stage Candles Rosco's flicker candle looks realistic under most viewing conditions. It can be powered with a 9-volt battery or dimmed with the use of an AC adapter.

are available commercially. Local fire authorities should be consulted if there is any doubt concerning the legality of using candles onstage. In no case should candles be placed near draperies or other flammable materials.

Even if allowed, real candles probably should be avoided. Their bright light and flickering in an air current can distract the audience. A small battery and lamp or pencil flashlight hidden in a white paper tube can produce an effective simulation. In addition, Rosco and others make convincing flicker candles. Complete candles are available, or the flame module can be purchased for custom work (Figure 18-9).

Practical Lighting Fixtures

Chandeliers, wall sconces, table lamps, and similar household lighting fixtures generally offer no problems except for the intensity of the lamps actually used in them. This is particularly true when the fixtures have bulbs visible to the audience. If at all bright, they create an annoying, even blinding, glare. Bare bulbs must always be of extremely low wattage, and even then may have to be dimmed. Because little usable light emanates from such fixtures, supplemental stage lighting is needed to illuminate the actor properly. Designers should never depend on low-wattage fixtures to produce all the light that seems to emanate from them. However, if lamp bulbs are shielded by opaque shades, the glare is hidden, and extra-large-wattage lamps may be used to give a more realistic effect. An additional baffle over the bulb may be necessary to prevent an undesirable hot spot on the walls and ceilings of a box set.

Practical lamps should be controlled at the dimmer board. As such, when switching on a major motivating practical, an actor must hold the moment until the stage lighting responds. The light board operator cannot respond instantaneously to the actor's motion.

Special Effects

Uses of light that are not directly involved in lighting the actor or illuminating the scene are grouped in the category of *special effects*. Examples include explosions, fires, lighting, and strobe effects. Working out special effects is almost always enjoyable but can take a great deal of time. It should never be left as an afterthought.



SAFETY PRACTICE ■ Fire Safety

It is best not to use open flame onstage at all. If you absolutely must do so, take these precautions:

- Have a crew member with a fire extinguisher stationed on both sides of the stage ready to react to any emergency.
- If performers make any entrances or exits with open flame, establish the policy that anytime the flame is offstage, it is handled by crew only.
- Never use a filled oil lantern or any other liquid fuel onstage.

Moon and Stars

Creating a believable moon and stars is not as easy as it might seem. A gobo or effects machine can be used for either front or rear projection. A good full moon can be created by using a Fresnel to form the outer edge in conjunction with an iris ellipsoidal forming an inner disk.

Stars can be quite effective but are tricky to handle. Even tiny “twinkle” lights appear as great blobs of light against a dark sky-drop. One can, however, paint or tape the bulb so that only the very tip of the envelope is exposed. If a dark blue or black scrim is hung a few feet downstage of the drop, it will help cut excessive brightness and hide the wiring to the star bulbs.

Another method of creating a good star field is to punch small holes in a black drop and shine light on a white bounce drop located upstage. If a shimmer curtain is placed between the star field and the bounce drop, a wonderful twinkling effect can be achieved.

By far the best stars are created by using fiber optics. A light source located at one end of a tiny thread of glass is conveyed the length of the thread and emitted with little loss of intensity. Bundles of these threads can be sewn onto a drop with their ends arranged to create a wonderful star field. The drawback to fiber optics is their expense.

Lightning

Many scripts call for lightning, which can be produced by several methods depending on the desired effect. A convincing display of forks of light springing from the sky is quite difficult. However, one can achieve distant effects through either gobo or slide projection. Fortunately, presenting only great bursts of high illumination will usually suffice. Luminy's, a Hollywood company, manufactures a line of extremely bright lightning generators called Lightning Strikes® (Figure 18-10).

Intense flashes of light can also be achieved by strobe lights, flashbulbs, or photoflood lamps. Today's strobe lights can be very bright and remotely controlled. Several companies—including Diversitronics and Martin—manufacture high-intensity strobe units, most with xenon arc sources (Figure 18-11).

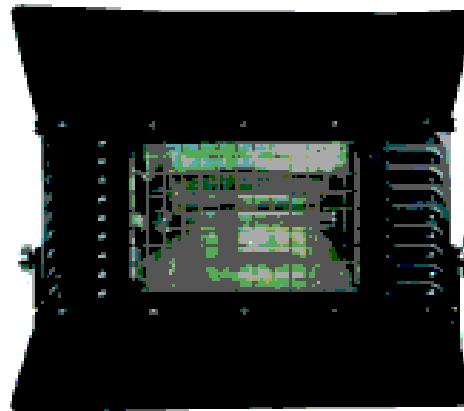
Large photoflash bulbs, although fairly expensive, create a wonderfully bright burst of light. The larger lamps can be mounted in homemade housings to eliminate unwanted spill and hung overstage. Smaller lamps can easily be placed about the stage and hidden by properties or scenery.

A final method is to switch several intense sources on and off rapidly. Momentary contact switches or a control board's “bump buttons” work well for the switching. To be effective, lamps need to have small filaments that respond quickly. This indicates low voltage sources. However, 120-volt photoflood lamps can be quite effective. Two good choices are the 500-watt, medium screw base EBV (17,000 lumens; 3,400 K) or EBW (11,400 lumens; 4,800 K). Because color temperature of lightning is very high, use color-correction filters or select lamps around 5,000 K.

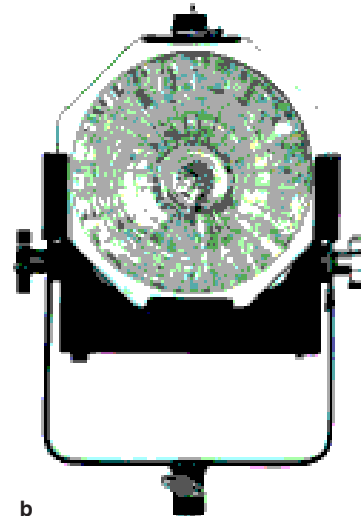
18-10 Lightning Effects Lightning can be produced in a variety of ways: arc-discharge units, photo flood lamps, or specialized lightning generators such as the Lightning Strikes fixtures shown:

- a Lightning Strikes by Luminy's Linear Lightning Generator available both fixed and focusable and in wattages from 25,000 to 250,000.
- b Lightning Strikes by Luminy's Parabolic Lightning Generator available in wattages from 8,000 to 200,000.

a & b COURTESY LUMINY'S SYSTEMS CORP.



a



b

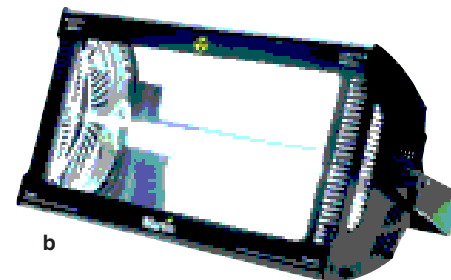
18-11 Strobe Fixtures Strobe lights, available in many sizes and intensities, create special effects; many types can also be used for lightning effects.

- a The Diversitronics DK-2000-DMC Dome Strobe Cannon delivers a 4,500-watt peak and offers DMX-controlled effects. It operates on a 15-amp circuit.
- b Martin's Atomic 3000 DMX has a 3,000-watt Xenon lamp with DMX-controllable flash rates.

PHOTO COURTESY DIVERSITRONICS, INC.



a



b

PHOTO COURTESY MARTIN PROFESSIONAL, INC.

flash pot A device made to hold and ignite a highly explosive powder for onstage special effects.

Explosions and Flashes

To produce explosive flashes from offstage, one can use the same general techniques for creating lightning. Sound can be added as appropriate. If the script calls for these effects to take place in view of the audience, a **flash pot** is necessary (Figure 18-12). A flash pot is a device that ignites a prepackaged cartridge or highly explosive powder called *flash powder*. Available from special effects supply houses, flash powder was once used as a light source for still photography. Suppliers of pyrotechnic devices and effects include Theatre Effects, Ultratec, Pyrotek, and LeMaitre. Use of homemade flash pots is illegal and extremely dangerous.

Atmospherics

Dry ice and smoke machines have been used in the theatre for many years to create effects intended to enhance the mood of a scene. The popularity of using smoke and haze in the air to accentuate light beams has led to the development of newer, safer methods of production.

There are three types of atmospheric effects: fog, smoke, and haze. Fog, as the name implies, is low-lying and clings to the ground. Smoke rises into the air and dissipates rather quickly. Haze fills the air and remains for a period of time depending on ventilation. The



a



b

a & b PHOTOS COURTESY LE MAITRE SPECIAL EFFECTS, INC.

18-12 Pyrotechnics Flash-pot systems are dangerous and should be used with great caution. Shown is a system available from LeMaitre.

a LeMaitre Prostage Standard Pod with Pyroflash Cartridge.

b Prostage Pyroflash Fire 8 Pyro Controller.



SAFETY PRACTICE ■ Flash-Pot and Smoke Safety

Flash pots are extremely dangerous. Serious injury can result if they are misused. Use only the safe, commercially available flash-pot systems, and always follow the directions carefully. Never fire a flash pot close to flammable materials or to people.

Some chemicals and materials that were commonly used in the theatre have been found to be unhealthy. Asbestos is one of these,

and another is ammonium chloride (sal ammoniac), used to produce smoke onstage. The use of any substance except pure ammonium chloride is harmful to the lungs and should be discontinued. In addition, even pure ammonium chloride must never be heated in contact with metal.

distinction among the three is blurred by manufacturers, who tend to generically label their machines “fog machines.”

There are three ways to produce fog:

- chilled smoke
- dry ice
- liquid carbon dioxide

Chilled smoke is produced by attaching a common smoke machine to a chiller unit. The chilled smoke stays low for a period of time but rises as it warms, destroying the fog effect. However, if the smoke is made very cold by chilling it with liquid carbon dioxide (CO_2), the effect can be very convincing.

Dry ice is the old-school method of producing a fine fog effect, but it has drawbacks and limitations: dry ice production is very labor-intensive, the machine is big and bulky, it is noisy, and the dry ice itself can become expensive if much is needed.

By far the best way to produce a good fog is with liquid CO_2 . However, the machines are expensive and so is the CO_2 .

Fog Machines Solid carbon dioxide (dry ice) changes from its solid state to a vapor without becoming a liquid. The rapidity of the change is increased if the dry ice is exposed to hot water. Machines that produce dry ice fog are easily and cheaply built or can be purchased from various theatrical suppliers. To make such a machine, technicians

need only a 55-gallon drum, an electric immersion heater like those used in home hot-water heaters, and a wire basket to suspend the dry ice. When the water is hot, dry ice is dropped in, producing a good deal of fog. This fog can be directed over a short distance by using flexible dryer hose connected to a vent in the lid of the 55-gallon drum. Such fog gives a splendid effect, although it dissipates rather rapidly. When the dry ice is exposed to the water, it makes a loud bubbling noise. Store dry ice in an insulated cooler and avoid dry ice burns by wearing gloves when handling it.

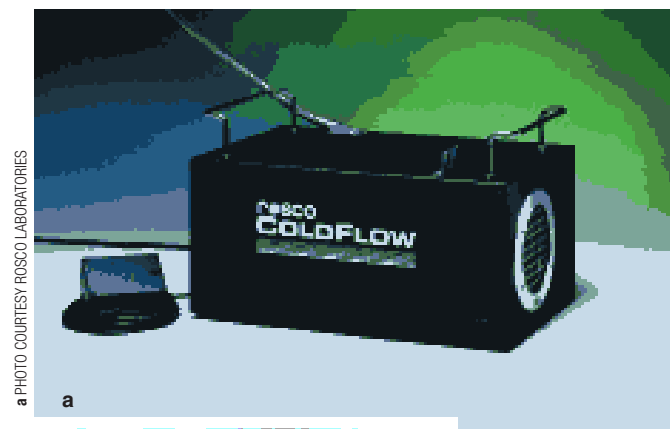
Using liquid CO₂ for either super-chilling smoke or in a machine made to manufacture fog is the best way to produce stage fog. The more economical method of the two is chilling the smoke from a smoke machine. However, standard smoke fluid doesn't produce the best fog because it doesn't dissipate when it gets warm; rather, it rises. If using a chiller, special fog solution is recommended.

Fog produced directly from liquid CO₂ is the best—it retains its low-lying quality for a good period of time and then dissipates. The equipment is bulky and expensive and the fog leaves a slightly damp floor. Fog machines are available from a number of manufacturers. Figure 18-13 shows three.

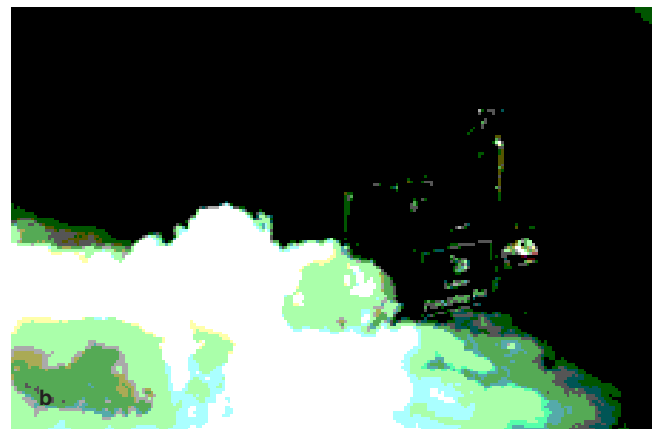
fog juice The liquid used in fog and smoke machines.

Smoke/Fog Machines Stage smoke is created by heating up a special liquid called **fog juice**. This smoke fluid is entirely water-based and leaves no residue with the exception of a tiny bit of moisture. The smoke rises slowly and only fills the air if a great quantity is produced. Hiding plastic hose about the stage is a good way to make the smoke appear wherever wanted. Smoke/fog machines are available in several models depending on density or quantity of smoke delivered over a period of time. All have the capacity for remote control, and some are quieter than others (Figure 18-14).

Haze Machines The difference between a smoke machine and a haze machine or hazer is that the latter uses either liquid nitrogen or a water-based liquid to create a long-lasting



a PHOTO COURTESY ROSCO LABORATORIES



b COURTESY LE MAITRE LTD.



c PHOTO COURTESY MDG

18-13 Fog Production Stage fog can be produced by dry ice, chilled smoke, or liquid CO₂.

- a Coldflow by Rosco attaches to a standard smoke machine to produce a low-lying fog. It converts liquid CO₂ into dry ice, which then cools the smoke.
- b FreezeFog Pro from Le Maitre is used in conjunction with a Le Maitre smoke machine to produce a dry ice effect.
- c ICE FOG Compact from MDG produces a low fog using liquid CO₂.



PHOTO COURTESY ROSCO LABORATORIES

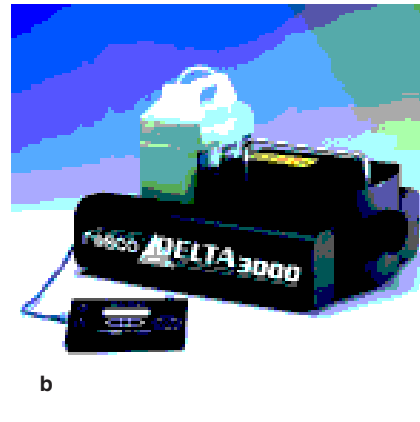


PHOTO COURTESY ROSCO LABORATORIES

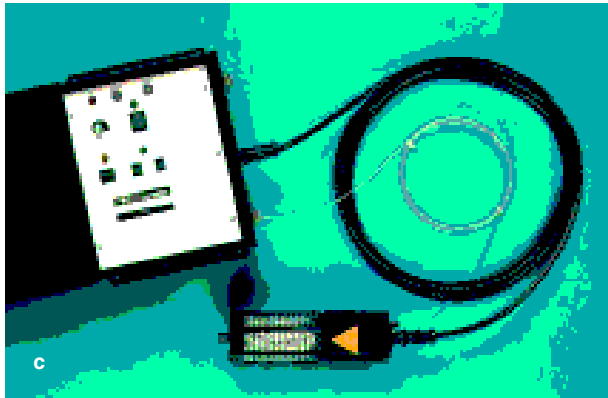
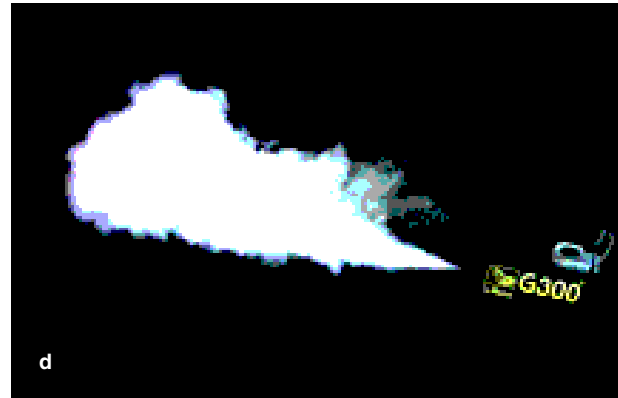


PHOTO COURTESY ROSCO LABORATORIES



COURTESY LE MAITRE LTD.



PHOTO COURTESY MDG FOG

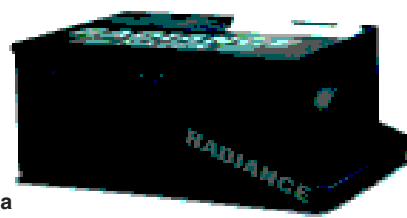


PHOTO COURTESY ULTRATEC SPECIAL EFFECTS

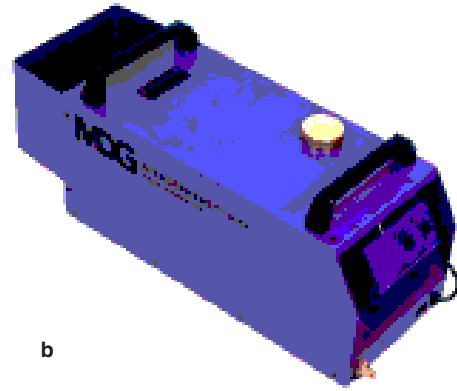
18-14 Smoke/Fog Machines Smoke rises into the air; fog hugs the ground. The model number of the following machines indicates smoke volume in cubic feet per minute.

- a** Rosco's Alpha 900 is an inexpensive portable machine that delivers an adequate quantity of smoke for many purposes. Remote control on/off switch only.
- b** Delta 3000 from Rosco produces a high volume of smoke or fog and has sophisticated DMX remote control.
- c** The PF-1000 Remote Head Fogger from Rosco is designed to be hidden, delivering smoke from unusual locations. Its heat exchange module is separate from the control module and only measures 9×3 inches.
- d** La Maitre's G3000 is capable of producing smoke or haze in large quantities.
- e** The MAX series from MDG is a line of quality smoke generators. Shown is the MAX 5000 with a very high output.
- f** Stage Fogger DMX from Ultratec delivers 4,000 cfm and has timed remote control.

PHOTO COURTESY ULTRATEC SPECIAL EFFECTS



a



b

PHOTO COURTESY MDG

PHOTO COURTESY MDG



c

18-15 Haze Machines Haze machines produce a light smoke effect that remains suspended in the air longer than smoke.

- a Ultratec's Radiance Hazer has an internal fan that is DMX-controlled for good control over the haze.
- b ATMOSPHERE from MDG is a quiet machine that offers continuous or momentary haze emission.
- c theONE from MDG produces large quantities of haze or fog and is available in a touring version (shown).

haze in the air. Haze is not as dense as smoke and does not dissipate as quickly. Hazers are favored for concerts, which are often performed outside under poorly controlled conditions. Manufactured in a variety of types, hazers are more expensive than either dry ice or smoke machines (Figure 18-15).

Controlling Smoke Anyone using smoke of any nature on the stage is frequently faced with the problem of preventing it from flowing or blowing to where it is not wanted. Heavy fog that tends to hug the stage floor may easily spill over the apron into the auditorium—a touch that is seldom appreciated by the audience (not to mention an orchestra).

The lighter-than-air smoke that rises is subject to the slightest breeze or draft. A ventilator at the top of the stage house may draw it swiftly upward or a cross-draft may set up unwanted eddies and swirls. An exhaust fan that evacuates stale air from the auditorium can bring the smoke billowing into the house.

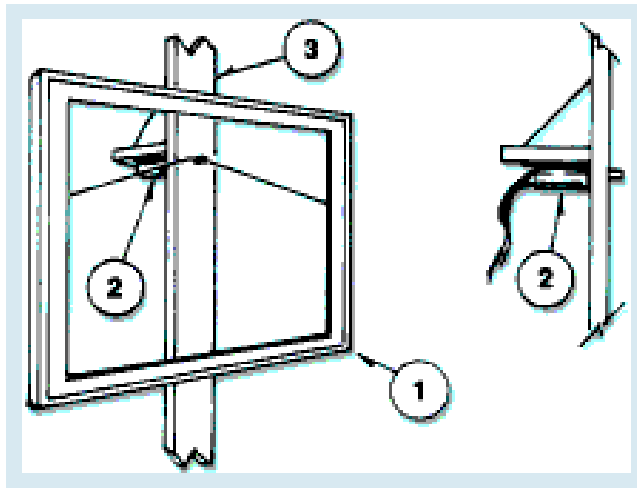
Each theatre and auditorium will affect smoke and fog in a different manner. The only way to discover how best to use these effects in a given space is to experiment in that facility under conditions that are as close to performance as possible.



SAFETY PRACTICE ■ Stage Atmospherics

Prolonged exposure to certain types of atmospherics can be unhealthy. Thus Actors' Equity has prohibited use of glycols and mineral oil (cracked oil)-based atmospherics for stage productions in which their members participate. Any indoor theatre production

should use only water-based fluid in fog or haze machines. For more information on atmospheric safety studies conducted by Actors' Equity, visit their website at www.actorsequity.org and click on "Document Library."



18-16 Electrically Triggered Effects In its off position, the spring-loaded pin is extended through the batten to hold the picture frame in place. When current is sent into the coil, the pin withdraws and the picture falls.

- 1 Picture frame in place.
- 2 Solenoid coil mounted on rear of picture batten.
- 3 Picture batten.

Electrically Triggered Effects

Designers and technicians are constantly searching for new methods of creating stage illusions. Breakaway properties, pictures falling off the wall, or any number of magical occurrences can be achieved with the help of a device called an **electrical solenoid**.

The magnetic power of the solenoid coil can be used to withdraw the support of a picture on the wall or as a trigger for any other breakaway (Figure 18-16). When a current is passed through its coil, the solenoid becomes an electromagnet that draws the spring-loaded center pin into the coil. When the circuit is broken, the pin is released with considerable force. Either action can be used to trigger a breakaway.

electrical solenoid An electromagnet that can be used for remote control of special effects.

9

Design: Choices and Process

Recall that a lighting design evolves from script analysis, good research, and collaboration. The primary objective is to illuminate the actor in a meaningful way, always supporting the playwright's story. To do so, the lighting designer must make many decisions concerning the type and position of the fixtures, their color, and their intensity.

Design Decisions

Before we go into the specifics of plotting the lights, we should review the following all-important design considerations: instrumentation, angle and direction, color, and control.

Choice of Fixture

As previously noted, a designer chooses a particular stage-lighting fixture because it comes closest to satisfying the three requirements of intensity, coverage, and quality of light.

Ellipsoidal Reflector Spotlights Adjustable beam spread and shaping, high intensity, and variable quality of light make the ERS the theatrical lighting designer's most valuable fixture (Figure 19-1). In addition, it is the only conventional instrument capable of creating texture and pattern by means of a gobo. An ERS is the logical choice for front-of-house applications and also serves well overstage.

Fresnels These fixtures deliver a soft light whose beams blend very well and therefore are ideal for short throws and upstage areas of a box set (Figure 19-2). Because of their variable beam-spread capability, Fresnels can be used over a wide range of throw distances. Attached barn doors allow for reasonably good beam shaping. The soft light of a candle, the quality of dusk or an overcast sky, or the scattered, almost shadowless illumination from fluorescent fixtures can be reproduced with a Fresnel.

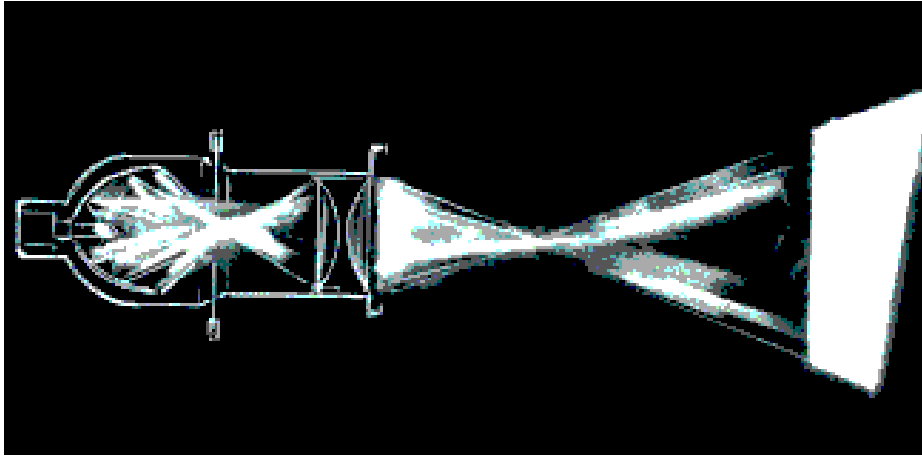
PAR Fixtures and Beam Projectors The light from these fixtures cannot be shaped, but their near-parallel rays come closest to resembling those of the sun (Figure 19-3). This quality can serve as a motivational source, while Fresnel and ERS light act as fill or bounce. The PAR-64 lamp, available in four beam spreads, has a lens that breaks up the light, softening the edge of its oval beam. Yet it still delivers sharp and intense light, harsh in quality. PAR fixtures make good back-lights and work well for color washing.

LED Fixtures Available in numerous types and sizes, current LED-source fixtures are most valuable for their color washing capabilities (Figure 19-4). Color is uniquely vibrant,

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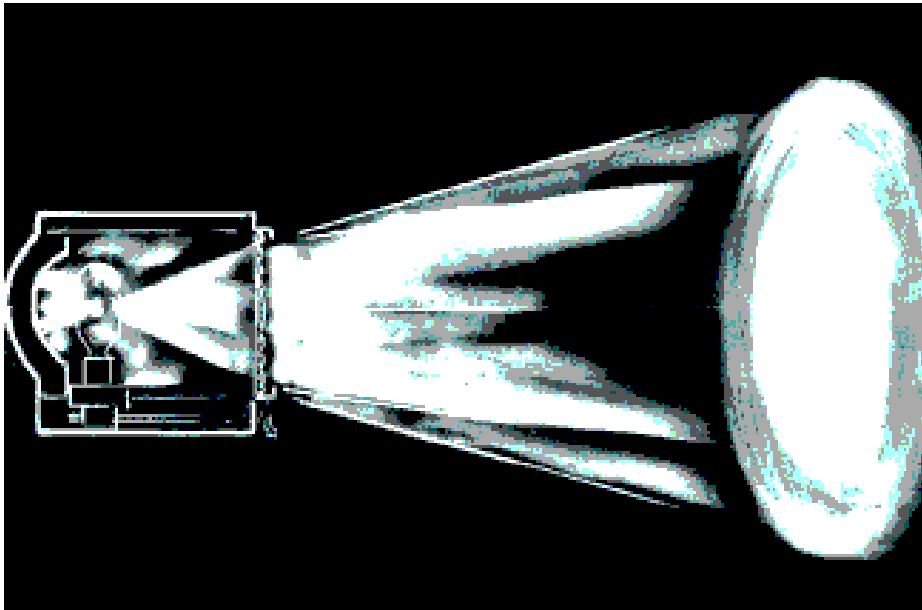
For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

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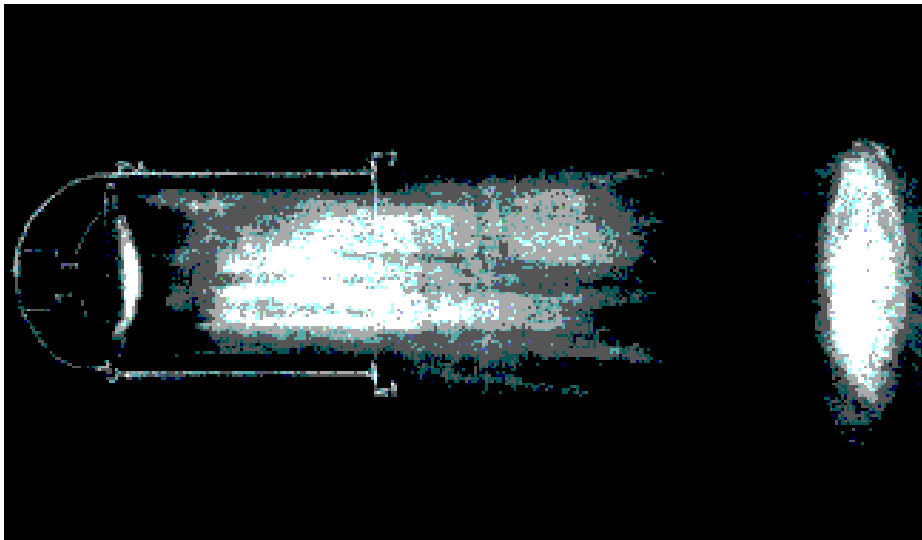
19-1 Choice of Fixture: The Ellipsoidal Reflector Spotlight The versatile ERS has internal beam shaping, can take a gobo, and comes in a variety of beam sizes.

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19-2 Choice of Fixture: The Fresnel The Fresnel spotlight can take barn doors for beam shaping and allows for variable beam spreads. It delivers the softest quality of light of all types of fixtures.

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19-3 Choice of Fixture: The PAR Fixture The PAR fixture is durable and bright, but its oval beam is impossible to shape. 1,000-watt PAR-64 lamps are available in four different beam spreads.



19-4 LED Automated Fixture
LED fixtures such as the Chauvet Legend 412 shown are excellent color mixing fixtures.

with RGB (red, green, blue) mixing most prevalent; however, more variety and subtlety can be achieved by adding secondary colors and white to the mixture. Variable beam size is commonly achieved by adding one of a variety of available lenses. The fixtures themselves can be difficult to mask and beam shaping is in its infancy.

Automated Fixtures Remotely controlled spot and wash fixtures with arc light sources produce an intense light that outshines the brightest ERS and PAR. They make superb specials because of their high color temperature or can act as intense and flexible side-lighting fixtures. Built-in gobo patterns and color versatility can instantaneously change the texture and the mood of a scene. Their flexibility alone makes them a light source worth considering. If very many are put to use, an automated fixture control console is necessary.

Choice of Distribution: Angle and Direction

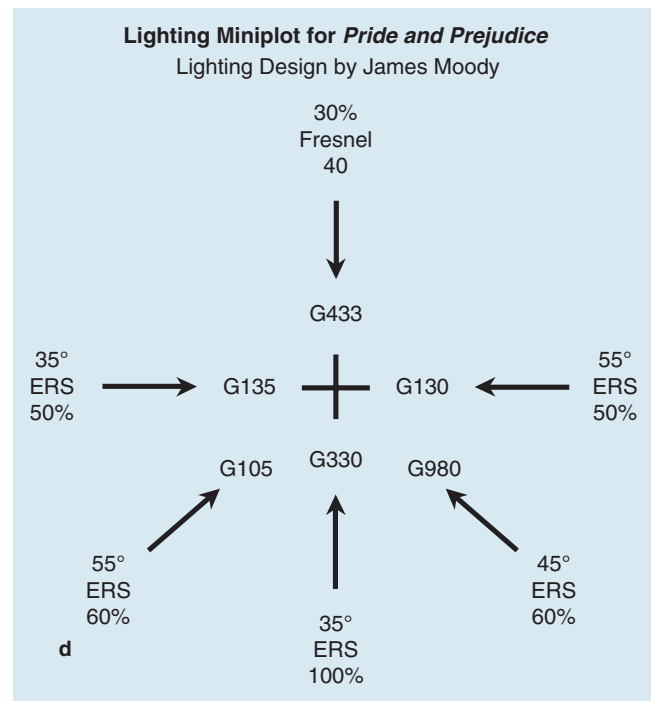
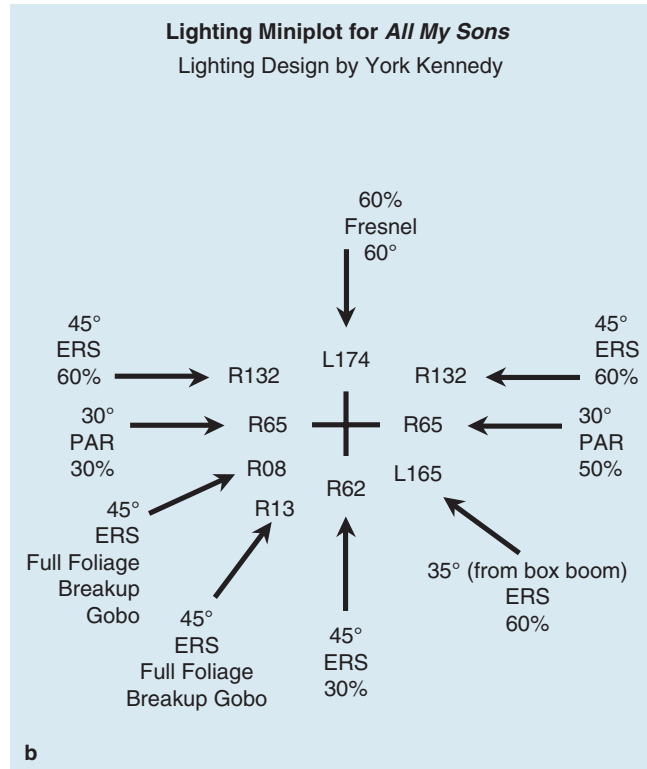
Altering the look of a scene through lighting was once primarily done by changing color. With today's increased instrumentation and control, new looks are readily achieved through changes in angle and direction. Distribution is probably the most overlooked

tool in the designer's palette. Careful shifting from a frontal to a more side direction of light or perhaps a low angle to a higher one can subtly influence the viewer's perception. *Angles* of light striking the performer can vary from below the horizon (as in footlights) to straight overhead. Most natural angles of light imitate nature and, for good visibility, their sources are located roughly 45 degrees above the horizon, somewhere in front of the actor. *Direction* of light is equally variable, from front- to side- to back-light. Angle and direction combine to create an infinite variety of light and shadow possibilities. For a change to be noticeably different, the new lighting angle or direction needs to be roughly 30 degrees from that of the old.

Front-Light Front-light provides visibility more than any other direction of light (Figure 19-5). The purpose of using two front-lights at various angles to each other, rather than a single unit straightaway, is to add dimension to the actor's body and face. The horizontal angle between these two sources can vary from 60 to 120 degrees. Less than 45 degrees horizontal between two sources acts much like a single source. More than 120 degrees horizontal results in a lack of blending. As the height angle of front-light is lowered, it tends to flatten features. As the angle is raised, features become sharper, with deeper shadows.

Side-Light Whether it is a bit frontal or straight out of the wings, side-light provides both variety and revelation of form (Figure 19-6). Low-angled side-light commonly used in dance lighting evenly lights the entire height of the body. Slightly higher-angled side-light (from 30 to 60 degrees) is often used for theatrical productions to avoid spill on the scenery. The designer can begin to use richer and more expressive colors in side-light to establish a motivational source or simply to set the mood of a scene. Exciting distribution variety can be achieved using a single front-light in combination with a side-light source.

Back-Light Primarily used to create three-dimensionality, back-light offers the additional benefit of separating the actor from the background (Figure 19-7). Colored light from the back is extremely useful in toning the stage floor, and the choice of colors can be more aggressive than in other kinds of lighting. Back-light textured by



19-5 Front-Light

- a** Front-light sculpts the actress beautifully in this production of *All My Sons* at South Coast Repertory Theatre. Directed by Martin Benson; lighting, York Kennedy.
- b** Mini-plot for the lighting of this scene from *All My Sons*.
- c** Beautiful warm front light helps to make the faces of these actresses radiant while at the same time revealing rich and true costume and sofa fabric colors. Scene from a production of *Pride and Prejudice* at Los Angeles City College-Theatre Academy Production. Lighting by James Moody.
- d** Mini-plot for the lighting of this scene from *Pride and Prejudice*.



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19-6 In this production of Brecht's *Edward II*, directional light from the side helps create line and focus. Scenery design, Robert Darling; costumes, Zelma Weisfeld; lighting, R. Craig Wolf.



COURTESY OF RALPH FUNICELLO

19-7 Back Light Back light creates tension, composition, and interest in this production of *The Madness of George III* at San Diego's Old Globe Festival Theatre. Directed by Adrian Noble; set design, Ralph Funicello; costumes, Deirdre Clancy Steer; and lighting, Alan Burrett.

gobos can be of great help in establishing a locale. Compared with front gobos, rear ones are not as noticeable on the actors; yet, they texture the stage floor well, creating a broken light through which the actors move (Figure 19-8). Back-light angles should be kept between 45 and 60 degrees—lower angles cause too much spill into the audience and higher angles act like top-light.

Choice of Color

Confidence in color selection requires experience—experience in traditional theatrical usage, experience in how colors mix with one another, and experience in how particular colors behave onstage. It is probably best to begin color exploration by using filters rather than color-mixing fixtures. In this way, individual shades and tints can be easily and accurately identified and analyzed. Lighting laboratories and color mix boxes help, but a lighting designer ultimately must experiment with the real thing. A masterful use of color is the goal of every lighting designer. Achieving that goal takes time.

Choice of Control

At the mention of “control,” one normally thinks of channel levels; however, **control** also includes the degree of specificity the light can achieve as well as the way channels are assigned to dimmers.

Channel control involves two types of decisions: the first is whether to “gang” two or more fixtures onto a single dimmer/circuit; the second is how to assign the soft patch. If made arbitrarily, such assignments can complicate the process of cue writing and level setting. Through

PHOTO BY MATT HAZARD, COURTESY MARY TARANTINO



19-8 Gobo Back Light Multi-colored gobo patterns texture the floor and actors in this production of *The Camouflage Project*, a new devised work at The Ohio State University's Thurber Stage. Project conceived by Lesley Ferris and Mary Tarantino; directed by Lesley Ferris and Jeanine Thompson; scenery, Dan Gray; costumes, Kristine Kearney; video design, Janet Parrott; and lighting, Mary Tarantino.

rehearsals, discussions with the director, and review of lighting-movement requirements, the designer can begin the necessary task of anticipating control needs.

Lighting the Actor

Lighting someone from various positions and angles is relatively simple if the subject remains in a fixed position. An actor, however, usually moves. To produce consistency in lighting a moving person, the lighting designer must constantly duplicate the focus of lighting fixtures on many similar areas over the entire playing space. This is the basis of **area lighting**, which aims at lighting the stage evenly and in a consistent manner. The principles of area lighting should be understood completely before the young designer considers other methods.

Area Lighting

Dividing the acting space into convenient areas and then lighting each area with the same number of fixtures from similar angles and directions provides a balanced illumination. In addition, having discrete lighting areas allows the designer to create focus by increasing the relative intensity of any given area. This technique, first developed by Stanley McCandless in the 1930s, has proven to be quite efficient and systematic. Used for setting focus points for automated fixtures as well as fixed lighting instruments, it allows the designer to view the stage as a grid of overlapping lighting focus areas.

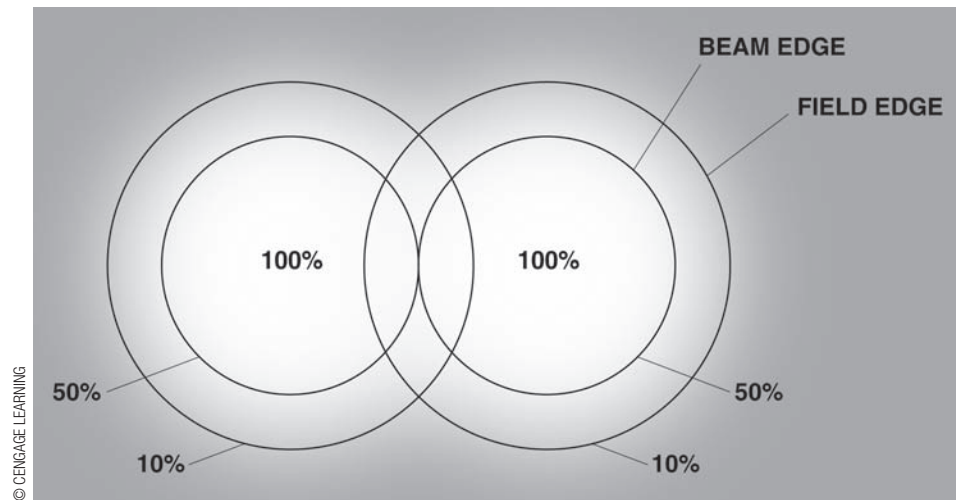
As scenery styles have changed and lighting fixture design has improved, the area method has been modified and expanded. Today, numerous fixtures are assigned to each area, providing great flexibility in terms of color and distribution.

Area Alignment In using the area system, one of the things a designer learns is that areas must overlap considerably. If not, the actor will pass through dark spots (“dips”) in lighting when moving from one area to another. Properly adjusted stage-lighting fixtures shine a light that has maximum intensity along the center line of its beam and falls off in brightness toward the edge. If light beams are overlapped so that the fall-off of one beam is compensated for by that of an adjacent light, a smooth and even coverage is achieved (Figure 19-9).

control The degree to which a designer can isolate a specific section of the acting area. Control depends on dimmers and lighting-area size.

area lighting An organizational method of lighting in which lighting areas are assigned throughout the acting area and fixtures are focused on those areas in the same ways, thus providing consistency in lighting the actors as they move about the stage. Also called *area method* and *area system*.

19-9 Beam Alignment For smooth and even coverage of the acting area, light beams must be overlapped as shown. The numbers represent the percentage of light intensity.



focusing The process of aiming and adjusting lighting fixtures to suit the needs of an individual production. Focusing is normally done by the lighting designer and a crew of electricians.

Focusing The process of **focusing** a show takes time to learn; it involves:

- Aiming a lighting fixture so that its beam falls exactly in the desired location
- Adjusting the quality of light and/or size of the beam
- Shaping the beam

It is at once a technical and a creative endeavor as the designer begins to discover how the light that has been planned so carefully is actually going to take form. The focus session is really the first time that light comes to life.

When they focus, television and film designers often check for intensity variation by using a light-sensitive meter. Readings are taken at head height throughout the playing space. If meter readings indicate that intensity levels are uneven, the designer adjusts the focus or adds fixtures to fill in the gap. The acceptable degree of variation is determined by camera sensitivity or film stock.

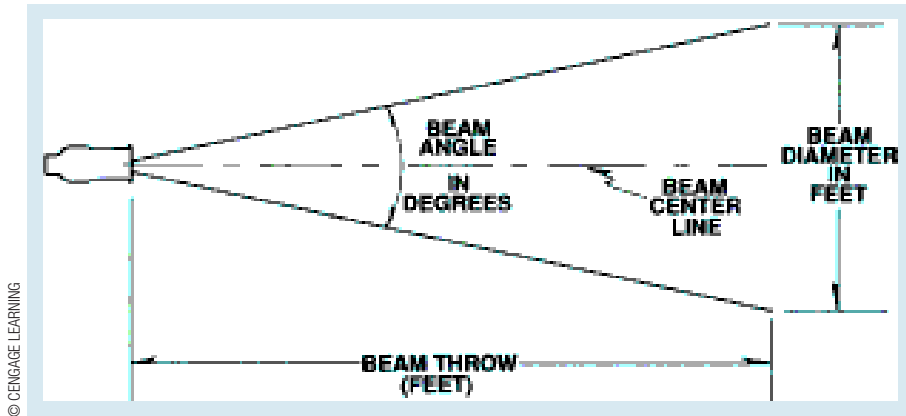
However, live-audience designers (theatre, concerts, industrials, and the like) visually check fixture focus for even coverage, relying on experience and their personal perception of design requirements. Although less exact than studio focus, this method promotes a higher level of intuitive design during the focus process.

Focus techniques and procedures are passed along from designer to designer. Theatrical designers soon learn to “back-focus”—that is, facing away from the lighting fixture while focusing. This allows the designer to examine his or her shadow in the beam of light, determining coverage and beam spread while saving valuable eyesight. Apprenticing is very much alive and well in the relatively small world of lighting design; a beginning designer is wise to observe the focus sessions of as many experienced designers as possible.

Area Size Lighting fixtures are manufactured so that their intensity is appropriate for stage lighting when their beams of light striking a performer are approximately 10 feet in diameter. Normal lighting areas vary from 8 to 12 feet in diameter, with 10 feet considered a good average.

Most lighting fixtures provide a beam of light that has a predetermined size or spread. Since it is cone-shaped, this beam may be measured either in degrees or by the diameter of its circle of light at a given distance from the source. As Figure 19-10 shows, the diameter of a light beam when it strikes a surface is determined by the distance from the source, or *throw* distance, as well as the beam angle or spread.

Normally using front-light as a basis, the designer first determines optimum lighting-area size. Then he or she chooses specific fixtures that will provide the proper coverage.



19-10 Light Beam As the light beam spreads, its diameter increases and its intensity decreases.

Area Placement The placement and choice of the number of areas is the lighting designer's decision. It is determined by:

- Size and shape of the playing area
- Furniture/prop placement
- Scenic level differences
- Actor blocking
- Amount of control desired

Here the term *control* refers to the ability to alter light on each portion of the stage independently. The more lighting areas, the greater the control possibilities. Figure 19-11 shows some examples of lighting-area placement. It is normally desirable to design for an odd number of areas across the stage, thus providing a valuable center area. Also, perimeter areas require special attention. In a box set, perimeter areas (particularly upstage) are often called upon to light the walls as well as performers. In addition, light from the outside beams of perimeter areas fades off. Note that area "V" in Figure 19-11b is fairly close to the stage-right side wall to make sure that an actor standing by the wall is adequately lit.

Attending rehearsals and paying particular attention to blocking will greatly help the designer when the time comes for assigning areas. In a multiscene production, some of the areas can be planned for use in more than one set, providing that the floor plans are close to the same configuration.

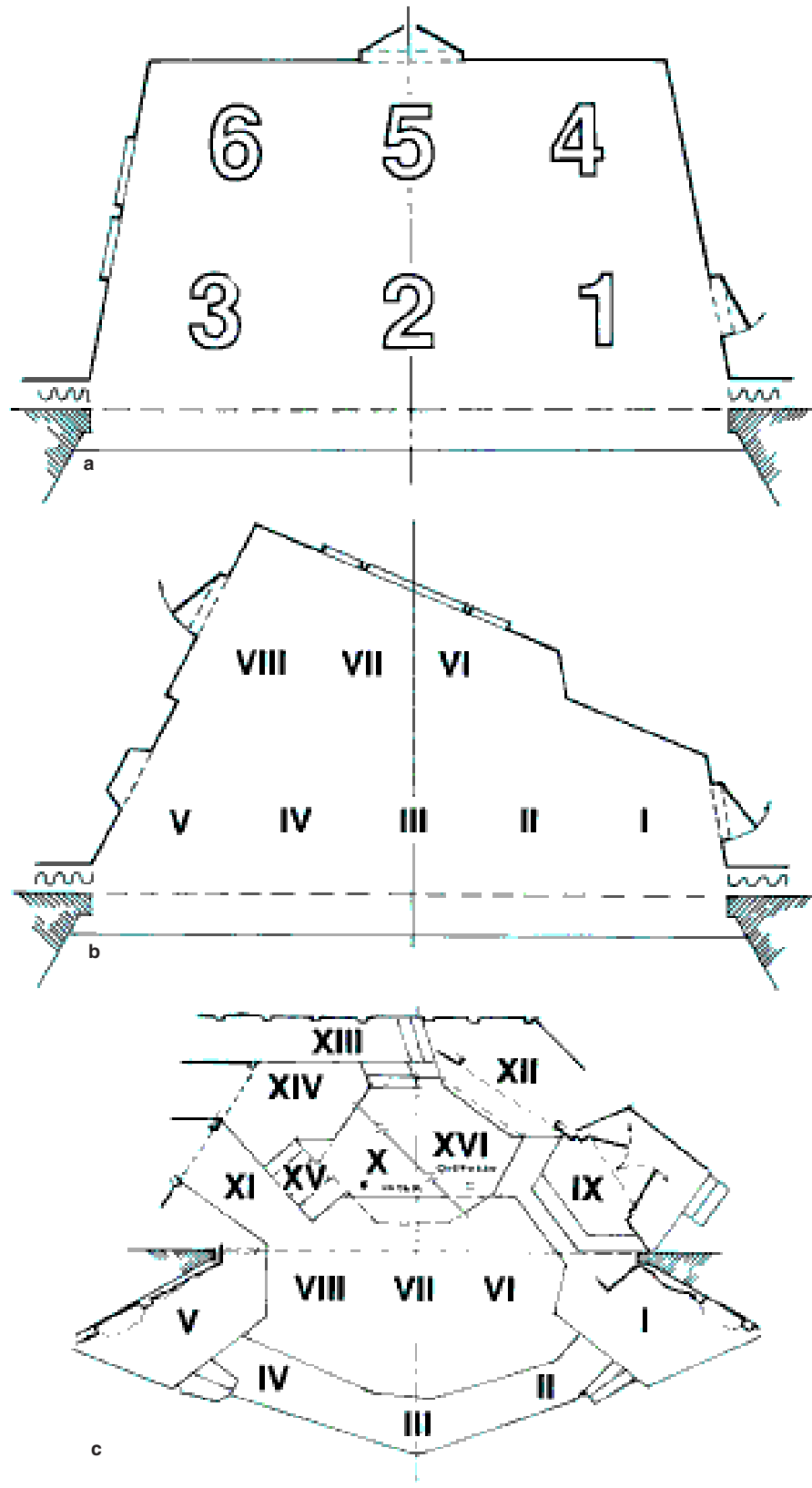
Front-Light Placement Figure 19-12 illustrates front-light placement with a simple 45-degree two-front-light area system. Looking at the upstage areas 4, 5, and 6 in the figure, note that each area is lit by two fixtures: one from stage left and one from stage right. Each light beam hits the area at approximately a 45-degree vertical angle and from opposite directions. This procedure is repeated for each lighting area until all are covered. The three upstage areas are lit from the first electric. To keep a similar angle, the three downstage areas are lit from the ceiling position.

Next, examine the fixtures lighting downstage areas 1, 2, and 3. Ideal lighting angles and direction often must be compromised. An example particular to lighting the proscenium stage is illustrated by the placement of fixtures 1L and 3R. Because the proscenium arch makes the desired front-side direction impossible to maintain, these units must be shifted toward center until they adequately cover the area.

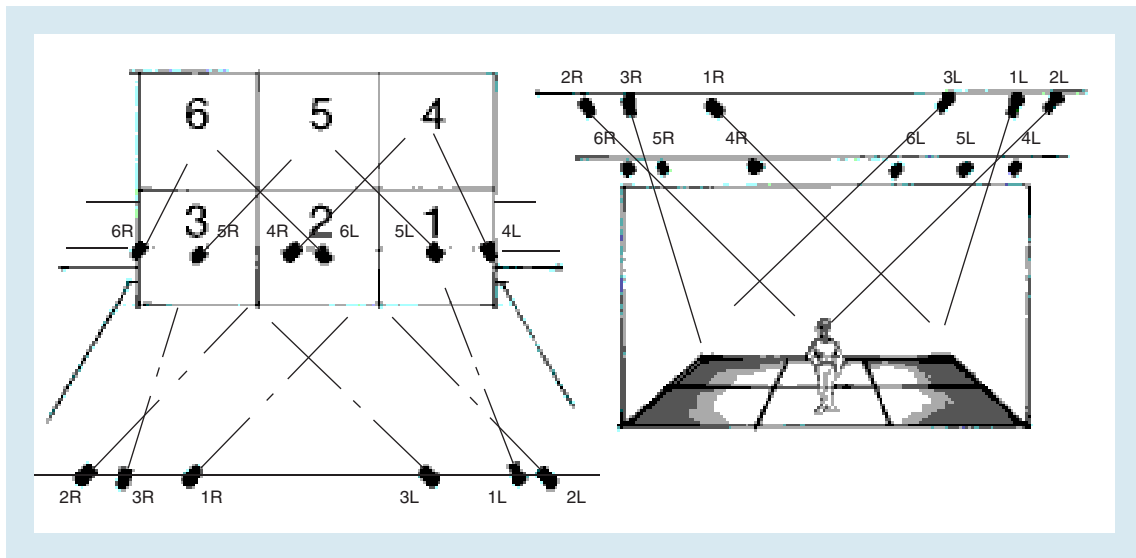
Back- and Side-Light Placement Designers normally use front-light areas to determine back and side angles and to plot fixtures. However, coverage from side-lights does not duplicate that of front-lights. Light projected at an angle to a surface produces an oval-shaped beam. Front- and back-light ovals run upstage and downstage, while side-light ovals run across the stage. If front-light areas are three zones (lanes across

19-11 Lighting Areas

- a A conventional box setting. Note the numbering of the areas from downstage left to upstage right.
- b An irregularly shaped interior setting with a larger number of lighting areas providing greater control. Some designers prefer to designate the areas with Roman numerals to avoid confusion with other numbers on the plot.
- c A complicated set. Using many levels often requires more lighting areas.



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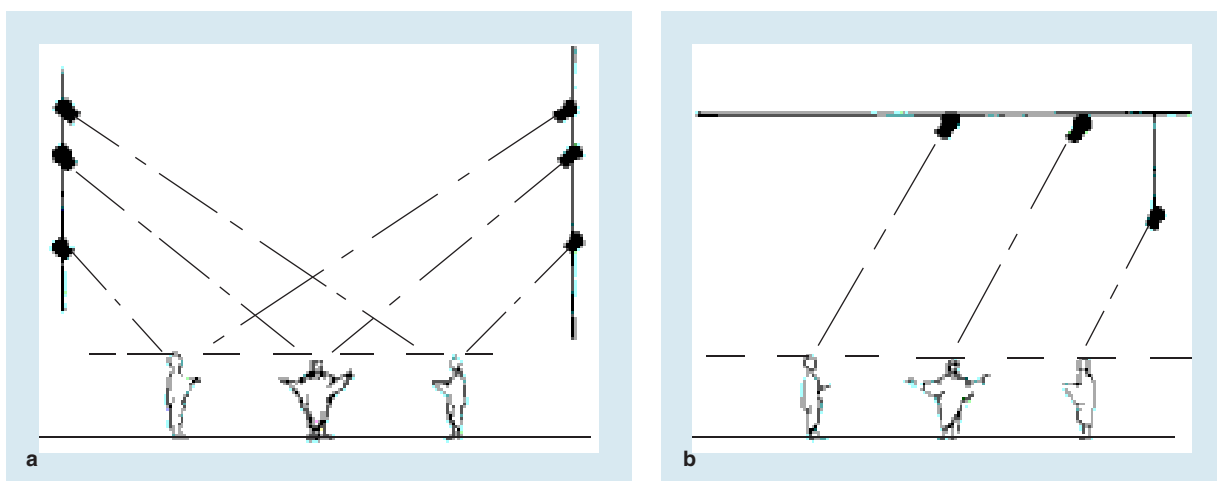
19-12 Lighting the Acting Areas: Front-Light The area system with minimum front-lighting. A ceiling or beam port position covers the downstage areas, while the first electric position is used to light the upstage areas.

the stage) deep, perhaps four zones will be required for side-light. Normally, this presents little problem unless the side-light is used as a key source. In that case, it is advisable to develop a second area layout exclusively for side-lighting angles.

Figure 19-13a illustrates a side-light angle of approximately 45 degrees. For these and lower angles, a boom is the appropriate hanging position. However, for higher angles, a boom or a ladder in conjunction with an overstage pipe must be used (Figure 19-13b).

Other Methods

Area lighting is an important, but not exclusive, technique of lighting the stage. There are a variety of other approaches as well, which may or may not be used in combination with area lighting.

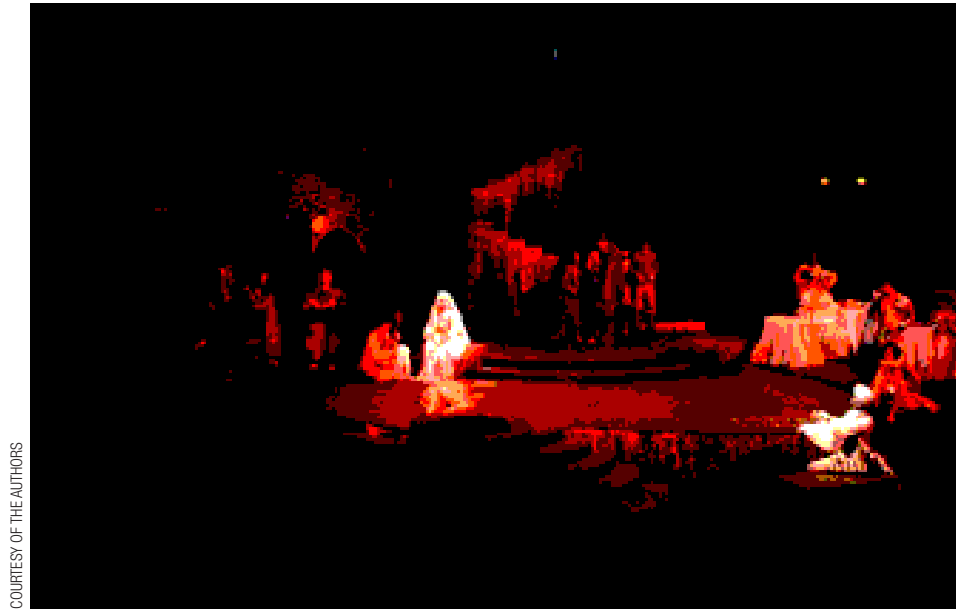


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19-13 Lighting the Acting Areas: Side-Light Side-light areas do not have the same shape as front-light areas because the beams are oval.

- a** Three side-lights on drop pipes or booms from right and left light across the stage in a “zone.” They are at a 35- to 40-degree angle.
- b** High side-light from an overstage position and a drop pipe or ladder lights the actor at a 60-degree angle.

19-14 Wash Lighting This photograph from a production of *Camino Real* by Tennessee Williams shows the use of clear light creating focus in combination with a strong side and front color wash enhancing the stylization of the production. Lighting design by Craig Wolf.



COURTESY OF THE AUTHORS

variable area lighting Large as well as small lighting areas are arranged throughout the acting area. The small areas offer greater control and are used in conjunction with the larger areas.

wash lighting Use of general illumination to cover the entire acting area; this technique offers little, if any, control.

single-source lighting Creating the quality of one distinct source of illumination by clustering several lighting fixtures together or by using one large, bright source.

motivated lighting Lighting sources arranged to duplicate the effect of a specific source such as a chandelier.

Variable Areas A deviation from standard area lighting, **variable area lighting** can provide a dramatic key-light with excellent control. Two sets of areas, one smaller than the other, are plotted over the stage. The smaller area is lit with narrow-beamed fixtures from a fairly steep angle (60 degrees). This light provides good isolation and a strong, bright key source. The larger areas are lit in a more traditional manner, acting to fill the steep key-light. This method allows the designer greater variety in using multiple systems to cover the larger areas while still achieving tight area control focus by means of the smaller areas.

Wash Lighting The term **wash lighting** refers to the use of general illumination to cover a large area, sometimes the entire playing space. Normally coming from a single direction, wash light is excellent for color-toning the stage and actors. Various angles, directions, and colors of wash light are used in conjunction with higher intensity *accent* lights to achieve variety, interest, and good visibility (Figure 19-14).

Single-Source Lighting A variation on wash lighting, **single-source lighting** attempts to re-create the feeling of one distinct source of illumination. The sun, after all, is a single source. However, it is so far away that its rays of light are nearly parallel by the time they reach us. Single-source stage lighting has diverging rays. It is normally achieved by clustering several lighting fixtures and focusing them to cover the entire playing area. Alternatively, the designer may literally use a single source in the form of a high-powered arc light. The effect is unique, as lighting angles and intensity change while an actor moves from place to place on the set (Figure 19-15).

Motivated Lighting Similar to single-source lighting, the **motivated lighting** method stems from the desire to duplicate a specific light source or sources. A chandelier hanging center stage can be the impetus for arranging a series of lighting fixtures in a circle above, cross-shooting to light actors in the manner of the chandelier. Such a source is normally the key-light, filled by other lights that are positioned relative to the direction of their particular key source (Figure 19-16).

Designing with Color

In everyday life, we make many subconscious color choices. The interior designer, fashion designer, and theatre designer, however, must force such choices to the conscious level, analyzing how and why specific color determinations are made.



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19-15 Single-Source Lighting An example of single-source back-light used in a production of *The Trojan Women* at the Oregon Shakespeare Festival. Scenery by Richard Hoover; lighting, Chris Parry.



PHOTOGRAPHY BY ROBERT BRILL; PHOTO COURTESY YORK KENNEDY

19-16 Motivated Lighting This production shot from *Oleanna* at the Old Globe Theatre in San Diego beautifully illustrates motivated light through a window. Directed by Jack O'Brien; scenery, Robert Brill; costumes, David C. Woolard; lighting, York Kennedy.

Before further considering designing with color, we need to make several points. First of all, the term *white light* is most often used to describe the color of unfiltered light. However, the color makeup of “white” light can, in fact, be highly variable. Our eye accepts an astonishing range of colored light as “white,” depending on circumstances. For this reason, the term *no color* (abbreviated N/C) is preferable to “white” in discussions of color and filtering (the British use the term *open white*, or OW).

Understanding the effect of a source’s color temperature on the quality of light is imperative. Equally important is knowing how color temperature affects color filtering (see Chapter 16).

amber drift The color shift of an incandescent lamp as it is dimmed.

Amber Drift

The lighting designer must always keep in mind the effect of dimming on the color of an incandescent light source. Dimming an incandescent fixture lowers or alters the electrical flow sent to the lamp. As a lamp is dimmed, the filament burns less brightly and it radiates a warmer color of light, a phenomenon known as **amber drift**. The more a lamp is dimmed, the greater the shift in color. By the time a dimmer reaches 50 or 60 percent of the original intensity, the color of light has changed significantly. This effect is particularly harmful to colors in the blue range. A blue filter in front of a fixture shining at 100-percent intensity emits a very different color from that of the same filter in front of a fixture at 70-percent intensity. Like many other lighting phenomena, this quality can represent either a problem for a designer or a creative advantage.

Choosing Color

Most often the lighting designer's challenge centers not on whether to use color but on which color to choose. This decision is made easier by the fact that most design teams determine a production's color scheme early in the design process. The scenic and costume designers will have made their final color choices based on these earlier discussions; the lighting designer should follow suit.

The designer chooses colored light for one of four reasons:

- The light is motivated by a specific source (the sun, a lamp, the fireplace), and colored light helps convey the motivation. This involves audience expectations such as “sky is blue” or “sun is yellow.”
- The mood of a scene is reinforced by the light; color heightens the effect.
- A visual contrast between light sources is desirable; color enhances that contrast.
- Change or dramatic effect for its own sake is desired.

Careful consideration must first be given to scenic and costume colors. Unless by intention, colored light must not significantly alter the true colors of an actor's skin, clothing, or environment.

Mood Successful use of color depends on a lighting designer's most important color resource—a strong visual memory. People associate feelings with certain colors and remember feelings or color impressions more readily than they do actual colors. In creating a certain mood, the lighting designer uses color to tap into those feelings.

The warmer and brighter hues, such as ambers and pinks, convey high energy and happiness. Blues tend to be more calming and restful, whereas yellow and cyan express tension. As we have seen, a yellow tint is useful for sunlight and a blue tint for night light. Violets and lavenders are good neutral colors and serve well to indicate dusk. Candlelight and incandescent light are relatively warm sources often represented by an amber tint.

Saturation Once a color hue is chosen, the designer must consider saturation. The more saturated a color is, the greater effect it will have on any surface color it strikes. As a general rule, lighting an actor from the front works best with unsaturated tints. As the light moves around the actor, color saturation may be increased. Be aware that lighting colors appear less saturated or intense over longer throw distances.

Color Contrast

Without contrast, a stage picture appears dull and lifeless. In lighting, contrast is first achieved by varying distribution—the angle and the direction of the sources. Contrast is further achieved through differences in intensity and/or color.

The precise feeling conveyed by most tints depends purely on comparison. A pale blue that seems positively icy next to a bastard amber appears quite warm when placed adjacent to a stronger shade of blue-green. Unsaturated pinks and lavenders are frequently used on the stage as neutral tints whose effect can be reversed merely by changing the hues used in association with them.

Unfiltered light may also appear to be warm in one situation and cool in another. Opposite a cool color, such as the palest of blues or greens, uncolored light appears quite warm. In comparison to a pink or pale amber, white light will definitely be on the cool side.

When using pale tints or white light, the effect of dimming on the color of incandescent light becomes particularly significant. A clear incandescent source at full intensity is not only brighter than one reading at lower dimmer levels but also cooler and harsher in color. Intensity as well as color contrast is achieved—without the use of filters.

Using Color Modification

All designers in the theatre have to consider not only the colors of a painted background, costumes, and other materials of a set but also the colors of the lights that reveal them.

Fortunately, color modification is not quite as complicated as it may seem. The effect of colored light on a colored surface is the result of mixing. If a red light is thrown on a yellow surface, the yellow is modified into orange tones.

The modification of a color in a costume or on scenery by colored light is a theatrical example of the joining of two color media—pigment and light. Designers in the theatre are constantly aware of how colored light and pigment influence each other. The lighting designer may enhance the mood of a scene by washing the stage with pale blue light. Perhaps this effect alters the brown walls or floor of the set, resulting in a cooler, gray feeling. The reverse could be achieved by using a pale pink tint on the scene (Figure 19-17).

Colored Light and the Actor

We have learned that complementary colors placed in two fixtures (such as light blue and warm amber) produce white light when mixed. If these fixtures are arranged to light the actor from different directions, the amber acts as a *key* or primary source light, while the blue works as *fill* or reflected light. An audience views the warmer of two equally intense light sources as primary (the “key”); the cooler source serves as shadow (the “fill”).

In acting area front-lighting, avoid saturated and unnatural shades that will adversely affect the faces and costumes of the actors. Tints of either blue or yellow that contain green can be detrimental to skin tones, whereas warmer tints are often complimentary.

Preserving the color integrity of costumes can be a difficult task. Often the acting areas are illuminated with tints of pinks and ambers, flattering enough to the human face but deadly to green costume materials. Because the scene may definitely call for such colors in the light, the lighting designer must at all times keep abreast of the costume designer’s color palette.

Breaking down the colors into primaries simplifies the task of determining what will happen to a given costume under colored light. For example, assume a yellow dress is lit by a cool blue light from one angle and a straw or cool amber from another (Figure 19-18). The cool blue light contains a mix of green and blue. The cool amber is made up of red and green. The yellow dress reflects red and green. The conclusion, reached by simply noting the preponderance of green, is that we are probably going to be in trouble. A warmer blue or lavender and a warmer amber light would be a better choice.

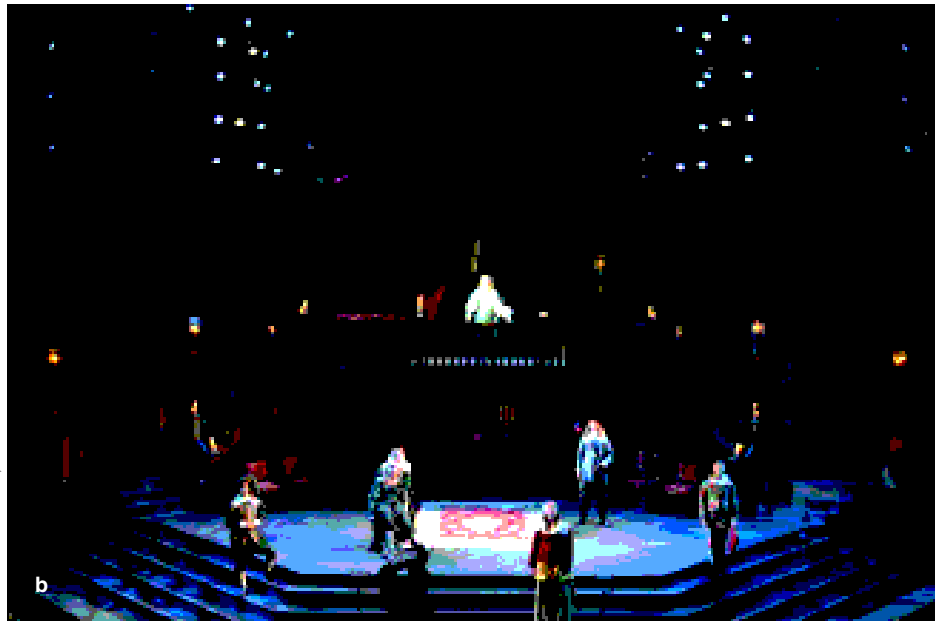
19-17 Color Modification

- a** Strong side-light color creates the mood in this production shot from *Cyrano de Bergerac*.
- b** A blue wash and texture convey a totally different look for *Cyrano*. *Cyrano de Bergerac* produced by San Diego's Old Globe Theatre. Directed by Darko Tresnjak; set design, Ralph Funicello; costumes, Anna Oliver; and lighting, York Kennedy.

PHOTO BY JASON BIEBER, COURTESY YORK KENNEDY



PHOTO BY JASON BIEBER, COURTESY YORK KENNEDY

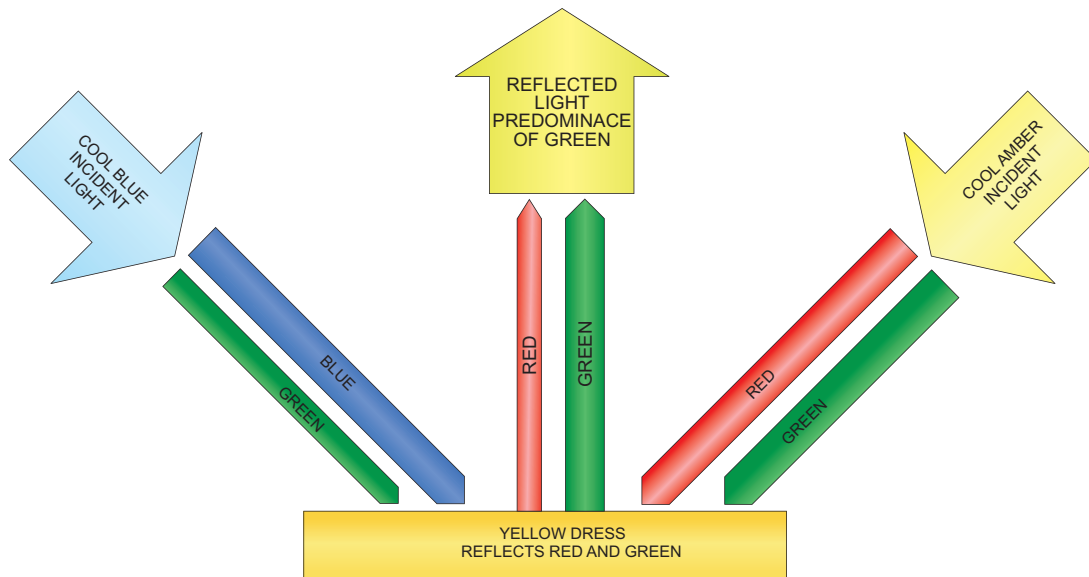


If a scene calls for strong color, consider using it in back-light. Colored back-light does not affect the costumes or faces of the actors and can tone the floor in an effective manner. A strongly contrasting back-light color acts to separate performers from their background.

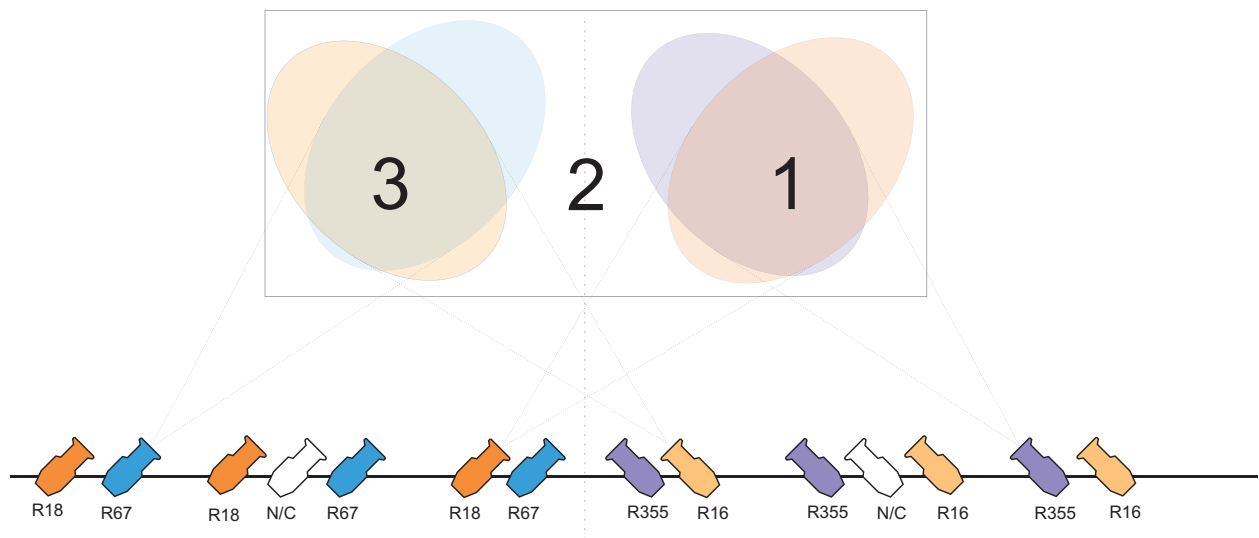
Color Flexibility

As the demands on stage lighting increase, so do the demands of designers for greater flexibility. The ability to change angle, direction, and color depends solely on equipment. Designers in the past have answered this need by specifying ever greater numbers of fixtures. Rather than depending on quantity, however, today's designer may specify more technologically advanced equipment.

Double and Triple Hanging Designers often want to improve on the limited flexibility that using one fixture from each direction into an area provides. To do this, they



19-18 Color on the Actor This illustrates the effect of a yellow dress lit by two differently colored light sources. When mixed, the cool blue light and the cool amber light have a predominance of green; the color of the yellow dress shifts toward green, appearing more lemon-yellow.



19-19 Double and Triple Hanging Triple hanging on area 2, with double hanging for areas 1 and 3. The center area has both a tight and a more open focus while all areas provide variable color and direction of key and fill sources.

may double- or even triple-hang fixtures. Two lights hung side by side with different color filters allow for variable color. By duplicating the area coverage on each side, as illustrated in Figure 19-19, designers can create several possibilities for color control, including the following:

- Change the warm-cool direction from one side of the stage to the other
- Change the area color by independently mixing the colors from either side
- Flood the stage with only one of the two area colors

Hanging a third fixture offers even greater flexibility. The third fixture added to area 2 in Figure 19-19 can adjust focus and intensity in this center area. It can also be designed to alter the quality of light into the area through the use of a diffusion filter or perhaps a gobo.

Color Changers Double and triple hanging allows for greater color flexibility and can provide some degree of focus control; however, a better solution might be remotely controlled color changers. Commonly called “scrollers,” this auxiliary equipment offers the designer a wide range of color at a reasonable cost. They are fairly quiet, dependable, and easily controlled.

Color Mixing Color mixing provides even more variety than scrollers. Several forms of color mixing are available: *color faders*, essentially color mixing scrollers; dichroic color mixers, dichroic filters brought together to mix color; and LED color mixing fixtures. All of these are more expensive than scrollers, and each offers its own advantages.

Automated Fixtures

Automated fixtures provide a flexibility for the theatrical lighting designer that was previously impossible. Designing with them, though, requires a slightly different approach from that of non-automated fixed instruments.

Programming Like any other lighting instrument, automated fixtures must be focused on a particular area. The coordinates of that focus are then stored in computer memory for recall when needed. There are currently two systems of automated fixture focus: a grid or *focus point* system and a “special” system. The grid or focus point system is nearly identical to the fixed-instrument area method. A grid of focus areas is determined, and each automated fixture is programmed to focus on each one of the grid points or areas. That focus can then be called up at will by the designer. The “special” system identifies heavily used areas of the stage where automated fixtures are likely to be needed. Each light is then programmed to those selected areas. Although the “special” system is fine for concert lighting, the grid system is best for most theatrical applications.

Dark Sets Focus is only one attribute to be considered when you are designing with automated fixtures. Most lights offer control over color, pattern (gobos), beam size (iris), intensity (mechanical douser), and beam quality (diffusion). One or more control channels must be assigned to each attribute. Common attribute channels for several fixtures can be arranged in groups for ease of operation. In programming, one must write extra cues, called **dark sets**, that allow various attributes of the automated fixture to be preset. For example, the focus point of a fixture must be preset before the cue in which the light is on in order to avoid having the audience see the light move.

Placement The location of automated fixtures depends on the effect desired and number of fixtures available. They may work alongside fixed instruments as specials or perhaps as key-lights. Because of their intensity and high color temperature, automated fixtures are quite effective as specials. Otherwise, high-angle front- and side-lighting are the most popular applications.

Specials and Follow Spots

Lighting fixtures used for very specific purposes add interest and focus. However, designers must carefully consider whether the use of specials is appropriate to the style of the production.

Specials Fixtures that are used in addition to the regular production lighting are called **specials**. Their normal function is to emphasize a part of the setting or an actor in a specific location. Examples include a *door special* (a light carefully framed to brighten an actor standing in a doorway), a *couch special* (extra illumination where an important

dark set A special lighting cue for the sole purpose of allowing changes in automated fixture attributes.

specials Lighting fixtures used in addition to the regular production lighting.

scene takes place), or a *pin spot* (a narrow beam of light that is held a moment longer on an actor's face during a final fade-out). Specials influence composition by attracting the eye to a desired center of attention.

Enhanced visibility may involve specials that follow the moving actor. This can be achieved in one of two ways:

- The actor may be lit by a series of fixtures focused along the path of movement, with each light dimming up or down at the proper moment.
- The actor may be lit with an automated fixture or a follow spot.

Follow Spots Actor movement is followed by a single, freely mounted spotlight. The follow spot has long been used for musicals, revues, and other presentational productions in which realism is of minor importance. It usually appears as a sharply defined, hard-edged circle of light that is brighter than all the other stage lights. Its use in this manner is frankly presentational.

A subtler method of follow-spotting is high-angle follow-spotting (sometimes called *European follow-spotting*, referring to the practice of placing lights and operators on the first light bridge). A soft-edged incandescent follow spot is used to highlight the action unobtrusively. To keep the light off the scenery and minimize shadows around the actor, the follow spot should be hung at an angle of 60 to 70 degrees. Even if the moving light is noticed, audience members soon become accustomed to it and accept it as a stylized element of the production.

Lighting the Background

Even though the lighting designer deals chiefly with lighting the actor, lighting scenery and backgrounds also requires a great deal of consideration. For example, light on a background or sky cyc contributes significantly to mood and atmosphere.

Walls

In the case of a conventional interior or box setting, normal actor illumination usually lights the walls sufficiently. However, several precautions are necessary. Fixtures lighting the walls of a box set should be softly focused or frosted in order to blend well and reduce shadows.

Shadows on the walls from actors or furniture can be a difficult problem. The best solution is to change the angle of light causing the shadow, but at times this is impossible. A wall wash comprising lights specifically hung, focused, and colored for this purpose may help. Fresnel-type fixtures are a good choice (see Chapter 17).

Backings

Lighting backings offers their own set of challenges. For example, the backing behind a doorway is rarely seen for more than a moment, and then not directly by most of the audience, but it must be lit. However, designers do not need elaborate equipment to give these backings adequate illumination. The objective is to provide enough light so that an actor, when leaving the stage, does not seem to be retiring into a dark closet. Such attention to detail can make the difference between an adequate and a good design.

Of course, backings can assume proportions greater than those of a doorway. A painted exterior seen through a large window is one good example. Rooftops or the exterior walls of an adjoining building may be visible in a more detailed backing. Such scenic elements demand greater attention to light distribution and color control.

Colored Light and the Scenery

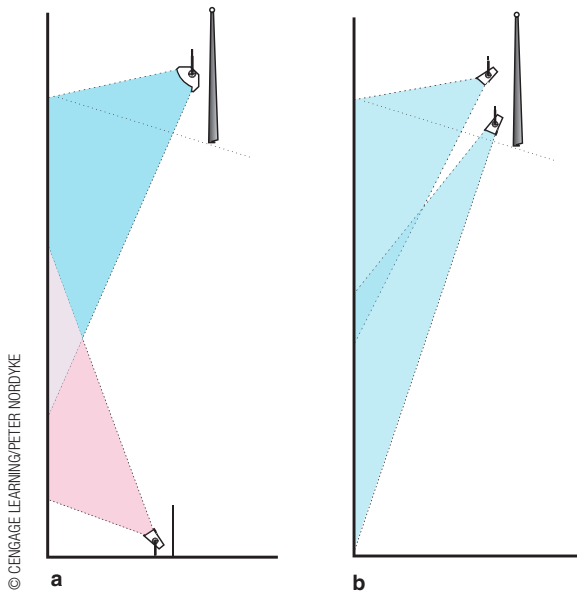
In choosing lighting colors, designers need to consider two main types of scenery: three-dimensional scenic forms, which can be sculpted and colored by the light; and two-dimensional, flat scenery, which is most often painted.

Three-Dimensional Scenery Sculptural three-dimensional scenery provides the lighting designer great opportunities to create and alter composition. Direction of light is most important, but color plays a significant role. Color creates life, especially in the shadows cast by three-dimensional forms. Color can make forms appear to come forward or recede and can alter the apparent space between objects. Of course, it can also change the surface color of the object.

Two-Dimensional Painted Scenery Unless otherwise informed, designers always assume that the scene designer has painted the settings the way they should appear. Thus, for a lighting designer to attempt to improve on the scene designer's artistry would be impertinent. Enhancing it is fine, but only in strict accordance with the scene designer's wishes. Close collaboration between scene and lighting designers is crucial. The result will usually be that nearby scenery, such as the walls of an interior setting, will receive acting-area tints of light only. Too often a box set's stage-right walls seem to be a totally different color from its stage-left walls. This mistake is a result of poor color mixing from the front-lights. It is corrected by making sure that all frontal colors hit the walls with relatively equal intensity.

Here is a good basic guideline: If you are debating whether or not to light two-dimensional scenery—don't. Generally, light on scenery such as flats and drops will cast unwanted shadows and possibly create a situation in which the walls and the actors are competing for focus. Steeply-angled top- or side-light on a flat surface brings out all the dimples and blemishes inherent in the surface.

However, color washing the scenery (including the floor) can help to create some harmonious and useful effects. Nearly any scenic or costume color can be made to appear warmer or cooler—more or less inviting—through the use of colored light. A scene designer may, in addition, actually paint the set in several different colors that can be selectively accentuated or de-emphasized by colored light.



19-20 Lighting the Background

- a A painted backdrop, sky-drop, or cyclorama lit from above with cyc lights and from below with striplights. When one is lighting from below, a *scenery ground row* is necessary for masking.
- b The backing lit only from above with striplights. This technique often requires two sets of lights, one aiming high and the other low. Having to use a scenic ground row is avoided.

scrim An open-weave fabric used in the theatre for its transparent properties.

Backdrops and Sky Cyps

It is not unusual to have vast areas of sky behind the performers. These backdrops or cycloramas require lighting fixtures specially designed to provide the proper amount of light as well as even distribution and blending of color over the entire surface. Such fixtures are hung above the drop and sometimes placed on the stage floor as well (Figure 19-20). This is a perfect application for LED color mixing fixtures if the designer wants to change the atmosphere created by the background during a performance.

Scrim Open-weave material called **scrim** is particularly useful in the theatre because of its capability to appear either opaque or transparent. A scrim hung in front of a backdrop or a cyclorama adds a hazy quality to the backing that contributes to the sense of distance. The scrim itself can be lit, or, better yet, the drop behind the scrim can be illuminated, as shown in Figure 19-21.

Scrim may also be used by itself as a drop. In this case, the designer must pay close attention to the light that falls directly on the scrim as well as behind it. Using high-angle top-light is the best way to opaque a scrim. To make a scrim transparent, the designer keeps as much light as possible off the material itself while illuminating objects behind it (Figure 19-22).

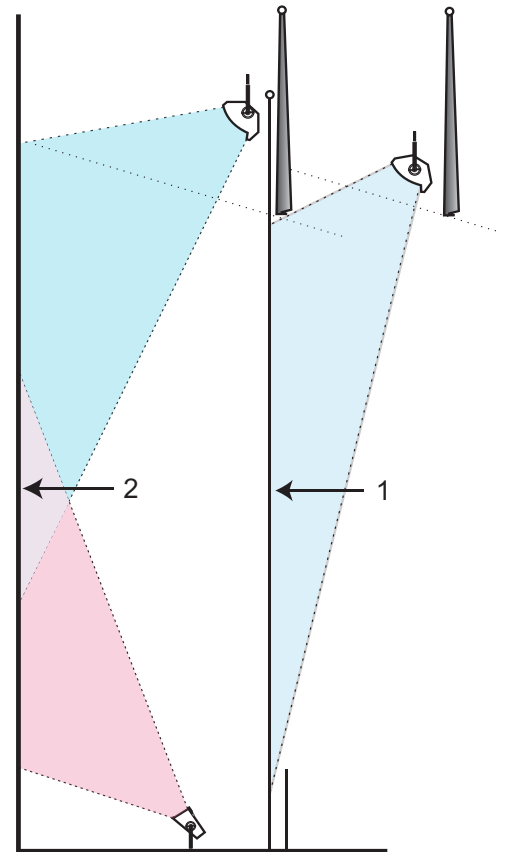
Another valuable use for scrim is to place a black or dark gray scrim downstage of a rear projection screen to keep light spill off the projected image. The scrim will trap the ambient stage light while allowing the projection to show through.

Color on the Sky Lighting designers are frequently called on to use color on a backdrop or cyclorama. A **sky-drop** is a large expanse of cloth that may be lightly colored but is not painted with any kind of sky or landscape. It is often referred to as a cyc. Historically, a **cyclorama** (“cyc”) was a hard (often plaster) neutral background that was curved to create more of a surround.

Careful consideration and experimentation must go into choosing cyc colors. If at all possible, colors under consideration should be examined by projecting them onto the actual background. The color of the drop itself will affect the lighting choice; sky-drops can vary from numerous shades of white to blue. If the drop is unavailable, experiment on a similar surface in the lighting lab.

Is it better to select a single color medium that gives the exact hue desired, or is a blending of several colors preferable? Of course, if there is to be a color change during the scene, then more than one color must be provided. More delicate and precise shadings can also be achieved if several different colors are blended into one. However, mixing the three primaries is a traditional, but often wasteful, method of achieving variable cyc color. Designers rarely use primary red or green by itself.

Tints are seldom useful as sky color. They are too pale and tend to do nothing but muddy the drop. Unlike acting areas, cycs require more saturated lighting colors. Unfortunately, light transmission from primary colors, particularly blue, is extremely



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19-21 Lighting the Background:

Scrim A scrim (1) is placed in front of the backing (2). The scrim is lit from the front, and the backdrop is separately lit from both above and below.

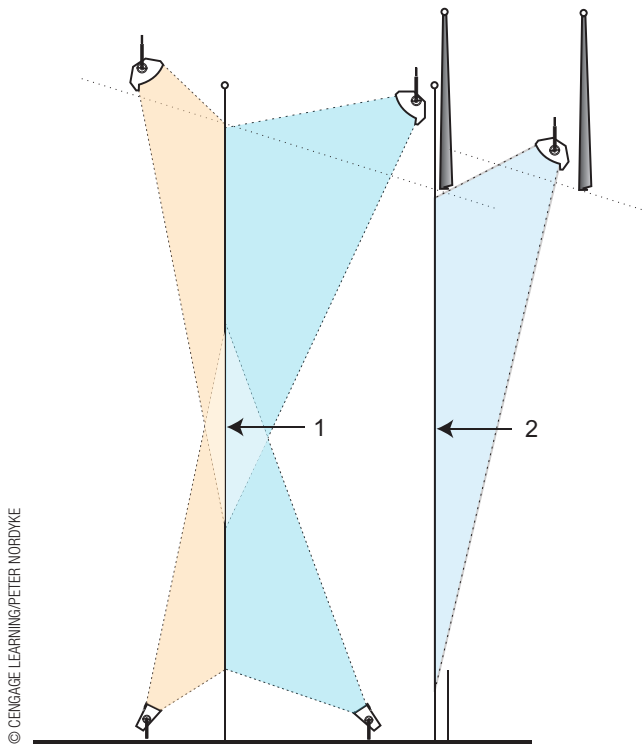
sky-drop A backdrop that is not painted with anything representational. Sometimes called a cyc.

cyclorama Historically, a curved hard background. Today the abbreviation “cyc” is used for any sky-drop.



PHOTO COURTESY LUKE OLSON

19-22 Scrim as a Transparency This shot from a production of *The Labyrinth of Desire* by Caridad Svich, produced by San Diego State University, illustrates the use of scrim as a transparency. Directed by Delicia Turner-Sonnenberg and Peter Cirino; scenery, C.L. Ward; costumes, Caroline Rousset-Johnson; and lighting, Luke Olson.



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19-23 Lighting the Background: Translucencies A translucent drop (1) is positioned upstage of a scrim (2). The drop has both front- and back-lighting to change effect, and the scrim is lit from the front to add depth and atmosphere.

translucency A fabric that can be either opaque or translucent, depending on how it is lit.

19-24 Translucent Sky Cyc The “Beautiful Candy” scene from *Carnival!*, produced by The Kennedy Center in Washington, D.C. The background is a painted translucent muslin drop. Directed and choreographed by Robert Longbottom; scenery, Andrew Jackness; costumes, Paul Tazwell; and lighting, Ken Billington.

Now that we have discussed various considerations that go into lighting design, we move on to the actual process of plotting and production.

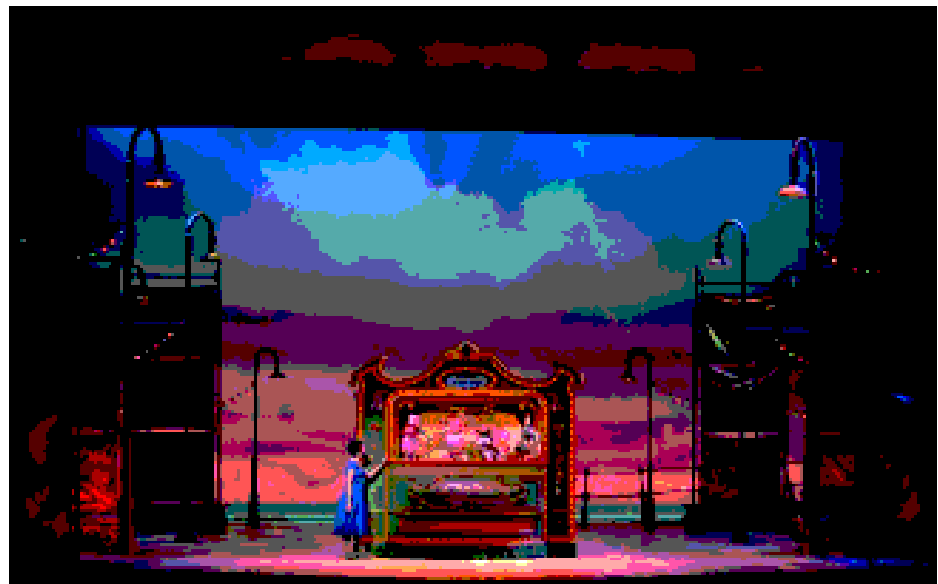


PHOTO BY ANDREW JACKNESS, COURTESY KEN BILLINGTON

low. This presents a problem because near-primary blue is an important sky color. A possible solution is to double the output by using two circuits of blue and mixing them with other secondary hues. The best solution is blue LEDs.

Translucent Backings A **translucency** allows for the possibility of dramatic changes in the look of a backdrop through lighting. A backdrop may be partially or completely translucent, with the translucent areas often painted with dyes rather than regular pigment. If lit from the front, the drop will appear one way; if lit from behind, it can have a completely different look (Figure 19-23). Figure 19-24 shows the look that can be achieved using a translucent muslin drop for a background.

Hanging Space Successful background lighting depends on the close cooperation of the lighting and scene designers. For instance, all too often the scene designer does not leave enough space between ground rows and the backdrop or between borders and the cyclorama for proper lighting. No matter how good the equipment, a certain distance is required for colors to mix and blend well on a backdrop. Moreover, sometimes backgrounds representing distant fields are so close to a window or a door that it is impossible to avoid shadows from area lighting. Any illusion created by good painting is then destroyed. Most of these and other potential problems can be avoided by consultation and careful study of the scene designer’s floor plan.

Design: The Light Plot, Paperwork, and Production

2011

We now come to a discussion of the lighting designer's basic communication tool: the light plot. The purpose of a light plot is to convey to the production electrician exactly how and where each lighting fixture is to be hung. The plot normally specifies color, circuiting, control, and related information concerning each individual fixture. A great deal of time, preparation, and thought goes into this plot, which represents the lighting designer's "working drawings." Creating a light plot is exacting work; little time is available in the theatre to remedy any serious mistakes.

The Light Plot

The light plot, along with its accompanying paperwork (the section and hookup or fixture schedule), forms the link between the designer's ideas and the reality of theatrical production. The importance of the light plot cannot be overstated. It must be 100 percent accurate and complete, so that the load-in (hang, circuit, and focus) can proceed in an orderly and rapid fashion. While executing a plot, the designer discovers and remedies many artistic as well as technical problems. Careful and accurate plotting allows the designer to address these problems well before he or she sets foot in the theatre.

This chapter covers the process of developing a light plot and executing the design, while Chapter 24 offers further design information including examples of simplified plots in various theatres. For illustration purposes, we use a light plot and section for the play *Art* by Yasmina Reza (Figure 20-1). The theatre is the Old Globe in San Diego, which seats 580 people with a small balcony. For this production, the Globe is used in proscenium configuration.

Drafting the Plot

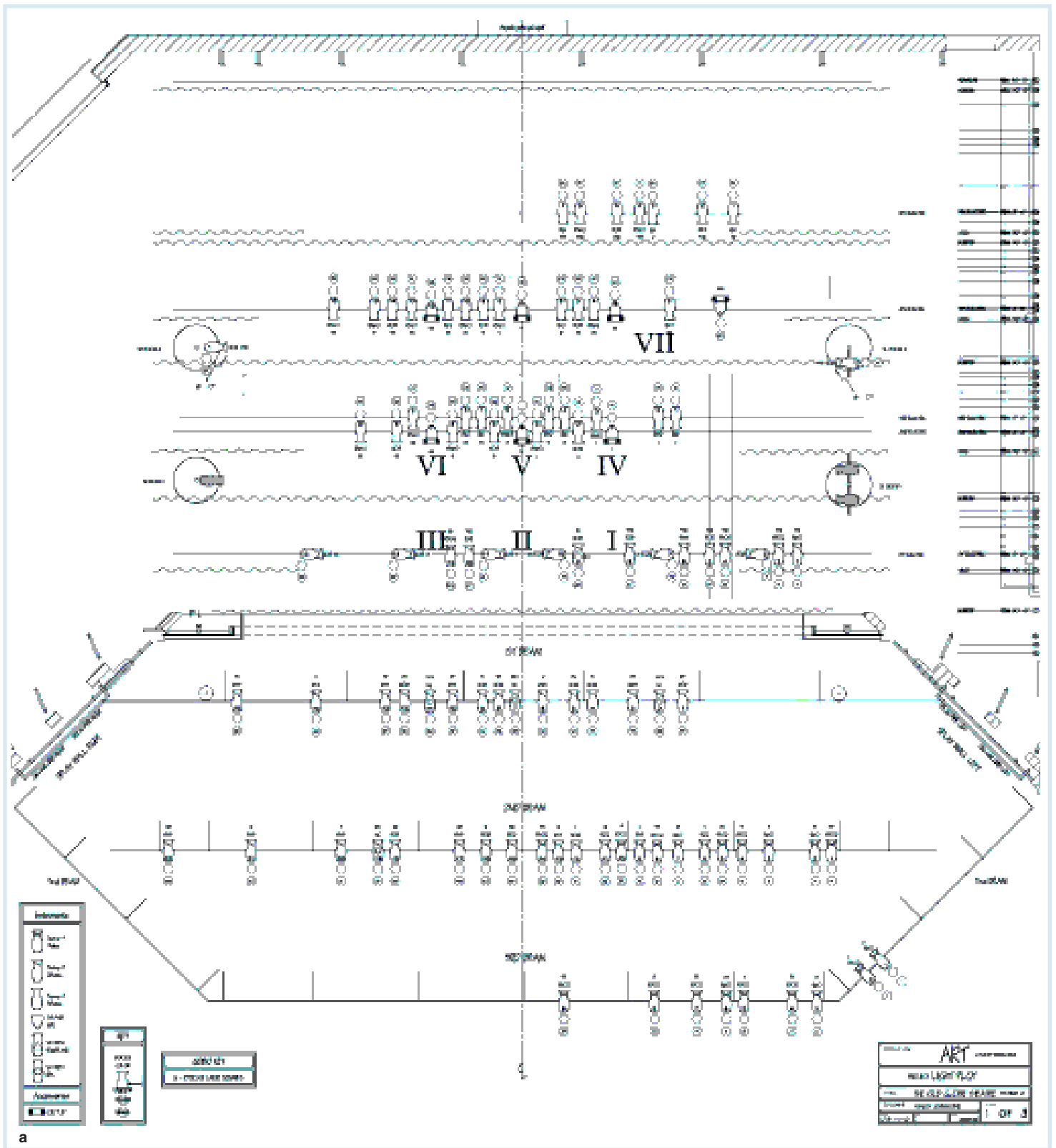
Whether using a CAD program or drafting by hand, the lighting designer must learn mechanical drawing in order to read and understand scenic drafting as well as to execute a lighting plot and section. (See Chapter 5 to review drafting.)

The light plot is drawn at a scale of ½ inch equals 1 foot. This size is necessary to assure that all information required for a complete light plot is readable.

The first step in drafting a light plot is to secure copies of the plan and section of the theatre. Information from these drawings is then transferred onto the drafting plates that will soon become light plot and section. Next, details from the scenery ground plan and section are added to the two drawings. Finally, fixtures are plotted, color is chosen, and control decisions are made.

CENGAGE **brain**.com

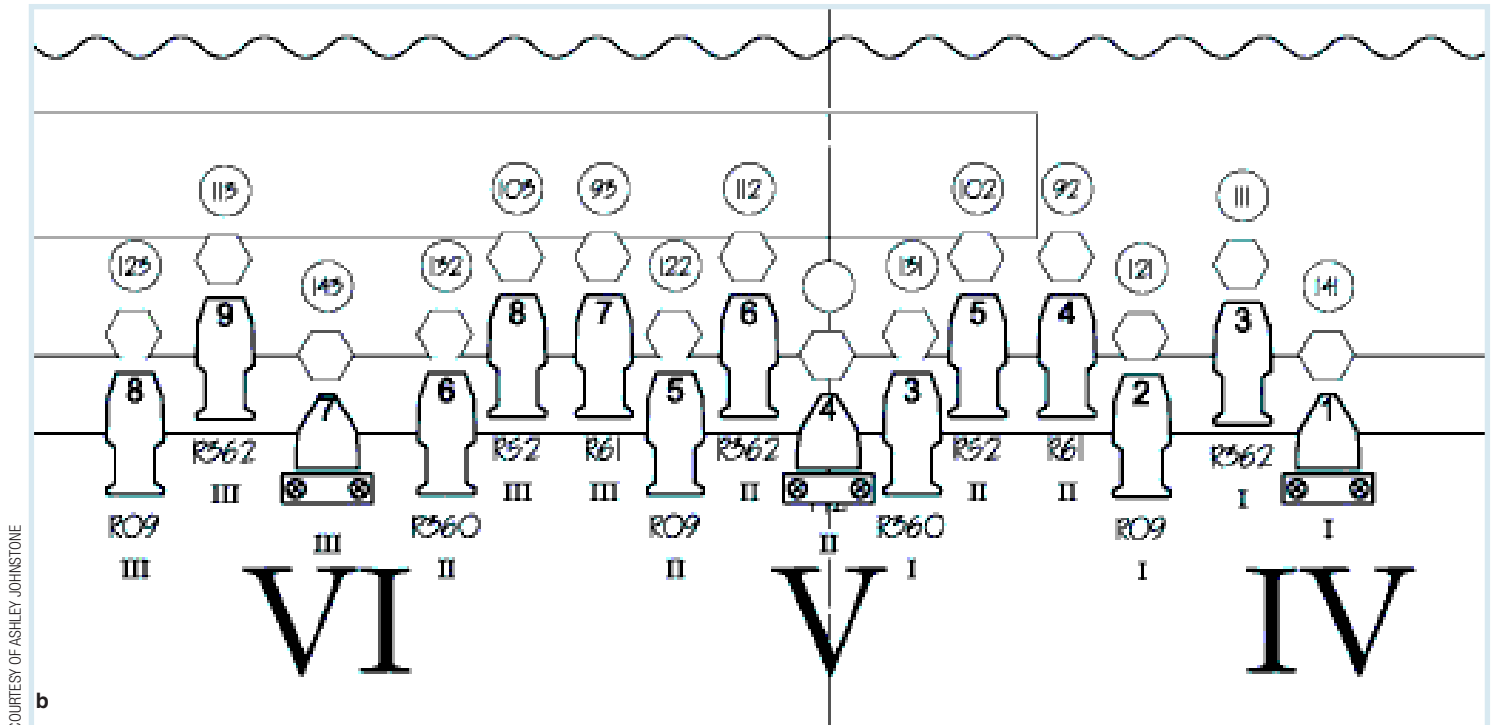
For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.



COURTESY OF ASHLEY JOHNSTONE

20-1 Light Plot The 1/2-inch scale light plot for a production of *Art*. See Figure 20-7 for the boom plate, and Figure 20-9 for the section.

a The complete light plot (above).

**20-1 Light Plot (continued)**

b A portion of the plot reproduced at actual size (above).

Theatre Plan and Section A theatre's technical director, electrician, or production manager should be able to provide an electronic version of the theatre's plan and section. These drawings should include all the information needed to transfer the theatre plan onto the light plot. However, it is possible that the theatre plan and section may not show circuits or every light-hanging position. If this is the case, designers should ask the appropriate producing agent to provide a circuit chart and/or a light-hanging plan. The house will also provide the designer with an up-to-date fixture inventory as well as control specifications. Despite all this, a visit to inspect the theatre is highly recommended.

The designer should transfer all rigging for the production to the light plot and section. This includes masking, flying scenery and drops, and electric pipes. Critical audience sight points, indicated by a cross, must be included on the lighting plan and section as well. If drafting by hand, designers initially indicate a lighting hanging position by a single solid line of very light weight (it will later be darkened and made bolder). Each position must be clearly labeled. To save space, a designer can show distance to front-of-house positions in a smaller scale, but this deviation should be clearly noted. Some designers prefer to include a plaster-line scale and sometimes an upstage-to-downstage scale in order to facilitate the hanging and placement of fixtures.

Designers do best to draft the basic lighting plan and section (without fixtures) as early as possible in the design process—at least several weeks before the plot deadline. This allows time to digest the theatre and scenic information and saves valuable drafting time later.

Scenery Plan and Section The scenic designer should provide the lighting designer a copy of the scenery ground plan and section as soon as they are complete. Scenery information transferred to the light plot and section need not be as complete or detailed as



LIGHTING DESIGN BASICS ■ Light Plot Elements

Given that some standardization is desirable for any communicative tool, the light plot should include the following elements:

- A ½-inch plan of the theatre drawn to scale, showing and labeling all lighting positions
- A simplified plan of the stage setting drawn to scale in lightweight lines
- Lighting areas indicated by letters of the alphabet or Roman numerals in heavyweight lines—beginning downstage-left, working stage-right, and then upstage
- Exact fixture placement, type and size, color, and number
- Title block in the lower right-hand corner, fixture key, fixture annotation key, and gobo key (if needed)

it is on the scenic ground plan. It should include only elements important to the lighting, such as walls, doors, major levels, large pieces of furniture, and so forth. The only scenic elements included in the *Art* plot are the walls of the set. All this is drafted in lightweight lines so that lighting fixtures can be plotted directly over scenery lines.

The plaster line and center line should be included. If the production requires several sets, the lighting designer may need to use transparent overlays of each set.

Fixture Annotation If drafting by hand, the designer should use one of the several available lighting fixture templates to trace outlines of the various fixtures (Figure 20-2). One-half-inch scale templates can be ordered in either plan or section view. If drafting with a CAD program such as VectorWorks®, designers will have fixture symbols included as part of the software. Specific symbols may also be imported from manufacturer websites, or software such as SoftSymbols™ can be used. These outlines must be bold enough to stand out from all the other information on the plot. The lighting fixture should intersect the lighting pipe, but the pipe itself should not be drawn through the fixture.

In most situations, fixtures are numbered by position, beginning house-right and working house-left. Numbering by position means that all fixtures located in each lighting position are numbered consecutively beginning with “1” (Figures 20-1 and 20-3). Some situations, however, may make numbering by position rather confusing (for example, a flexible theatre with a full, overhead lighting grid). In such cases, all fixtures should be numbered consecutively.

The fixture annotation illustrated in Figure 20-3 is recommended. The fixture number is centered in the rear body; the fixture type is indicated by a symbol and located at the barrel position (Figure 20-4); the focus area (if used) goes behind the fixture; and the color number goes in front of the lens. In addition, the channel number is circled, and the dimmer/circuit number is placed within a hexagon. Both the circle and the hexagon connect to the rear of the fixture as shown. If the designer does not assign circuits or wishes to leave a specific place for them to be recorded, the hexagon may be eliminated.

Fixture, Color, and Gobo Keys The fixture key indicates exactly which symbol the designer is using for a specific unit. This key, which should include the wattage as well as the beam spread of the fixture, is normally located in the lower-left corner of the plate.

The color key explains what numbering and lettering system the designer is using for each brand and type of color medium. For example:

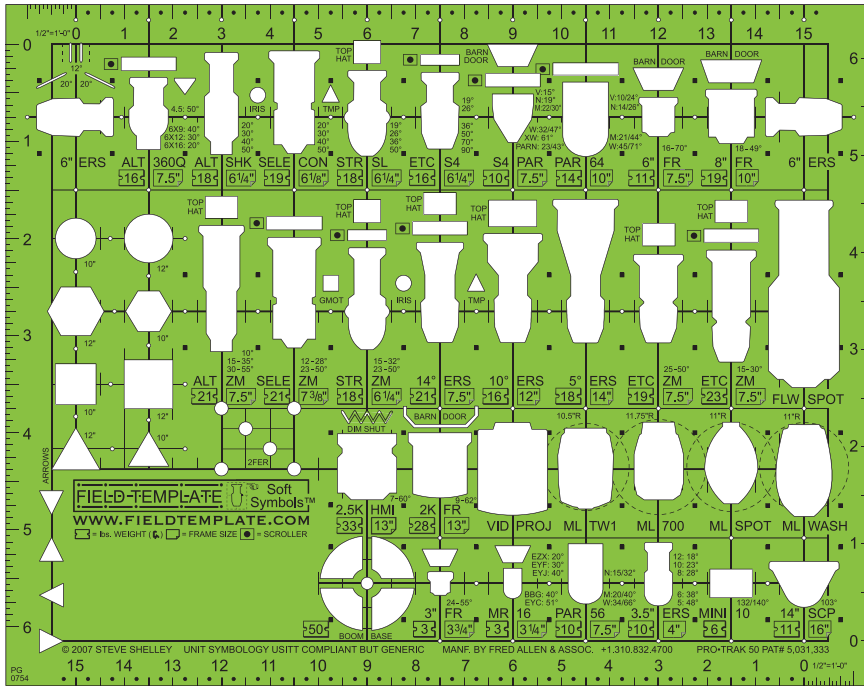
“R” series = Roscolux

“L” series = LEE Filters

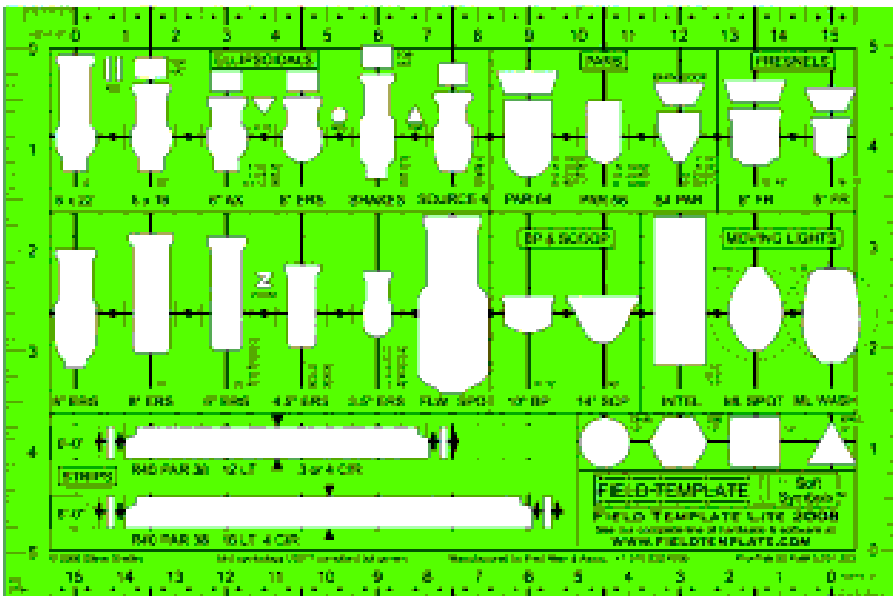
“G” series = GAM Color

20-2 Lighting Templates The templates shown are available from fieldtemplate.com.

- a Field Template.
- b Field Template Lite.

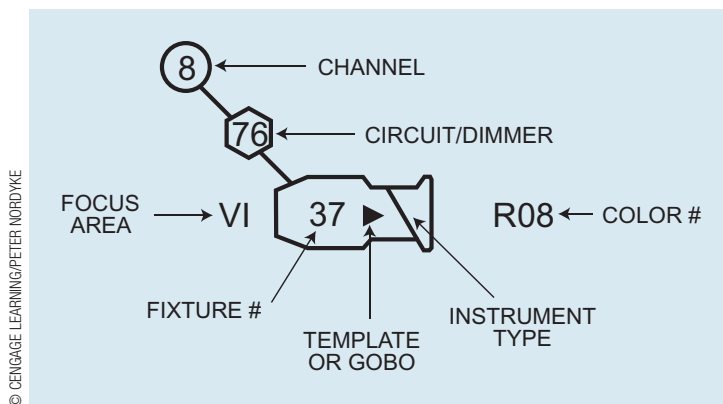


a



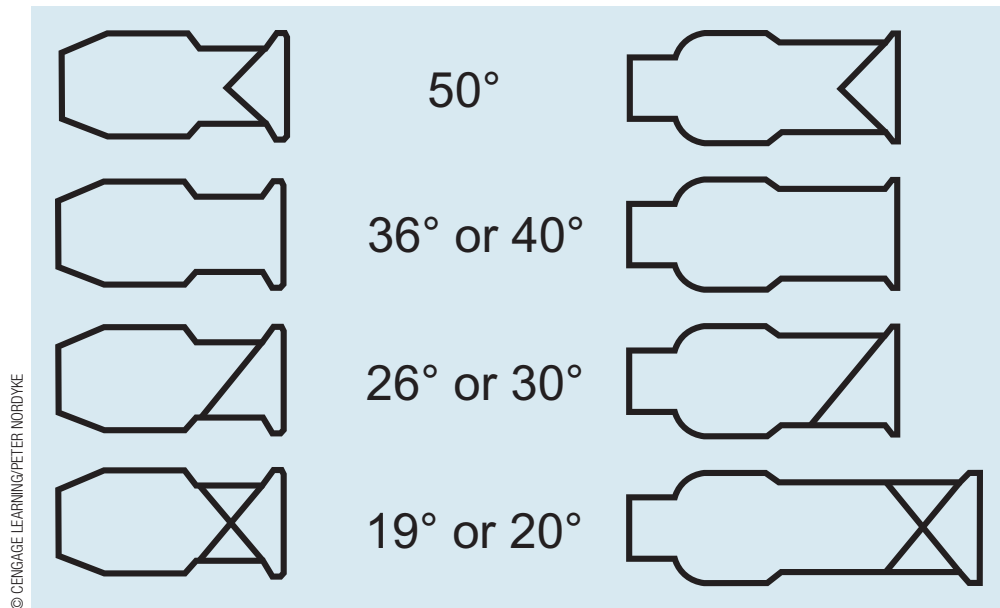
b

a & b FIELD TEMPLATES™ DESIGNED BY STEVE SHELLEY



20-3 Fixture Annotation Some designers prefer to place the focus area in front of the fixture, along with the color number.

20-4 Fixture Types These symbols, used in the fixture's barrel, indicate beam spread.



The gobo key indicates how the designer is identifying each pattern in use:

“G1” = GAM 305: Pointed break-up

“G2” = Rosco 7795: Shattered

side-arm An accessory valuable for hanging lights on booms or other vertical positions.

Booms Designers also need to represent floor stands or booms. A boom normally consists of a heavy metal base into which is screwed a length of 1¼- or 1½-inch black pipe. Any length of pipe may be used, but 14 or 15 feet is a recommended maximum. Booms of any great height must be safely tied off from above. A lighting fixture is then hung off the boom by using a cross-pipe or **side-arm** (Figure 20-5).

A boom can be represented on the light plot in one of two ways:

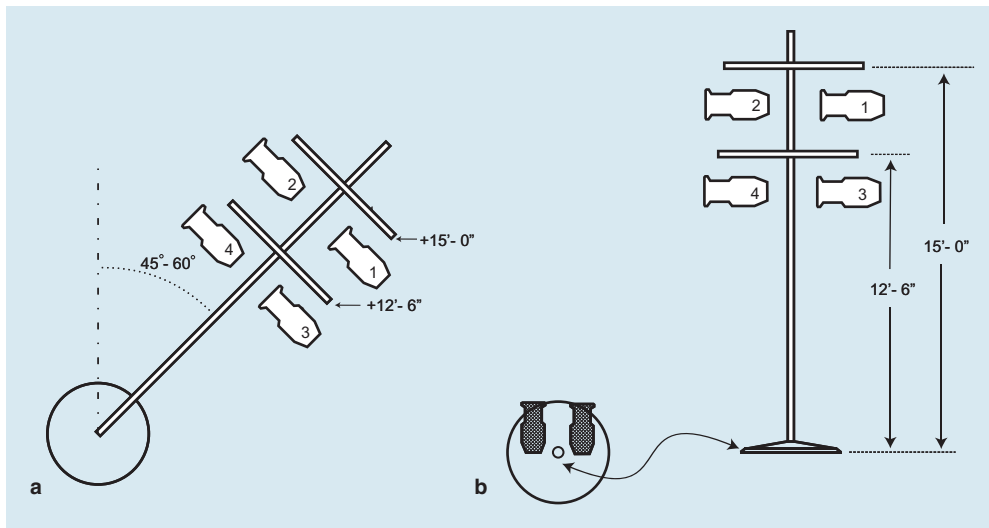
- The boom base is drawn as a circle and located in its proper position on the plan. The pipe is drawn at scaled length and at an angle of 45 to 60 degrees directly out of its base. The various fixtures are then shown in relationship to their boom pipe (Figure 20-6a). This is similar to an isometric view.
- The boom base and pipe are drawn as circles and located in their proper position on the plan. A crosshatched lighting fixture is drawn in proper relationship to the boom pipe, indicating that another view of the fixture appears elsewhere in the plot. An elevation of the boom is then drawn on the side or bottom of the drafting plate and labeled by position name (Figure 20-6b). If a large number of booms is used, as in dance design, a separate boom plate is recommended. Fixture specifications are indicated on the elevation (Figures 20-1 and 20-7).

In both methods of plotting boom positions, fixture height must be indicated. Similar drafting conventions should be used for ladder, box boom, and side cove positions where several fixtures are stacked above one another.

Lighting Areas As discussed in the previous chapter, the lighting designer determines lighting areas by considering several factors: shape and size of the setting, degree of control desired, blocking of actors, and equipment inventory. The diameter of the beam from a lighting fixture is a function of throw distance and the fixture's beam spread. The beginning designer is wise to make up beam-and-field



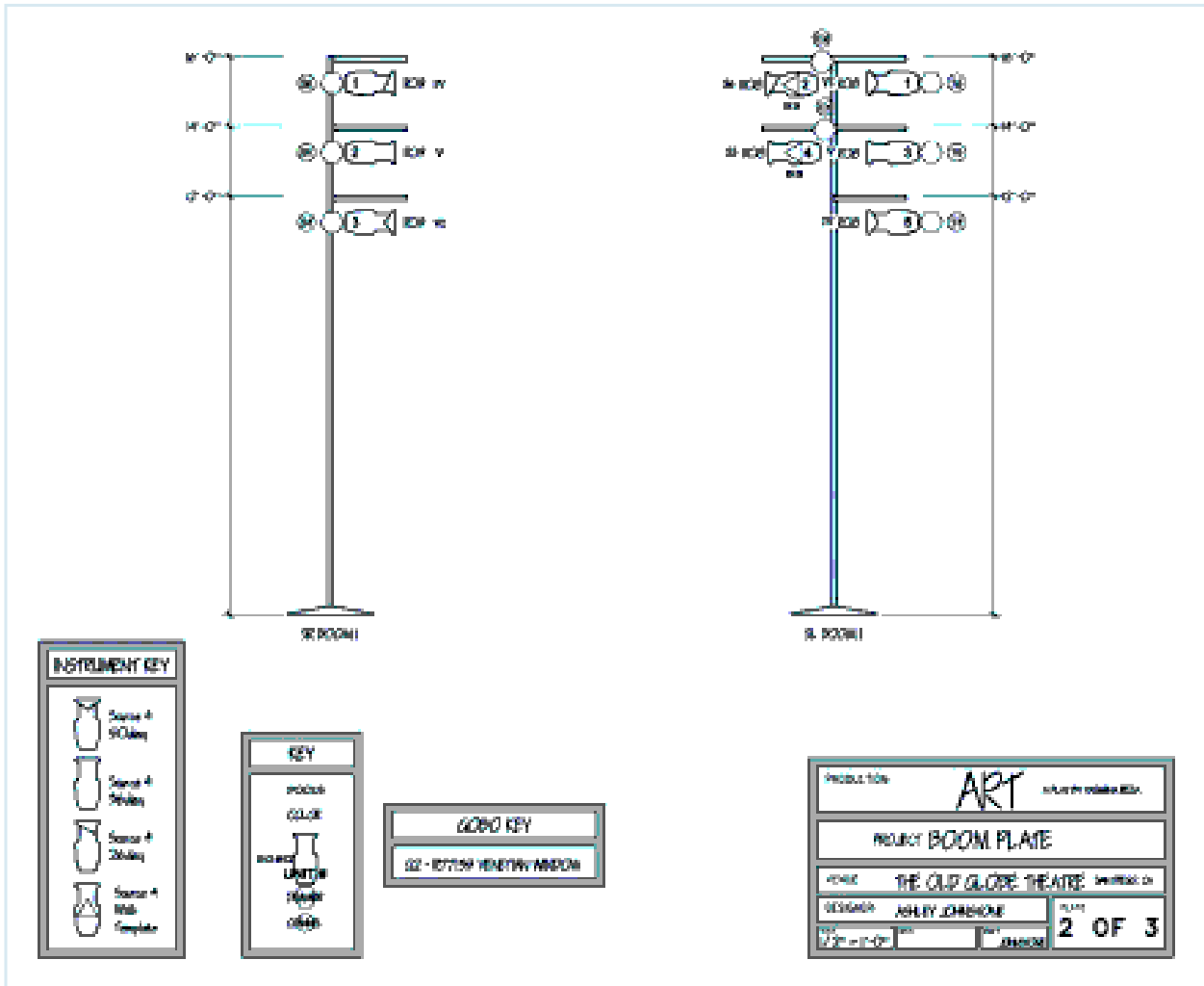
20-5 Boom with a Side-Arm A side-arm allows one to focus a fixture more easily.



20-6 Representing a Boom on the Light Plot

- a The isometric method shows the boom base in its actual position onstage.
- b The plan and elevation method is often desirable when space on the plan is limited. Note the cross-hatching of the fixtures in plan view.

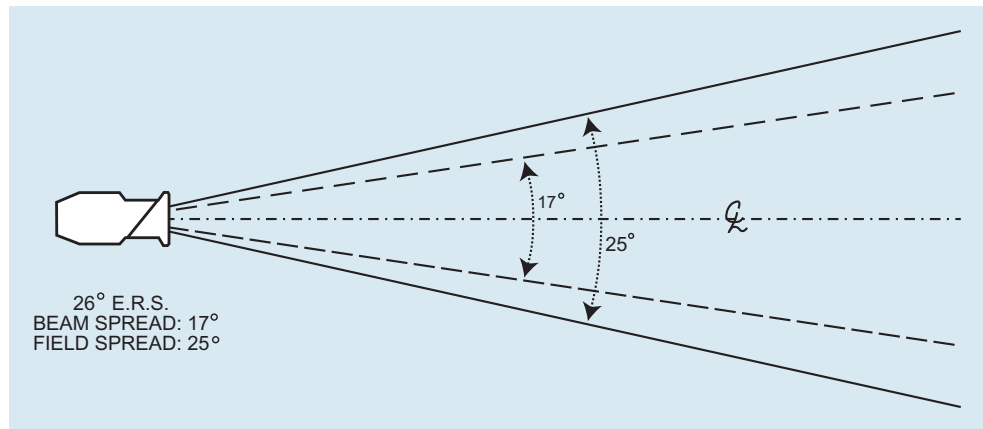
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20-7 Boom Plate The boom plate for the light plot of the production of *Art* shown in Figure 20-1.

20-8 Beam Spread Template The lighting designer can use a protractor and drafting paper to make templates such as the one shown.



spread templates for each of the fixtures in common use. Such a template, drawn to scale on drafting or tracing paper, can be used as an overlay on a section view of the theatre and will quickly show approximate area coverage (Figure 20-8).

The heavyweight Roman numerals or letters used as area indicators on the light plot should mark the center of the focus area (Figure 20-1). Using Roman numerals or letters helps to keep area numbers distinct from all other numbering on the plot. Circles indicating beam or field spread should not be included.

CAD Light Plots Computer-aided design and drafting programs enable a designer to use computer graphics to create lighting plots. Most lighting designers today draw with a mouse rather than a drafting pencil. Architectural firms and much of the entertainment industry expect that prospective employees be CAD-literate.

The two most popular software programs are AutoCAD® by Autodesk and VectorWorks® by Nemetschek North America. AutoCAD is the industry standard in architectural, engineering, and consulting firms. VectorWorks is the preference of many theatrical lighting designers. Learning to use a CAD program takes time, and the software is expensive, but the skill is important for survival in today's highly diverse lighting design field. With access to software such as Lightwright® and equipment such as a **plotter** (a drawing machine capable of drafting a light plot from digital information), the designer need only input the desired lighting fixture information, and the system will generate a plot as well as the required paperwork.

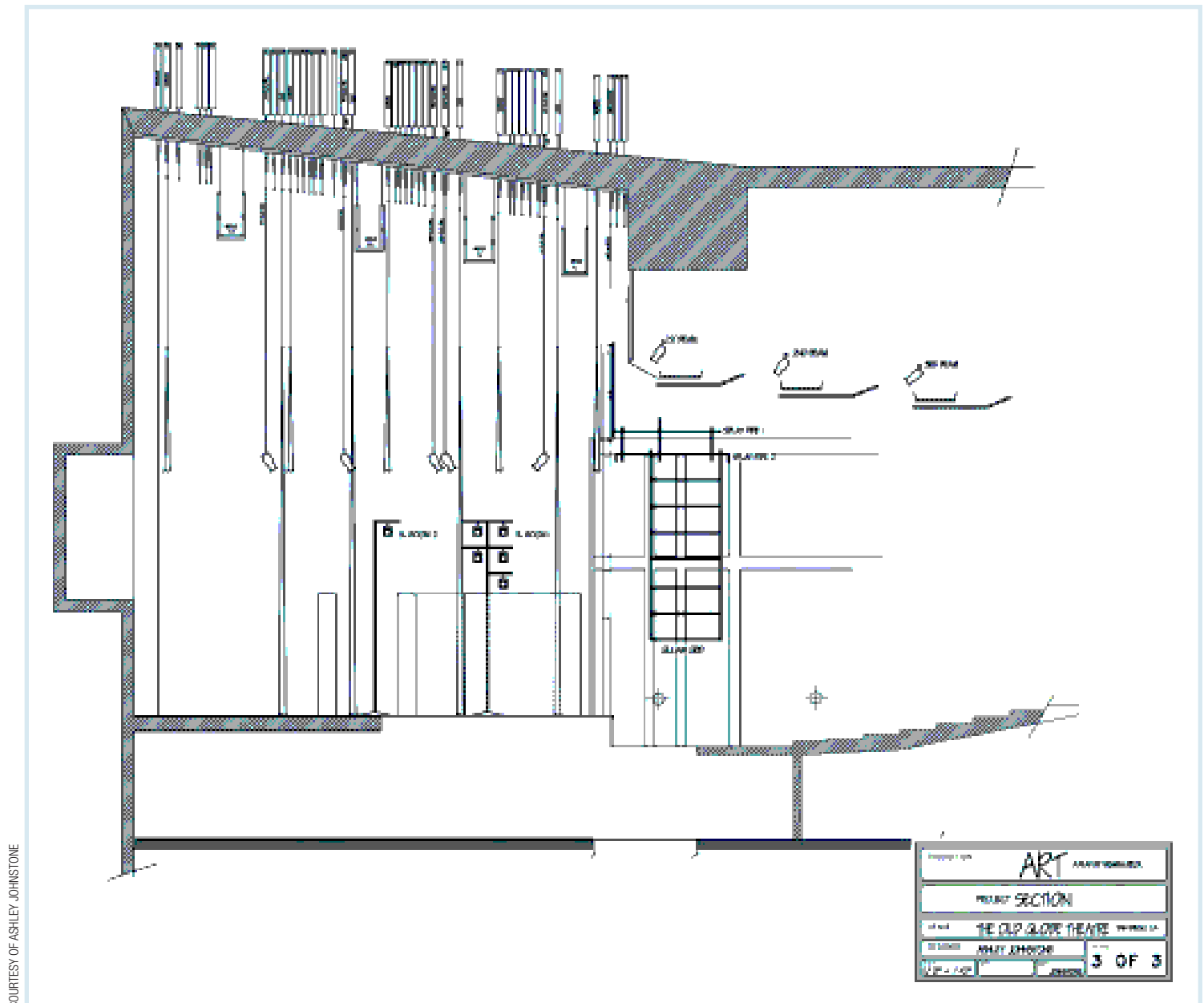
plotter A mechanical drawing machine used to draft light plots and technical drawings from digital files.

The Lighting Section

section A view of the stage, auditorium, and scenery from one side, as if cut across vertically at the center line.

A **section** is an important tool for the lighting designer. The section must be completely drafted in $\frac{1}{4}$ - or $\frac{1}{2}$ -inch scale before lighting fixtures are placed on the plot. A sectional view helps the designer visualize the height and the placement of scenery and lights, thereby improving the accuracy of the light plot. The designer consults the section for vertical sightlines, throw distances, acting levels above or below stage height, and accuracy of lighting angles. Electric trims (height of electric pipes off the stage floor) and horizontal masking are determined by using the section (Figure 20-9).

Recall that the section view is actually a side view with the picture plane on the center line. It is as if a large slice were taken through the theatre and the auditorium along the center line and we are looking into the cut surface. If the stage house is drawn on



COURTESY OF ASHLEY JOHNSTONE

20-9 Lighting Section The 1/2-inch scale center-line section of the *Art* light plot shown in Figure 20-1. Sections are important indicators of throw angle and distance, scenery heights, and masking.

the left-hand side of the drafting plate, we are looking stage-left. If the stage house is on the right-hand side of the drafting plate, we are looking stage-right. Normally, only one section view is necessary.

Note that the section is primarily a lighting designer's tool. If electric trims are indicated on the plan, the production electrician need never see the section.

As noted earlier, the scene designer provides the lighting designer with a center-line section view of the stage that includes horizontal masking at trim height, critical audience sight points, and scenery placement. Occasionally, various supplementary



LIGHTING DESIGN BASICS ■ Designing the Light Plot—Step by Step

1. Gather venue drawings and inventory.
2. Get scenery drawings (plan and section) from designer.
3. Draft section with scenery.
4. Draft plan with scenery but without lighting.
5. Attend rehearsals.
6. Do mini-plots or rough plot to get ideas on paper. Include color ideas.
7. Design and draft lighting areas.
8. Consider control and inventory limitations referring to rough plot.
9. Put fixtures on plot.
10. Add channels and color information.

section views are necessary (such as a front section along the plaster line to show side-light angles); the lighting designer can easily and quickly draft them.

Lighting Paperwork

Proper planning and the resulting paperwork are critical to a successful design. The best lighting designers are creative as well as methodical—character traits not often found together. Designers have developed a variety of types of paperwork in order to simplify the load-in and the execution of the design. Lighting paperwork and related items include hookups, fixture schedules, cue sheets and preset sheets, color cut lists, designer magic sheets, batten tapes, hanging cardboards, focus charts, and shop orders. Much of this paperwork can be generated by lighting software programs.

Paperwork Software

Many individuals and companies have developed software programs that are intended to ease the lighting designer's paperwork load. A good example is Lightwright®, developed by John McKernon and distributed by City Theatrical, Inc. Depending on the circumstances of a production, such programs can save the designer or the assistant designer a great deal of time. Some initial time and effort may be required to enter the lighting data into the computer. However, once the information has been entered, changes and/or additions to keep the paperwork up-to-date are extremely fast and simple. This is of particular advantage to productions that will tour or be revived. If the plot has been computer-drafted, a supplementary software program can produce paperwork without additional data entry (Figure 20-10).

The Hookup and Fixture Schedule

In most cases, the only paperwork item submitted with the light plot is either a hookup or a fixture schedule. Both pieces of paperwork list anything anyone would ever want to know about each fixture used in the plot. The difference between the two is the order in which they do so.

CHANNEL HOOKUP

VENUE: The Old Globe Theatre, San Diego, CA
 LIGHTING DESIGNER: Ashley Johnstone

ART

PROJECT

CHANNEL	DIM.	UF	POSITION	INSTRUMENT TYPE	WATT.	COLOR	TEMP.	ACCESSORIES
1		1	3RD BEAM	SOURCE 4 19 DEG	575w	R60		
2		3	3RD BEAM	SOURCE 4 19 DEG	575w	R60		
3		6	3RD BEAM	SOURCE 4 19 DEG	575w	R60		
4		3	2ND BEAM	SOURCE 4 19 DEG	575w	R60		
5		3	2ND BEAM	SOURCE 4 19 DEG	575w	R60		
6		7	2ND BEAM	SOURCE 4 19 DEG	575w	R60		
7		1	1ST ELECTRIC	SOURCE 4 26 DEG	575w	R60		
11		2	3RD BEAM	SOURCE 4 19 DEG	575w	R902		
12		4	3RD BEAM	SOURCE 4 19 DEG	575w	R902		
13		7	3RD BEAM	SOURCE 4 19 DEG	575w	R902		
14		1	2ND BEAM	SOURCE 4 19 DEG	575w	R902		
15		4	2ND BEAM	SOURCE 4 19 DEG	575w	R902		
16		8	2ND BEAM	SOURCE 4 19 DEG	575w	R902		
17		2	1ST ELECTRIC	SOURCE 4 26 DEG	575w	R902		
21		5	3RD BEAM	SOURCE 4 19 DEG	575w	R902		
22		8	3RD BEAM	SOURCE 4 19 DEG	575w	R902		
23		9	3RD BEAM	SOURCE 4 19 DEG	575w	R902		
24		5	2ND BEAM	SOURCE 4 19 DEG	575w	R902		
25		10	2ND BEAM	SOURCE 4 19 DEG	575w	R902		
26		14	2ND BEAM	SOURCE 4 19 DEG	575w	R902		
27		4	1ST ELECTRIC	SOURCE 4 26 DEG	575w	R902		
31		6	2ND BEAM	SOURCE 4 26 DEG	575w	R92		
32		11	2ND BEAM	SOURCE 4 26 DEG	575w	R92		
33		15	2ND BEAM	SOURCE 4 26 DEG	575w	R92		
34		1	1ST BEAM	SOURCE 4 26 DEG	575w	R92		
35		4	1ST BEAM	SOURCE 4 26 DEG	575w	R92		
36		5	1ST BEAM	SOURCE 4 26 DEG	575w	R92		
37		9	1ST ELECTRIC	SOURCE 4 26 DEG	575w	R92		
41		9	2ND BEAM	SOURCE 4 26 DEG	575w	R50		
42		13	2ND BEAM	SOURCE 4 26 DEG	575w	R50		
42		17	2ND BEAM	SOURCE 4 26 DEG	575w	R50		
44		3	1ST BEAM	SOURCE 4 26 DEG	575w	R50		

CHANNELS 1 THRU 44

PAGE 1

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20-10 The Hookup Shown is the channel hookup, created by Lightwright software, from Art.

The Hookup There are two types of **hookups**: One is arranged by dimmer number and intended for installations that still use a patch panel (left column below); the other is arranged by channel number and used with dimmer-per-circuit systems (right column). Note that items 5 through 9 in both columns contain common information.

hookup A lighting chart that is arranged by dimmer or channel number and that lists a variety of fixture information.

Patch Panel Hookup

Dimmer-per-Circuit Hookup

1. Dimmer number
2. Position name
3. Fixture number
4. Circuit number
5. Fixture type
6. Fixture wattage
7. Color
8. Purpose/focus
9. Remarks

1. Channel number
2. Dimmer/circuit number
3. Position name
4. Fixture number
5. Fixture type
6. Fixture wattage
7. Color
8. Purpose/focus
9. Remarks

Hookups were originally intended as a supplement to the fixture schedule, so not all of the information listed above is always necessary. With more information included on light plots themselves, a hookup can replace a fixture schedule.

fixture schedule A lighting chart that is arranged by fixture location and number and that lists a variety of fixture information.

The Fixture Schedule Listing all fixtures by location and number, the **fixture schedule** is primarily used to provide fixture information that does not appear on the light plot. Information is listed in the following order:

1. Location and fixture number
2. Fixture type
3. Wattage/lamp designation
4. Color number
5. Use/focus area
6. Circuit
7. Dimmer/channel
8. Remarks (gobo, two-fer, iris, top hat, barn door, etc.)

Other Paperwork

Additional paperwork provides a means of accurate communication with an assistant designer or electricians. It is a very important part of a successful lighting design.

Cue Sheets and Preset Sheets Cue sheets and preset sheets were intended for use with non-computer-based control systems. However, a form of the preset sheet is valuable for writing cues “blind” for any type of control situation in which an offline editor is not available.

cue sheets A list of a production’s lighting cues in numerical order.

Cue sheets are simply a list of a production’s lighting cues in numerical order. In a preset system, information about each cue may include preset number, fade time, and description. In a computer-based system, information includes cue number, fade time, link or follow, delay, and possibly a description.

preset sheets A means of recording channel levels for each lighting cue in a production.

On **preset sheets**, designers record channel levels for each lighting cue in a production. All channels are listed by number, and there is space for the designer to pencil in level information.

Color Cut Lists Once the plot is complete, color filters must be cut. A color cut list, organized by color manufacturer and then by color number, specifies size and quantity of each filter. This list may need to be completed quite early in order to allow time for purchasing. Software programs can generate a cut list that includes required sheet quantity. If no software is used, electricians find it easiest to generate a color cut list from a hookup or a fixture schedule rather than from the plot. If the individuals cutting color are inexperienced, the designer must be sure they know that a 6-inch color frame does not literally mean a 6-inch cut of color.

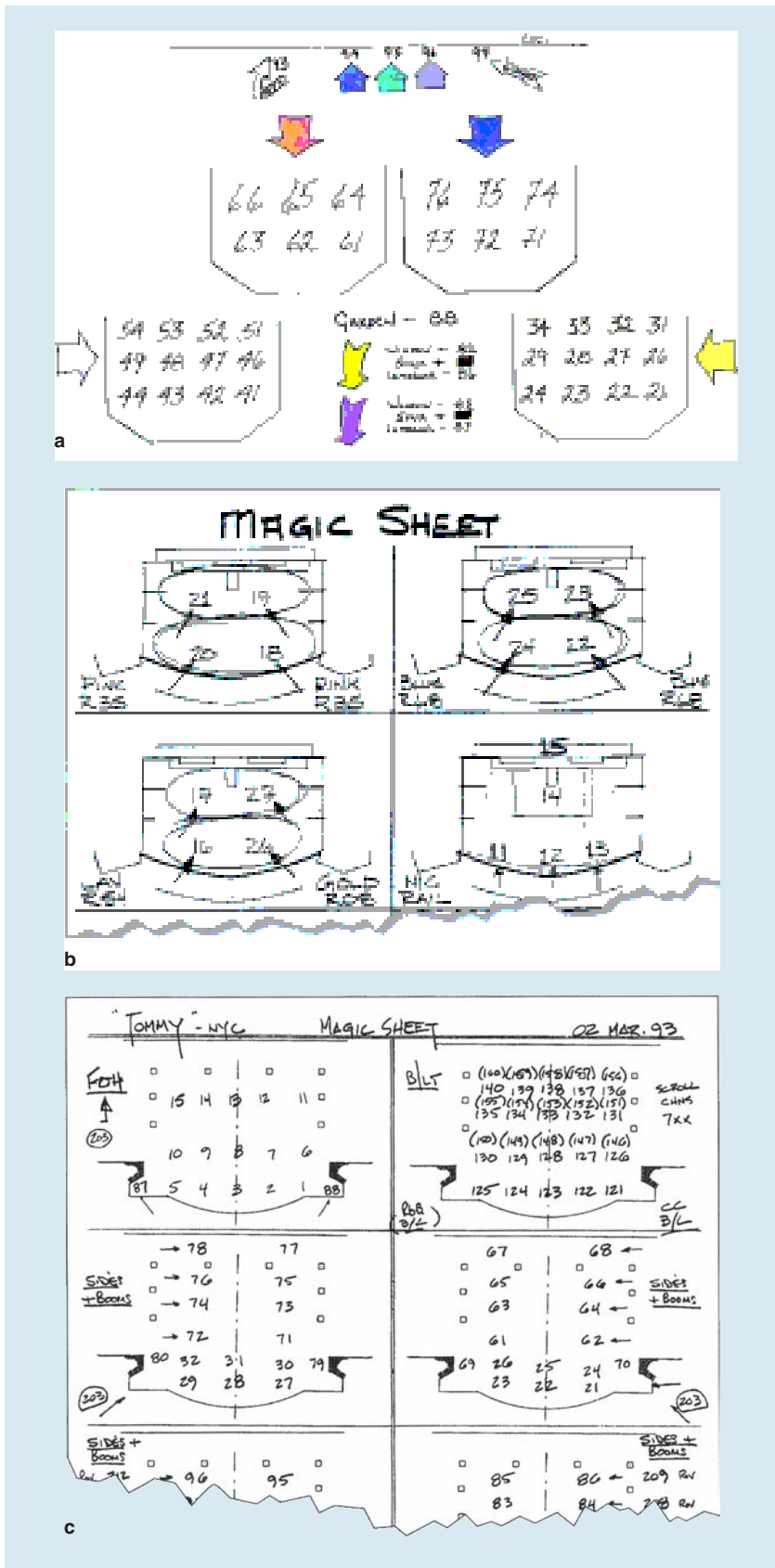
magic sheet Custom-designed paperwork used to assist the designer in setting and adjusting light levels; also called a *cheat sheet*.

Magic Sheets Paperwork that aids a designer in setting and adjusting lighting levels is referred to as a **magic sheet**, or “cheat” sheet. With the impressive increase in numbers of channels used, designers need help remembering what is assigned to each one—magic sheets are the answer.

Although each designer likes to customize his or her own sheets, and nearly as many styles exist as do designers, Figure 20-11 illustrates several of the most common types. Many magic sheets list groups of channels by either function or color. Some can be quite elaborate and pictorial. The primary objective in designing a magic sheet is to keep it clear and concise—hopefully on one page.

20-11 The Magic Sheet

- a A magic sheet aided by color for a production of *Hay Fever* designed by Craig Wolf.
- b A pictorial magic sheet, used by designer Tom Schraeder.
- c The magic sheet used by designer Chris Parry for his production of *The Who's Tommy*.



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COURTESY TOM SCHRAEDER

COURTESY THE ESTATE OF CHRIS PARRY

batten tape Strips of paper or cloth attached to a lighting batten to assist in the hanging and circuiting of fixtures.

hanging cardboards Pieces of cardboard onto which a section of the light plot has been attached; used to assist in the hanging and circuiting of fixtures.

focus chart Charts containing focus information for all fixtures in a production; used to reproduce the focus accurately.

shop order A contract for the rental of lighting equipment and accessories that lists, in detail, all the equipment to be rented for a production; used for bidding purposes and ordering.

Batten Tapes To expedite hanging and circuiting the electric pipes, a designer may wish to have **batten tapes** prepared for each hanging position. These consist of rolled strips of paper or cloth that have been premarked with center line and specific fixture information. The tapes are attached to the batten, and then the electricians follow the instructions on the tape. Information may include fixture number, circuit number, fixture type, color, and even focus. Tapes eliminate any measuring and chalking of the battens and, in combination with hanging cardboards, can provide so much information to electricians that they never need to consult the master light plot. Tapes are particularly valuable for touring productions or for working with inexperienced electricians.

Hanging Cardboards The assistant designer or master electrician can prepare **hanging cardboards**, pieces of stiff paper or cardboard onto which a single location and its respective instrumentation have been transferred from the master plot. Normally, a copy of the plot is cut up into positions and attached to a cardboard backing. A cardboard is given to electricians during the load-in, allowing them the freedom of hanging and circuiting the position without having to refer to the unwieldy master plot. Hanging cardboards may contain more detailed information than the plot does and, like batten tapes, are especially useful for touring situations in which they can be reused many times.

Focus Charts and Shop Orders Two paperwork items especially important in the commercial theatre are tour focus charts and equipment shop orders. First, a **focus chart** is a precise record of the focus information for all the fixtures in a production. It allows operators to reproduce focus accurately in each venue. Like magic sheets, focus charts come in many styles and forms.

Second, a **shop order** is essentially a contract for the rental of lighting equipment and related hardware between an equipment rental house and a producer represented by the lighting designer. These items are discussed further in Chapter 25.

Realizing the Plot

The final and most challenging step in lighting a production is, of course, realizing the plot. This process may last only two or three days but can take as long as two weeks or more. Again, any preparation completed before move-in will pay off tenfold later on.

Final Preparations

After completing the plot and before moving into the theatre, the designer must be sure that all supplies are on hand, all paperwork is ready, and all cues are written.

Cues Motivated cues such as a lamp switched on are relatively simple, but cues to support a change in mood or tempo can be more complicated. Although lighting cues can help keep an audience's attention, the movement of light must never feel forced or inappropriate. Most often, lighting cues should not draw attention to themselves.

Writing cues is actually relatively simple for the lighting designer, although at first this might not seem to be the case. If a designer carefully watches several rehearsals, the *rhythm* of the production will dictate where most of the cues belong. Cues may be needed to expand or isolate the scene, to establish new focus, or to change mood. Noting cue placement in the script during one of the final run-throughs before move-in is a good idea. Cues can then be numbered and levels written. Cues should be numbered sequentially, with inserted cues having a decimal point (for example, Light Cue 12.1).

The cues and their placement must be given to the stage manager, who will “call” the show. This cue-writing session should take place early enough to allow time for the stage manager to properly notate each cue before the technical or first lighting rehearsal. Ideally,

20-12 Preset Sheet A preset sheet used for recording dimmer levels “blind.” It can also function as a designer’s magic sheet.

Lighting Preset Sheet: SOLERA DANCE CO. 11/20/11

CUE #		COUNT: /									
CHANNEL #	1	2	3	4	5	6	7	8	9	10	
USE	S.L. ALL-SIDE	MID	MID	MID	MID	USE	USE	USE	USE	USE	FRONT SP. WIDE
LEVEL											
CHANNEL #	11	12	13	14	15	16	17	18	19	20	
USE	S.L. BOOTH	MID	MID	MID	MID	USE	USE	USE	USE	USE	FRONT SP. WIDE
LEVEL											
CHANNEL #	21	22	23	24	25	26	27	28	29	30	
USE	S.L. ALL-SIDE	MID	MID	MID	MID	USE	USE	USE	USE	USE	FRONT SP. WIDE
LEVEL											
CHANNEL #	31	32	33	34	35	36	37	38	39	40	
USE	S.L. BOOTH	MID	MID	MID	MID	USE	USE	USE	USE	USE	FRONT SP. WIDE
LEVEL											

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this session should include both the stage manager and the board operator as well as the director. The designer should set aside enough time for an uninterrupted discussion of the cues so that everyone understands why a cue happens and what the fade times are.

The stage manager must understand that some cue placements will change during the rehearsal process. Each and every cue must be assigned a precise moment when it is called, if only to facilitate changing the placement of the call. See the box to the right.

Writing Levels Setting channel levels for the first time is difficult and time-consuming, but it gets easier with practice. There are two ways of writing levels: “blind” and live in the theatre. Setting levels blind is a valuable skill that can mean the difference between an adequate and a good lighting design.

When writing blind, designers determine cues and channel levels several days before they actually see them onstage. Time should be allotted to think through each preset or stage picture: Which sets of fixtures should be reading highest, and which control areas should take focus? Levels are recorded on a preset sheet (Figure 20-12), using one sheet for each cue. The completed sheets are then given to the board operator and entered into the memory of the control system.

Many control system manufacturers now offer software that allows a designer to write and edit a show offline. Most programs can be used with only that manufacturer’s control system, but some software allows exchange of data between systems. Writing blind takes time to learn, but it can result in a better-looking product and can cut hours off a lighting rehearsal.

In general, it is best to write and design for the highest dimmer levels to be between 80 and 90 percent. Then, if more light is required, the designer has room to maneuver. A rule of thumb when setting levels: light from two identical sources will begin to be perceived as contrasting when their intensities differ by approximately 15 percent. Depending on the curve of the dimmers, a reading of 15 to 20 percent barely warms the filament, and a reading of 25 to 30 percent just begins to produce visible light. The saturation of color filters must be kept in mind, because more saturated filters significantly cut down light transmission.

LIGHTING DESIGN BASICS

Cue Placement

Cues should be called as follows:

- “Warning Light Cue 12” (approximately 10 seconds before “GO”)
- “Light Cue 12 . . . GO”

Note the order: the words “Light Cue” are not prefaced by any other word on the “GO” call.

The Production Electrician and Crew The lighting load-in must be carefully scheduled well in advance with the production manager or technical director in order to coordinate lighting and scenery. A definite crew schedule should be published at least a week before the actual load-in of equipment. This is to ensure adequate participation by crew members and minimize any space conflicts. Equipment must be ready and waiting to be hung. Certain tasks are best accomplished by a large crew, whereas others are better suited to one or two people. Preparing equipment (checking lamps, lens adjustment, color, gobos, cable, and so on) is best accomplished by the production electrician and an assistant or two. The actual hang requires a larger group of four to eight individuals. Before the larger crew is called, the production electrician must have all necessary equipment in good working order for the hang. This simple policy allows the production electrician a fighting chance of doing a good job as crew head.

The Hang

Just as the goal of the preparation period should be to make the hang go smoothly, the goal of the hanging session should be to make the focus uneventful.

The lighting designer or assistant must be available during the load-in to answer any questions that may arise. Although the responsibility for the load-in lies with the production electrician, the designer can do a great deal of good by being attentive and setting a positive tone without getting in the way. The entire crew should aim their work toward a good and smooth focus session. If an electrician always keeps the focus in mind, quality of work is usually excellent. The designer should never play a major role in physically hanging the show. This is the crew's job, and a designer's energy is best spent elsewhere.

The Hanging Crew It is most efficient for the production electrician to split the crew into groups of two or three people with a group leader reporting back. In this way, one group can begin working on the booms (which always take a good deal of time), another on the first electric pipe, and a third on hanging front-of-house. The production electrician coordinates all, checking from time to time on a crew's progress and seeing that everything is done properly. A given hanging position should be completely hung before cabling begins. C-clamps should all face the same direction (bolts either upstage or downstage) so that the focusing electrician knows where they are. If the designer indicates focus on the light plot, fixtures should be roughly aimed in that direction—this also saves valuable focus time. Fixture adjustments for pan and tilt should be snug, but not so tight that a wrench is required to change them when setting focus.

Circuits and Cabling Depending on the circuit layout of the house, cabling may be the most time-consuming part of the hang. The designer often leaves circuits unspecified on the light plot, thereby allowing the electricians freedom to cable to the best locations. If this is the case, a single person (assistant designer) should be assigned the task of recording circuits onto the plot and subsequently doing the hookup. The only disadvantage of this system is that the patching cannot be completed until circuiting is done and recorded.



SAFETY PRACTICE ■ Precautions During the Hang

- When working overhead, remember to carry a minimum of tools and always tie off your wrench. Take special precautions to avoid falling gel frames, pens and pencils, and gobo holders.
- If working with an inexperienced crew, be sure that adequate supervision is provided—even if it seems to be taking too much time.
- Remember that appropriate crew breaks promote safety.

Circuiting begins as soon as each position is hung, with one, or at most two, electricians assigned to the task. Because of the work's complexity, cabling a hanging position is best done by a single electrician. Cable should be attached to the pipe with black tie-line (cotton sash cord works well) using bow ties. Adequate slack must be left in the fixture leads to allow for free focus. If a connection is loose, it should be tied, taped, or repaired at this time rather than later during focus. A good electrician constantly anticipates the needs of the upcoming focus.

The Focus

Lighting focus takes concentration. If at all possible, electricians should have the stage to themselves during focus hours. Everyone should be prepared for the focus: be on time, be alert, and be efficient. Normally a designer focuses in order, from one fixture to the next along a position. In this case, having the assistant designer call channel numbers to the board operator cuts down on distractions and saves a good deal of time.

The designer should never begin the focus before an accurate checkout has been completed. Interrupting focus for a lamp or a patch mistake or a bad circuit is a serious waste of time and, more importantly, concentration. Front-of-house is often focused first. Learning to focus two electricians at once and to focus with one's back to the light, looking at one's shadow, are important skills. Learning to focus quickly is even more important. And giving the crew periodic breaks is essential.

A focus crew normally consists of the designer, an assistant, the production electrician, two focusing electricians, a board operator, and one or two additional electricians. The production electrician has done a full checkout and completed all necessary repairs well before the focus crew arrives. With communications in place, general focus philosophy discussed, and coffee drunk, the focus begins.

A good focus team in action is wonderful to watch. Talk is kept to a minimum as the electricians keep ahead of the designer, anticipating his or her next move. The team works like a well-oiled machine. Soon a pace is established, and the job is done before the crew realizes that they are hungry or tired.

However, an unprepared and/or unskilled focus team is dreadful to observe and even more painful to be part of. Headsets do not work, lamps are burned out, one fixture is discovered without a lamp in it at all, shutters stick, cables short out, barrels refuse to budge, and three lights are hung upside down. By lunchtime, thirty fixtures have been focused with 120 still to go, and everyone is tired and irritable.

Lighting and Technical Rehearsals

The first time a director sees the results of the lighting designer's work is probably at the technical or lighting rehearsal. This should not, however, be the first time the lighting designer sees his or her work. The ideal situation is to look at presets during the final run-through before the technical rehearsal. The designer should explain to the cast and director that he or she will be adjusting a few lighting levels and most will probably not be in sequence with the action onstage. (Leave enough light for rehearsal, never blacking out the stage.) This gives the designer a good chance to see the lighting on actors without the added pressure of a technical rehearsal.

The technical and dress period is most crucial to the lighting designer because this is when critical design decisions are made. This is also the time when the lighting designer is working the hardest and is under the most pressure. Accordingly, the designer must be fresh and alert—one cannot see or think for very long with only a few hours of sleep.

Lighting Rehearsals Some directors prefer to sit with the lighting designer and the stage manager and move slowly through a production's lighting cues. This practice is

lighting rehearsal Moving cue-to-cue through a production's lighting looks with the director and stage manager—hopefully with actors in costume, but without other tech—takes place before the technical rehearsal.

usually called a **lighting rehearsal** and can take several different forms. Some directors like to take the time to build cues during these sessions; others may want to see presets already written—knowing this in advance is crucial. The precise way of working matters little; what matters is that there are no surprises. Everyone involved should know how the session will work and what the goals are.

Not all productions need lighting rehearsals. In fact, for many years, it was understood that technical rehearsals were the place to first see the lighting. However, with increased complexity comes a greater need for lighting rehearsals, and large shows such as musicals require them.

Technical Rehearsals Infamous for being long and laborious, technical rehearsals are disliked by technicians as well as by actors. However, with proper preparation and someone who keeps things moving, these rehearsals can be relatively painless. Good judgment must be used in determining when to stop and fix something and when to keep moving. Tactless people must be banned from technical rehearsals.

Calling this rehearsal from the house rather than an isolated booth somewhere is best because the stage manager will be in better contact with the director, the designers, the technical staff, and the actors. Headsets must be carefully checked out well before the technical rehearsal begins. Nothing is more frustrating (and, unfortunately, more common) than communications problems during a technical rehearsal.

The purpose of a technical rehearsal is to solve technical problems—not to constantly adjust light levels, and certainly not to write lighting presets. If presets are not complete before the technical rehearsal, the rehearsal should go on without lights. This is also not the time for a director to adjust blocking, a temptation sometimes difficult to resist. If the director gives full attention to the process at hand, results will be better and the end reached sooner.

Here are a few rules of thumb: Always begin a technical rehearsal on time. Pace yourself during the technical rehearsal. Never schedule an open-ended time period; always have a stopping time. Take periodic breaks, and remember that positive reinforcement works well. Remain objective, observe time deadlines, and—above all—be sure that your operators and stage manager understand and record changes as they are made.

Notes Anticipate needing time in the theatre to take care of lighting notes. Notes taken during a technical rehearsal might be minor, but the tasks may also require several hours to complete. The designer verbally gives notes to an assistant during the rehearsal. The assistant then divides them into “board notes” and “work notes.” The work notes need to be relayed to the master electrician, who subsequently makes a crew call if necessary. The board notes will normally require dark time in the theatre with a board operator. All this requires clear lines of communication and careful advance planning.

Dress Rehearsals

A production normally has two or three dress rehearsals, with the first one devoted primarily to costumes. Lighting-level changes can be made during the dress rehearsal, but the performance must not be stopped except for a serious problem. Second and third dresses must never be stopped. The fewer changes made during dress rehearsals, the better the stage manager and operators will learn the show.

The assistant designer should take notes so that the designer can keep his or her eyes on the stage. The designer's remote monitor enables the assistant to know what cue the designer is in. If a remote does not exist, the assistant should follow a script with the cues written in it. The director's attention is divided among a great number of equally important things during this stage of a production. The designer should never leave after a dress rehearsal without first talking to the director, the stage manager, and the operators.

Previews

Previews refer to performances with an audience that take place after the dress rehearsal process but before the official opening. The purpose is usually to expose the actors to audience reaction before the production is reviewed. The number of previews can vary from one or two to several weeks' worth; the role of the lighting designer on these occasions often depends on need. If the production's lighting is complete, the designer has no reason to attend all previews. However, if changes continue to be made during the preview process, the designer must be in attendance.

Opening

Of course, opening the show is what it's all about. By attending opening night, the designer shows support for the cast and crew. However, it is not a time to give notes. The lighting is done when the show opens. The designer should try to relax and enjoy the show as an audience member.

Clearly, much goes into realizing the light plot. This chapter has emphasized the paperwork and types of collaboration required. The lighting designer must also know about power distribution and lighting control; the next chapter explores this topic in detail.



Power Distribution and Control

Not long ago, the word *control* meant dimming lights up and down. Today it involves a great deal more than that. Lighting consoles are now called on to send a vast array of information to moving lights, to tell haze machines when to turn on and off, to adjust the speed of animation discs, and even to trigger cues on the sound computer. However, we begin our discussion with a more fundamental concern: distribution of power in the theatre.

CENGAGE **brain**.com

For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

Distribution of Power and Control

The theatre is currently undergoing significant changes in power distribution requirements. The upheaval began slowly and quietly with remotely-controlled color scrollers and faders, grew in momentum with automated fixtures, and is now nearing a breaking point with LED sources. The challenge is two-fold: (1) DMX as a communication protocol is inadequate, and (2) a great deal of AC power is needed in places where theatres traditionally had little or none.

Power Needs

Arc-source moving lights require their own 20-amp AC power supply as well as DMX. Remotely controlled equipment, such as color changers or I-Cue moving mirrors, requires a more moderate supply of power plus DMX. LED sources as well require a modest supply of AC power and DMX. As the theatre moves toward more extensive use of this kind of equipment, the demand for distributed non-dimmed AC power circuits grows. Unfortunately, theatres generally have a modest supply of such circuits and must improvise. Breakout power can be achieved by obtaining a power distribution box such as those shown in Figure 21-1 and drawing power from the backstage disconnect if one exists—if not, auxiliary power must be drawn from other, usually remote, locations. While this solution leads to a mess of temporary stage cables strung about the theatre, it gets the job done. However, a saturation point will be reached when simply too much time is being devoted to running cable—both power and DMX. Manufacturers are responding with power raceways such as Philips Strand Lighting's eS21 LED raceway (Figure 21-2). This particular product is built to customer specifications and can contain any combination of dual IGBT dimmer modules, LED power supplies, and DMX-controlled power relays.

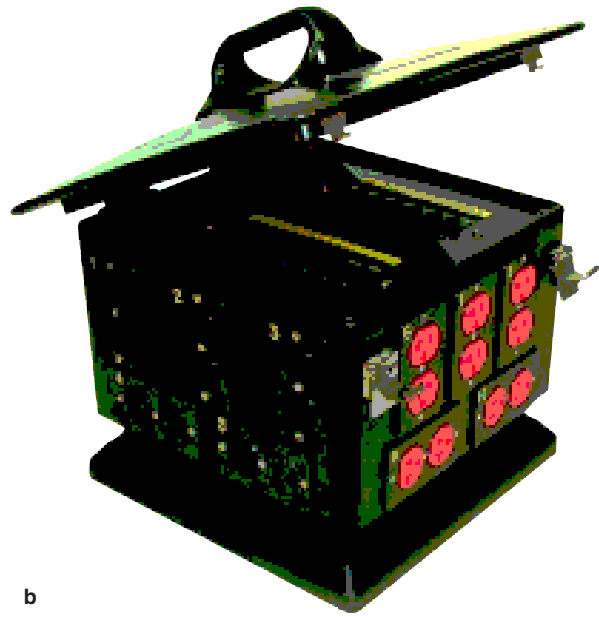
Control Needs

As theatre's use of remotely-controlled devices increases, so does the need for a greater number of control channels. A single DMX universe provides 512 control channels of one-way communication to a remote device. Two things have happened: We have come

PHOTO COURTESY ENTERTAINMENT POWER SYSTEMS



a



b

PHOTO COURTESY LEX PRODUCTS

21-1 Power Distribution

- a Entertainment Power Systems' EPS Dura-Power EGS distribution rack has 400-amp, 3-phase Cam-Lok inputs with 12 duplex (Edison) outputs.
- b LEX PowerHOUSE™ Portable Distribution Rack with 200-amp, 3-phase Cam-Lok inputs and 24 duplex (Edison) outputs.

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21-2 Power Distribution Raceway

The Philips Strand eS21 LED raceway is available with any combination of dual dimmers, dual relays, or Quad LED power supply modules.

to appreciate and demand bidirectional communication, and we are in need of more and more control channels. The solutions to these problems seem to reside with *Ethernet*, *RDM*, and perhaps *ACN*.

Ethernet This communication technology was developed by Xerox in association with DEC and Intel in the late 1970s and has become a standard local area network (LAN) technology for digital devices. It provides very fast transmission speeds over twisted-pair network cable with inexpensive and widely available connectors. Ethernet is capable of transmitting numerous universes of DMX in a bidirectional fashion with the assistance of **RDM**.

Remote Device Management RDM is a lighting protocol developed by ESTA (Entertainment Services and Technology Association—now PLASA) several years ago. It works alongside DMX, providing two-way communication between a controller and remote fixture. The catch is that both the controller and the remote device must be RDM capable. Today, new equipment from a great number of manufacturers is being produced RDM enabled.

Architecture for Control Networks (ACN) **ACN**, also recently developed by ESTA, is designed to replace rather than supplement DMX. The fact is that DMX was

RDM Remote Device Management is a stage lighting protocol intended to allow two-way communication between a control console and a remotely-controlled device.

ACN Architecture for Control Networks is a stage lighting protocol designed to replace DMX, improving two-way communication and signal reliability.

never designed to communicate with anything other than dimmers—it has done so very nicely for many years. However, accurately communicating with hundreds of remote-device attributes is beyond the design parameters of DMX protocol. ACN is comprised of three sub-protocols: one is meant to communicate from a control console to a remote device in a very specific and straight-forward manner; the second allows a fixture to explain back to the console exactly what its attributes are; and the third assures that all communication is accurate and reliable. Of course, all consoles and remote devices must be able to support ACN and very few currently do; so its common use is in the future.

DMX and RDM over Ethernet are happening now. However, it is probably a temporary solution. ACN or another advanced communication protocol is the future.

Dimming in the Theatre

As noted above, moving lights and LED fixtures both have built-in dimming capability. However, the theatre still needs conventional dimmers as long as the incandescent lamp exists.

A dimmer is the lighting designer's paintbrush. Broad strokes are accomplished by controlling several lighting fixtures with one dimmer or by grouping dimmers together. Detail work requires individual control over each light.

Dimming an incandescent fixture is normally achieved by reducing the electrical voltage sent to the lamp. This causes the lamp's filament to glow less brightly and give off a warmer light. The process of bringing up one group of lights while dimming out another group is called a **cross-fade**.

cross-fade The process of bringing up one group of lights while dimming out another.

A Brief History of Dimming

Throughout theatre history, lighting designers have wanted more dimmers than were available. It was often felt that lack of control was the most limiting factor in a production's design. Difficult and time-consuming choices had to be made as to which fixtures would be controlled independently and which would be ganged together. A mistake in dimmer assignments was always costly.

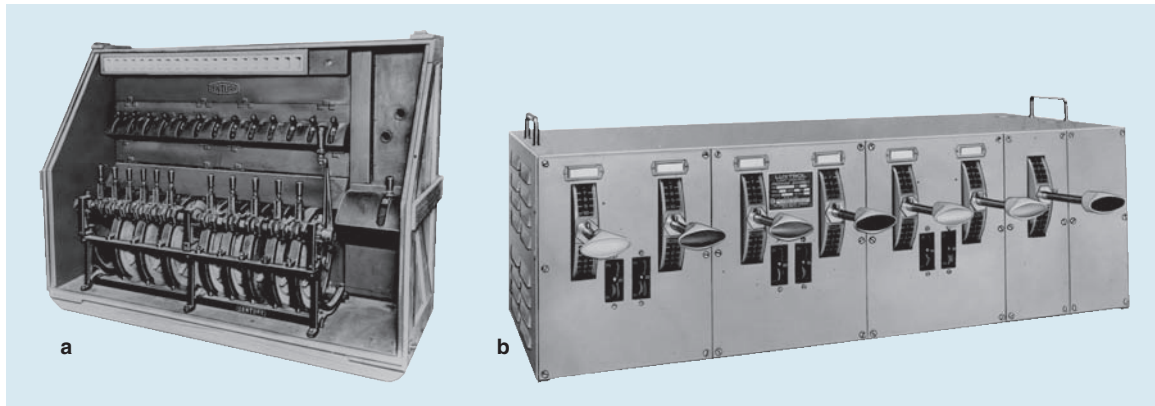
Finally, in the 1970s, a revolution in lighting control took place. The electronic dimmer was developed and became affordable and practical for use in the theatre. Soon after, computerized control consoles became a reality. The lighting designer was free to create as never before.

Pre-Electricity The history of dimming offers much perspective on lighting design today. The demand for dimming in the theatre began as soon as productions moved indoors. On seventeenth-century stages, cans suspended by cords were lowered over candles to vary the light. In the eighteenth century, candles in the wings were mounted on vertical boards that could be revolved to turn the light away from the stage or back toward it.

Light fueled by natural gas was introduced in the nineteenth century. *Gas tables* were the first vestiges of modern lighting-control systems. A series of valves located backstage controlled the flow of gas to various jets arranged about the playing space. Rubber tubes connecting gas jets to control valves made the location of the jets flexible. Theatre fires were commonplace.

Resistance Dimmers With the incandescent lamp came crude forms of electrical dimming. All utilized the principle of dimming by means of variable electrical resistance: the dimmer created resistance to the flow of electricity, and the amount of resistance could be varied. The most popular and long-lasting was the resistance dimmer.

Most commonly found in the form of a large disk, the resistance plate consisted of lengths of wire used to create electrical resistance. When properly loaded, these dimmers



a COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON
b PHOTO COURTESY SUPERIOR ELECTRIC

21-3 Early Dimmer Boards

- a Example of an early resistance dimmer board built into a box for touring. At the right end of the row of dimmer handles is a long interlock handle and beyond it is the master switch.
- b An autotransformer “package” board with six 2,500-watt dimmers with an interlocking master handle at the far end.

could fade a light source or sources evenly and smoothly. A “road board,” such as that shown in Figure 21-3a, consisted of several plates mounted next to one another. Typically, several boards were arranged backstage, close to the power supply. A jungle of stage cable ran from the dimmers to lighting fixtures located overstage and front-of-house. As many as six or eight electricians operated the switches and dimmer handles on cue from the stage manager. Road boards remained a part of rental house stocks well into the 1970s, when they were replaced by the electronic dimmer.

Resistance dimmers had many disadvantages, but the greatest disadvantage from an artistic point of view was their fixed capacity—that is, the plate’s electrical capacity was dictated by the length of wire it contained. Accordingly, a lamp or lamps plugged into a resistance dimmer had to total the same wattage as the dimmer; otherwise, the dimmer could not dim the light(s) completely out. To load a dimmer to its capacity, extra lights were plugged in. Often placed out in the alley behind the theatre, these “ghost loads” faded up and down in unison with the lights onstage.

Autotransformer Dimmers Many of the problems with resistance dimming were solved by the autotransformer dimmer, put into use in the 1940s (Figure 21-3b). Electricity flowing through copper wire wound around a donut-like iron core created magnetic fields. These fields worked against each other, restricting the flow of current—a phenomenon called “back-electromotive force.” A sliding contact moving along the coil conducted a variable flow of electricity to the lamp. Although heavy, these boards were transportable and were a popular means of control for many years. In the early 1980s, the final package board rolled (or lumbered) its way off Superior Electric’s assembly line—the electronic dimmer had finally and rightfully taken over the entire market of intensity control.

Preset Systems

The first truly electronic dimming system was put into operation by George Izenour in 1947 at Yale University. The two-scene **preset console** shown in Figure 21-4 was built by Izenour in 1955. It served as a model for preset systems throughout the next two decades.

Remote Control With the electronic dimmer came the possibility of remote control. Control consoles were designed to be located front-of-house, away from the dimmers. This represented a huge breakthrough for lighting designers—finally the operator could see the stage! Low-voltage analog signals were sent to the dimmers located backstage or in the basement.

preset console A control system with at least two rheostats or controllers per dimmer located on the control console. One set of controllers can be preset for the next lighting look, while the other set represents what is “live” onstage.

21-4 An Early Two-Scene Preset

Console The transparent disks with the white handles are the controllers for thirty dimmers, one apiece for each preset. At the right end of the white plate is the cross-fade handle.

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preset The name given to a lighting look—especially when the preset system is used.

Preset Consoles In addition to control of each dimmer from the console, preset systems provided one or more additional sets of controllers. The Izenour console shown in Figure 21-4 controlled thirty dimmers. As a two-scene preset board, it has two rows of thirty controllers each. While the controllers in the active row are communicating with the dimmers, the operator can preset the inactive controllers for the next lighting look. The looks are numbered, and each one is called a **preset**. A single lever, the cross-fader, is then used to fade from one preset to the next. To accommodate a rapid sequence of cues, preset consoles were developed with multiple sets of controllers—up to ten.

Electronic Dimming

SCR dimmer A modern electronic dimmer. The silicon controlled rectifier (SCR) is the electronic component that controls the current.

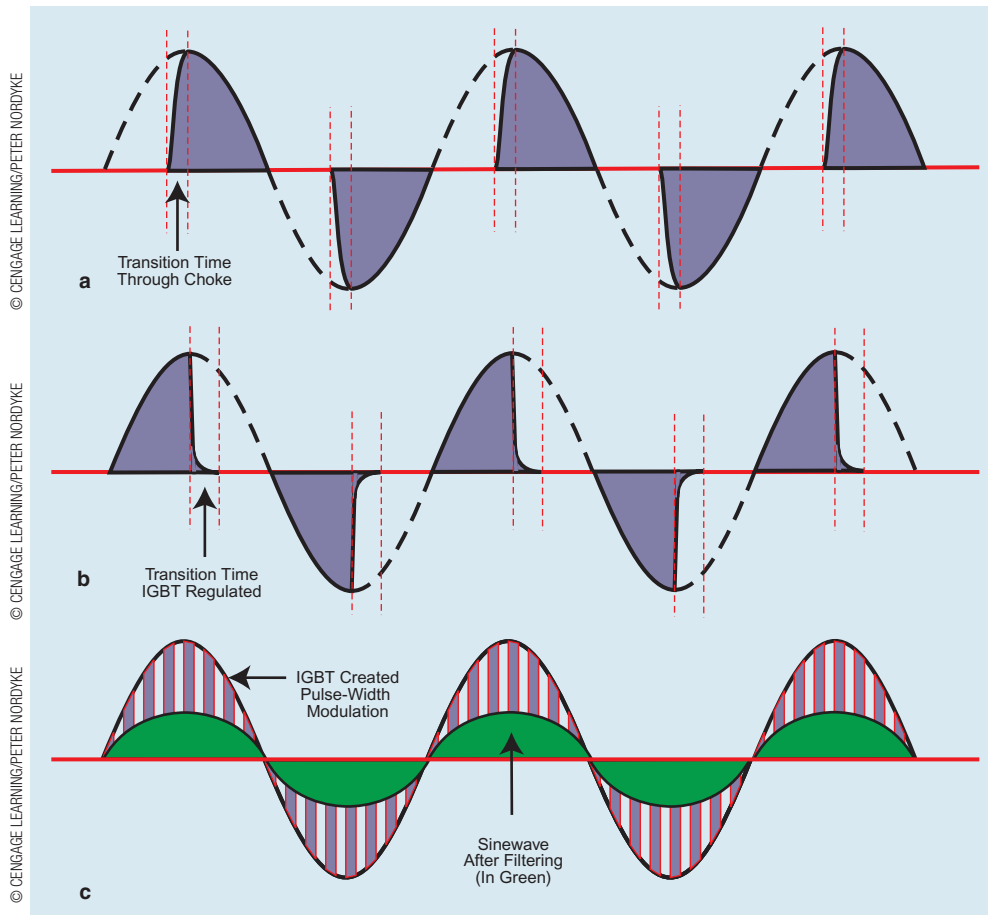
IGBT dimmer A modern electronic dimmer. The Insulated Gate Bipolar Transistor is the electronic component that controls the current.

The first electronic dimmer, the SCR (Silicon Controlled Rectifier), was put to use in stage lighting in the early 1960s. The **SCR dimmer** became more compact and reliable, but little else changed until 1992 when a new technology, the IGBT (Insulated Gate Bipolar Transistor), was used in distributed dimming developed by Entertainment Technology. The **IGBT dimmer** is a semiconductor that offers several improvements over older SCR technology.

Silicon Controlled Rectifiers A silicon controlled rectifier is the electronic component that actually does the dimming in the vast majority of theatrical dimmers. The SCR controls the flow of electricity to the lamp in a unique manner: it quickly switches on and off—120 times per second! The electrical current actually reaches the lamp in bursts, occurring so rapidly that the filament doesn't have time to react. The longer the SCR remains on before switching off, the greater the electrical flow to the lamp and the more light it gives off. This is referred to as forward phase control (Figure 21-5a).

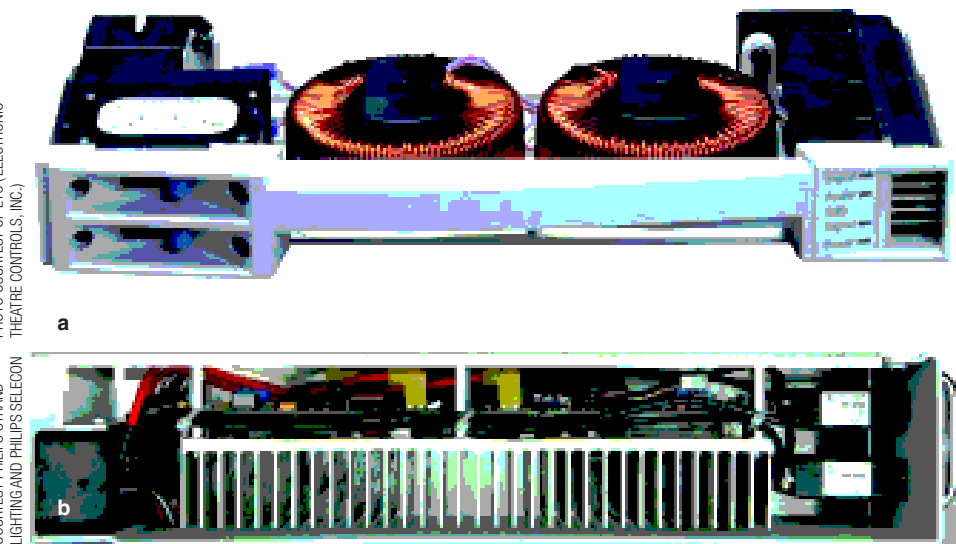
Two SCRs are required for each dimmer, but the actual SCR is only the diameter of a nickel and ½ inch thick. These little “buttons” are connected to a donut-shaped coil called the *choke*. The choke functions to reduce dimmer noise as well as to smooth out the “spike” of electricity generated by the SCRs.

The other major components are a magnetic circuit breaker provided to protect the SCR electrically and a fin-like “heat sink” that dissipates the heat generated by the rapid switching of the SCR. Advantages of SCR dimmers are that they are a proven technology and they are relatively inexpensive. Disadvantages include the weight of the choke, filament noise, and noise generated by the dimmer itself. Early SCR dimmers were the size of a shoe box but are now less than half that size (Figure 21-6a).



21-5 Electronic Dimming Waveforms

- a SCR dimmer using forward phase control.
- b IGBT dimmer using reverse phase control.
- c Sinewave dimmer using pulse-width modulation.

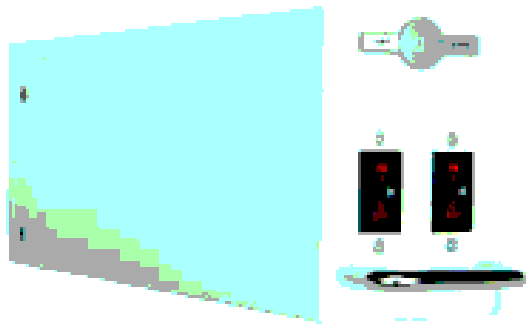


21-6 Electronic Dimmer Modules

- a ETC Sensor[®] SCR dimmer module.
- b IGBT dimmer module from Philips Strand.

Insulated Gate Bipolar Transistors The IGBT was invented by Frank Wheatley at RCA in the late 1970s. It works like an SCR dimmer, switching off and on to produce the effect of lower voltage to a lamp. However, due to reverse phase control illustrated in Figure 21-5b, this electronic component reduces filament noise caused by vibration and does not require forced-air cooling. Other advantages over the SCR include greater efficiency and lighter weight, making them ideal for distributed dimming (Figure 21-6b).

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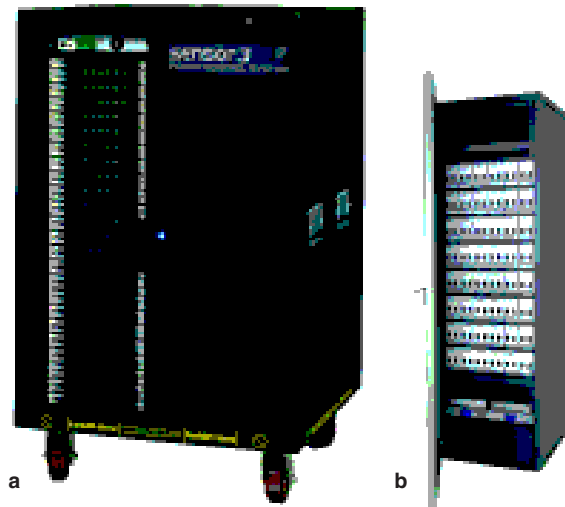
21-7 Sinewave Dimmer Module Dual 2.4 kW C21 sinewave dimmer module from Philips Strand.

sinewave dimming Use of IGBT electronics to reduce the height of the electrical sinewave, resulting in lowered voltage to the lamp.

distributed dimming Placing groupings of dimmers directly on electric pipes near the fixtures rather than in a remote location.

patch panel A flexible system allowing the connection of any stage circuit to any dimmer; used in non-dimmer-per-circuit systems.

PHOTO COURTESY OF ETC (ELECTRONIC THEATRE CONTROLS, INC.)



21-8 High-Density Dimmer Racks

- a ETC Sensor® 3 touring rack.
- b Philips Strand C21 rack.

Sinewave Dimmers A new form of dimming called **sinewave dimming** was introduced in the United States in 2005 by Strand and ETC. It uses IGBT technology and pulse-width modulation to create high frequency pulses that alter the height of the electrical sinewave (Figure 21-5c). It eliminates dimmer and filament noise by switching on and off much more rapidly than a SCR. The biggest advantage of sinewave dimming is that it is virtually silent and can control a variety of loads such as LEDs, compact fluorescents, and electronic dimming ballasts. The disadvantage is its greater expense (Figure 21-7).

Dimmer Racks Normally, two dimmers are enclosed in modules that fit into racks of various sizes. The dimmer module can be slid out of its rack for servicing; electrical connection is made by virtue of plugs located at the rear. One must always remember to turn off the circuit breaker(s) in the front panel of the module before removing or replacing the dimmer. Miniaturization of components has allowed for the creation of high-density dimmer racks; a full-size rack contains ninety-six dimmers in a relatively small space (Figure 21-8).

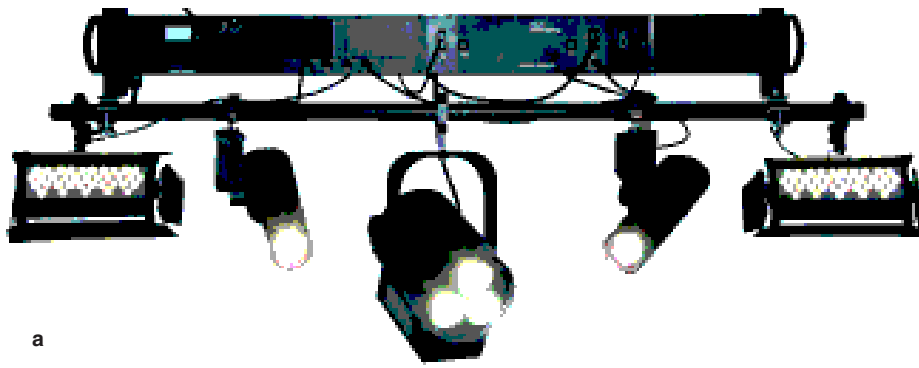
Distributed Dimming The concept of **distributed dimming** is not a new one to the theatre. It involves placing dimmers near the lighting equipment, thereby avoiding long cable and high amperage wire runs. Problems with earlier attempts at such a dimming system included large and bulky equipment, dimmer noise, and unreliability. The development of the IGBT dimmer solves these problems with its small size and silent operation. As a result, distributed dimming has become very popular, especially for smaller installations. The dimmers are available in strips that resemble electrical wireways or in drop-down boxes (Figure 21-9).

The Interconnect System

In the days when SCR dimmers were large and expensive, a flexible system was necessary to allow the connection of any stage circuit to any dimmer. The major component of this system was called the **patch panel**.

Patch panels are still in use today in smaller and older theatres that have not yet converted to dimmer-per-circuit (see next section). Since multiple fixtures can be connected to a single dimmer, the electrician must make sure that the total fixture wattage does not exceed that of the dimmer.

a COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON



21-9 Distributed Dimming

- a Philips Strand S21 Dimmer Strip—six dimmers in three modules with forward and reverse phase IGBT dimming.
- b ETC SmartBar 2 is a portable dimmer bar system containing two linear forward-phase SCRs that allow fixtures to be mounted directly on the bar.



b PHOTO COURTESY OF ETC (ELECTRONIC THEATRE CONTROLS, INC.)

The Dimmer-per-Circuit System

By the early 1980s, the cost of SCR dimmers had fallen to the point at which it became reasonable for a theatre to provide a dimmer for each circuit (outlet) in the house. As its name implies, the **dimmer-per-circuit** system allocates an individual 2,400-watt dimmer to each circuit. Dimmer numbers and circuit numbers are one in the same. No longer was the lighting designer limited by lack of individual control over lighting fixtures—every fixture could have its own dimmer.

dimmer-per-circuit A dimming system that permanently assigns an individual dimmer to each lighting circuit in the house.

With dimmers permanently assigned to circuits, control flexibility is achieved by means of **soft patch**, an electronic patching feature of computer control. The familiar rheostat or controller found in the preset system is now called a **channel**. By virtue of the soft patch, any channel can be assigned to any dimmer/circuit. In addition, an unlimited number of dimmers/circuits can be assigned to a single channel (Figure 21-10).

soft patch An electronic patching system present in most lighting consoles that allows the connection of any control channel to any dimmer/circuit.

channel The dimmer controller in a memory.

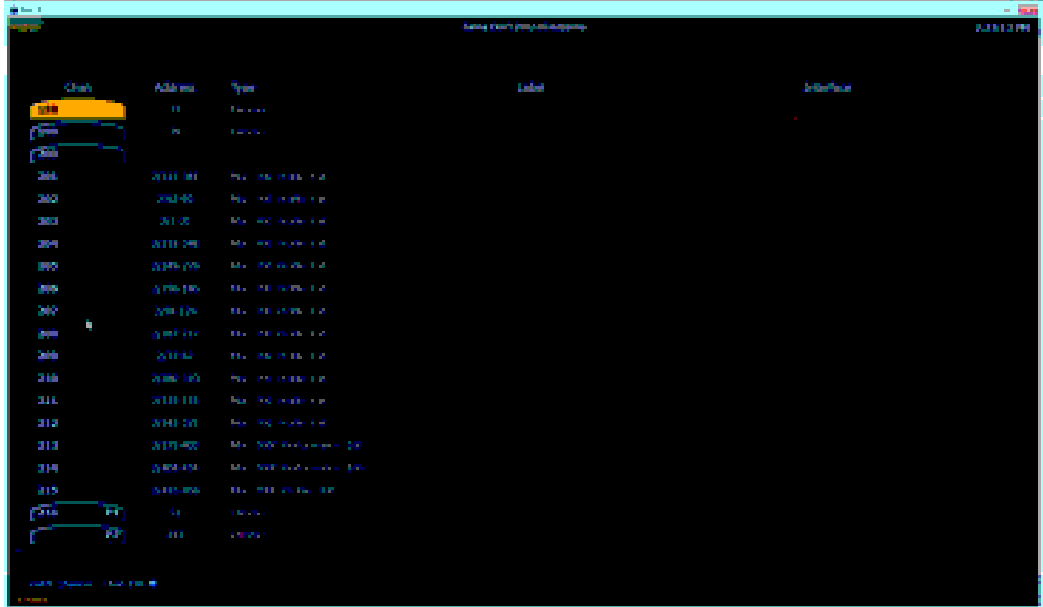


PHOTO COURTESY OF ETC (ELECTRONIC THEATRE CONTROLS, INC.)

21-10 Electronic Patch (Soft Patch) Screen Shown is the channel-to-dimmer patch screen of an ETC Ion[®] control console.

Types of Electronic Control

Several categories of electronic control exist:

- Manual preset systems
- Combination preset/memory systems
- Small-capacity memory systems
- Large-capacity memory systems

Memory systems are computer-based; manual systems are not. Manual systems always consist of at least one controller per dimmer as well as a master controller. They may be quite sophisticated and flexible, offering several presets, masters, submasters, and group masters.

Manual Preset Systems

Manual preset systems are almost a thing of the past, having been replaced by combination systems, which include some degree of memory storage. As mentioned earlier, preset systems allow an operator to cross-fade between sets of controllers. Such systems are inexpensive and function well in certain applications.

Control Features Manual control systems can offer numerous features that add flexibility and increase the potential for complex lighting effects. Most common are the following:

- *Electronic mastering.* A single controller acts as a proportional master over all active controllers. This is useful for fading all dimmers to black.
- *Submastering.* A single controller acts as a proportional master over all controllers assigned to it. Any number of controllers can be assigned to a **submaster**. Submasters offer additional flexibility to a standard preset system.
- *Split cross-fading.* In a preset system, the cross-fader is a single controller that lets the operator fade from one preset to another. A **split cross-fader** consists of two faders, one for each preset, allowing the fade time of one preset to be different from that of the other. The most common application is to fade up an incoming preset more quickly than an outgoing one.
- *Timed fades.* A timing device automatically executes a cross-fade at a predetermined rate set by the operator. The fade is initiated by the press of a “go” button.
- *Effects.* A limited number of prewritten effects (such as a channel chase) are available.

submaster The name given to a single lighting master controller to which any number of individual control channels has been assigned.

split cross-fader Two faders: one assigned to those lights going down in intensity and the other assigned to those lights going up in intensity. This tool allows for variation in up and down fading times.

Combination Preset/Memory Systems

Systems that provide both presetting and some degree of memory are available in a wide variety of packages: from simple two-scene presetting with some memory to highly sophisticated systems with great capacity.

Preset/Memory Systems The most desirable manual system combines the virtues of presetting with the convenience of memory storage. Having evolved from earlier preset systems, most combination systems offer manual presetting, numerous memories, and many extra features. Small-capacity systems such as those shown in Figure 21-11 offer at least twelve channels in two-scene preset mode, 100 memories, and a timed split cross-fader. Medium-capacity systems such as that shown in Figure 21-12 offer a greater number of memories, and larger systems can be extremely sophisticated with control of many channels and numerous memories (Figure 21-13). Combination systems provide the alternative of very simple or relatively complex lighting control.

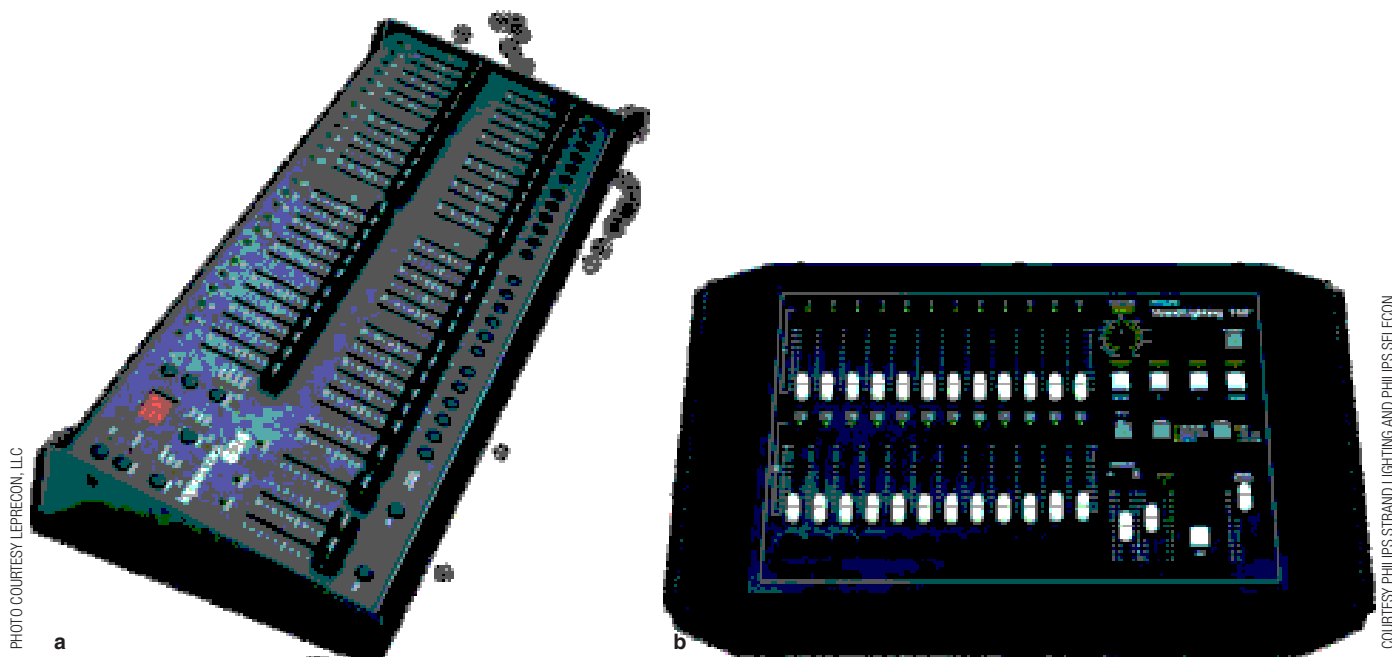


PHOTO COURTESY: LEPRECON, LLC

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21-11 Small-Capacity Combination Systems

- a The compact LP-600 console from Leprecon Lighting controls up to 96 dimmers on 12 or 24 faders.
- b The Strand 100 Series Console provides a 12-channel two-scene preset or a 24-channel single-scene preset with 96 memories.

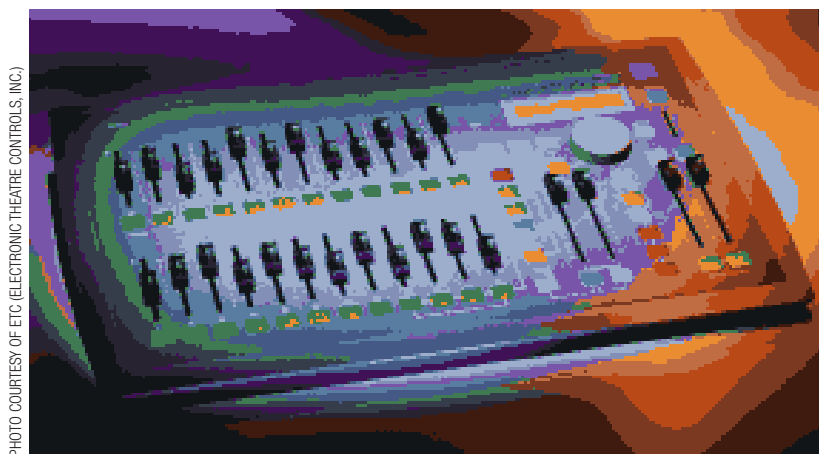


PHOTO COURTESY OF ETC (ELECTRONIC THEATRE CONTROLS, INC.)

21-12 Medium-Capacity Combination System ETC SmartFade® 1248 controls 12 channels in two-scene mode and 48 channels in normal mode with 288 memories.

Concert lighting demands its own specialized combination control system. The consoles shown in Figure 21-14 grew from a group mastering system in which lighting channels were assigned to group masters. The **groups** could be used independently of one another like presets, or they could be combined to create a variety of stage looks. In addition, most of these systems provided memory storage of presets. Today's consoles work with multiple preset faders which control various *palettes*—pre-programmed “looks” that function much like groups.

groups Similar to lighting submasters in that any number of individual channels can be assigned to one group master. Submasters can also be assigned to groups.

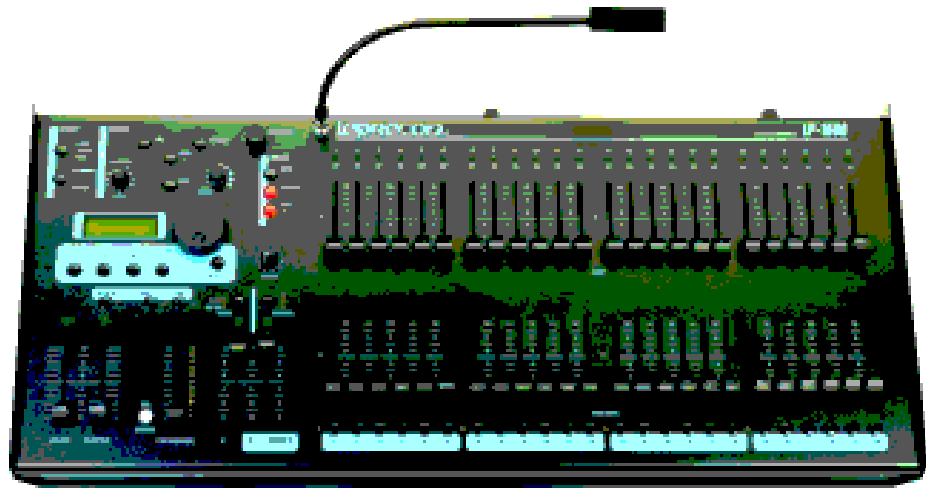
Small-Capacity Memory Systems

Small-capacity systems are more than adequate for most theatres as long as they are not controlling a large number of automated fixtures or other remotely-controlled devices.

21-13 Large-Capacity Combination Systems

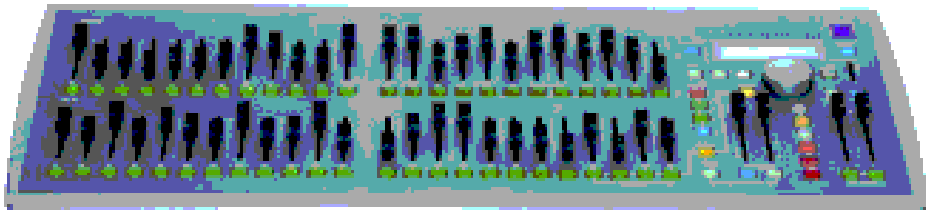
- a Leprecon Lighting's LP-1600 console is available in several models and will store up to 576 fader presets.
- b SmartFade® 2496 from ETC has 24 channels in two-scene mode and 96 in normal mode with 576 memories.

PHOTO COURTESY OF LEPRECON, LLC



a

PHOTO COURTESY OF ETC (ELECTRONIC THEATRE CONTROLS, INC.)



b

The ones shown in Figure 21-15 can control up to 2,000 channels, depending on the make and model. They offer all necessary features for normal show operation. Modern small-capacity memory systems are uncomplicated to operate and take little time to learn. Their cost is reasonable and they are highly reliable.

PC-Based and Nondedicated Systems The term *nondedicated* refers to a control system that uses specialized software with a standard computer to perform the tasks required of a lighting-control system. GAMPRODUCTS distributes a PC-based software system called GAM Plexus®. It is unique because its layout and operation is based on magic sheets (graphic representations of lighting systems). The system can support multiple DMX universes and up to 16 magic sheets (Figure 21-16a). The advantages of

21-14 Concert Lighting Consoles

- a The Avolites Sapphire Touch Control Console is designed to allow immediate operator control of numerous intelligent lights, conventional fixtures, and other DMX devices. It has 45 motorized master faders controlling programming palettes.

PHOTO COURTESY AVOLITES LTD.



a

COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON



b

21-14 Concert Lighting Consoles (continued)

b Strand Light Palette Live has 12 playback faders, 48 submasters, and can control 8,000 channels/attributes.

COURTESY PHILIPS STRAND LIGHTING AND PHILIPS SELECON



a



b

PHOTO COURTESY OF ETC (ELECTRONIC THEATRE CONTROLS, INC.)

21-15 Small-Capacity Memory Control Systems

a Strand Palette II can be configured from 150 to 3,000 channels. It has network support for Ethernet data protocols including ShowNet, streaming ACN, and ArtNet.

b Part of the Eos Family, Element® from ETC is a powerful budget-minded memory system. It comes with 250 or 500 channels, can handle 10,000 cues, and supports Ethernet.

c MA Lighting's grandMA micro console can control up to 1,024 channels and is effective with both conventional fixtures and moving lights.

PHOTO COURTESY A.C.T. LIGHTING, INC.



c



PHOTO COURTESY GAM PRODUCTS, INC.



PHOTO COURTESY HIGH END SYSTEMS

21-16 PC-Based/Nondedicated Memory Control

- a Screenshot of GAM Plexus, designed to be used on Windows Vista or later. It is magic sheet-based software for use with both automated and standard fixtures.
- b Screen shot of Hog 3PC software from High End Systems. It can control up to 4,096 channels and supports Ethernet protocols.
- c The Wholehog Expansion Wing adds 40 playbacks to any Wholehog control system.



PHOTO COURTESY HIGH END SYSTEMS

a system like GAM Plexus are its low cost and the fact that the computer can be put to uses other than stage lighting. Bookkeeping, box office, and a host of other software programs can all be run on a single computer. The disadvantages of the system include lack of functions and relatively difficult operation.

Another PC-based system intended for use with moving lights is the Hog® 3PC from High End Systems (Figures 21-16 b & c). Like all Wholehog systems, it is particularly good with automated fixtures.

Dedicated Systems Figure 21-15 shows three typical small-capacity dedicated systems. Such systems offer all the standard operational features as well as some specialized ones depending on the manufacturer. They are categorized as small systems because of their lower cost and limited number of channels, dimmers, and cues.

A quality system includes a reliable battery backup, an easy-to-use entry keyboard, a video monitor or monitors for the operator, and an optional remote monitor for the designer. Important functions include the ability to insert additional cues into an existing cue list, soft patching, the ability to link one cue to the next, split time fades, and a help display for the operator.

Large-Capacity Memory Systems

As lighting control has been called on to perform more and more functions, demand for larger-capacity systems has increased. In the 1980s, the need to control more than 100 channels was unusual. Today, with the control demands of automated fixtures and other devices, more than 1,000 channels may be necessary. Several large-capacity systems are shown in Figure 21-17.



21-17 Large-Capacity Memory Control Systems

- a Ion from ETC can control 10,000 channels, has 200 active playbacks 300 submasters, and supports Ethernet protocols.
- b Strand's Light Palette Classic can control up to 8,000 channels and has four DMX universes. It features familiar Light Palette command line programming.
- c The grandMA2 light is a compact version of the full-size grand MA console. It offers 4,096 parameters with 15 motorized faders.

All the larger systems support two monitors with selectable onscreen displays. During normal operation, the cue sheet is displayed on the primary screen, with channel levels or other information as needed on the second screen.

The displays shown in Figure 21-18 are from an ETC Ion control system. The cue sheet display includes cue number, time, and other playback information, such as cue parts, delays, and effects. The channel display lists each control channel along with its assigned level in the designated cue (in this case, the live cue onstage).

One of the major functional advantages of the larger and more sophisticated control systems is programmable effects. To be most useful, such a program must be easy to both write and operate and be flexible enough to accommodate any kind of effect desired. *Automated Fixture Control Systems* are discussed in Chapter 13.

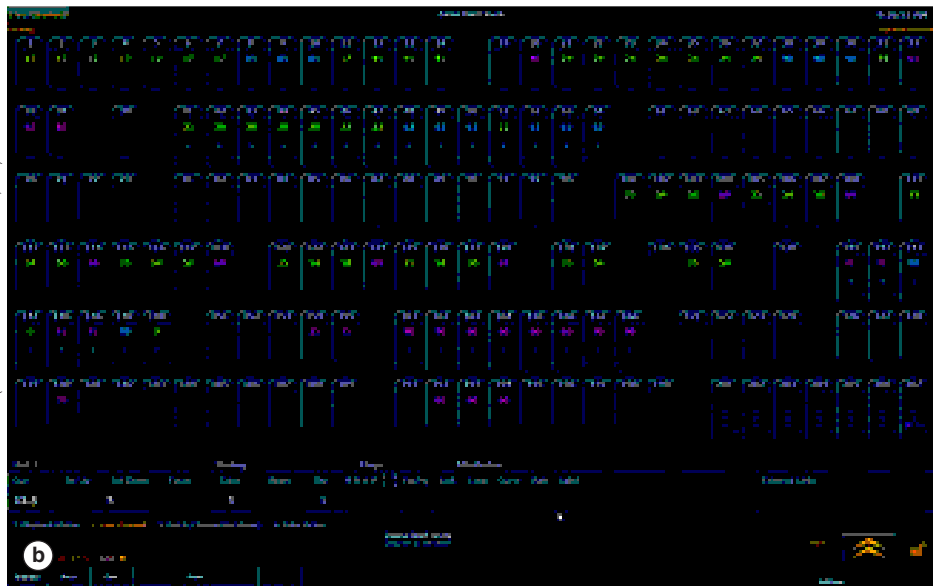
Interfacing from Lighting Control Consoles

Early control signals from remotely located control consoles to their dimmers were analog electrical signals. Their voltages varied roughly from 0 to 15 volts, depending on the system, and no two systems were compatible. This irritated users until, finally, manufacturers developed systems based on a new digital protocol called DMX.

DMX Control Protocol Thankfully, members of USITT (the United States Institute for Theatre Technology) were concerned enough to develop a standard digital language for communication between control consoles and dimmers. It was called

21-18 Monitor Screen Displays Screen displays from an ETC Ion® Control Console.

- a Cue sheet display.
- b Channel display.



a & b PHOTO COURTESY OF ETC (ELECTRONIC THEATRE CONTROLS, INC.)

DMX-512 A standard communication protocol for lighting-control systems.

DMX universe One universe of DMX consists of 512 discreet control channels.

DMX-512 (the “512” referring to the amount of information transmitted). One **DMX universe** can control 512 separate channels; many larger control consoles provide at least two universes of DMX.

Using DMX As noted earlier, DMX is currently used to control automated fixtures, scrollers, LEDs, and other remotely controlled devices. The control signal is carried over a 3-wire cable similar to audio cable but designed for digital rather than analog waveforms. The recommended connector is 5-pin XLR to differentiate it from audio 3-pin.

Some devices, such as fog machines, have power supplied via a standard AC cable with the DMX control cable plugging right into the machine’s controller. In other situations, such as with color scrollers, a 5-pin DMX cable from the control console is plugged into the scroller’s power supply. In the case of a Wybron scroller, a 4-pin XLR digital cable then carries the DMX as well as motor power to an individual scroller. Several scrollers can be “daisy-chained” together, up to the capacity of the power supply. Likewise, the control signal for automated fixtures can be “daisy-chained” using DMX cable, with a terminating plug often necessary. All this is to say that running DMX signals has gotten complicated. An electrician must know precisely what is required for each

piece of DMX-controlled equipment. Modern theatres are equipped with permanently wired DMX outlets (nodes) conveniently located throughout the house, backstage, and overstage where the use of auxiliary equipment is anticipated.

Networks Demand for greater remote control of equipment has led to the use of **Ethernet** as a means of signal distribution. One can send multiple DMX signals through Ethernet lines. In addition, Ethernet is a convenient way to connect differing systems with one another. For instance, a theatre's architectural and theatrical lighting systems can be connected via Ethernet. Figure 21-19 shows an ETC Net3® DMX node intended for wall mounting.

Designing with Electronic Control

In 1975, when designer Tharon Musser insisted on a Light Palette control system for her Broadway production of *A Chorus Line*, it became obvious that even New York was going to accept memory lighting control. There is no doubt that lighting designers achieved a higher level of artistry as a result of computerized control. Cue writing is simplified, the potential for complex and sophisticated cues is greatly increased, and changes are made quickly and accurately—every time.

Working with Limited Dimmer Control

Some smaller theatres may not have dimmer-per-circuit. If that is the case, the designer faces the task of assigning fixtures to dimmers. Color control is normally a high priority. Seldom is it desirable to have two fixtures of differing colors on the same dimmer. Area control is the next priority: which stage areas should be controlled individually and which should be “ganged,” or grouped together? The latter is a critical decision, for the designer must work with the chosen control flexibility throughout the production. Before a choice is made, the designer should view rehearsals and discuss control-related questions with the director.

Control and Patching

Before the days of electronic control, dimmer board layout was a critical operational concern for the designer. He or she had to anticipate the best way to aid the various operators in performing their sometimes octopus-like maneuvers. Although these concerns are less critical today, channel layout is still important to the designer.

Soft Patching The computer's electronic patch system makes logical dimmer/circuit-to-channel assignments an easy task. The designer normally follows basic guidelines:

- Channels that are frequently controlled together should be grouped together. Operationally, for example, it is much faster and easier to keystroke channels 23 through 31 than a random series of nine channel numbers.
- If using an area-lighting method, designers should assign all the fixtures lighting a given area to a logical sequence of channels. For example, all fixtures lighting area 1 can be assigned to channels 1, 11, 21, 31, 41, and so on. The front-light for area 2 is assigned to channel 2; the side-light for area 2 is assigned to channel 12; the back-light for area 2 is assigned to channel 22, with other assignments following in the same manner.

Some soft patch systems include a feature called *proportional patching*. This simply means that if two dimmers are ganged on a single control channel, one of them can be assigned a proportional intensity level. For instance, if fixture A is assigned a proportional

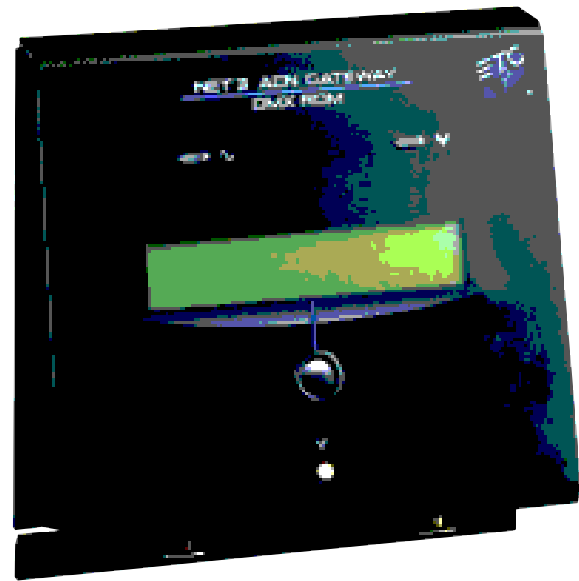


PHOTO COURTESY OF ETC (ELECTRONIC THEATRE CONTROLS, INC.)

21-19 Ethernet Networks ETC Net3® ACN Gateway, a two-port wallmount node.

Ethernet A universally used digital communications protocol capable of carrying numerous DMX signals at the same time.

level of 90 percent while fixture B is assigned a level of 100 percent, the intensity readings of A will always be 90 percent of those of B.

Part of the setup procedure before beginning to write a show is the creation of patch assignments. If the system's patch is left unassigned, dimmer-to-channel will default to a one-to-one relationship. Patch assignments never need to be touched during playback—a good reason for using the “record lock” key switch found on some control consoles.

Features of Electronic Systems

As noted earlier, available functions vary from one system to another. However, the designer can normally depend on several fairly common operational features, including submasters, split time fades, cue copying, and the ability to insert and/or link cues. Other features, which may or may not exist on a given system but deserve comment, are tracking and cue-only functions, groups, tracking of channels, follow cues, a level/rate wheel, simultaneous cue playback, channel or dimmer parking, and direct dimmer access.

Common Features As discussed earlier, *submasters* allow the control of several channels with one fader. When writing cues, the designer can save time by using a submaster to access channels commonly used together, such as same-colored cyc lights.

The concept of *groups* originated with the preset type of control and, as noted earlier, is popular for concert lighting-control systems. Any number of selected channels can be labeled a group and accessed as such with a single command. This tactic is valuable for the rapid building of various stage looks.

Movement of light is greatly enhanced by the previously discussed split time fade. Rather than be restricted to a simple linear cross-fade, the designer can customize a fade to perfectly coincide with action onstage.

One of the most time-saving features in writing cues live is the ability to copy them. It is often desirable to alter an existing cue rather than begin from scratch. Normally, this is performed by assigning a new cue number to an existing cue after adjustments are made.

For making corrections and additions, **cue insertion** is a must. Most control systems allow **point cues** to be inserted between whole-number cues. An example would be the insertion of cue 3.5 between cues 3 and 4. Many designers like to assign point cues to specialized functions such as scrollers or dark sets. **Cue linking** is also handy and can be used in some cases to form effect “loops” (link cue 6 to cue 10, then cue 10 back to cue 6).

Specialized Features The operational concept of **tracking** is a holdover from the days of resistance dimmers. When a dimmer level was set at a certain reading, it remained there until the operator was instructed to change it. In tracking-only systems, such as early Light Palettes, a channel assigned to a level in a cue retains that level in all subsequent cues until told otherwise. Although this makes perfect sense, tracking can sometimes be confusing, with channels apparently popping up out of nowhere. Many newer systems provide the designer with the option of working in either a tracking or a cue-only mode. As its name implies, *cue-only* means that a channel's level is set for the active cue only and will not track into subsequent cues. Channel tracking is particularly useful when one is working with automated fixtures or scrollers. For instance, if a scroller color is to remain the same through several cues, tracking it saves a good deal of programming time.

Tracking of channels is a useful feature offered by some systems. It allows the operator to view the levels of a single channel throughout all the cues in the show. Figure 21-20 shows the channel track screen from an ETC Ion control console.

The action of one cue automatically following another is normally not desirable for live performance. If the timing onstage changes, the calling of the cue must follow suit. However, **follow cues** can be valuable for a sequence effect or for timing to something other than live action. If a stage manager has a very complex cue list to call in a short period of time,

cue insertion The ability to insert a new lighting cue between two existing cues in the cue list.

point cue An additional lighting cue that is assigned a decimal point number placing it between two whole-numbered cues.

cue linking A feature that allows the linking of one lighting cue to another out of normal cue-list order.

tracking An operational mode in which a channel or dimmer level remains the same in all lighting cues until told otherwise.

follow cues An important lighting control function that allows one cue to follow another automatically with a single press of the “go” button.

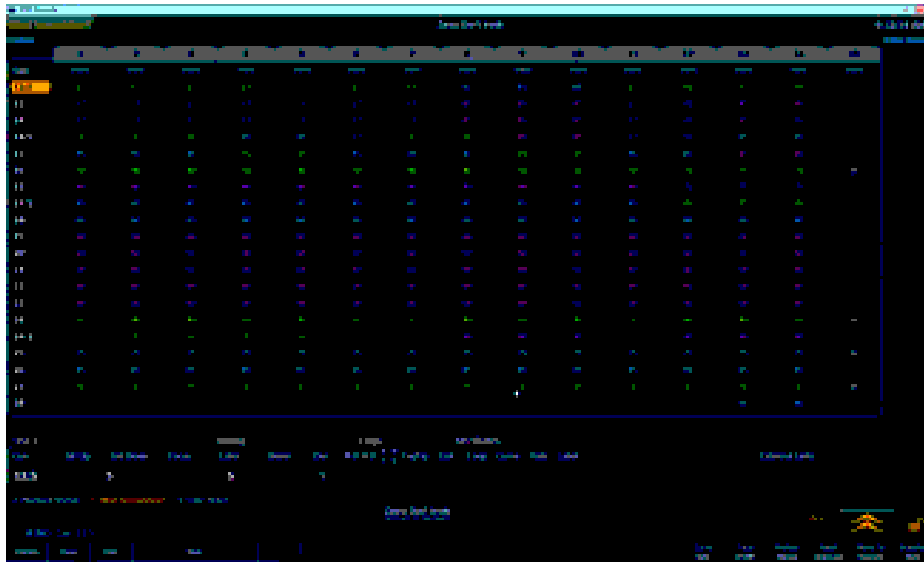


PHOTO COURTESY OF ETC (ELECTRONIC THEATRE CONTROLS, INC.)

21-20 Tracking of Channels Screen Display The ETC Ion channel track sheet shows readings of a selected channel (channel No. 1 in this case) in all programmed cues.

the lighting designer may be able to assist by writing some of the light cues as follows. In addition, follow cues are quite useful in programming scrollers or automated fixtures when dark sets are often necessary and need not be called by the stage manager.

The operational term *wait* has different meanings depending on each system's manufacturer. In general, the *wait function* (sometimes called follow/hang) usually provides a preset wait time between the completion of one cue and the execution of a second, following cue. The term *delay* normally refers to a cue delaying a set amount of time to begin after the “go” button is pressed.

With proper use, a **level/rate wheel** greatly facilitates both writing cues and playback. Anything from a single channel to an entire preset can be assigned to this wheel. If a group of dimmers is “put on the wheel” and the wheel is rolled down, the intensity levels of all channels in the group are lowered. If an active fade is suddenly assigned to the wheel (“captured”), the speed of the fade in progress can be altered. In other words, the operator can seize control of any fade speed by using the rate wheel. An experienced console operator performs a great number of operations with the aid of this wheel.

Simultaneous playback of several cues or a **multipart cue** is a valuable feature that many control systems provide. The slow sunset can now continue undisturbed while other lighting movements take place.

A useful feature when visually writing levels into the control board is **channel or dimmer parking**. When a designer records a lighting look into memory, the reading of a “parked” channel or dimmer will be ignored and not recorded. This means, for example, that he or she could write cues but still leave the house lights up at a low level by parking them. Finally, although *direct dimmer access* is not used very often, it is extremely helpful when needed. When several dimmers have been soft patched onto a single control channel, this option allows the operator to access any of them individually.

Most control systems have an on-line tutorial that should be read by both the designer and the operator. Systems vary enough that the designer will discover new and exciting possibilities by reviewing the operational features of unfamiliar boards.

Programming Cues

With today's control consoles, **programming** cues into the board is relatively simple unless complex effects, scrollers, or automated fixtures are used. It is important for the designer to

level/rate wheel A wheel or touch pad that can control individual lighting channels, groups of channels, or an entire cross-fade.

multipart cue Several cues running together at different speeds that are handled as one cue by the control board.

channel or dimmer parking A lighting control-board feature in which the intensity level of a channel or dimmer will not be recorded in a cue.

programming The process of inserting cues or presets into a lighting control console.

understand that effects and scroller programming takes extra time. The programming of automated fixtures is altogether another matter and is discussed in Chapter 13.

The best control system manufacturers provide an offline editor for their consoles. This software duplicates the programming functions of the console, allowing the designer or assistant the freedom to program levels and cues using any computer connected to the Internet. “Blind” programming via an offline editor can save immense time (and money) in the theatre.

The Operator and Remote Control

The operation of a memory control system is a quite different task from that presented to an electrician standing backstage manipulating several large and heavy handles. Often the control apparatus is delicate and complex, not at all like a bank of simple and rugged resistance or autotransformer dimmers. An error could very well result in every light on the stage assuming the wrong reading. Although a good memory control system will lessen the chances of operational error, a highly competent operator is still essential.

During rehearsals, moving the control console into the house near the lighting designer allows the operator and the lighting designer to easily and directly communicate with each other, the director, the stage manager, and other designers.

All computer memory control systems provide a backup for library storage. It is extremely important for the operator to keep this copy of a production’s cues and dimmer levels up-to-date. As changes are made, periodic copying of the show is good practice, but is something the designer may forget.

A good operator has confidence, a cool head, and enough understanding of the control system to rectify an error before it gets out of hand. The operator must know the show and fully understand the lighting designer’s intentions. He or she *must watch the stage*. Cues will be taken from the stage manager, but the operator may be called upon to take sight and sound cues from the stage action itself.

Perhaps most of all, the operator requires sensitivity and a sense of timing akin to an actor’s. An operator does not merely snap lights on—he or she dims in gently, with feeling, perhaps at a varying pace to best suit the action on the stage. If the actors are fast in their pace one night, an adjustment must be made to the new tempo. A large part of the success of a production depends on the operational skills of the stage manager and light board operator.

It’s now time to go into more depth on the subject of electricity. The stage electrician must know enough about electrical theory and practice to function safely. The designer is wise to know a bit, too. The following chapter covers this subject.

Stage Lighting and Electricity

Lighting design requires both artistic and technical skills. A knowledge of electricity and electrical practice as it applies to stage lighting is important for the lighting designer. At the very least, designers should understand electricity and basic electronics well enough to make informed choices concerning use and safety. Unfortunately, many individuals believe that electricity is the concern of electricians only. This thinking results in a curious mystique that surrounds electrical practice and theory. Actually, electrical theory and basic electrical practice are simple and accessible.

Basic Elements of Electricity

As we saw in the previous chapter, electrical requirements for stage lighting are undergoing a significant change. Traditional dimmer and circuit arrangements are being altered to accommodate automated fixtures and new LED sources. However, despite the trend away from high-amperage dimming requirements, we still do and will continue to require a source of electricity to create light.

Atomic Theory Atoms consist of a positively-charged center, the **nucleus**, around which orbit negatively-charged particles called **electrons**. The nucleus is comprised of an equal number of neutrally-charged *neutrons* and positively-charged *protons*. While the number of electrons vary, each atom has as many electrons surrounding the nucleus as it has protons within, thus achieving a balance of positive and negative charges. The electrons are in constant motion, revolving around the nucleus in much the same way that the planets orbit the sun. Figure 22-1 shows a few examples.

In the atom of lithium, the lightest of all metals, the three protons are balanced by two electrons in the inner orbit plus one in the outer orbit. Copper, the metal most commonly used in electrical wiring, requires four orbits to contain its twenty-nine electrons. The various orbits are not all in the same flat plane, but rather, they are at angles to one another, somewhat like rubber bands stretched haphazardly about a baseball.

The single electron in the fourth and outer orbit of copper can be easily dislodged; only a small force or voltage is necessary. An electron removed from its atom is called a **free electron** and forms the basis of the flow of electrical current. All metals are good conductors because they have electrons that are easily dislodged.

Sources of Electric Current

Free electrons will not move through a conductor unless a supply of free electrons is being introduced into it. Such a supply of electrons is known as **voltage**, or as an **electromotive force (EMF)**. Sources of EMF include batteries; the action of friction, sunlight, heat, or compression on certain substances; and generators.

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For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

nucleus The positively charged center of an atom; composed of protons and neutrons.

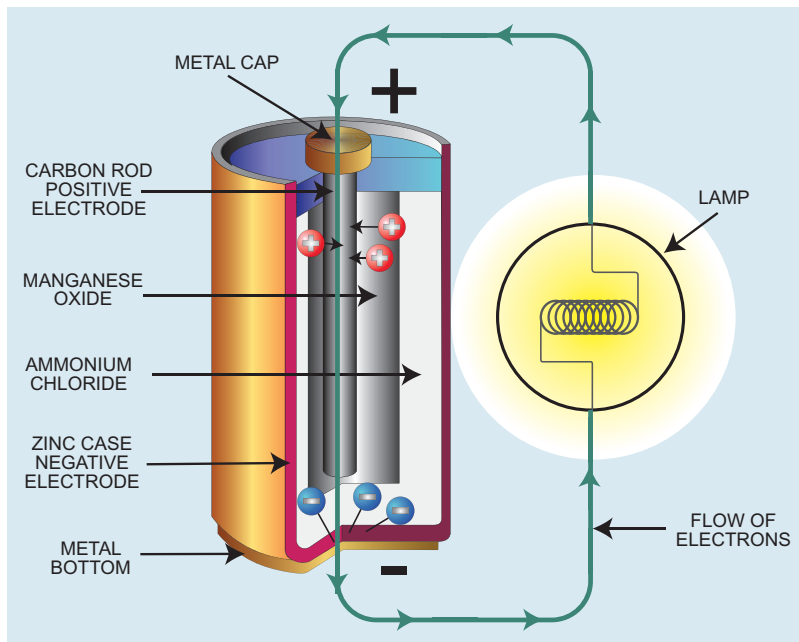
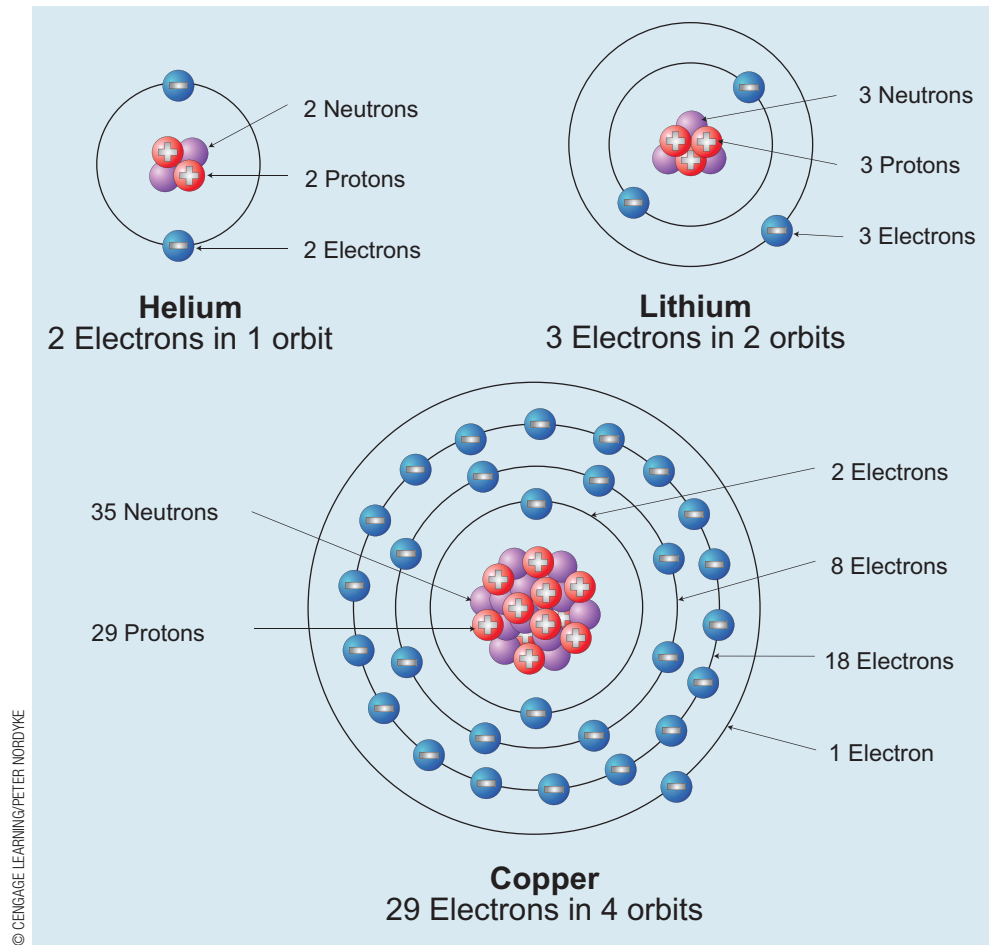
electrons Negatively charged particles that orbit the nucleus of an atom.

free electron An electron removed from its atom, providing the means of electrical flow.

voltage or **electromotive force (EMF)**

A difference in potential—the force that causes free electrons to move in a conductor.

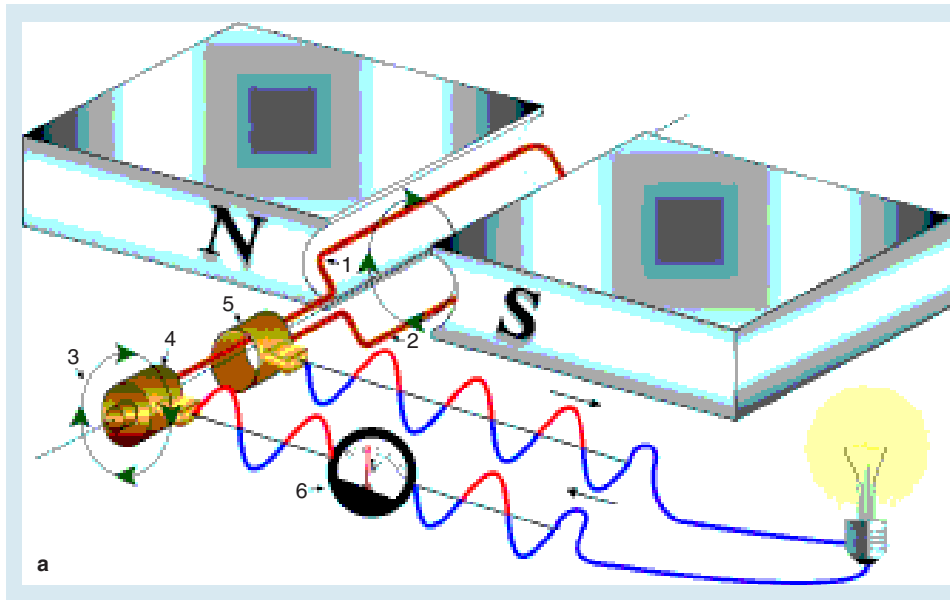
22-1 Atomic Structure of Common Elements Note the single electron in the outer orbit of the copper atom.



22-2 DC Voltage From a Battery
Example illustrating D-C current flow from a battery through a lamp filament, returning to the battery.

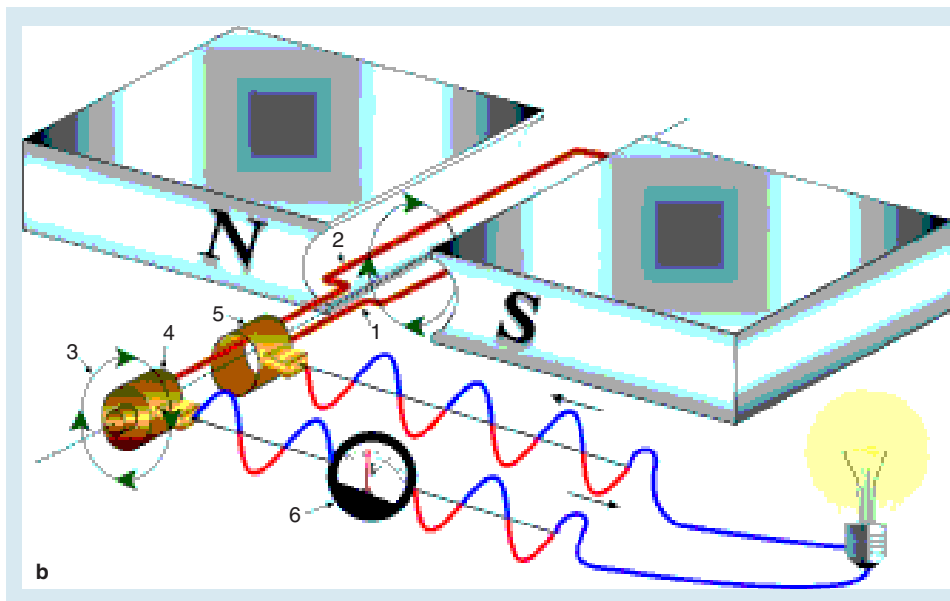
Batteries A common device for supplying **direct current (DC)** is a *battery*. As shown in Figure 22-2, the battery is comprised of a top and bottom terminal, a zinc casing which contains various chemicals, and a center carbon rod. When a path for electricity is created between the two terminals, a chemical reaction occurs inducing a flow of electrons from the bottom (negative) terminal to the top (positive) one. If we introduce a low-voltage DC lamp in the circuit, it will illuminate. The common carbon-zinc battery cell was invented in 1866 and used well into the twentieth century. Modern alkaline and lithium batteries create an electron flow in much the same way using various combinations of metals and chemicals. These more efficient batteries were developed to supply higher current and greater storage capacities needed for today's electronic devices.

Generators New techniques to produce electricity have been developed, but the method most important to the stage electrician is that of **electromagnetism**—the creation of an EMF by means of a **generator** powered by water, steam, or atomic reaction. A generator works by moving a conductor within a magnetic field. The conductor can be moved while



22-3 An AC Generator or Alternator

- a** Current flow in one direction.
 - 1 Side one of the coil.
 - 2 Side two of the coil.
 - 3 Direction of rotation of the coil.
- 4, 5** Slip ring and brush.
- 6** Voltmeter.
- b** Current flow in the opposite direction.
 - 1 Side one of the coil.
 - 2 Side two of the coil.
 - 3 Direction of rotation of the coil.
- 4, 5** Slip ring and brush.
- 6** Voltmeter.



a & b © CENGAGE LEARNING/PETER NORDYKE

the field is stationary, or the field can be moved while the conductor remains stationary. The latter is typical in large installations, but it is easier to understand the operation by considering a moving conductor within a stationary magnetic field.

The two diagrams in Figure 22-3 show a highly simplified **alternating current (AC)** generator, usually called an **alternator**. An armature in the shape of a single coil of wire is rotated through a magnetic field created between the two poles of a magnet. This action induces an EMF in the coil, causing free electrons to accumulate at slip ring 5. The electrons flow off the slip ring through the brush and the connecting wire to a voltmeter and then to slip ring 4, where they reenter the coil. In the second diagram, the coil has rotated 180 degrees, reversing the position of its sides, and the electrons flow in the opposite direction. Each complete revolution of the coil is called a *cycle*. The current is said to be alternating because the electrons move in one direction for half of each cycle and in the opposite direction for the other half.

Figure 22-4 is a sine curve showing the variation of induced EMF for any portion of the complete cycle of the armature through the magnetic field. When the armature is

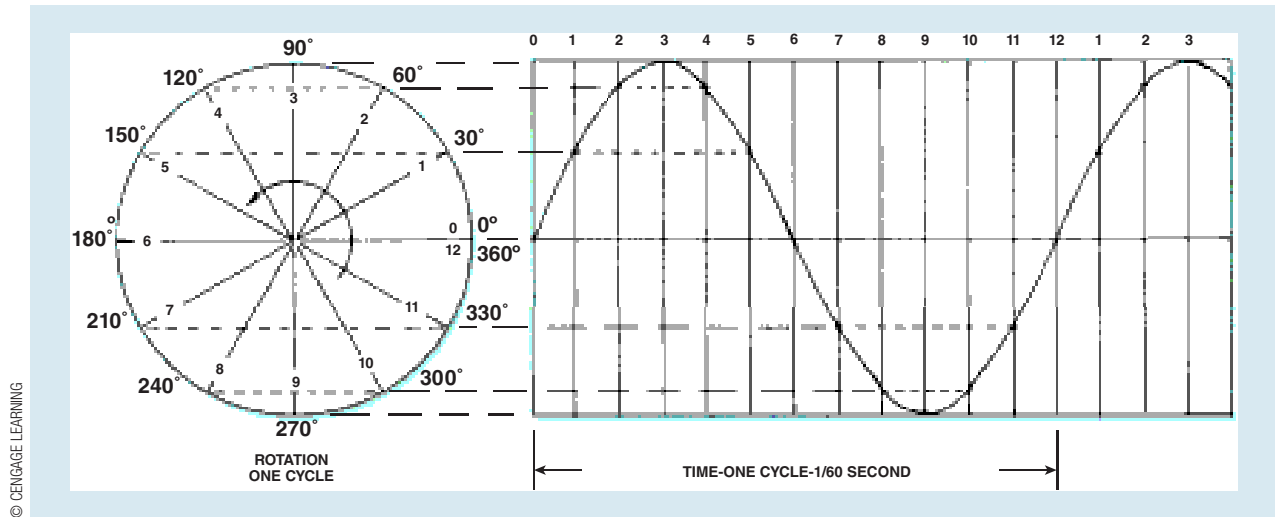
direct current (DC) An electric current flowing in one direction only.

electromagnetism The creation of an electromotive force (voltage) through the use of a generator.

generator A device that creates an electromotive force (voltage) by moving a conductor within a magnetic field.

alternating current (AC) An electric current that periodically reverses direction of flow.

alternator A simple alternating current (AC) generator.



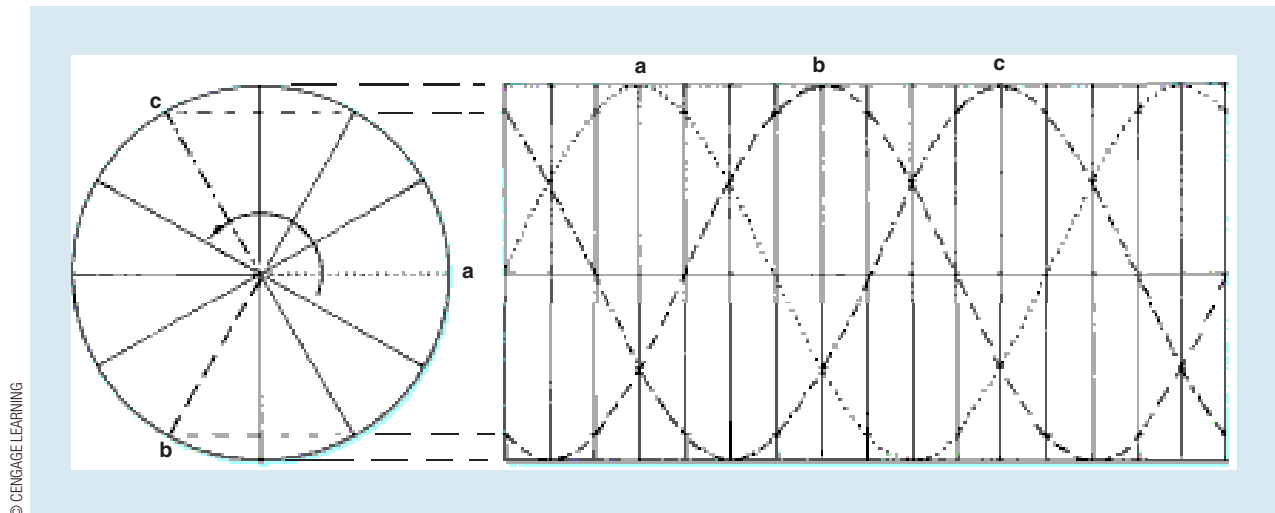
22-4 AC Sine Curve The alternating current sine curve created by an AC generator.

passing the 0-degree point in its rotation it is moving parallel to the magnetic field, not through it, and therefore is producing no EMF at all. As it reaches the 30-degree mark, it is beginning to cut into the magnetic field and generate some EMF. At the 60-degree position an EMF of greater magnitude is produced, and at 90 degrees the maximum EMF is attained. After this, the EMF drops back to zero, then it starts to build up in the opposite direction as depicted below the time line.

Building several armatures into a generator is economical. Because the armatures must be at angles to each other, their respective EMFs will not reach any one point at the same instant but rather will produce sine curves as indicated in Figure 22-5. Here we see the common arrangement of three armatures, each producing its own curve out of phase with the others. This is known as *three-phase current*, the standard for theatrical installations.

Electrical Units of Measurement

circuit An established path of electrical flow. A **circuit** is an established path of electrical flow. Four basic measurements can be made in any electric circuit: volts, amperes, ohms, and watts.



22-5 Three-Phase Sine Curves The overlapping sine curves produced by an AC generator with three armatures at 120 degrees to one another.

Volts The volt measures the *force* that causes free electrons to flow in a circuit. It is actually a measurement of the difference in electrical potential between two points in a circuit. Another way of putting it is to ask how many more free electrons there are at point A than at point B, to which they will flow if a path is opened for them. As you know, voltage is also called electromotive force (EMF); as such, its symbol is E. Standard voltage in the United States is 120 volts.

Amperes The **ampere** is the *rate of flow* of current through a conductor. It measures how many electrons pass a given point in 1 second. The mathematical symbol for the ampere is I (for intensity of current flow). Amperage is used to describe a circuit's electrical capacity. For instance, most stage circuits carry 20 amps.

Ohms All substances offer some *resistance* to the flow of electrical current. Some, such as copper, offer very little resistance, whereas others, such as rubber, offer a great deal. In an electrical circuit, larger-diameter wires offer less resistance than smaller ones do. The **ohm** is the measurement of such resistance, and its symbol is R.

Watts The **watt** is the *rate of doing work*, whether it is turning an electric motor, heating an electric iron, or causing a lamp to glow. Its symbol is P for power. Wattage can be thought of as “consumption” of electricity, although flowing electrons are never actually consumed.

ampere The measurement of flow rate of electrons (current) through a conductor. Also used to indicate the capacity of a circuit or a conductor.

ohm The measurement of a conductor's resistance to the flow of electrical current.

watt The measurement of the electric power rate, or the rate at which work is done through the use of electricity.

The Power Formula

The **power formula** expresses the relationship among wattage (P), amperage (I), and voltage (E). It states that the rate of doing work (wattage) is equal to the product of current flow (amperage) and potential (voltage):

$$P = I \times E \text{ (called the “pie” formula)}$$

Or

$$W = V \times A \text{ (using first letters of unit names— called the “West Virginia” formula)}$$

An application of the power formula might be to determine how many 750-watt lamps (x) one could plug into a single 20-amp circuit, as follows:

$$W = 750 \text{ per lamp}$$

$$V = 120 \text{ (U.S. standard)}$$

$$A = 20 \text{ (given)}$$

$$x \times 750 = 120 \times 20$$

$$x = \frac{2,400}{750}$$

$$x = 3.2$$

A 20-amp circuit will carry three 750-watt lamps.

power formula Wattage = amperage \times voltage.

Ohm's Law

Ohm's law presents resistance (R) in a useful formula. It states that amperage equals voltage divided by ohms:

$$I = \frac{E}{R}$$

Ohm's law A circuit's amperage is equal to its voltage divided by its resistance (measured in ohms). Used to calculate resistance.

Alternating Current

Direct current has never been an efficient way to transport electricity over long distances. However, it was the only way known in the early days of electricity, and for that reason it was installed in the downtown areas of many cities. Today, it has been replaced by the more versatile alternating current.

Transformers

transformer A device used to increase or decrease the voltage of alternating current (AC).

Alternating current has the distinct advantage of being easily changed from low voltage to high and from high voltage to low by means of a transformer. A **transformer** consists of an iron core, frequently donut-shaped, around which are coiled two wires, the primary and the secondary (Figure 22-6). When an alternating current is sent through the primary coil, it sets up a magnetic flux in the iron core, and this flux, in turn, induces a new current in the secondary coil. There is no electrical connection whatsoever between the two coils. The voltage transformation is solely the result of fluctuating magnetic fields that surround any electrical conductor through which power is flowing.

If the primary has few turns around the core and the secondary has more, the voltage induced in the secondary will be higher than that in the primary. If the primary has more turns than the secondary, then the induced voltage will be lower. These are known as “step-up” and “step-down” transformers, respectively.

AC Service

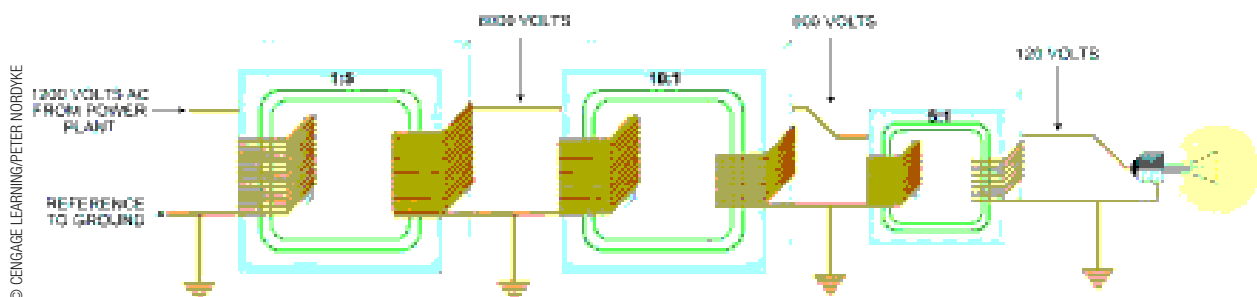
Figure 22-6 depicts part of a typical arrangement for a modest alternating current service. At far left sits an AC generator producing an EMF of 1,200 volts. This is fed to the substation, where a transformer boosts it to 6,000 volts. Higher voltages provide less loss in transit (some high-power lines carry up to 500,000 volts!). As the current nears the neighborhood in which it will be used, it passes through another substation, where the EMF is reduced to 600 volts. This is sent out over a local wiring system until it reaches a house, where a small transformer located on a street-side pole finally reduces it to 120 volts.

In the United States, the most common household service is 120 volts AC at 60 cycles. Other countries use different voltages, ranging from 105 to 240 volts, usually at fifty cycles or fewer.

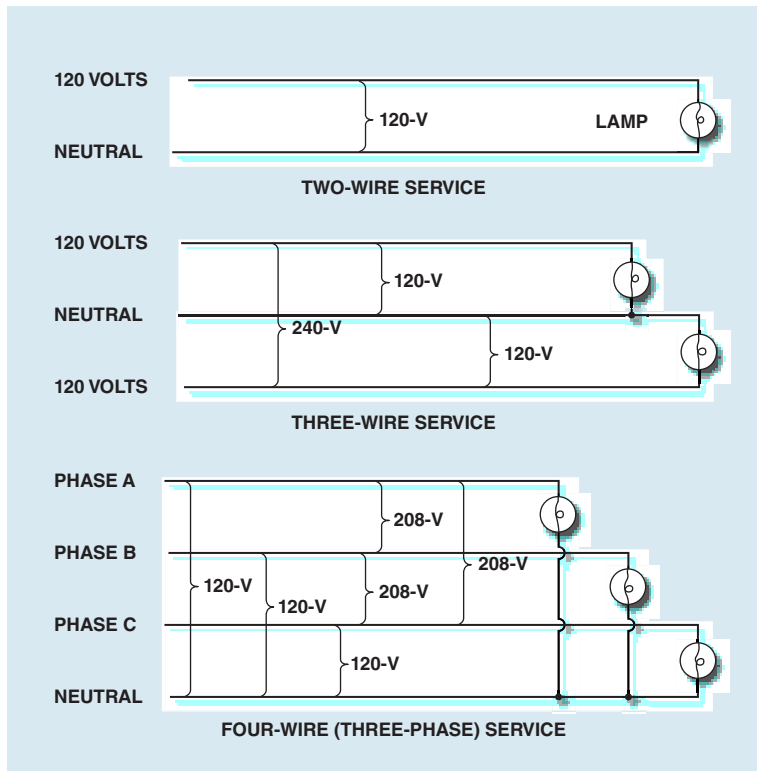
Two-, Three-, and Four-Wire Systems

service power Refers to the type of wiring system providing electricity to a user as well as its amperage.

It is essential for the stage electrician to know which of several possible wiring systems (referred to as **service power**) is carrying electricity to the theatre. This is especially true when a touring company moves into an unfamiliar building and must connect its portable dimmers and other equipment. Figure 22-7 illustrates the three forms of electrical distribution service.



22-6 Transformers A schematic drawing of AC transportation from a generating station to a home, illustrating the function of transformers.



22-7 Electrical Distribution The three kinds of electrical distribution service. Four-wire, three-phase service is found in most theatres.

Two-Wire System In a **two-wire system**, the first line is said to be **hot** and the second **neutral**. The potential between the two lines is 120 volts. Note that 120-volt service is often, in fact, closer to 115 volts and may drop to as low as 110 volts. Today's lighting equipment operates well on any of these voltages.

Three-Wire System The second form of service is the **three-wire system**, in which the two outside (hot) wires usually have a potential of 240 volts between them. However, each hot wire has a potential of only 120 volts between it and the third wire, the **common neutral**. A familiar application of this service is found in many homes, where the electric lights are on several circuits of 120 volts each, while the stove and clothes dryer operate on 240 volts.

Four-Wire System The third type of service is popular because of its efficiency in distribution. It is the AC 120/208-volt, four-wire system, also known as the **three-phase system**. The generation of these three phases is illustrated in Figure 22-5. The sine curve of the EMF produced by each phase is at 120 degrees to the others. If the EMF in relation to a common neutral conductor is 120 volts, then any two phases will have a potential of 208 volts (this being the product of 240 volts times the sine value of angle 120 degrees, or .8660). Many motors are built to run on 208 voltage. This type of service is found in most theatres.

Series and Parallel Circuits

Regardless of whether the current reaches the building by two-, three-, or four-wire systems, on the inside it is distributed by two-wire systems like the one diagrammed in Figure 22-7. The various elements that work in these circuits—lamps, switches, dimmers, fuses, and the like—may be connected in either of two ways: series or parallel.

In a **series circuit**, the flow of current passes through the various elements successively. The top diagram of Figure 22-8 shows that the current must pass through each

two-wire system A 120-volt AC electrical wiring system consisting of two wires: one hot and one neutral.

hot wire The conductor that carries electricity to the place of work.

neutral wire The conductor that carries electricity back to the generating plant.

three-wire system A 120/240-volt AC electrical wiring system consisting of three wires: two hot and one neutral.

common neutral A neutral wire serving two or more hot wires.

three-phase system A 120/208-volt AC electrical wiring system consisting of four wires: three hot and one neutral. Also known as the *four-wire system*.

series circuit A type of electrical circuit in which current passes through the various elements successively. If one element fails, the current will stop.



SAFETY PRACTICE

Matching Voltage

Great care must be taken with multiple-wire systems to avoid connecting any apparatus designed for 120 volts across the two hot lines. The 208 or 240 volts will blow lamps at once, ruin other equipment promptly, and provide a potential for fatal shock. The British, who use 240 volts for all their home lighting, must take precautions that would seem very irksome to us, who are used to our comparatively mild 120-volt service.

parallel circuit A type of electrical circuit in which portions of the total current flow through the various elements simultaneously.

circuit breaker A switch that automatically opens if the current exceeds a circuit's capacity.

short circuit An accidental path of low resistance, allowing an abnormally large flow of current; usually caused by improper wiring or broken insulation.

of the four lamps, one after the other, before returning through the neutral wire. If one of the lamps burns out, the circuit is broken, and current cannot flow.

The center diagram illustrates the same four lamps connected in parallel. In a **parallel circuit**, a portion of the total current can flow simultaneously through each lamp.

Combination Circuits Almost all practical lighting circuits are a combination of series and parallel. The bottom diagram of Figure 22-8 shows a typical example. The switch and fuse are in series with each other and they are also in series with each of the lamps, but the four lamps are in parallel with one another. If the switch is opened or the fuse is blown, all the lamps will be extinguished. However, one of the lamps may burn out without affecting the remaining three. In other

words, the series portion is used to control the circuit as a whole, while the parallel portion distributes the current efficiently.

In stage lighting, switches and fuses are replaced by **circuit breakers**. These breakers and the dimmers are put in series with the stage lights for the sake of control, whereas the lighting fixtures themselves are in parallel. The circuit breaker can act as a switch, but its primary function is to protect the entire circuit against a **short circuit** or an overload that would result in a dangerously high flow of current.

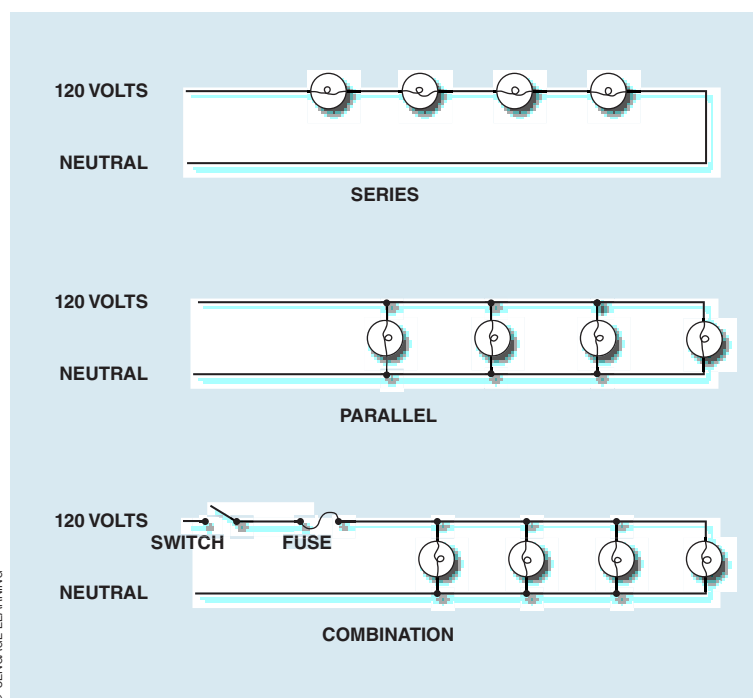
Circuit Capacity Electricians must be able to calculate the amperage flow in a circuit quickly. This is usually necessary when several lighting fixtures are ganged together or several striplights are fed through each other.

Suppose we have four lights ganged on one circuit, each one with a 575-watt lamp. We may invert the power formula ($P = I \times E$) to read

$$I = \frac{P}{E} \text{ then:}$$

$$I = \frac{4 \times 575}{120} = 19.17 \text{ amps}$$

22-8 Types of Electric Circuits Stage lighting uses a combination of series and parallel circuits.



If our circuit is rated at 20 amps, we are safe. But if we wish to change the lamps to a brighter 750 watts, then:

$$I = \frac{4 \times 750}{120} = 25 \text{ amps}$$

This would cause an overload and trip the breakers, so we must go back to the 575-watt lamps or remove one of the fixtures from the circuit.

Conductors and Insulators

Materials that readily support the flow of electricity are called **conductors**. Everything offers some resistance to electrical flow, but metals are relatively good conductors, and silver is the best of any substance known.

Using silver for extensive wiring is too expensive; copper is the best alternative. It conducts almost as well as silver, it is relatively inexpensive, and it is easy to work with. Aluminum is seeing more use for some applications, and brass is valuable for large, permanent parts that need to be especially rugged. Other materials are also used for special purposes, but by and large, copper is the conductor of choice for electric wires, switch parts, and the like.

Just as no material is 100 percent conductive, so nothing has 100 percent insulative properties. Nonetheless, many materials serve well as **insulators**. Glass and ceramics are excellent for small permanent parts such as sockets and switches. Rubber and fiber are used for wires and cables. Many insulating plastics have been developed for assorted uses. The most useful insulator of all is dry air. If this were not so, every open socket or wall outlet would drain off current!

Permanent wiring such as **stage circuits**, which should be installed only by a licensed electrician, have a solid copper core through which the current flows. Temporary wiring **cable** used on the stage always has a core made up of small strands of wire. This is to provide proper flexibility in handling and laying. Standard stage cable consists of three such cores, each surrounded by strong rubber insulation. For physical strength, tough fiber cords are laid alongside the strands of wire, and everything is surrounded by a rubber and fiber sheathing.

Grounding

National electrical codes specify that all new electrical installations be grounded. **Grounding** requires that a circuit or cable have three, rather than two, wires. The third, the ground wire, is designed to offer an emergency path through which the current can flow in case of a short circuit.

The ground wire of a stage-lighting fixture is connected to its metal housing. If a short circuit occurs and the housing becomes “hot,” the current will flow through the ground wire safely to earth.

conductor Materials that allow the free motion of a large number of electrons.

insulator Materials that have few free electrons and therefore resist the flow of electricity.

stage circuit Permanent stage wiring—normally 20-amp capacity.

cable Temporary stage wiring—normally 20-amp capacity to match stage circuits.

grounding A safety feature in modern wiring. A third wire acts as the ground wire, providing an electrical path of low resistance in case of a short circuit.



SAFETY PRACTICE ■ Short Circuits

An important rule to remember is that *electricity will always follow the path of least resistance*. Some sort of insulation is necessary to prevent the electrons that are flowing in a conductor from short-circuiting—that is, escaping into other channels. This “short” may

result in severe shock to anyone coming in contact with the new and unprotected channel of flow. Further, because it may offer little resistance, this new channel may allow a higher current than the legitimate circuit was designed to carry, thereby causing damage to it.

Wire Color Codes

U.S. In the United States, the wires of a stage cable or circuit are always covered with rubber insulation, color-coded as follows:

black or red = “hot” line
 white = “neutral” or “common” line
 green = ground

Europe, UK, and Elsewhere Wire color codes established by the International Electrotechnical Committee (IEC) are:

brown = “hot” line
 blue = “neutral” or “common” line
 green and yellow striped = ground (or earth)

Stage Cable

gauge A measurement of the diameter of a wire; directly relates to the wire’s capacity.

Electrical wire comes in different diameters, measured in **gauge** (AWG, American Wire Gauge). The smaller the wire, the larger the gauge number. Each wire size is designed to carry a specific maximum current measured in amps. These limits should never be exceeded. The most useful sizes are these:

Size (AWG)	Capacity (amps)
18	3
16	6
14	15
12	20
10	25
8	35
6	50

The most common (nearly standard) stage circuit has a capacity of 20 amps. Accordingly, the most common cable is No. 12, Type SO (rubber coated). Ordinary lamp cord (or zip cord), which has a 16- or 18-gauge core, may be used on occasion but only for very small loads and very short runs.

Care and Handling When not in use, cable should be neatly coiled in large coils (diameter of 2 to 3 feet), tied with tie-line, and hung up for storage. It is a good idea to permanently attach a length of black tie-line next to the female connector on all pieces of cable. Such a line can be used to secure the cable to a batten as well as to tie the coil together when it is stored. Cable length marking codes should be maintained, and connectors should be periodically checked for proper strain relief. Cables with damaged or cracked rubber coating should be discarded.

two-fer A special cable that allows for the plugging of two lighting fixtures into one circuit.

Cable Accessories There are two types of cable accessories. Cables that allow an electrician to plug multiple lighting fixtures into a single circuit are called “**two-fers**,” “Y-connectors,” “spiders,” or “three-fers.” They allow the electrician to

plug two or three fixtures into one circuit, as long as the 20-amp circuit capacity is not exceeded.

Adapters are the other type of accessory. Simple adapters are seldom more than 2 feet long, with a different connector on each end. They allow an electrician to plug something with one type of connector into an outlet having a different type. Applications are numerous, but an example would be plugging a backstage work light equipped with a pin connector into an “Edison” or parallel-blade socket.

adapter A special cable with different types of connectors on each end; allows a fixture with one type of connector to be plugged into a circuit with a different type of connector.

Feeder Cable

High-amperage cable used to provide temporary power from the electrical service entrance of a theatre to portable dimmers or other equipment is referred to as **feeder cable**. The table below shows various sizes of type SC, 600-volt feeder and their capacity in amps:

feeder cable High-amperage flexible cable used to connect portable dimmers and other equipment to a theatre’s power supply.

AWG Size	Amps
4	140
2	190
1/0	260
2/0	300
4/0	405

4/0 (pronounced “four-aught”) feeder is about ¾ inch in diameter and weighs roughly a pound per running foot.

Multi-Cable

Multi-cables, or “**mults**,” are temporary cables which typically contain six circuits within a single rubber coating. Their primary use is to run circuits to temporary lighting positions such as booms or ladders. They take a specialized connector called a *Socapex connector* that has 19 pins (Figure 22-9a). Attached to either end of the mult is a “break-out,” a Socapex connector out of which comes six “tails” – short 20-amp stage cables with standard twist-lock or stage pin connectors on the end (Figure 22-9b).

mult Short for multi-cable. A single stage-lighting cable normally containing 18 conductors used to get circuits to temporary lighting positions.

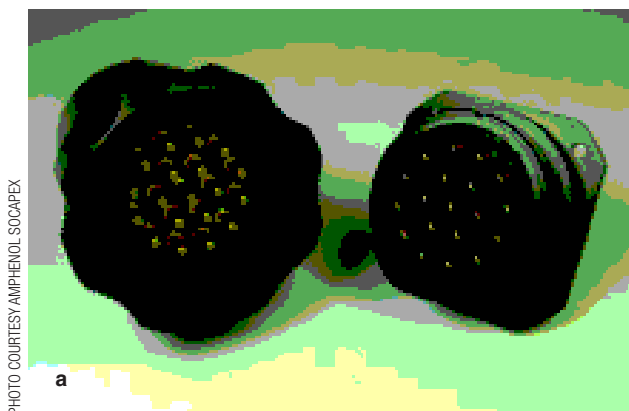


PHOTO COURTESY AMPHENOL SOCAPEX

22-9 Mults

- a Socapex 19-pin connector.
- b Socapex 6-circuit break-out.



PHOTO COURTESY A.C.T. LIGHTING, INC.

Stage Connectors

connectors Electrical plugs.

Hanging placement of stage-lighting fixtures must change from production to production. **Connectors** are electrical plugs that provide this flexibility. They are rated by amperage according to their electrical capacity. Ordinary household plugs with parallel blades, sometimes called “Edison” plugs, are occasionally used in small facilities because they are inexpensive and readily available. However, their use is discouraged because they are easily disconnected in error and are not designed for large amounts of current. The connectors most commonly used in the theatre are *twist-lock* and *pin connectors* for 20-amp service and Cam-Lok connectors for higher amperages.

twist-lock connector A stage connector that provides a sure connection by means of prongs that lock within the receptacle.

Twist-Lock Connectors Used in many educational and community theatres, the **twist-lock connector** solves the problem of two connectors pulling apart. It is designed with prongs that allow the male and female caps to be locked together easily and firmly (Figure 22-10a).

Unfortunately, manufacturers have created an amazingly large number of twist-lock blade configurations. Aside from the number of pins, the most significant difference among these styles is in the grounding blade. In some models, a part of the grounding blade is bent toward the center of the plug; in others, it is bent toward the outside. These two variations are commonly called “pin-in” or “pin-out,” respectively, and cannot be used interchangeably. By far the most common stage twist-lock is a 20-amp, 3-pin with ground pin in.

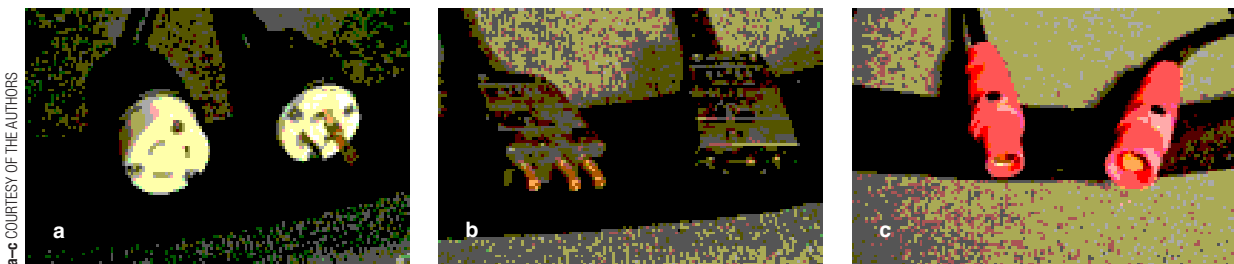
When wiring a twist-lock, electricians must always be sure that the grounding (green) wire is connected to the grounding prong, which is marked “G” or has a green screw head. Twist-lock plugs are available in a wide variety of amperages.

pin connector A stage connector with round brass pins that slide into holes in the receptacle.

Pin Connectors Used as a stage connector long before twist-locks were invented, **pin connectors** remain the staple of the commercial theatre. The standard size has a capacity of 20 amps and consists of a heavy-duty fiber or plastic body with sturdy brass pins and sockets (Figure 22-10b). Most professional theatres use pin connectors because rental house equipment has them. They have the disadvantage of not always giving a firm electrical connection and are easily pulled apart by mistake unless the two cables or connectors are tied together.

Pin connectors have a split down the center of each brass pin (hence the name “split-pin” connector). When a pin does not make a good connection, electrical arcing occurs, causing the connector to overheat. To avoid this, the individual pins can be “split” or slightly separated with a small knife blade.

The grounding pin is always the center pin of a 20-amp pin connector. Pin connectors are available in 60- and 100-amp sizes in addition to the standard 20-amp size.



a-c COURTESY OF THE AUTHORS

22-10 Stage Connectors

- a Female and male three-wire (grounded) twist-lock connectors.
- b Male and female three-wire pin connectors.
- c Cam-Lok connectors capable of handling higher amperages.

Cam-Lok Connectors These specialized connectors are made to handle the high-amperage current required for theatrical dimmers. The Cam-Lok “J” Power Series connector is rated for 2/0 and 4/0 feeder cable up to 600 volts and 400 amps (Figure 22-10c). The connectors easily slide together and twist to create a firm lock. In a three-phase, four-wire hookup, the connectors’ rubber sleeves should be color-coded red, black, and blue for the three hot wires; white for the neutral; and green for the ground (U.S. standard). In connecting to a power supply, always follow these steps:

1. Connect the green ground connector first
2. Connect the white neutral connector next
3. Connect the hot wires last

When disconnecting, reverse the order.

Wiring Connectors and Strain-Relief Proper wiring of stage connectors ensures against short-circuiting or loose connections that can result in arcing within the plug. As pointed out earlier, stage cable consists of three groups of small strands of copper wires, each surrounded by a rubber sheathing. This rubber sheathing must be stripped away by using a cutting tool called a *wire stripper*. Expose only as much bare wire as necessary and twist the small individual strands of the wire together to form a more cohesive single strand. Make sure that the screw terminal is tightened down firmly on the wire lead (Figure 22-11).

The strain-relief mechanism of a stage connector grips the rubber coating of a cable, ensuring that any pulling tension affects the cable rather than the connecting terminals. Be sure that the connector’s strain-relief mechanism is effective.

Perhaps it is obvious, but a male connector must never be “hot” or “live.” For example, leads from a lighting fixture always terminate in a male connector so that it plugs into the “live,” shielded female connector.

Switches and Circuit Protection

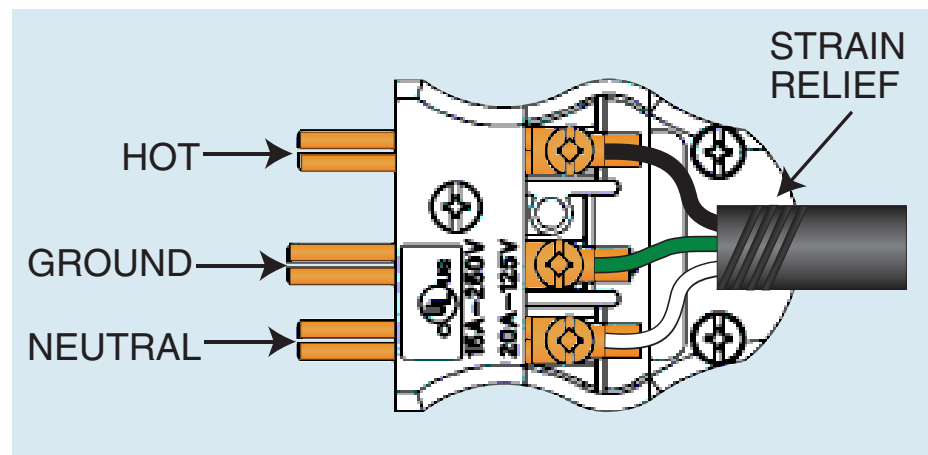
Switches A *switch* is a device that is put into a circuit to interrupt and restore the flow of current as desired (to “open” and “close” the circuit). Types of mechanical switches range from the familiar domestic wall-type switch to large knife-blade



SAFETY PRACTICE Proper Grounding

In wiring plugs onto cable, electricians must take particular care to attach the ground wire to the proper pin of the connector.

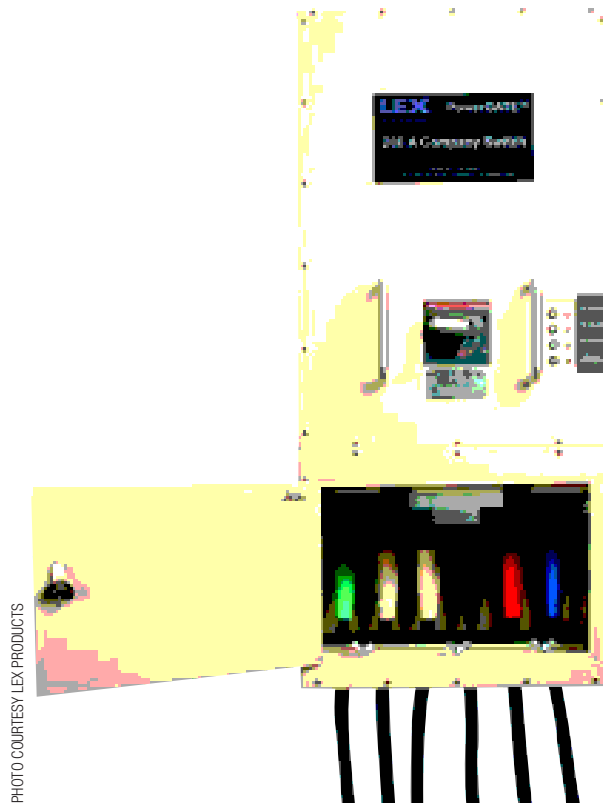
Always remember: green is ground.



22-11 Pin Connector Wiring Illustration shows a stage pin connector with proper wiring and strain relief.

© CENGAGE LEARNING/PETER NORDYKE

22-12 Company Switch Shown is a 400-amp, three-phase company switch manufactured by LEX Products. It is available with Cam-Lok connectors or lugs.



company switch A switch, commonly found backstage in theatres, that supplies high amperage power for touring dimmers.

contactor An electrically operated device in which a small switch controls a larger, remotely located switch.

arrangements that handle hundreds of amps. Like everything else electrical, which type and size to use depends on the duty the switch is expected to perform and the load it is intended to handle.

A switch commonly found backstage in the theatre is a **company switch**. This heavy-duty switch, sometimes called a “disconnect box,” also contains a high-amperage circuit breaker (Figure 22-12). The company switch is permanently mounted in the theatre to receive temporary lighting-control equipment, allowing quick and easy access to a power supply. A touring production might carry its own disconnect box equipped with a circuit breaker rated for the touring control system or other electrical apparatus. In this case, the disconnect is wired to a larger-amperage power supply in order to protect the touring equipment from a power overload.

A **contactor** is an electrically operated device in which a small switch controls a larger, remotely located switch. When operated, the conveniently located smaller switch activates a magnet that opens or closes a switch capable of handling hundreds of amps. A contactor allows high current to be kept away from the operator. Additionally, the loud noise created by large magnetic switches is kept away from the audience.

Fuses If current flow increases to a dangerous level, the *fuse* gives way, breaking the circuit and preventing more serious damage. The fault is then located and corrected, and a new fuse is inserted with a minimum of trouble. Figure 22-13 shows various cartridge-type fuses at the voltages usually encountered in stage-lighting circuitry.

If a fuse continues to blow when replaced, there is either an overload or a short circuit. Immediate steps should be taken to eliminate the hazard. Overfusing or bypassing a fuse is a dangerous and foolish practice that can cause a fire. It is good practice to keep spare fuses on hand for all equipment using them.

**22-13 Cartridge-Type Fuses**

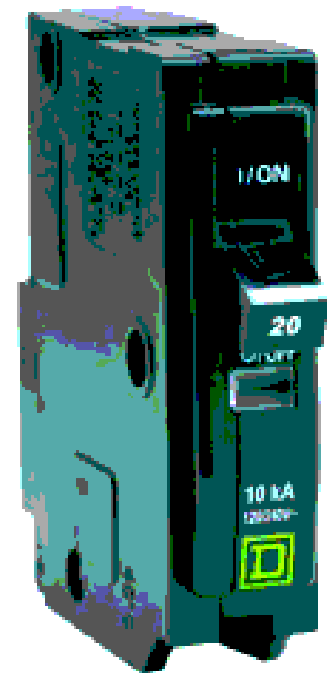
- a Knife-blade.
- b Time-delay.
- c Ferrule-tipped, standard.
- d Ferrule-tipped, ceramic.
- e Ferrule-tipped, glass fast acting.
- f Ferrule-tipped, glass slow-blow.

Circuit Breakers Because of their convenience, circuit breakers have replaced fuses in most applications. A circuit breaker is a form of switch that automatically opens when the flow of current becomes higher than it should (Figure 22-14). A thermal circuit breaker detects excessive current flow through a buildup of heat. Magnetic breakers react to the larger magnetic field created by greater-than-normal amperage. Although more expensive, magnetic breakers are desirable because they react more quickly and can be reset immediately; thermal breakers may need a short period of time to cool before being reset.

Testing Equipment

A stage electrician must have ready access to various testing tools in order to troubleshoot the electrical problems that invariably arise precisely when time is most critical. These tools range from the simplest test lights to sophisticated meters that combine several functions.

A test light, such as the one shown in Figure 22-15, lights up if an electrical circuit is “live.” Test lights should be inexpensive, easy to carry, and hard to break.

**22-14 Circuit Breaker**

COURTESY SCHNEIDER-ELECTRIC



SAFETY PRACTICE ■ A Healthy Respect for Electricity

Electrical safety, like most everything else, is a matter of common sense. If you don't know what you're doing, don't do it! Attention to the following points will be helpful:

1. Always remember that electrical current will follow the path of least resistance, and your body could be that path.
2. Insulation is a good thing. Tools should be insulated with plastic or rubber handles. Soles of shoes should provide good insulation.
3. Electrical fires are most commonly caused by heat buildup resulting from arcing or a short circuit.
4. Know the locations of electrical (red) fire extinguishers.
5. Fuses and circuit breakers protect equipment and ensure circuit safety. Never attempt to bypass them.
6. Never use a metal ladder for electrical work unless it is insulated with rubber footpads on all legs. Wooden or fiber ladders are always safest.
7. Be particularly wary of damp or wet conditions. Water is a fairly good electrical conductor.
8. Strain relief in electrical connectors is important.
9. Green is ground.
10. Voltage kills.

22-15 Neon Test Light A handy tool for testing electrical circuits.



IDEAL INDUSTRIES, INC.

continuity tester A piece of testing equipment that supplies a low-voltage current in order for an electrician to ascertain whether a circuit is complete or broken.

A **continuity tester** enables an electrician to test a circuit to see that it is complete (not broken). The tester's battery allows a low-voltage current to run through the circuit (or not, if the circuit has been broken). This type of tester is particularly useful for detecting burned-out lamps where the broken filament has opened the circuit. GAM sells a combination circuit/continuity tester called *GAM CHEK* (Figure 22-16a).

More-sophisticated testing equipment in the form of meters can read voltage, amperage, and resistance in a circuit. Most meters combine several functions, such as the Fluke Digital Multimeter shown in Figure 22-16b. Amprobe manufactures a meter called an *Amprobe*, which measures volts, ohms, and amperage (Figure 22-16c). Meters are fairly delicate and are also fairly expensive.

An understanding of electricity lays the foundation for working with specific stage-lighting sources. The next chapter focuses on the types of sources available as well as specific properties of these sources.



PHOTO COURTESY GAM PRODUCTS, INC.

a



COURTESY FLUKE CORPORATION

b

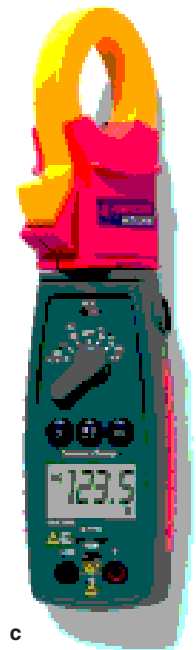


PHOTO COURTESY AMPROBE®

c

22-16 Test Equipment

- a GAM CHEK tools for testing Edison, twist-lock, and stage pin cables and circuits.
- b Digital Multimeter manufactured by Fluke measures frequency, capacitance, resistance, and continuity.
- c Amprobe Swivel Clamp Meter measures AC/DC current: voltage, resistance, and capacitance.

Light Sources

We are on the threshold of great change in light source technology; it would seem that the reign of the old work-horse incandescent lamp is nearing an end. Due to its inefficiency (only 10 percent of energy is turned into light), the common incandescent household lamp is being replaced by fluorescent light sources. However, fluorescence is not desirable for theatrical and any other type of illumination that depends on the projection of light over distance. In order to work with reflectors and lenses, optical devices such as spotlights require a source of light that is physically small. Such a source is impossible with fluorescence. The solution lies with an even more efficient source of light that does have potential for stage-lighting applications: the LED, or light emitting diode.

LED light sources are unlike any other: they aren't a lamp—they don't have bases or bulbs or filaments; they require very little electricity; they give off heat, but not in the light; and their color rendering is inherently poor.

All incandescent and arc light sources are in the form of lamps. We will discuss them first. A **lamp** is composed of the *light source* (the filament in an incandescent lamp); a glass envelope, or *bulb*; and a *base*.

During the second half of the twentieth century, great advances were made in lamp design and manufacturing. Development of the tungsten-halogen lamp in the 1950s brought about a revolution in stage lighting-instrument design. In 1954, the German firm Osram introduced the first practical arc lamp, which was filled with xenon gas; and in 1971, a xenon arc lamp was put to use in a theatrical follow spot: the Xenon Super Trouper. This lamp is the forerunner of today's great variety of arc sources.

Compact-filament low-voltage lamps, combined with new reflectors, have created a source of parallel rays of light unheard of two decades ago. The HPL, a 575-watt high-performance tungsten-halogen lamp, was developed by ETC to become an integral part of their Source Four fixtures. Owing to its enhanced filament design, it is brighter than older 1,000-watt lamps!

Theatrical lighting designers must be aware of the great potential provided by the various light sources at their command. The theatre currently uses three basic types of lamps:

- *Incandescent*. Light is given off by a glowing metal filament.
- *Arc*. An electrical arc gives off intense illumination.
- *Gaseous discharge*. Light production depends on the reaction of gases to an electric arc.

CENGAGE **brain**.com

For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

lamp A light source consisting of a filament, a bulb, and a base.

incandescent filament lamp A glass bulb enclosing a tungsten filament that emits light when an electrical current is passed through it.

Incandescent Lamps

The most common source of light used on the stage is still the **incandescent filament lamp**: a glass bulb enclosing a tungsten-metal filament that emits light when an electrical current is passed through it. An incandescent lamp has three basic parts:

- The *filament*, which passes the current yet offers enough resistance to change electrical energy into light energy
- The *bulb*, or the glass envelope that encloses an inert gas
- The *base*, which fits into a socket and holds the lamp in proper position and provides electrical contact

The bulb contains an inert gas that prevents the metal filament from oxidizing and thus burning up. Tungsten, the same wire used in toasters and toaster ovens, is relatively resistant to electrical flow. As a result, it heats up and glows when a current is passed through it.

There are two basic categories of incandescent lamps: the *standard incandescent lamp* and the *tungsten-halogen lamp*. Thomas Edison developed the standard incandescent lamp in 1879; since then, it has not changed much. The tungsten-halogen lamp is an incandescent light source with a special quartz-glass envelope containing a halogen gas. At the outset, it was a popular theatrical lamp because of its small size and increased efficiency (Figure 23-1).

Tungsten-Halogen Lamps

tungsten-halogen lamp An incandescent lamp with a halogen-family gas sealed within its quartz-glass envelope. Also called a *quartz lamp*.

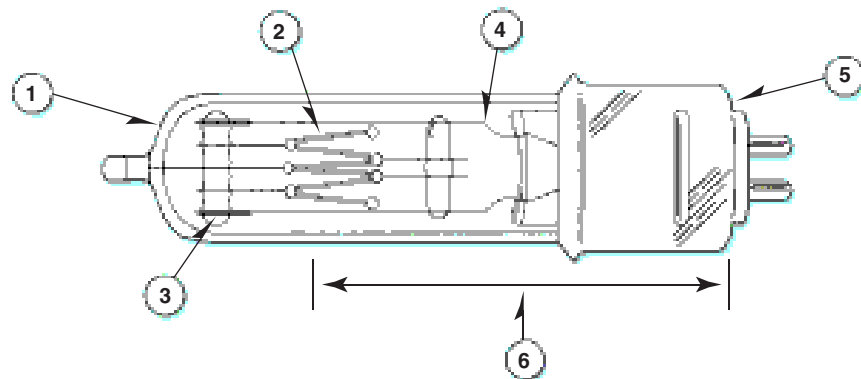
The development of the **tungsten-halogen lamp** (often called a *quartz lamp*) led to significant changes in the stage-lighting industry. The most important of these was the creation of smaller and more powerful lighting fixtures designed specifically to use these lamps. Not only are tungsten-halogen lamps much more compact than standard incandescent lamps, but they also maintain initial intensity throughout their life span.

As a tungsten filament burns, carbon particles evaporate from the filament and deposit themselves on the cooler glass envelope. The result of this process is a gradual darkening of the bulb and a decrease in light output (Figure 23-2). However, in quartz lamps a halogen gas introduced into the bulb collects the tungsten particles and redeposits them at the hottest point: the filament. Due to higher temperatures, the tungsten-halogen glass envelope is constructed out of strong quartz glass (thus the name *quartz lamp*).

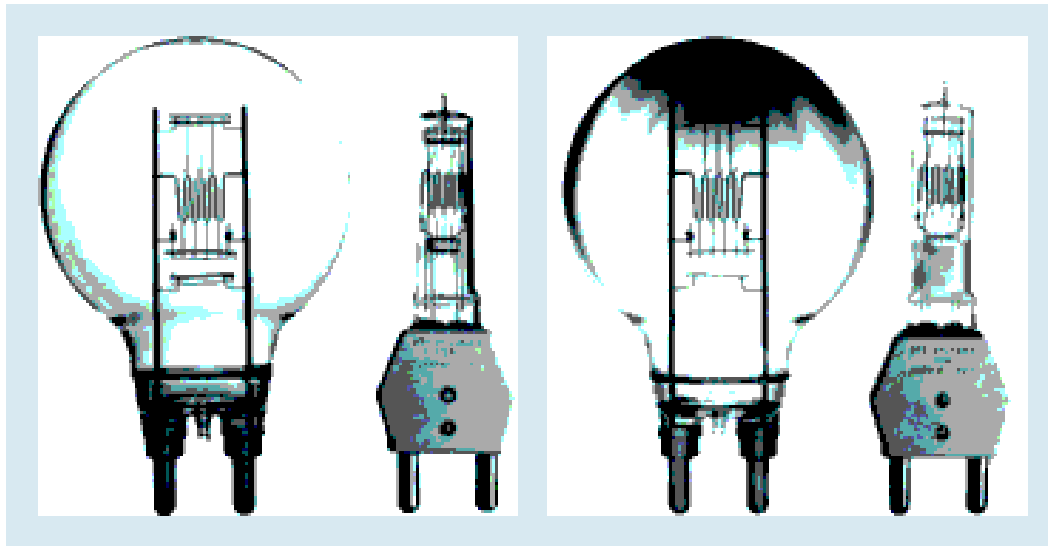
A disadvantage of the tungsten-halogen lamp is that the quartz glass envelope cannot be touched by fingers. No matter how clean one's hands are, oil from the skin is

23-1 Parts of a Tungsten-Halogen Incandescent Lamp

- 1 Quartz-glass bulb filled with halogen gas.
- 2 Biplane filament.
- 3 Filament supports.
- 4 Lead-in wire.
- 5 Medium 2-pin base.
- 6 LCL (light center length).



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PHOTOS COURTESY OSRAM SYLVANIA, INC.

23-2 Comparison of Tungsten-Halogen and Standard Incandescent Lamps Note how dark the standard incandescent bulb grew after 100 hours of continuous use.

deposited on the glass and will react with the quartz when it is heated. The result of this reaction not only weakens the envelope (possibly causing an explosion) but also produces a frosted effect on the glass.

The HPL lamp mentioned earlier is a tungsten-halogen lamp with a redesigned filament. The new compact filament configuration allows the lamp to be brighter than previous lamps while consuming only half as much energy (Figure 23-3).

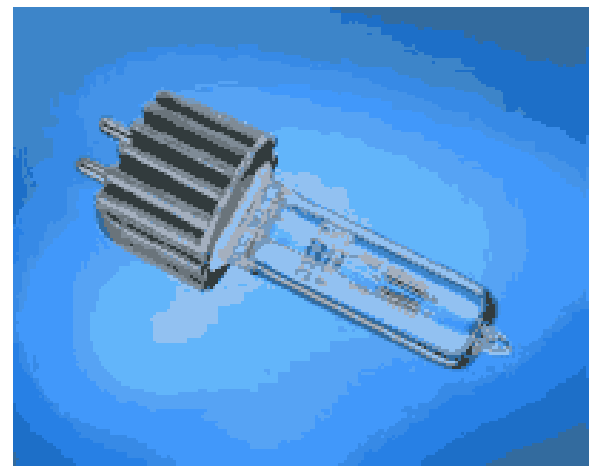
Filaments

Most stage-lighting fixtures use reflectors to increase the efficiency of their light source. The smaller the light source, the more efficiently a reflector gathers and precisely redirects light rays. The ideal lamp **filament** would be what is referred to as a point source. To make filaments as compact as possible, the tungsten wire is often coiled (designated “C”) in order to maintain as small a size as possible. In the case of some tungsten-halogen lamp filaments, the wire is double-coiled (designated “CC”) and called a *coiled coil* (Figure 23-4e).

filament A thin piece of tungsten that glows and emits light from within a lamp.

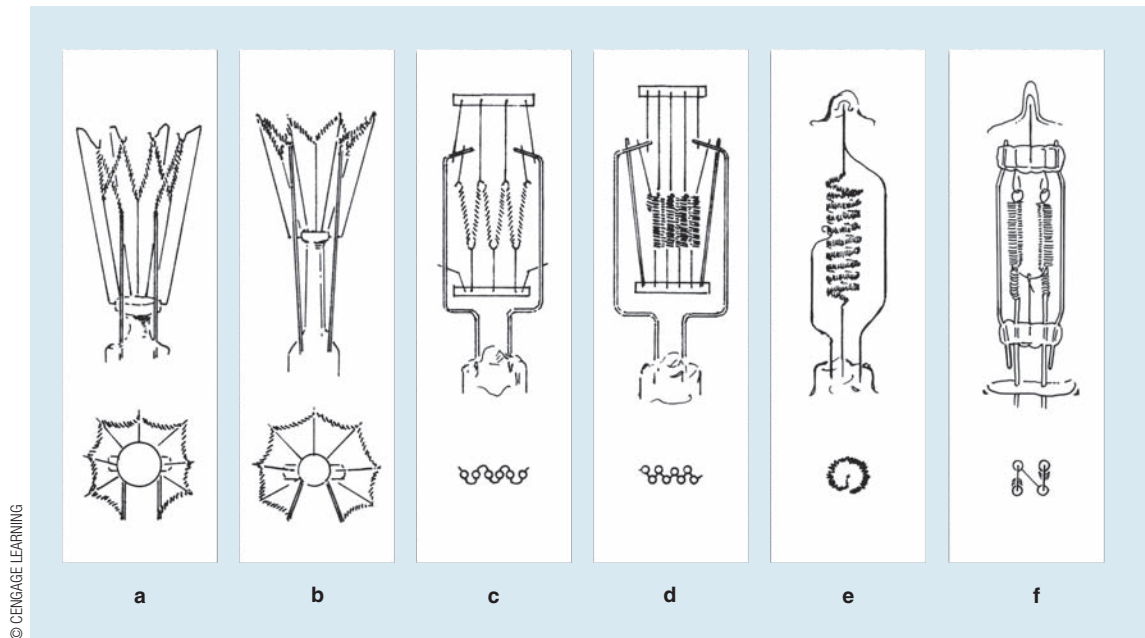
Filament Forms Many different filament configurations exist. The barrel and corona filaments (Figures 23-4a and b) are used for floodlights and household lamps because they distribute their light equally in all directions. The monoplane and biplane filaments (Figures 23-4c and d) used in spotlights emit most of their light to the front and rear of the filament. This permits a larger portion of the light to be gathered and redirected by a reflector or a lens. The coiled coil, a common tungsten-halogen lamp filament, tends to be a bit longer and narrower than other filaments. The efficient HPL filament is a compact coiled coil, comprising four double-coiled elements in a symmetrical box arrangement (Figure 23-4f).

No matter what form a filament takes, the tungsten metal becomes supple when it heats up. In this state, any excessive jarring of the filament can cause it to break. Spotlight filaments such as the biplane and the coiled coil are particularly susceptible to this sort of breakage. Lighting fixtures should be handled gently when their lamps are on.



COURTESY OSRAM SYLVANIA INC., AND PAUL KEVIN PICONE/IPC CORP

23-3 HPL lamp The 575-watt High Performance Lamp (HPL) shown is as bright as a standard incandescent 1,000-watt spotlight lamp and uses less energy.



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23-4 Filaments The upper row shows a side view and the bottom row a top view of the following types of filaments:

- | | |
|---------------------|---------------------------|
| a Barrel. | d Biplane. |
| b Corona. | e Coiled coil. |
| c Monoplane. | f HPL coiled coil. |

LCL (light center length) The distance from the center of a lamp's filament to some predetermined place in its base.

Light Center Length The **LCL (light center length)** of a lamp is the distance from the center of the filament to some predetermined place in the base. With a screw-base lamp, the measurement is to the contact button at the bottom of the base; with a prefocus base, it is to the fins; with the 2-pin, it is to the base of the pins (Figure 23-1). It is particularly important to be aware of the LCL in spotlights, in which a lamp is used in conjunction with a reflector or a lens. The center of the filament must line up exactly with the focal points of such optical devices.

Bulbs

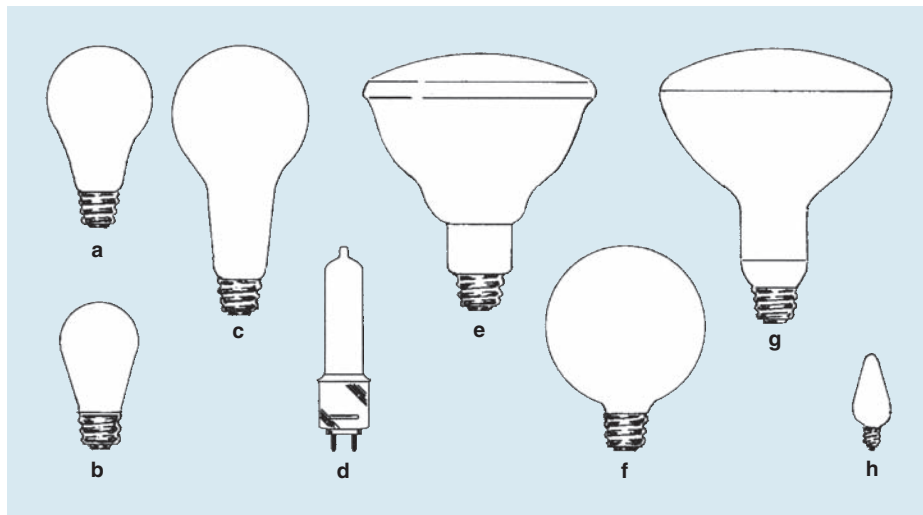
bulb The sealed glass enclosure of a lamp. Also called the *envelope*.

The **bulbs** (or *envelopes*) of incandescent and arc lamps contain a gas which, in the case of incandescent lamps, prevents the filament from oxidizing, and in the case of arc lamps, supports the burning of the arc.

Shapes Bulbs come in a variety of shapes, each designated by a letter or letters (Figure 23-5). The A (arbitrary) and PS (pear shape with straight sides) are common forms of household lamps. Lamps used in stage lighting fixtures were once globe shaped (G) to allow even dissipation of heat. Today's tungsten-halogen lamps are nearly all tubular (T), allowing the filament to be brought closer to a reflector. There are other shapes as well, some of which are purely decorative. The familiar R-type and PAR lamps are discussed separately later in this chapter.

Size The size of a bulb is designated by a numbering system that may seem unnecessarily complex but is at least standardized. The diameter of the bulb at its largest point is expressed in eighths of an inch. For example, the common T-6 quartz lamp has a tubular envelope and is $\frac{6}{8}$ (or $\frac{3}{4}$) inch in diameter.

Finishes and Color Lamps used in stage-lighting fixtures are made of clear glass. Common A and PS lamps are most readily available with an inner finish called *frosted*.

**23-5 Typical Bulb Shapes**

- a Arbitrary (A).
- b Straight-side (S).
- c Pear shape (PS).
- d Tubular (T).
- e Parabolic aluminized reflector (PAR).
- f Globe (G).
- g Reflector (R).
- h Cone (C).

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A frosted finish diffuses the light, thereby reducing glare. These lamps can also be ordered in the clear-glass style, used in signs and for decorative purposes.

There are many kinds of finishes available, some purely decorative and others for special applications. Low-wattage PAR lamps can be bought with colored lenses, and small G and A lamps can have variously colored bulbs.

Lamp Bases and Sockets

A lamp base provides three important functions:

- It holds the lamp precisely in a predetermined position, which is critical to the proper operation of a reflector.
- It conducts electrical current from the socket to the filament.
- It allows for quick and easy lamp replacement.

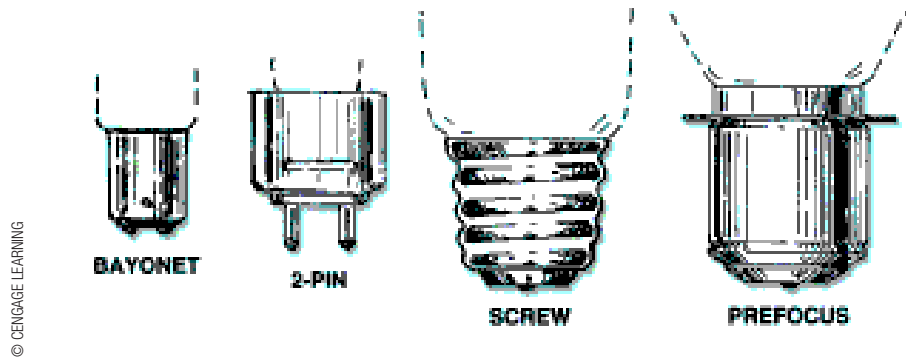
Similar to connectors in an electrical circuit, base and socket assemblies make changing lamps quick and easy. The electrical contact in the base is made of brass or aluminum. In the medium-sized screw base of a common household lamp, the button at the bottom conducts the electricity to the filament. The return path of electricity is through the metal screw-base rim.

Base Sizes and Shapes Normally, the size of a base varies with the wattage of a lamp. Large bases are called *mogul*, middle-sized bases are called *medium*, and small bases are called *miniature*.

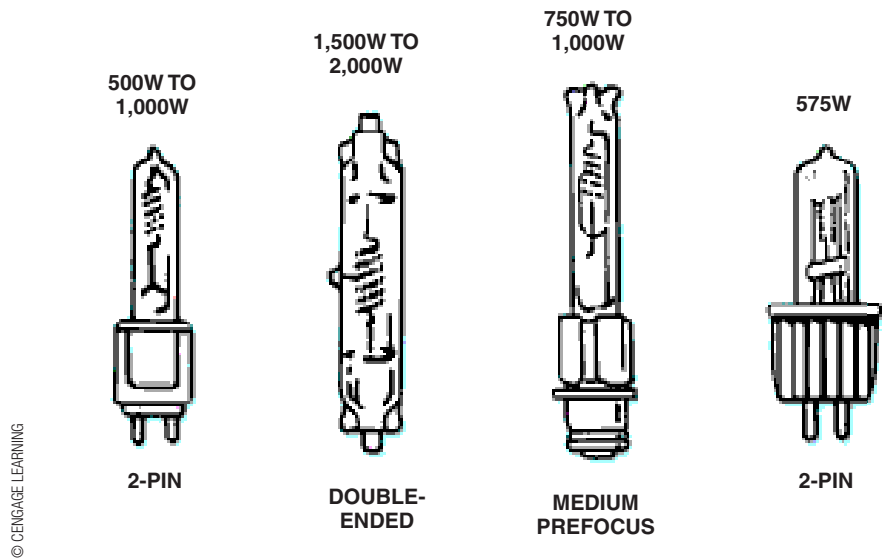
Screw bases work well for low- to medium-wattage lamps whose filaments do not need to be precisely aligned. Prefocus and 2-pin bases are used on medium- to high-wattage lamps that need proper alignment (Figure 23-6). A base called the *bi-post*, which looks like a large 2-pin, is used for very high wattage lamps.

Most tungsten-halogen stage lamps use a prefocus, a 2-pin, or a double-ended base (Figure 23-7). The prefocus base slips into its socket and requires slight pressure downward and a turn before the lamp “clicks” into alignment. The 2-pin lamp slides straight into its socket and is held in place by a pressure plate. Excessive handling or jarring may cause this lamp to dislodge from its base, so care must be taken with fixtures requiring this lamp. The double-ended lamp is held in place by two metal contacts, mounted so that they protrude through the reflector of an instrument. Depending on the design of the fixture, these lamps can be difficult to get seated properly. Care must be taken not to damage either the contacts or the seal of the lamp base.

23-6 Common Base Types



23-7 Common Theatre Lamps Four common tungsten-halogen lamp and base types.



ANSI lamp code A system for identifying lamps that uses a different three-letter code for each lamp.

The ANSI Lamp Code

The American National Standards Institute (ANSI) has established a system for identifying lamps using a three-letter code called the **ANSI code**. If one lamp differs in any way from another, it is assigned a separate three-letter code (Figure 23-8). Although the letters are totally nondescriptive by themselves, they have greatly simplified the process of specifying lamps. One may order a lamp simply by providing the supplier with its ANSI code.

Variables in Lamp Design

Lamp manufacturers may offer a designer several choices of lamps for a single lighting fixture. Variables include: wattage, voltage, color temperature, life, and lumen output (Figure 23-8). Each one of these variables is dependent upon the other. For instance, extended lamp life will normally result in decreased intensity.

Color Temperature As discussed in Chapter 16, most people consider the color of light emitted from an ordinary lamp to be white. However, so-called white light is relative, and the actual color of light given off by sources can vary greatly. The method we have to identify the color makeup of any light source is called *color temperature*, measured in **Kelvin (K)**. Kelvin is a temperature scale (developed by Lord Kelvin in the mid-1800s) with 0 degrees equal to -270 degrees Celsius (absolute 0).

In an effort to standardize light source color notation, a light-emitting device called a *blackbody* was developed. When heated, it emits light consisting of various color wavelengths. The blackbody responds to heat in much the same way that a tungsten filament does. It

Kelvin (K) A temperature scale used to identify the color of a light source.

Table 8: Halogen, Single-Ended, G9.5 Medium 2-Pin (9.5mm apart)

Watts	Bulb ID	GE Description	Faceted Safety Bulbless	APSI Code	ULP Code	Product Order Code	Stock Pack Qty.	Base Type	Design Voltage	Design Color Temp (K)	Rated Life (hrs)	Initial Design Lumens	Fill-gas Type	LCL (mm)	MCL (mm)	Burning Position	Bulb Finish	Fig. No.
500	T-6	EHD-0500CL/TP	62	EHD		38788	24	G9.5	120	2900	2000	10000	CC-8	86	105	Any		8
		EHC-0500/ACL	62	EHC		38789	24	G9.5	120	3150	500	12700	CC-8	86	105	Any		8
575	T-4	FLK-0575T6	62	FLK		11460	24	G9.5	115	3200	300	19500	CC-8	80	105	Any		9
		FLK/LL-0575T6	62	-	-	38730	24	G9.5	115	3180	1500	12800	CC-8	80	105	Any		9
		GLA-0575T6/ACL	62	GLA	-	93420	24	G9.5	115	3050	1500	13000	C-13D	80	105	Any		9
		GLC-0575T6/ACL	62	GLC	-	93420	24	G9.5	115	3200	300	14500	C-13D	80	105	Any		9
800	T-6	GKV-0875T6/ACL	62	GKV		38739	24	G9.5	230	3200	250	14000	C-13D	80	105	Any		9
		GKV	62	GKV		38750	24	G9.5	240	3200	250	14000	C-13D	80	105	Any		9
		GKV/LL	62	GKV		38751	24	G9.5	230	3000	1500	11000	C-13D	80	105	Any		9
		GKV/LL	62	GKV		38752	24	G9.5	240	3000	1500	11000	C-13D	80	105	Any		9
650	T-6	FKR	62	FKR		38734	24	G9.5	230	3100	300	15000	C-13D	80	105	Any		9
		FKR	62	FKR		38735	24	G9.5	240	3100	300	15000	C-13D	80	105	Any		9
750	T-4	EHG-0750CL/TP	62	EHG	-	38770	24	G9.5	120	3000	2000	15000	CC-8	86	105	Any		8
		EHF-0750/ACL	62	EHF	-	38771	24	G9.5	120	3200	300	20000	CC-8	86	105	Any		8

IMAGE COURTESY OF GENERAL ELECTRIC COMPANY

23-8 Comparison of Wattage, Color Temperature, Life, and Lumen Output Compare in particular the 750-watt EHG and EHF lamps.

begins to glow a warm red-yellow, moves toward “white” as more heat is applied, and finally appears to approach blue when a great deal of heat is applied. The color wavelengths of light emitted by the blackbody are identified by a sophisticated meter called a spectrophotometer. Any color of light can thus be equated with the temperature of heat applied to the blackbody, resulting in a meaningful Kelvin figure (see Chapter 16 and Figure 16-11).

This is fairly important for a lighting designer to understand because theatre sources vary in color—from standard incandescence, which is around 3,000 K, to much cooler arc lamps, which can be as high as 6,000 K. Obviously, the same filter placed in front of two such different sources will project very different colors. For all practical purposes, no one will notice a source color difference of less than 200 K, but any more of a difference is noticeable. The color temperature of stage lamps is often printed on their containers and is always noted in catalogs (Figure 23-9). Recall that the higher the color temperature, the cooler the light. Further, dimming a source decreases its color temperature significantly.

Lamp Life and Color Temperature The rated average life for the common household lamp is at least 750 hours, but for stage lamps it can be as low as 200 hours. Rated average life is determined by the manufacturer, who burns a group of lamps under normal conditions until either: (1) they burn out completely; or (2) their light output drops to 80 percent of what it was originally. Theatre lamps are often burned at a lowered dimmer level, resulting in increased life. Generally, longer lamp life results in lower color temperatures (discussed below).

Voltage If a lamp designed to be used on 120-volt service is powered with only 110 volts, it will last almost four times as long as it would on 120 volts. However, it will emit only about 74 percent as much light. If this same lamp is fed 130 volts, however, there will be 31 percent more light, but the lamp will last only a third as long.

Wattage versus Lumen Output Lamp manufacturers have taught the general public to equate the wattage of a lamp with its brightness. If our 75-watt reading lamp is too dim, we simply replace it with a 100-watt lamp. But, in fact, wattage is not necessarily an accurate measure of lamp intensity. Lamp manufacturers use a measure of

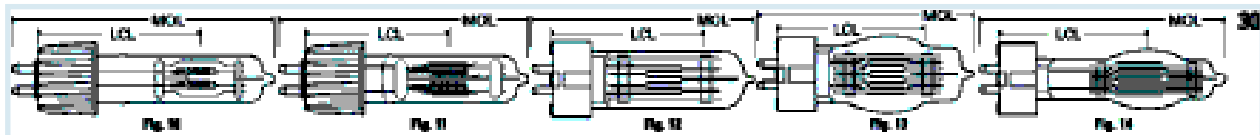


IMAGE COURTESY OF GENERAL ELECTRIC COMPANY

Table 9: Halogen, Single-Ended, G9.5/Heat Sink (Metal 2-Pin) (continued)

Watts	Bulb Size	GE Description	Footcandle Safety Notation	AGM Code	LIF Code	Product Order Code	Shel. Pack Qty.	Base Type	Design Watts	Design Color Temp. (K)	Rated Life (Hrs)	Initial Design Lumens	Filament Type	LCL (mm)	MCL (mm)	Banding Position	Bulb Finish	Fig. No.
575	T-6	HPL575/C 115W	62	-	-	82431	12	G9.5/H8	115	3200	300	16500	4-C8	80	106	Any		10
		HPL575/C 120W	62	-	-	82433	12	G9.5/H8	120	3200	300	16520	4-C8	80	106	Any		10
		HPL575/LL/C 115W	62	-	-	82434	12	G9.5/H8	115	3050	2000	12360	4-C8	80	106	Any		10
		HPL575/LL/C 120W	62	-	-	82435	12	G9.5/H8	120	3050	2000	12360	4-C8	80	106	Any		10
		HPL575	62	-	-	37128	12	G9.5/H8	230	3200	300	14800	6-C8	80	106	Any		11
		HPL575	62	-	-	37131	12	G9.5/H8	240	3200	300	14800	6-C8	80	106	Any		11
		HPL575-X LL	62	-	-	37817	12	G9.5/H8	230	3050	1500	11780	6-C8	80	106	Any		11
		HPL575-X LL	62	-	-	37818	12	G9.5/H8	240	3050	1500	11780	6-C8	80	106	Any		11
750	T-6	HPL750/C 115W	7, 62	-	-	82432	12	G9.5/H8	115	3200	300	22000	4-C8	80	106	Any		10
		HPL750/LL/C	7, 62	-	-	82770	12	G9.5/H8	115	3050	2000	16400	4-C8	80	106	Any		10
		HPL750	7, 62	-	-	37824	12	G9.5/H8	230	3200	300	19750	6-C8	80	106	Any		11
		HPL750	7, 62	-	-	37826	12	G9.5/H8	240	3200	300	19750	6-C8	80	106	Any		11
		HPL750-XLL-C	7, 62	-	-	82768	12	G9.5/H8	230	3050	1500	15800	6-C8	80	106	Any		11
		HPL750-XLL-C	7, 62	-	-	82769	12	G9.5/H8	240	3050	1500	15800	6-C8	80	106	Any		11

23-9 HPL Lamp Table General Electric's partial listing of 575- and 750-watt HPL lamps. Compare lumens, life, and color temperature.

lumen A unit of measurement of the intensity of a light source.

intensity called the **lumen** to quantify the light output of a lamp (see the accompanying box on lumen output of various lamps). Figure 23-8 shows how two lamps with identical physical specifications can be quite different in brightness (compare EHG and EHF at the bottom of the first table). Note that as lumen output increases, lamp life significantly decreases.

R-Type and PAR Lamps

The R-type (reflector-type) and PAR (parabolic aluminized reflector) lamps are discussed separately here because each is essentially a self-contained lighting instrument.

Both PAR and R-type lamps have a mirrored-glass parabolic-shaped reflector that sends light to the lens in parallel rays. Low-wattage versions have standard incandescent filaments; the brighter and larger sizes have a small quartz lamp placed at the focal point of the reflector.

R-Type Lamps All R-type lamps consist of a single-piece glass bulb that is inside-frosted to varying degrees depending on the desired beam spread. Their field of light is generally smooth and even, with a soft beam edge. Light and fairly fragile, they are intended for indoor use (Figure 23-10).

The following R-type lamps all with medium screw bases are available:

- 25- to 40-watt R-14 (1-3/4-inch diameter); flood only
- 40-watt R-16; flood only
- 30- to 50-watt R-20; flood only
- 45- to 65-watt R-30; spot, flood, and wide-flood
- 65- to 300-watt R-40; flood and wide-flood

TOOLS OF THE TRADE

Lumen Output of Various Lamps

Lamp	Lumen Output
60-watt household lamp	730
300-watt PAR-56 medium flood	3,840
500-watt Fresnel (BTL)	11,000
575-watt Ellipsoidal (HPL)*	16,500
1,000-watt PAR 64	19,400
750-watt Ellipsoidal (HPL)*	22,000
1,500-watt arc lamp for Vari*Lite VL3515 Spot	25,000

*300-hour rated life

The smaller R-14 to R-20 varieties can be tucked away in tight places for special effects or to solve a particular lighting problem. Many R-type incandescent lamps are currently being phased out and replaced with more energy-efficient LED sources.

PAR Lamps The parabolic aluminized reflector lamp is made out of heavy, heat-resistant glass designed to be used outdoors. It has a molded-glass lens which determines beam spread and, to some extent, shape (Figure 23-11). In higher wattages, its beam of light is oval rather than round.

The range of available PAR lamps is as follows:

- 75-watt PAR-16; 10-degree narrow spot and 30-degree narrow flood; medium screw base
- 35- to 50-watt PAR-20; 10-degree narrow spot, 30-degree narrow flood, and 40-degree wide flood; medium screw base
- 40- to 75-watt PAR-30; 9-degree narrow spot, 25-degree narrow flood, and 40-degree wide flood; medium screw base
- 35- to 250-watt PAR-38; 10-degree spot, 30-degree flood, and 50-degree wide flood; medium screw base
- 500-watt PAR-56; 15-degree narrow spot, 30-degree medium flood; and 45-degree wide flood; extended mogul end prong base
- 1,000-watt PAR-64; FFS wide flood ($24^\circ \times 48^\circ$), FFR medium flood ($12^\circ \times 28^\circ$), FFP narrow spot ($7^\circ \times 14^\circ$), and FFN very narrow spot ($6^\circ \times 12^\circ$); extended mogul end-prong base

The PAR-16 (2-inch diameter) is a particularly useful lamp due to its bright 75 watts (900 lumens), medium screw base, small size, and 10- and 30-degree beam spreads.

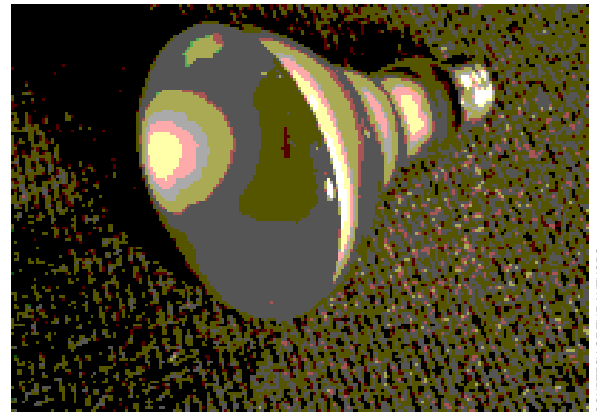
Automobile headlights used PAR lamps for years, but it took rock-concert lighting to introduce these powerful lamps to the theatre. Quartz PAR-64 lamps are mounted in a simple housing (aptly named a *PAR can*) and can throw a highly concentrated beam of light over a considerable distance. Because of its nearly parallel rays and its sheer intensity, the light has a distinctive quality. The color temperature is 3,200 K. The beam is oval because of the filament shape, and it has a soft and fuzzy edge.

Par-38 and -56 lamps are used in striplights to throw an intense wash of light on a drop or act as color-toning borderlights. As with R-type lamps, one can alter the beam spread of a PAR fixture by changing the lamp.

Low-Voltage Lamps

Low-voltage light sources are lamps designed to operate with less than 120 applied volts. Automobile headlights operate to full potential on only 12 volts. Aircraft lamps, useful in the theatre for special purposes, operate on 24 volts. The advantage of low-voltage lamps for theatre applications lies in the intensity and quality of the light they emit. The lower the voltage applied to a lamp filament, the smaller the filament can be. Therefore, low-voltage sources have filaments that really do begin to approach the much desired point source of light.

Power Sources Low-voltage lamps such as aircraft landing lamps (ACLs) deliver a highly coherent light that is intense and harsh in quality. To use such lamps on the stage, however, one must have a low-voltage power supply. A variable-voltage transformer is a



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23-10 R-Type Lamp The 65-watt R-30 lamp is available in spot, flood, and wide-flood beams.



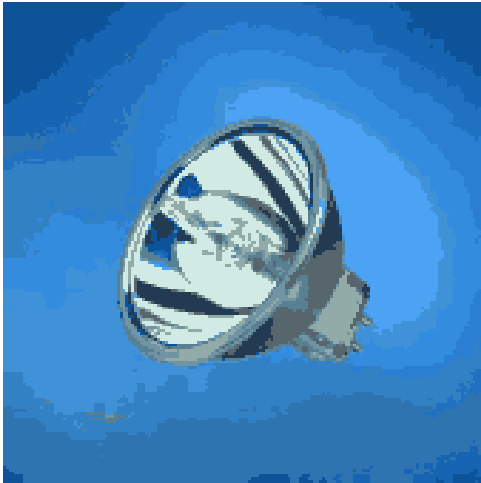
COURTESY OSRAM SYLVANIA INC., AND PAUL KEVIN PICONEPIC CORP

23-11 The PAR-64 Lamp Note the extended mogul end-prong base of the PAR-64 lamp.



SAFETY PRACTICE ■ Calculating Amperage

When using low-voltage sources, one must take care not to overload a circuit or the transformer. Given lamps with the same wattage, the power formula (wattage = voltage × amperage) shows that as the voltage is lowered, the amperage is subsequently raised.



COURTESY OSRAM SYLVANIA INC., AND PAUL KEVIN PICONE/PIC CORP

23-12 The MR-16 Lamp The MR-16 lamp with its miniature 2-pin base and dichroic reflector.

good equipment investment for a theatre, but it is fairly expensive. One alternative that will work in certain situations is a continuous-duty automobile battery charger. This is actually a step-down transformer from 120 to 12 volts. A second alternative is an autotransformer or sinewave dimmer, which functions by reducing the voltage to a lamp (not true of SCR and IGBT electronic dimmers). By measuring the output of a sinewave dimmer with a voltmeter, one can set it to provide any voltage up to 120.

MR-11 and MR-16 Lamps The MR-16 (multifaceted reflector, 2-inch diameter) lamp was originally developed as a light source for the Kodak Carousel slide projector (Figure 23-12). Its reflector is dichroic, allowing only visible wavelengths of light to be reflected. This results in the light beam having less heat and less harmful ultraviolet radiation. Put to wide use in restaurant, display, and museum lighting, these little reflector lamps are bright and extremely compact and serve as a valuable theatrical light source. Twelve-volt MR lamps are available in the following types, all with 2-pin bases:

- 20- and 35-watt MR-11; 10-degree spot and 35-degree flood
- 20-watt (300 lumens), 35-watt (500 lumens), 37-watt (800 lumens), and 50-watt (900 lumens) MR-16; 10-degree spot, 25-degree narrow flood, 35-degree flood, and 60-degree wide flood
- 75-watt (1,400 lumens) MR-16; 10-degree spot and 36-degree flood

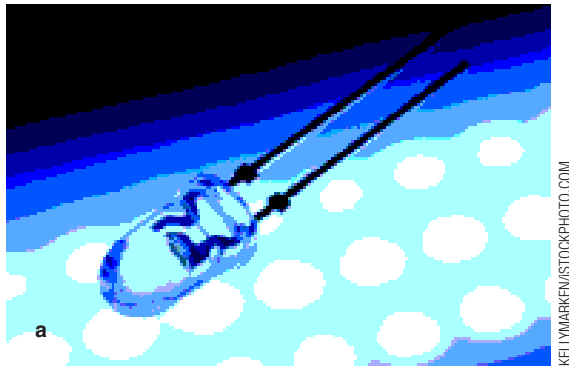
The MR-16 is also available in a 120-volt version: 150- or 250-watt with beam spreads ranging from 32 to 60 degrees. They burn very hot and require glass filters. The 12-volt MR-16 is used in a variety of lighting fixtures including striplights, but its most interesting application is on its own as a small spotlight. Mounted in a tiny PAR can, this lamp can be tucked into the tightest of spaces. Although it does require low voltage, recent developments have led to transformers that can be dimmed and located remotely. The light is of good quality with a brightness and harshness that is typical of low voltage but unusual from such a small lamp. The narrow beam spreads allow the light to be projected over considerable distances.

LEDs: Light Emitting Diodes

LEDs have been with us for quite a while, having been developed in the 1960s. Most familiar as indicator lights found in various control panels, these little devices are changing all that we assume about light sources.

How LEDs Work

As its name states, a LED is a *diode*. A diode is made up of two conductive materials bonded together to form a chip. If a small electrical current is applied to one of the semiconductors (the p-side, or anode), energy builds up at the junction and eventually flows to the other semiconductor (the n-side, or cathode). In the case of a light-emitting diode, this exchange results in a release of energy in the form of light (Figure 23-13). The

**23-13 LED Light Source****a** Close-up of a blue LED.**b** Parts of a LED.

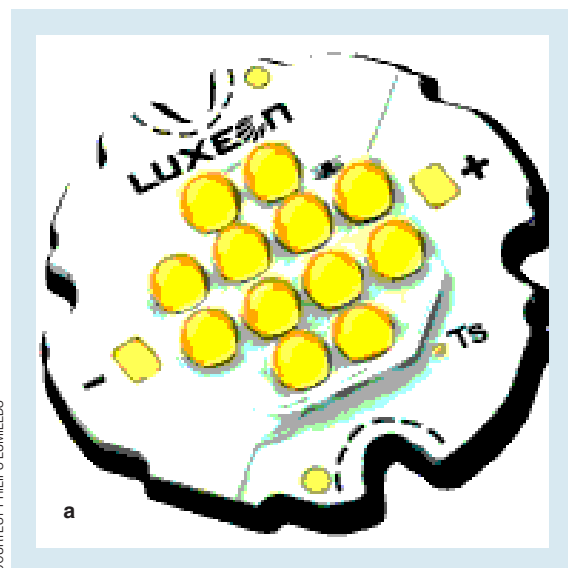
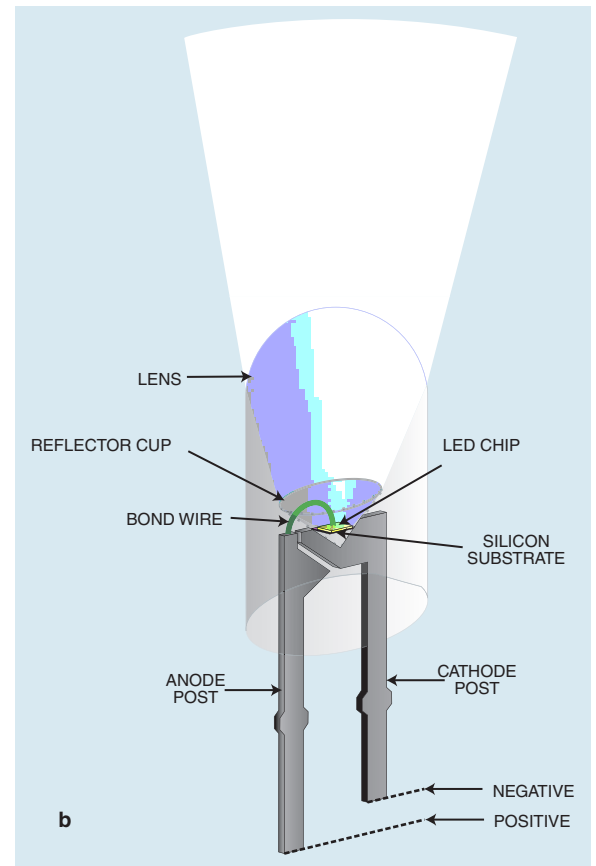
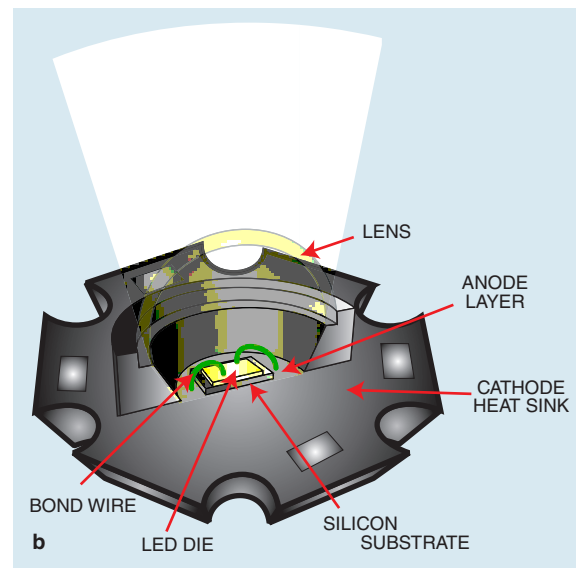
diode works only with current flowing in one direction; therefore, a direct-current voltage is necessary.

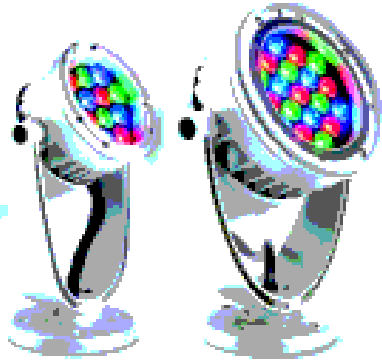
Added to the chip is a shiny surface referred to as a *reflector cup* that increases the light output. The color of the light emitted is determined by the type of materials used as semiconductors; today there are a large array of colors available, including white. Finally, a protective epoxy dome lens is placed over the chip, which helps to shape the beam of light (Figure 23-14).

Advantages of LEDs

LEDs have numerous advantages over incandescent light sources:

- Color mixing
- Small source
- Energy efficiency
- Long life

**23-14 High-Power LED Emitter****a** Philips Luxeon III 3-watt white LED.**b** Parts of a high-power LED emitter.



23-15 Color-Mixing LED Fixture Philips Color Kinetics ColorBurst Compact Powercore RGB color-mixing fixture has a native 8-degree beam angle producing 500 lumens intensity.

Color Mixing Filtering to produce color in stage lighting is extremely inefficient because it involves blocking certain wavelengths and allowing others to pass. A much more logical process is to have the light source itself produce the desired color. However, this has been impractical for stage lighting until the development of the LED. Red, green, and blue LEDs are readily available and can be mixed to a huge variety of colors. Core technologies developed and patented by Color Kinetics allow for seamless dimming and therefore mixing of colored LEDs controlled by DMX signals from any lighting control board.

Source Size As indicated earlier, a physically small source of light is important for stage-lighting applications. Although it is necessary to cluster several LED chips together to produce adequate intensity for stage lighting, each chip is only a square millimeter in size. Therefore a six-chip cluster forms a light source that is less than 3 millimeters in diameter—approximately $\frac{1}{10}$ inch.

Energy Efficiency One of the attractive features of the HPL lamp developed by ETC for their Source Four fixtures is its increased efficiency. It is able to deliver 16,500 lumens of intensity at 575 watts, an efficiency of roughly 28 lumens per watt. The new ETC Source Four LED profile fixture delivers 5,290 lumens of intensity (Tungsten Model) at 157 watts, an efficiency of 34 lumens per watt. The Philips Color Kinetics ColorBurst Compact Powercore fixture shown in Figure 23-15 delivers 500 lumens at 17 watts, an efficiency of nearly 30 watts per lumen.

Long Life Coupled with their energy efficiency, LEDs have an extremely long life. The rated life of the aforementioned HPL lamp is only 300 hours, whereas the longer life (2,000-hour) HPL provides only 12,360 lumens intensity. The rated life of the Luxeon Rebel LED emitters used in the Source Four LED profile is 50,000 hours! Even at a higher cost per light source, LEDs are a bargain.

The current limitation of LED light sources for stage lighting is low intensity. The new Osram spotlight noted previously has an intensity of only 1,000 lumens—very bright for an LED source but insufficient for most stage-lighting applications. The current problem to overcome in the development of brighter LEDs is heat. Although LED sources generate very little heat, the required energy reaction is extremely heat-sensitive. Research continues.

LED Lamps

A number of dimmable PAR and MR-16 LED lamps are currently available.

Dimmable LED PARs Philips manufactures the following dimmable LED PAR lamps (Figure 23-16):

- PAR 16—165-lumen flood; GU10 base
- PAR 20—280-lumen flood; medium screw base
- PAR 30—700-lumen spot, 800-lumen flood, and 700-lumen wide flood; medium screw base
- PAR 38—1,000-lumen spot, 1,000-lumen flood, and 900-lumen wide flood; medium screw base

Dimmable LED MR-16s Philips manufactures the following dimmable LED MR-16 lamps (Figure 23-17):

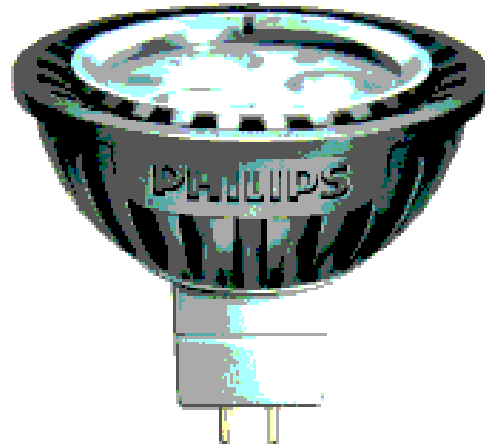
- 360-lumen spot, 550-lumen flood, and 440-lumen wide flood; GU5.3 bases

COURTESY PHILIPS LIGHTING



23-16 Dimmable LED PAR lamp Philips EnduraLED PAR-38 800-series lamp produces 1,000 lumens of intensity with a 45,000-hour rated life.

COURTESY PHILIPS LIGHTING



23-17 Dimmable LED MR-16 lamp Philips EnduraLED MR-16 lamp produces up to 550 lumens with a 25,000-hour rated life.

Properties of LEDs

Heat Management Because there is no glowing filament or heat-producing arc, the light emitted by an LED is cool. However, the energy exchange that happens at the junction of the emitter creates some heat. Unfortunately, if there is too much heat, the energy exchange can't happen. In addition, excessive junction temperatures significantly decrease the life of LED sources. Therefore, when clustering LEDs, some means of keeping the emitters cool is necessary—it can be a heatsink or, in more extreme cases, a fan.

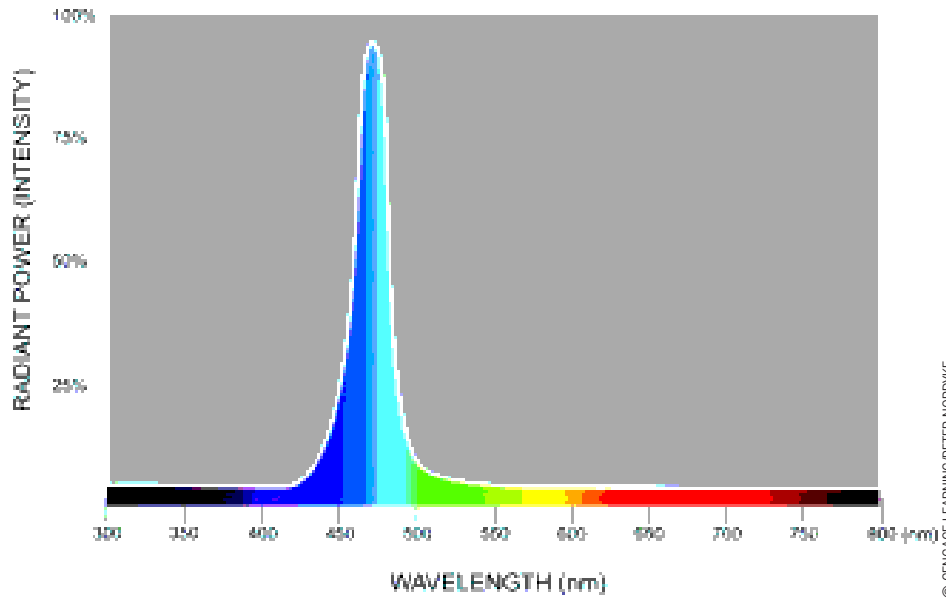
Color Color consistency from one LED to the next is an important concern for manufacturers. Generally, careful color control and measurement results in acceptable color matches within a batch of LEDs. However, designers must be aware that color variation from one manufacturer's fixture to another's can be quite large. One can't count on a blue from a Color Kinetics fixture to be the same as a blue from a MAC 301.

Spectral Distribution As noted earlier, the color of an LED source is dependent upon the type of materials used in its semiconductor. Most semiconductor materials emit light in a very narrow band, or "spike," as shown in Figure 23-18. In fact, white LEDs are currently produced by using a semiconductor material which emits a spike of blue light and then introducing a phosphor which adds a yellow (red and green) color to the light (Figure 23-19).

Color Rendering As seen in Chapter 16, the action of shining a white light onto a colored surface results in selective color reflection. In simple terms, the surface reflects only its own color. If a white light source consists of fairly equal energy in each of the spectral wavelengths, it will render color very well. This ability of a source to render color is measured on a scale of 0 to 100 using the CRI, or Color Rendering Index. In general, a CRI rating of 80 or more is considered acceptable, 90 or more is excellent. Good color-rendering LED sources are rated in the 80s. Research is ongoing in the quest to improve LED color rendering.

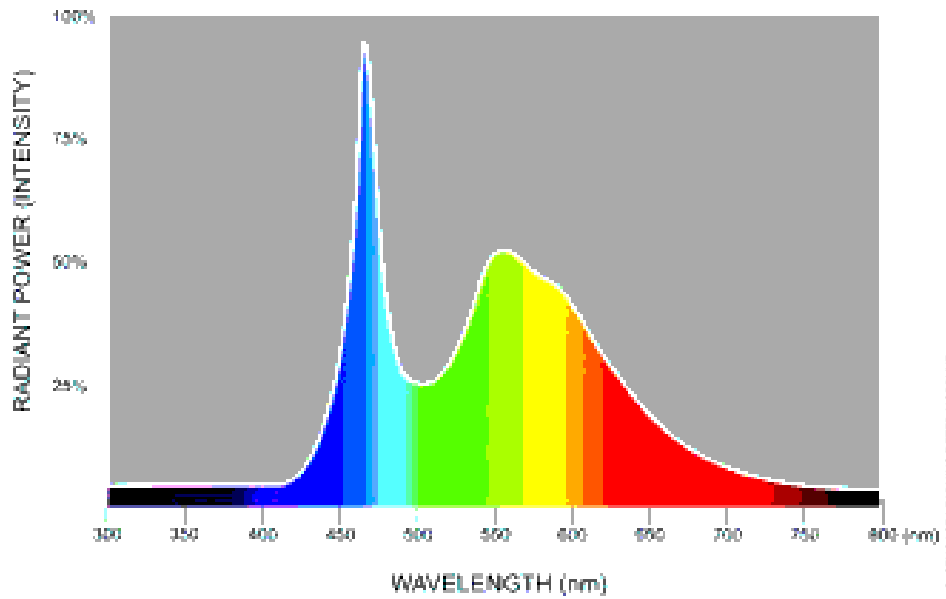
Because semiconductors by nature produce nearly monochromatic light, color rendering becomes an issue. Figure 23-20 shows the spectral distribution of 3,200 K incandescent white light versus a white LED source. Clearly, the blue LED spike in the

23-18 Spectral Distribution of a Blue LED The blue LED produces a spike of energy at approximately 460 nanometers.



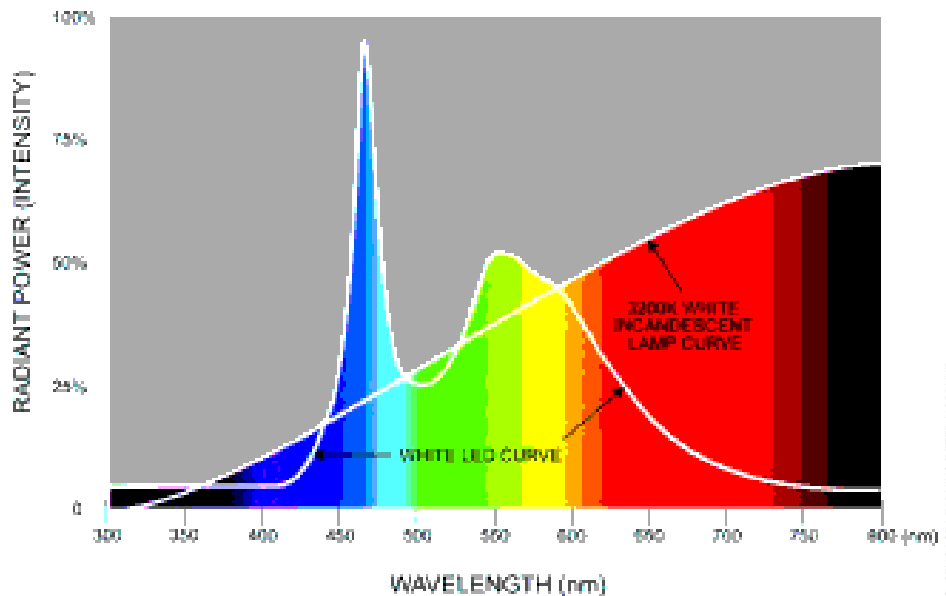
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23-19 Spectral Distribution of a White LED White LED light is currently produced with a blue LED and a yellow phosphor additive.

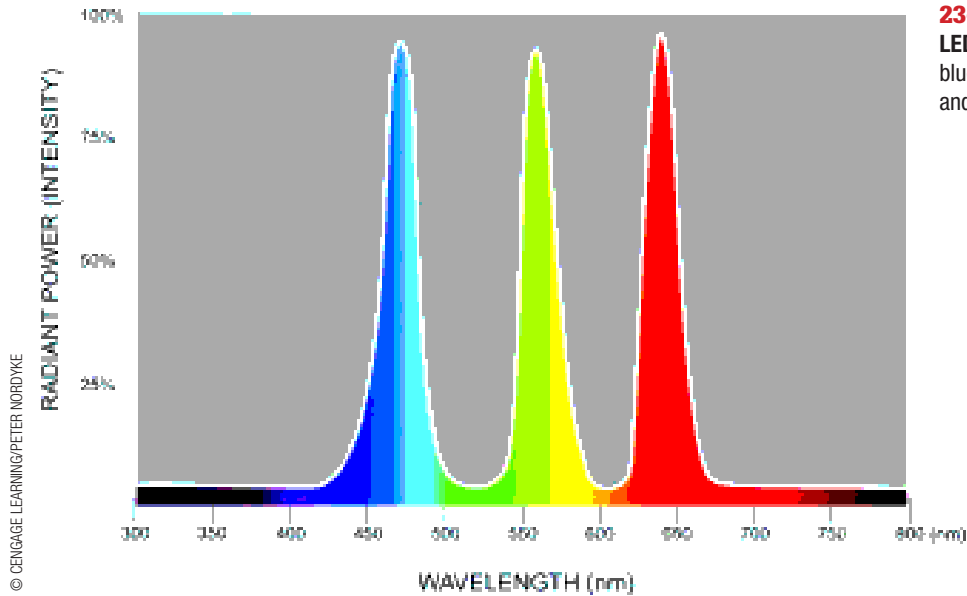


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23-20 Spectral Distribution of Incandescent versus White LED Showing the spectral energy curve of a 3,200 K incandescent source as compared to that of a white LED.



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23-21 Spectral Distribution of RGB LEDs Energy spikes of red, green, and blue LEDs at approximately 650-, 560-, and 460-nanometers respectively.

430 nanometer range followed by the big dip around 480 nanometers (blue-green) will reduce the color rendering quality of the source. Of even greater concern is color rendering produced by color-mixing RGB LED sources (Figure 23-21). The three RGB spikes leave out a great deal of the spectrum—a definite color rendering issue. When CRI is critical, manufacturers have responded by adding more colored LEDs to the mix—normally in the yellow range, sometimes cyan or magenta.

Arc Light

The first electric light source to be used in the theatre was an arc light form of limelight. Blocks of calcium oxide (lime) were mounted in a housing and heated until they glowed a brilliant white. Operators were required to keep the lime glowing as well as follow characters around the stage. The quality of limelight was reportedly so flattering that theatre patrons bemoaned the installation of more modern incandescent light sources.

No man-made light source is brighter than arc light. Today, arc sources are used in most follow spots and automated fixtures. In addition, specialized arc fixtures such as Fresnels and PARs are readily available. Arc sources can operate only with a DC power supply. Therefore, one needs a transformer that works with the individual lamp. Further, because few arc sources can be electrically dimmed, mechanical dimmers need to be provided as a part of the stage fixtures that use them.

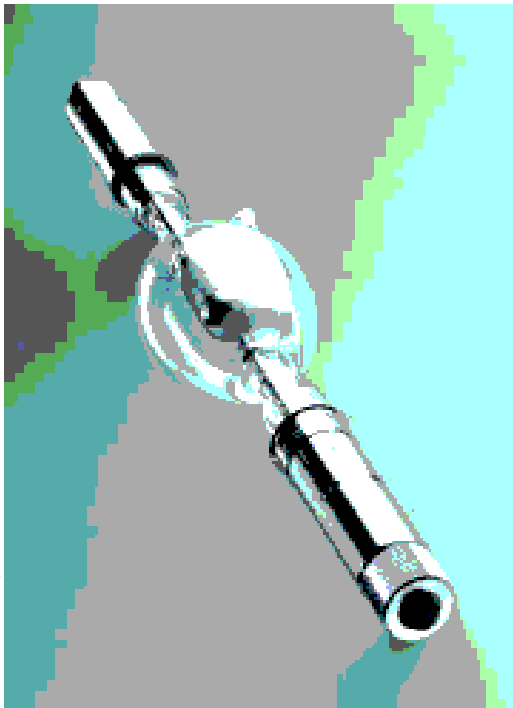
Although arc source lamps are brighter and have a longer life than incandescent sources, they are also considerably more expensive.

Types of Arc Lamps

Two tungsten electrodes in a strong glass enclosure of gas under high pressure produce an intense light source when an electric current arcs between the electrodes. Because the arc is shielded from the oxygen in the air, the tungsten electrodes don't disintegrate.

The Xenon Lamp Developed in 1954 by Osram Corporation, the XBO **xenon short-arc lamp** was the first arc lamp light source. Filled with high-pressure xenon gas, this lamp burns with a brilliant, cool light, maintaining a color temperature of approximately 6,000 K.

xenon short-arc lamp A bright arc lamp with xenon gas sealed within its envelope; develops high pressures within the bulb.



OSRAM SYLVANIA INC., AND PAUL KEVIN PICONEPIC CORP.

23-22 Xenon Arc Lamp An Osram XBO xenon arc lamp.

HMI and HTI Two types of metal halide arc lamps commonly used in follow spots and automated fixtures.

A 75-watt xenon lamp is roughly as bright as a 1,000-watt tungsten-halogen lamp, and the xenon lamp's life is twice as long. Because of its efficiency and long life, it became the standard lamp for follow spots and motion picture projectors. However, a drawback of xenon arc lamps is the high pressure built up within the bulb. Such sources require explosion-proof lamp housings (Figure 23-22).

Metal Halide Short-Arc Lamps Several years ago GTE Sylvania and Osram Corporation joined forces to become Osram Sylvania. They have had much to do with the development of the newest arc sources: the **HMI** and **HTI** metal halide arc lamps (Figure 23-23). Their bulb is quartz glass filled with metal halides. Their short arc works extremely well with the optics of projectors and stage-lighting equipment. The internal pressure within the bulb is lower than in xenon lamps, eliminating the need for expensive explosion-proof housings.

HMI lamps are available in wattages between 125 (80 volts) and 18,000 (225 volts). Their color temperatures range between 5,600 K and 6,000 K. HMI sources are also available in the form of PAR lamps. They offer a choice of four lenses: narrow spot (7 by 8 degrees), medium flood (9 by 21 degrees), wide flood (26 by 56 degrees), and super wide flood (47 by 47 degrees). Operating on 100 volts at 1,200 watts, they are very bright and have high color temperatures and long lives.

HTI lamps are available in wattages from 150 to 4,000, with color temperatures ranging from 4,800 K to 7,800 K. Martin's MAC 700 fixtures use the Osram HTI 700/D4/75 lamp shown in Figure 23-23a. It delivers 59,000 lumens at 7,200 K and costs a bit less than \$200.

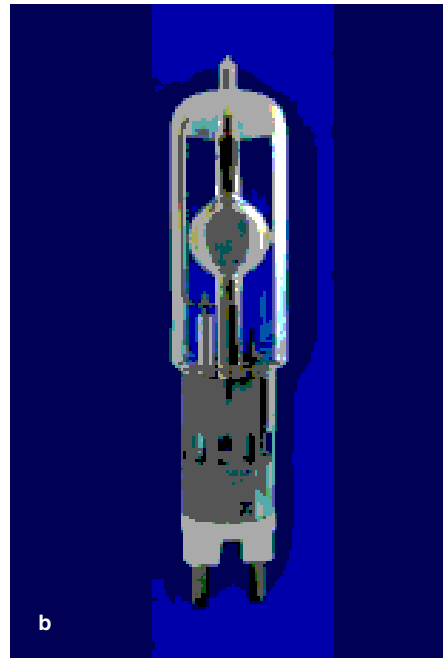
Philips developed their own version of the HMI lamp, calling it MSR (medium-source rare-earth). SHOWGUN 2.5 from High End Systems uses a very bright MSR



OSRAM SYLVANIA INC., AND PAUL KEVIN PICONEPIC CORP.

23-23 HTI and HMI Arc Sources Metal halide arc lamps from Osram Sylvania.

- a Osram HTI 700/D4/75.
- b Osram 6,000-watt HMI source.



OSRAM SYLVANIA INC., AND PAUL KEVIN PICONEPIC CORP.



SAFETY PRACTICE ■ Proper Handling of Lamps

A good electrician follows several simple rules when working with the various light sources found in the theatre:

- Always unplug a lighting fixture before replacing a bad lamp.
- Lamps are expensive, so be sure to treat them with care.
- Keep fingers off quartz bulbs. Clean with denatured alcohol.
- The envelope of a burning lamp gets too hot to handle even with the best of gloves.

2500/2 lamp with a lumen output of 190,000 lumens and a color temperature of 7,000 K—it costs a bit less than \$500 (Figure 23-24a). The Vari*Lite VL 880 fixture uses a MSR Platinum 35 lamp with a lumen output of 55,000 lumens and a color temperature of 7,800 K—it also costs a bit less than \$500 (Figure 23-24b).

Gaseous Discharge Lamps

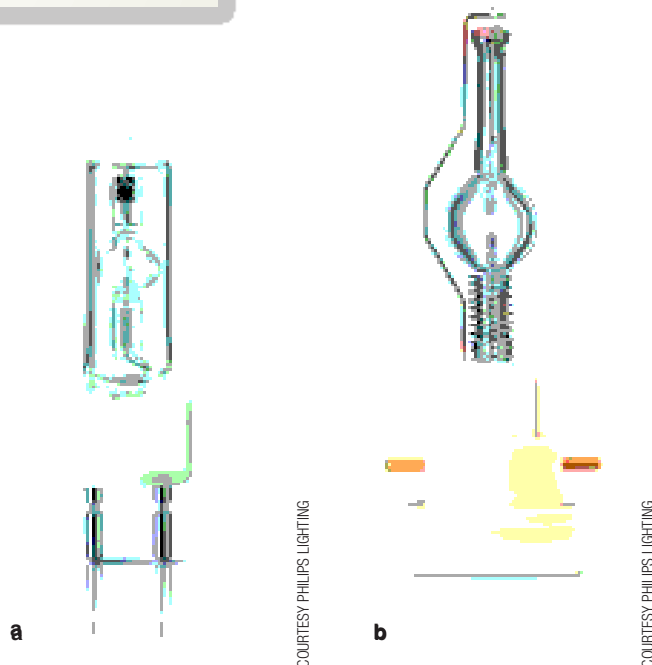
The most familiar form of a gaseous discharge lamp is the fluorescent tube, which never achieved its promise of becoming a major light source in the theatre. Current passing through a pressurized mercury vapor causes a gaseous discharge, predominantly in the ultraviolet zone. This energy is absorbed by the phosphorous coating on the inside walls of the tube and is emitted as light.

Because the fluorescent tube is a line of light and not a point source, its uses in the theatre are limited to producing a wash of light on a cyclorama or backdrop. The shape of the lamp makes it difficult to achieve smooth color blending. Dimming is possible, but only with special equipment.

Manufacturer Recommendations

A lighting fixture is designed with a certain lamp or lamps in mind. The fixture's ventilation, base type and size, and reflector specifications may all be determined by the choice of lamp. All stage-lighting manufacturers provide specific lamp recommendations for their fixtures, usually allowing a choice of several different lamps depending on the user's preference. Never use a lamp in a lighting fixture for which it is not intended. See the accompanying box for a sampling from the catalogs of several fixture manufacturers. Note that several lamps of the same wattage are listed, but their color temperature, lamp life, and lumen output differ.

The stage electrician should be familiar with all possible variations in lamp manufacture and should have access to up-to-date lamp catalog information. Not only is this information useful when ordering spare lamps, but it also offers quick access to special-application lamps such as flashbulbs, low-voltage lamps, arc lamps, and photofloods. The three major manufacturers in the United States (Osram Sylvania, General Electric, and Philips Lighting) maintain online lamp catalogs.



23-24 MSR Arc Sources Metal Halide arc lamps from Philips.

a MSR 2500/2.

b MSR 800w Platinum 35.


TOOLS OF THE TRADE ■ Recommended Incandescent Lamps

	Watts	ANSI Code	Color Temp.	Lumens	Life (hours)
ETC Source Four*	575	HPL	3,265 K	16,520	300
	575	HPL	3,050 K	12,360	2,000
	750	HPL	3,250 K	21,900	300
	750	HPL	3,250 K	16,400	1,000
	(115 V)				
6-inch Ellipsoidals**	500	EGE	3,000 K	10,450	2,000
	750	EGG	3,000 K	15,750	2,000
	750	EHF	3,200 K	20,400	300
	1,000	EGJ	3,200 K	27,500	400
6-inch Ellipsoidals*	750	EHG	3,000 K	15,400	2,000
	1,000	FEL	3,200 K	27,500	300
6-inch Fresnels**	500	BTL	3,050 K	11,000	750
	750	BTN	3,050 K	17,000	500
	1,000	BTR	3,200 K	27,500	200

*Medium 2-pin base **Medium prefocus base

Design Techniques

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This chapter presents light plots, sections, and supporting paperwork for different types of productions in a variety of spaces. We examine simplified designs for a realistic interior “box set” in the proscenium theatre, an “in-the-round” production in an arena theatre, a drama designed for the thrust stage, and a modern dance piece.

The following examples have been simplified for clarity and ease of interpretation. Each light plot is designed to show the minimum number of fixtures necessary to achieve acceptable design and visibility. Additional commentary on the individual designs offers suggestions for embellishing the basic plots with more equipment.

The Proscenium Theatre

When a proscenium theatre is used in the traditional manner, the main action of the play takes place upstage of the plaster line. Front-light for the downstage acting areas normally comes from lighting positions called **beam ports** located in the ceiling of the auditorium. Front-lights for upstage areas are hung on the first electric pipe.

The theatre in our example is of medium size: it seats 600 and has a proscenium opening that is 30 feet wide and 18 feet high. Hanging positions both overstage and front-of-house are adequate. About 20 feet out from the proscenium line is a beam port for mounting front-lights. Many proscenium houses have several beam positions providing variable front-of-house lighting angles.

A Realistic Interior

Realistic interiors often call for some variation of the conventional box setting, either with or without a ceiling piece. As one might expect, having a ceiling greatly affects lighting possibilities. The primary action takes place within the walls of this set; the backgrounds seen through windows and doors are less important. The lighting is often motivated by apparent sources such as sunlight through the windows, light from sconces, and firelight. In most cases the light is realistically plausible.

Figure 24-1 is a sketch of such a setting. In the upstage-left wall, a door leads into the kitchen. Upstage-center, a flight of stairs comes down into the living room, and just to the right an exterior door leads out to the porch. In the stage-right wall is a four-window alcove that looks out onto the porch.

Two lighting scenarios are involved. Act I takes place in the afternoon of a somewhat overcast day, and Act II is later that evening.

CENGAGE **brain**.com

For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

beam port Lighting positions located in the ceiling particularly in proscenium houses used primarily for front-light.

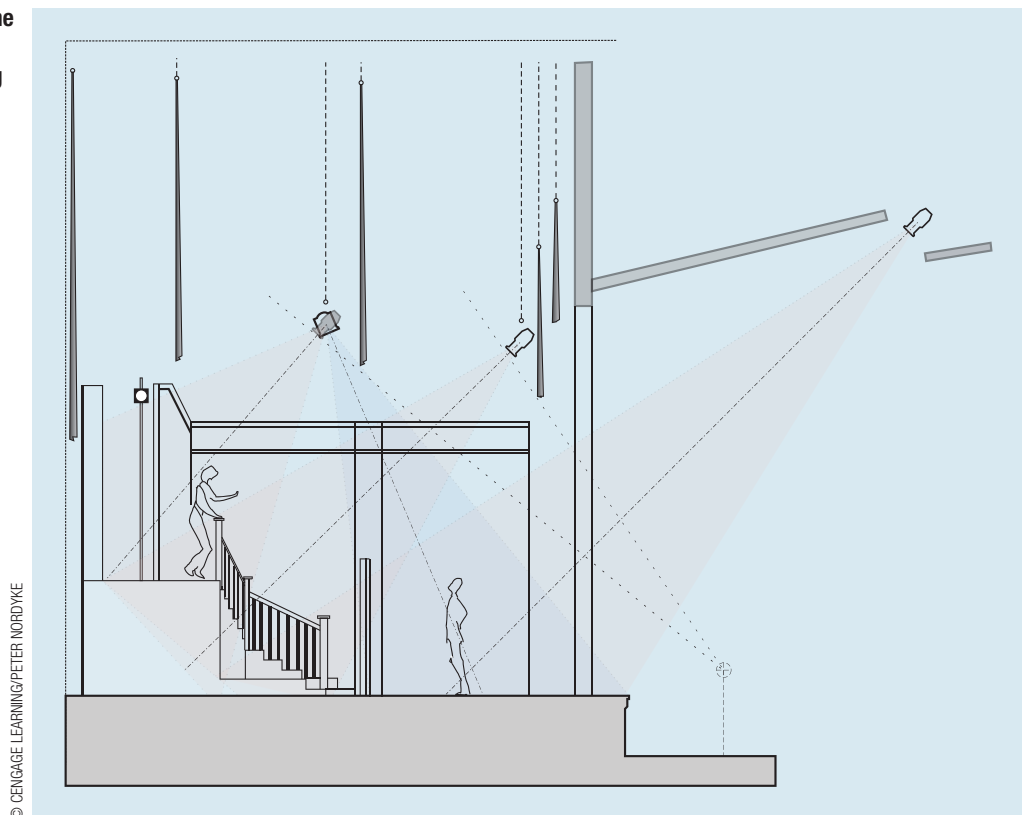
24-1 Realistic Interior: Sketch

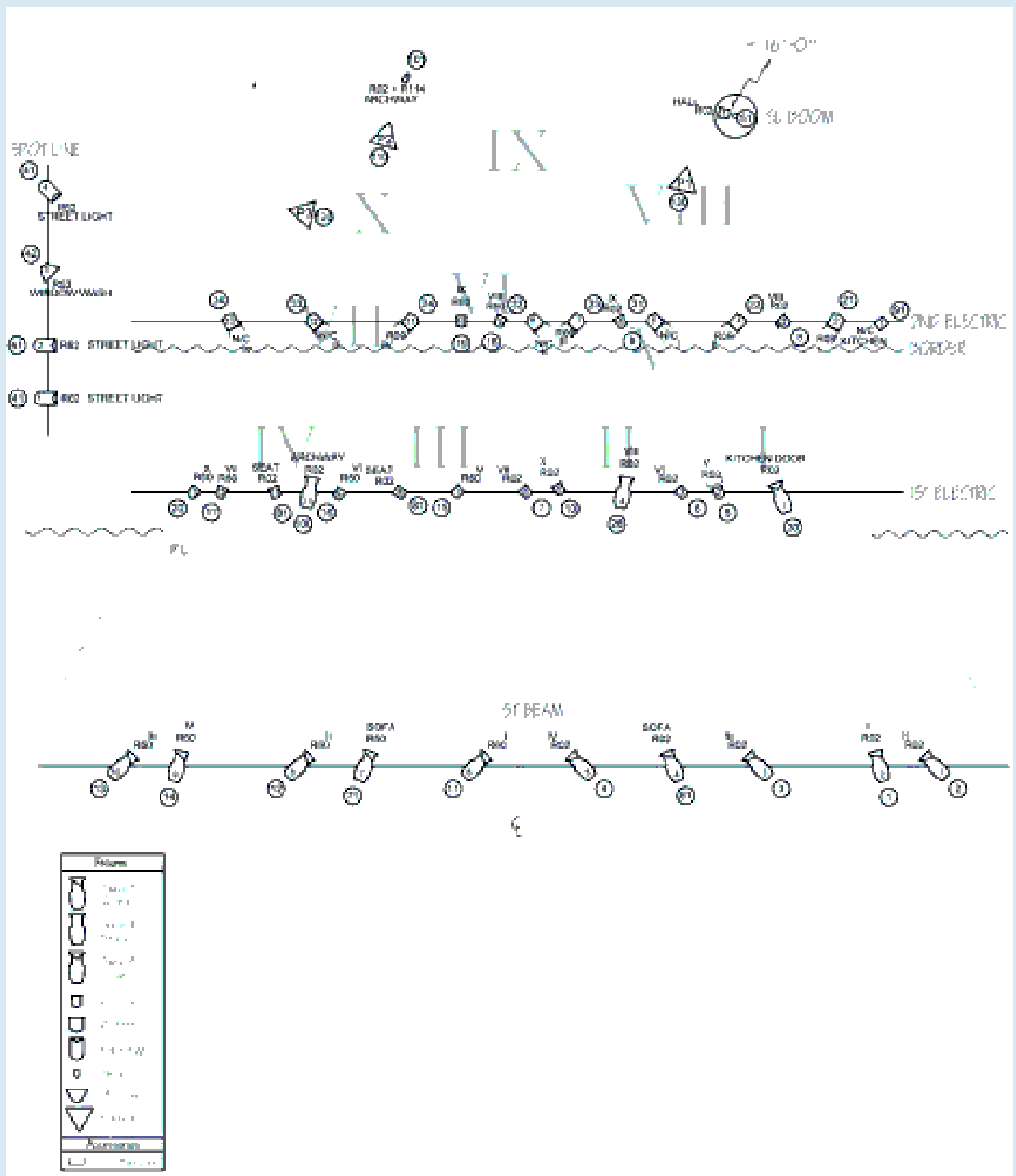


Sectional View Figure 24-2 is a center-line section of the stage and auditorium, showing lighting positions and angles. Especially useful is the elevation of the upstage landing and steps leading to it. The beam spreads shown from several of the fixtures indicate the amount of coverage in a given area. The center line of the beam is used to determine vertical angle. The sight point (indicated by a cross symbol) located in the auditorium represents the eye level of the first row of the audience. Sightlines from this point past the masking borders show whether or not the borders hide the lighting fixtures from the audience.

Light Plot and Fixture Schedule The two cross symbols on the light plot shown in Figure 24-3 indicate critical sight points from the seats extreme house-left and house-right in the front row. These sight points are used to determine what

24-2 Realistic Interior: Center-Line Section Note how the height and placement of the overstage masking borders are determined in part by using the audience sight point and sightlines.





COURTESY OF THE AUTHORS

24-3 Realistic Interior: Simplified Light Plot

the audience can see through door openings and windows and beyond side masking. (See Chapter 2 for further detail on sightlines.) Figure 24-4 is the fixture schedule for the plot in Figure 24-3. Refer to the fixture schedule for details such as fixture type, focus area, color, and channel assignment. Take the time to go back and forth between the reading and the plot.

The Light Plot

The lights in this plot must accommodate both scenes of the play. The primary motivational light source for the afternoon of Act I is daylight coming through the stage-right windows. The source of illumination in the evening of Act II is interior lighting, including the practical sconces located on the set.

POSITION	UNIT #	TYPE	FOCUS	LAMP	COLOR	CHANNEL	ACCESSORIES
1st BEAM	1	S4 26 DEGREE	II	575	R02	2	
	2	S4 26 DEGREE	I	575	R02	1	
	3	S4 26 DEGREE	III	575	R02	3	
	4	S4 26 DEGREE	SOFA	575	R02	61	
	5	S4 26 DEGREE	IV	575	R02	4	
	6	S4 26 DEGREE	I	575	R60	11	
	7	S4 26 DEGREE	SOFA	575	R60	71	
	8	S4 26 DEGREE	II	575	R60	12	
	9	S4 26 DEGREE	IV	575	R60	14	
	10	S4 26 DEGREE	III	575	R60	13	
1st ELECTRIC	1	S4 50 DEGREE	KITCHEN DOOR	575	R02	30	
	2	6" FRESNEL	V	500	R02	5	BARN DOOR
	3	6" FRESNEL	VI	500	R02	6	
	4	S4 36 DEGREE	VIII	575	R02	28	
	5	6" FRESNEL	X	500	R02	10	
	6	6" FRESNEL	VII	500	R02	7	
	7	6" FRESNEL	V	500	R60	15	
	8	6" FRESNEL	WINDOW SEAT	500	R02	81	
	9	6" FRESNEL	VI	500	R60	16	
	10	S4 36 DEGREE	ARCHWAY	575	R02	100	
	11	6" FRESNEL	WINDOW SEAT	500	R02	81	
	12	6" FRESNEL	VII	500	R60	17	
	13	6" FRESNEL	X	500	R60	20	
2nd ELECTRIC	1	6" FRESNEL	KITCHEN	500	N/C	91	
	2	6" FRESNEL	I	1K	R09	21	BARN DOOR
	3	6" FRESNEL	VIII	500	R02	8	
	4	6" FRESNEL	II	1K	R09	22	BARN DOOR
	5	6" FRESNEL	I	1K	N/C	31	BARN DOOR
	6	6" FRESNEL	IX	500	R02	9	
	7	6" FRESNEL	III	1K	R09	23	BARN DOOR
	8	6" FRESNEL	II	575	N/C	32	BARN DOOR
	9	6" FRESNEL	VIII	500	R60	18	
	10	6" FRESNEL	IX	500	R60	19	
	11	6" FRESNEL	IV	1K	R09	24	BARN DOOR
	12	6" FRESNEL	III	1K	N/C	33	BARN DOOR
	13	6" FRESNEL	IV	1K	N/C	34	BARN DOOR
SPOT LINE	1	PAR 64 WFL	STREET LIGHT	1K	R62	41	
	2	PAR 64 WFL	STREET LIGHT	1K	R62	41	
	3	14" SCOOP	WINDOW WASH	750	R63	42	
	4	PAR 64 WFL	STREET LIGHT	1K	R62	41	
SL BOOM	1	6" FRESNEL	HALLWAY	500	R02	51	
STAIRS	P1	WALL SCÖNCE	PRACTICAL	2 @ 40 W	N/C	130	
HALL	P2	CEILING FIXTURE	PRACTICAL	3 @ 40 W	N/C	110	
SR WALL	P3	WALL SCÖNCE	PRACTICAL	2 @ 40 W	N/C	120	
HALL	1	MR 16	ARCHWAY	75 W WIDE	R02 +R114	101	

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24-4 Realistic Interior: Fixture Schedule

The designer has chosen to use two lights from the front for each area, colored in Rosco R02 (bastard amber) and R60 (no-color blue). There are also two lights from the back in R09 (pale amber gold) and no-color. The color key indicates position of these fixtures (Figure 24-5).

Front and back area lights are used as follows:

Act I Afternoon

- Stage-right R60 front-light at 80 percent
- Stage-right no-color back-light at 90 percent
- Stage-left R02 front-light at 70 percent
- Stage-left R09 back-light at 80 percent

This provides the look of natural interior daylight and offers sufficient color and intensity contrast for dimensionality.

Act II Evening

- R60 front-light at 60 percent
- No-color back-light at 0 percent (not reading)
- R02 front-light at 60 percent
- R09 back-light at 70 percent

The warmer color produced by lower dimmer readings is intended to simulate interior incandescent lighting. For color contrast, the blue front remains at a medium-high reading. Taking the no-color back-light out completely creates a sense of darkness and shadow from one direction, a good feeling for evening.

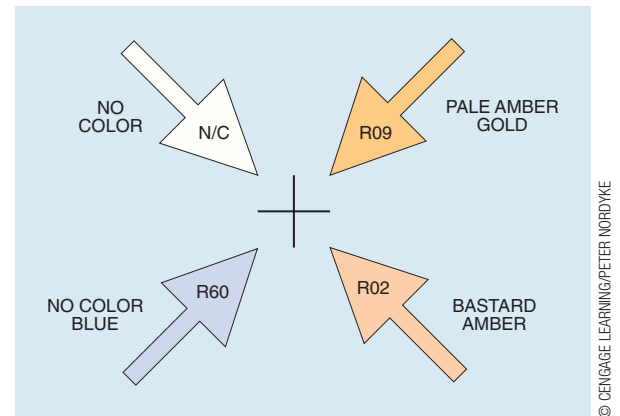
Lighting Areas The lighting focus areas are designated by Roman numerals in order to distinguish them from all other numbers on the plot. Note that they are numbered beginning downstage left, moving stage-right, and then upstage.

In dividing the stage into lighting areas, we find that four across the front will be fine as long as a center-stage sofa special covers the overlap of areas II and III. To cover these four areas, we hang 26-degree ellipsoidals in the beam position. The section shows that the angle from the beam port to the downstage areas is roughly 45 degrees—a good angle for visibility. The ellipsoidal reflector spotlight is an ideal front-of-house fixture because its light beam is very controllable. For a shorter throw than the one in our sample theatre, or for larger lighting areas, a 36-degree ERS would be a good choice.

An important skill for a lighting designer to learn is the ability to examine a light plot to determine where scenery, masking, or the architecture of the theatre might interfere with the path of light. In choosing hanging positions for the front-of-house fixtures, we have attempted to maintain the desired 45-degree horizontal angle. Note, however, that we must place 1st beam fixture #2 somewhat in from the end of the position in order to reach the extreme downstage-left corner of area I without being cut off by the proscenium arch. In addition, the color blend hitting the stage-left wall from the blue 1st beam fixture #6 and the warm 1st beam fixture #2 will be better with #2 moved a bit toward center. Likewise, 1st beam fixture #9 must move a bit toward center.

In sacrificing to some extent the ideal angle, we have achieved a necessary compromise. The remaining area fixtures can be placed just about where we prefer. All fixtures are carefully shuttered so as not to spill distracting light on the face of the stage apron and, in the case of fixtures #2 and #9, on the proscenium arch.

Back-Light Each of the four downstage areas is lit with two 8-inch Fresnel back-lights. A Fresnel is ideal for good blending from area to area, and the high-wattage



24-5 Realistic Interior: Color Key Color key for the light plot in Figure 24-3.

8-inch fixture can punch through the area lights without any trouble. Barn doors keep the light beam from spilling too far downstage and, in the case of 2nd electric fixture #2, off the top of the scenery wall. The upstage areas would be back-lit with another bank of Fresnels from a third electric pipe; however, for the sake of simplicity, we have chosen to exclude these fixtures.

The back-light helps to separate the actors from the background and gives them a pleasing, sculptural look. In addition, its R09 color from stage-left reinforces the feeling of daylight in Act I and, when lowered in intensity, provides a nice glow of incandescent light in the night scene of Act II.

Upstage Areas To cover upstage (areas V, VI, VII, and X), we use 6-inch Fresnels from the first electric pipe. Fresnels are chosen for two reasons: the soft edge of their beams makes blending between the areas easy, and no sharp and distracting beam patterns will appear on the walls of the set. The 1st electric fixtures #3, #5, and #6 can be focused close to a 45-degree angle for their respective areas, but 1st electric #2 into area V must be moved a bit center in order not to hit the wall just stage-right of the kitchen door. Likewise, 1st electric fixtures #7, #9, and #12 are close to the desired angle, but fixture #13 (into area X) must slide onstage to avoid the stage-right set wall.

Color Each lighting system (all the area lights from one direction) must be consistent in regard to color. The house-left fixtures are colored in R60 to create a cool key-light in Act I and a shadowlike fill in Act II. The corresponding house-right front-lights are colored in the warmer R02. This color choice is particularly useful because the two colors mix toward white light and will look quite natural on the actors and scenery.

The Stairway and Landings The steps and landings (areas VIII and IX) present a special lighting problem owing to their level differences.

To light the lower steps properly and avoid spilling, we use a 36-degree ERS in soft focus from the 1st electric (fixture #4). Its beam is framed to the stairs themselves and just high enough to cover an actor moving up and down. It has an R02 filter because a warm color seems most appropriate and blends well with the other colors. In area VIII, a pair of 6-inch Fresnels from the 2nd electric take over. These fixtures (2nd electric #3 and #9) are used for blending and to avoid harsh shadows on the wall behind the staircase. Area IX is similarly lit with another pair of Fresnels (2nd electric fixtures #6 and #10). See the section for an indication of vertical angle.

Practicals There are three practicals on the set. Fixture #P1 is a wall sconce at the first stair landing; #P2 is a ceiling light located in the vestibule; and #P3 is another wall sconce on the upstage-right wall. Note that the triangular “special” symbol is used for these fixtures.

All practicals should be on their own dimmers with actual control of the fixtures in the hands of the light board operator and stage manager, not the actor. The actors must be instructed to mime switching the practicals on and off while the light board operator does the actual operation.

Backing and Support Lights Backing and support lights are valuable in achieving the illusion that a box-set production requires. They must receive the same priority that visibility lighting does.

Beginning in the kitchen, we have hung a 6-inch Fresnel on the end of the 2nd electric to simulate a ceiling light (fixture #1). This light, without a color filter, illuminates an actor moving through the kitchen door and shines an interesting light into the living room when the door is open. A boom upstage left holds another 6-inch Fresnel (stage-left boom fixture #1) at 16 feet off the stage floor and focused down the “hallway” at the top of the stairs. This fixture, colored in R02, lights actors coming into view from behind the wall so that they do not appear to emerge from a black hole.

The upstage-right archway is an important area lit by a special (1st electric fixture #10). This ERS is placed in fairly soft focus and shuttered to the arch in order to light an actor entering from the porch door. In addition, the backing wall is washed with a tiny MR-16 attached to the back of the scenery, frosted and colored in the warm R02 (archway fixture #1). Its function is to fill in shadows on the back wall and at the doorway.

On the spot-line pipe outside the stage-right window is a scoop (fixture #3) that is used as a window-wash during the overcast afternoon scene. Another good fixture choice would be a color-mixing LED to provide greater color variety. Direct sunlight would require different instrumentation in this position, perhaps PAR fixtures. In the night scene of Act II, spot-line PARs #1, #2, and #4 shine in the bay windows like streetlights, casting long and eerie shadows into the living room.

Specials These are non-area-lighting fixtures used for special visibility or effect. As mentioned earlier, the center-stage sofa specials (1st beam fixtures #4 and #7) are important not only because they accent action on the sofa but also because the sofa is located between two lighting areas.

First electric Fresnels #8 and #11 act as specials into the window seat area, filling in where area lights for areas IV and VII do not provide adequate coverage.

Control Even though we attempted to keep the number of fixtures to a bare minimum, our schedule lists forty-five units. Channel assignments are based on a dimmer-per-circuit house with each fixture having its own dimmer. Note that fixtures lighting area I have channel assignments of 1, 11, 21, and 31; fixtures lighting area II are assigned channels 2, 12, 22, and 32; and so on throughout the areas.

If we were restricted by not having enough dimmers, the exterior streetlights could be ganged together. In addition, two areas that might work together would be VIII and IX. If we place the two R02 Fresnels (2nd electric fixtures #3 and #6) into one dimmer, and the two R60 Fresnels (2nd electric fixtures #9 and #10) into another dimmer, we save two dimmers. Note that like colors always are controlled together. Other ganging choices must be determined by the blocking and desired movement of light.

Possible Additions As noted earlier, back-light for the upstage areas would be the first thing to add. If more equipment and control were available, we might double-hang the stage-right front-lights. This would allow for more of a distinction between Act I and Act II. A better sense of night could be conveyed if the second set of fixtures was colored in more saturated blue or lavender. It would also be possible to vary the angle of the two stage-right front sources, thereby accentuating the difference in time of day between the two acts.

Adding a Ceiling If the scene designer adds a ceiling, it would likely eliminate the second electric pipe. However, the first electric pipe must remain and provisions for it must be made.

All back-light is lost with the second electric pipe. In such a case, the lighting designer must do everything possible to compensate. Extra light flowing into the room from the stage-right windows is a possibility. A set of high side fixtures from the first electric pipe is another. Side cove and box boom positions could be used to provide light that wraps around the performer better than traditional front-light would. Some ceilings can have false beam structures built into them, accommodating a lighting position.

Arena Productions

The term *arena* is derived from Roman amphitheaters in which the audience surrounded the action on all sides and the lighting was nature's. Present-day arena theatres, such as the Arena Stage in Washington, D.C., are fine examples of modern technology working in combination with one of the oldest and most intimate of staging configurations: theatre-in-the-round (Figure 24-6).

24-6 Arena Production Production shot from Act II of Eugene O'Neill's *Anna Christie* at San Diego's Old Globe Sheryl and Harvey White Arena Theatre. Directed by Daniel Goldstein; scenery, Wilson Chin; costumes, Denitsa Bliznaikova; lighting, Austin R. Smith.



PHOTO BY WILSON CHIN, COURTESY AUSTIN R. SMITH

Special Considerations

Scenery in the arena is kept to a minimum so as not to block the audience's view. Because the audience surrounds the playing space, lighting must be from all directions. Typically, throw distances are shorter in the arena than in proscenium or thrust theatres, and the audience is closer to the actors.

Functions of Arena Lighting Visibility remains, of course, the primary function in arena production lighting. The actors should be effectively lit for all members of the surrounding audience. Lighting must focus the spectators' attention on the acting areas, providing good definition and precision of form. Tight and specific area control is often desirable in the arena, adding another requirement, this time of a compositional nature, to the designer's list. Mood can be established through intensity and color toning, but both within limited ranges. In addition, because of the audience's viewing angle, the color, texture, and compositional makeup of the stage floor take on significant visual importance.

Accuracy of Focus With the audience arranged closely—often too closely—around the playing area, fixtures that have hard-to-control beams are of little value. Ellipsoidal reflector spotlights are the best choice. Fresnels must be focused with particular accuracy, with top hats or barn doors added to control the beam spill. Because of their extreme lens flare, PAR fixtures are seldom useful.

The smaller 3- or 4-inch ellipsoidals are quite useful in an arena space with a low grid. Because this space requires adjustable field spreads up to 50 degrees, zoom ellipsoidals are an ideal choice.

Arena Lighting Areas On the proscenium stage, each area is normally covered by a minimum of three lights. In an arena, however, where the actor is seen from all sides,

more fixtures are desirable. There are two popular area-lighting approaches in arena designs. The first uses three fixtures per area evenly distributed around the area and thus at approximately 120 degrees from one another. The second uses four lights on each area, spacing them at 90-degree intervals and shooting along the diagonals of the space.

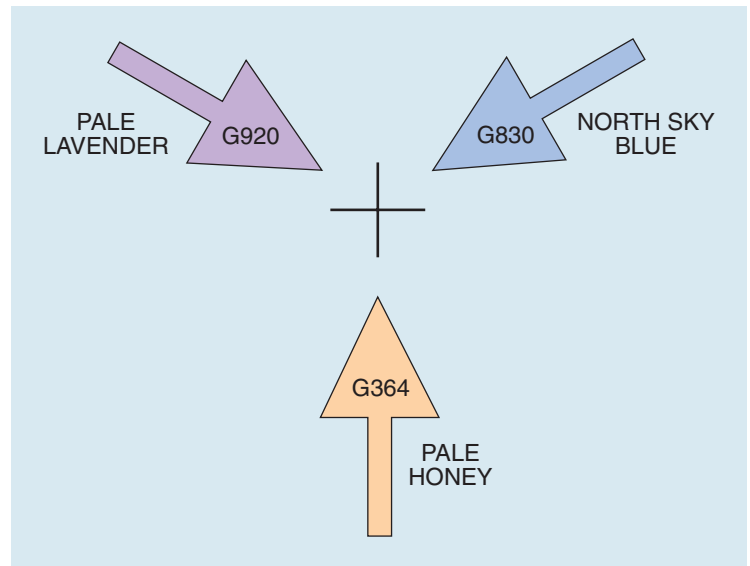
Color in the Arena With either approach, the system of using one warm and one cool color on each area is no longer applicable. In the three-fixture plan, the third fixture is assigned a neutral color, such as light lavender. Opposite a warm filter such as light pink, the lavender appears cool. Opposite a cool filter such as a blue tint, the lavender appears warm. Light bastard amber or no-color can also be quite effective in this application (Figure 24-7).

The four-fixture system suggests two color variations. In the first, a warm and a cool are used opposite each other. The other two fixtures have a neutral tint. An alternate approach is to use two warm opposite each other. The remaining two fixtures contain two cool, also opposite each other. The latter system often proves the most satisfactory and is used in our sample plot shown in Figure 24-10.

A word of warning about the saturation of filters used in arena production: because the directionality of the light on each side of each area is so definite, colors appear very strong on the actors. This is more pronounced than in a proscenium production, in which there is far more mixing of different beams. Or perhaps this seems true because the audience is so close to the action. In any event, use of very saturated colors is rarely advisable.

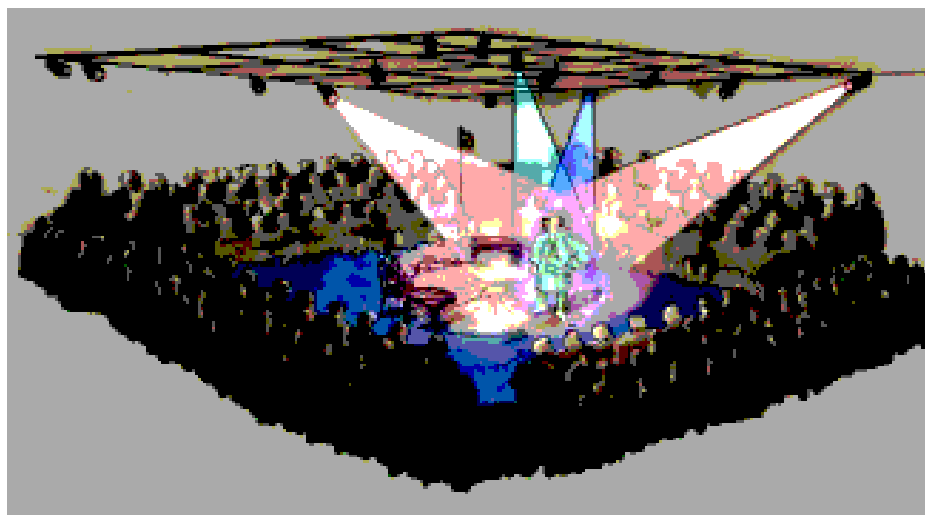
Hanging Positions Many arenas have a grid composed simply of crossed pipes creating a variety of hanging positions as in our example theatre (Figure 24-8). More elaborate spaces may attempt to hide the lighting fixtures by means of ceiling ports, but this arrangement actually provides less flexible lighting.

A better solution is the tension wire grid. Such a grid is suspended over the entire room, allowing great flexibility of fixture placement as well as safe and simple hanging



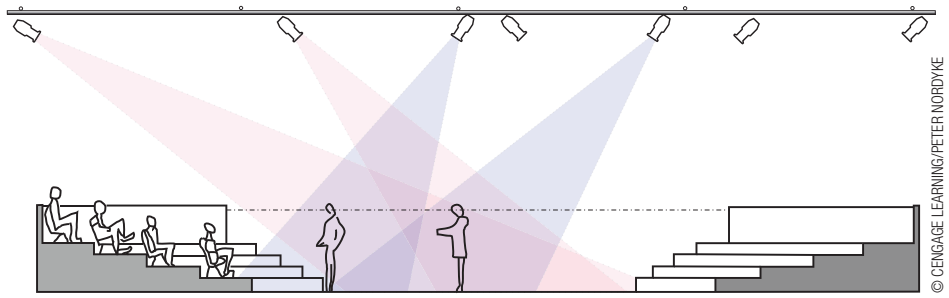
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24-7 Arena Color Key: 3-Fixture
A possible color key for the arena using three lights per area and a warm/cool/neutral approach.



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24-8 An Arena Production

24-9 Arena Section

and focus. Although the initial expense of such a system is greater than that of others, safety and lower long-term labor costs more than compensate.

Lighting the Audience A difficult problem in any form of arena production is keeping beams of light out of the eyes of spectators seated close to the stage. As long as directors block their actors at the very edge of the arena stage, a compromise is necessary between a well-lighted actor and a half-blinded spectator. Further, arena audience members look across the stage at other audience members. If the people opposite are lit too brightly, they draw focus from the actors.

To solve the problem, the angle of the fixtures spilling into the audience can be raised, but this compromise helps only to an extent. If the first row of the audience can be raised higher than the stage level, or be set back from it, or both, the problem can be greatly eased. In any event, this is one of the greatest challenges confronting the lighting designer in arena production (Figure 24-9).

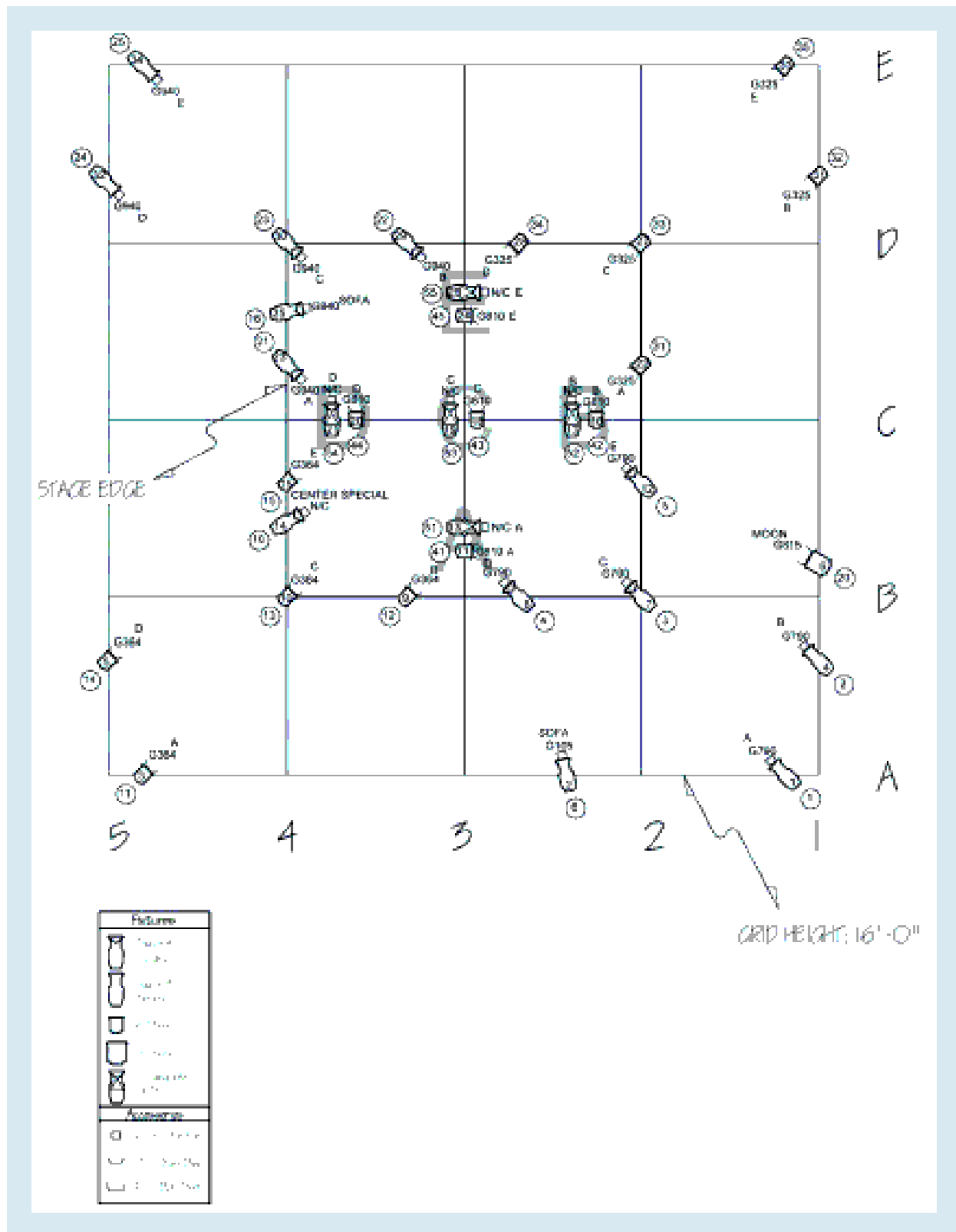
Designing the Lighting

The lighting designer need not attempt to create the same lighting picture for everyone in the arena audience. Experience has shown that such an approach is quite restrictive and leads to fairly bland lighting. Nonetheless, the designer should always be concerned about the quality of light from all viewing angles.

Our drama has a number of scenes, some of which are interior and some exterior. In addition, several scenes take place at night whereas others are in full daylight. The designer has chosen a color system that will allow warm colors to be predominant for the day scenes and cooler colors to read stronger in the night scenes. Top-light gobo and color wash systems will further enhance the difference. The section in Figure 24-9 shows some of the lighting positions and angles in our sample production. The plot and fixture schedule for a suitable lighting design are shown in Figures 24-10 and 24-11. Refer to these illustrations as needed in the following discussion.

The Theatre Ours is an intimate space with no more than four rows of audience on each side allowing for approximately 150 audience members. The playing space is 16 by 16 feet, and, as can be seen, the set consists of a simple floor treatment and a few furniture props that change from scene to scene. The grid is 16 feet above the deck and is 32 by 32 feet square. It has five pipes in each direction creating 9-foot square sections. Five- or 6-foot squares would provide for more lighting flexibility, but we have opted to keep our illustration simple.

The Light Plot The designer has divided the stage into five areas using letters of the alphabet to designate each area. We have chosen one direction to be “downstage” and the lettering begins there. The area allocation indicated in Figure 24-10 represents an absolute minimum. If the actors play any corner of the stage, they will be poorly lit. Using nine areas, three across and three deep, would provide better coverage. It would also nearly double the number of fixtures required.



24-10 Arena Simplified Light Plot

COURTESY OF THE AUTHORS

UNIT #	TYPE	FOCUS	LAMP	COLOR	CHANNEL	ACCESSORIES
1	S4 36 DEGREE	A	575	G790	1	6.25" TOP HAT
2	S4 36 DEGREE	SOFA	575	G105	6	6.25" TOP HAT
3	6" FRESNEL	A	750	G384	11	7.5" BARN DOORS
4	S4 36 DEGREE	B	575	G790	2	6.25" TOP HAT
5	6" FRESNEL	D	750	G384	14	7.5" BARN DOORS
6	8" FRESNEL	MOONLIGHT	1K	G815	20	10" BARN DOORS
7	S4 50 DEGREE	C	575	G790	3	6.25" TOP HAT
8	S4 50 DEGREE	D	575	G790	4	6.25" TOP HAT
9	6" FRESNEL	B	750	G384	12	7.5" BARN DOORS
10	6" FRESNEL	C	750	G384	13	7.5" BARN DOORS
11	6" FRESNEL	A	750	G810	41	7.5" BARN DOORS
12	S4 50 DEGREE	E	575	G790	5	6.25" TOP HAT
13	S4 50 DEGREE	A	575	N/C	51	6.25" TOP HAT
14	S4 50 DEGREE	CENTER SPECIAL	575	N/C	10	6.25" TOP HAT
15	6" FRESNEL	E	750	G384	15	7.5" BARN DOORS
16	6" FRESNEL	B	750	G810	42	7.5" BARN DOORS
17	S4 50 DEGREE	B	500	N/C	52	6.25" TOP HAT
18	6" FRESNEL	C	750	G810	43	7.5" BARN DOORS
19	S4 50 DEGREE	C	575	N/C	53	6.25" TOP HAT
20	6" FRESNEL	D	750	G810	44	7.5" BARN DOORS
21	S4 50 DEGREE	D	575	N/C	54	6.25" TOP HAT
22	6" FRESNEL	A	750	G325	31	7.5" BARN DOORS
23	S4 50 DEGREE	A	575	G940	21	6.25" TOP HAT
24	6" FRESNEL	E	750	G810	45	7.5" BARN DOORS
25	S4 50 DEGREE	SOFA	575	G940	18	6.25" TOP HAT
26	S4 50 DEGREE	E	575	N/C	55	6.25" TOP HAT
27	6" FRESNEL	C	750	G325	33	7.5" BARN DOORS
28	6" FRESNEL	D	750	G325	34	7.5" BARN DOORS
29	S4 50 DEGREE	B	575	G940	22	6.25" TOP HAT
30	S4 50 DEGREE	C	575	G940	23	6.25" TOP HAT
31	6" FRESNEL	B	750	G325	32	7.5" BARN DOORS
32	S4 36 DEGREE	D	575	G940	24	6.25" TOP HAT
33	6" FRESNEL	E	750	G325	35	7.5" BARN DOORS
34	S4 36 DEGREE	E	575	G940	25	6.25" TOP HAT

COURTESY OF THE AUTHORS

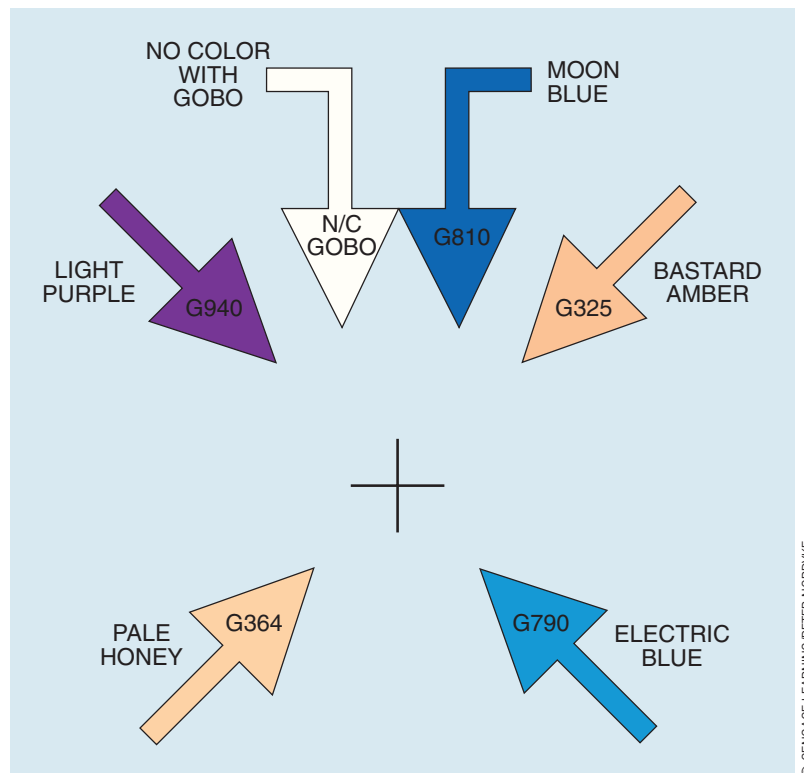
24-11 Arena Fixture Schedule

Attempting to number fixtures by position as we normally would becomes confusing in many arenas; therefore, they are numbered sequentially from downstage left to stage-right and moving upstage.

Area Lighting Ellipsoidals were chosen to come from two directions and Fresnels from the other two. This choice was made to offer a bit of quality contrast from the different directions. Each area is lit identically except height angles for those fixtures facing the audience are increased for the outer areas (A, B, D, and E). Looking at area A as an example, note that the vertical angle of fixtures #22 and #23 is steeper than that of fixtures #1 and #3. The higher angle also means a shorter throw, so 50-degree rather than 36-degree ellipsoidals are chosen and the Fresnels are flooded more. Shutters and barn doors are used so that the upper portion of the light beam can be cut to prevent spill into the eyes of the spectators.

Area C, in the center, is lit from the four corners. Here the problem of spill light annoying the audience is less extreme than in the outer areas. Nonetheless, top hats are used on the fixtures.

Environmental and Mood Lighting The top-light Fresnels and ellipsoidals with gobos are designed to change the mood and time of day from scene to scene. A top-light color wash is valuable in the arena because it does not affect actors' faces or costume colors but aids in establishing a different look. Likewise, the gobo wash from the top helps to distinguish between interior and exterior scenes as well as add an overall texture to the stage floor.



24-12 Arena Production Color Key Color key for the light plot in Figure 24-10.

Color The color system, using GAM filters, is that of opposite warms and cools with a top color wash (Figure 24-12). Each area is lit as follows:

- G325 (bastard amber) from upstage left in Fresnels
- G940 (light purple) from upstage right in ellipsoidals
- G364 (pale honey) from downstage right in Fresnels
- G790 (electric blue) from downstage left in ellipsoidals
- G810 (moon blue) from the top in Fresnels
- N/C (no color) gobos from the top in ellipsoidals

Light tints are chosen for all but the top-light, an appropriate choice in the arena. The warms and the cools are not identical in order to create more interest and color contrast. Fresnels are chosen for the warm colors in order to enhance the softness of the light from those two directions. Ellipsoidals with the cool colors increase the contrast and add a harshness to the light from the other directions. The G810 top-light color tones those scenes needing a cooler feel and helps to indicate night. This would also be a good place to use color changers if the budget allows.

Although the light purple is not an especially cool color, the nature of the drama warrants it. For a starker and more dramatic piece, we might have selected a combination of G790 and G830 (north sky blue) for the cools. The versatile G940 might have been one of the warms, with perhaps no color at all in the opposite fixtures.

Specials A few specials have been provided. On the stage-left side of the plot is an 8-inch Fresnel with a G815 (Moody blue) filter to give the effect of moonlight for a brief scene (Fixture #6). From the stage-right side, a wide-beamed ellipsoidal reflector spotlight without color (Fixture #14) serves as an accent on the central area for a special moment there. The sofa is covered by two specials for different moments in the play (Fixtures #2 and #25).

Control Thirty-four fixtures are required for our design, although nearly 60 would be necessary if the number of areas were increased. Following conventional logic for

channel assignments, area A is lit by channels 1 (G790), 11 (G364), 21 (G940), 31 (G325), 41 (G810 top), and 51 (N/C gobo). Subsequent areas are lit in a similar manner.

Arena and thrust lighting almost always require tighter and more individual control than proscenium productions do. If dimmers are scarce, gang the two warm colors lighting each area into one dimmer and do the same with the cool colors, saving 10 dimmers. Ganging a cool and a warm color together would not be a good idea because it would prohibit the possibility of color variation in the several scenes of the play.

Thrust Productions

Although normally larger in scale, thrust production has many of the same characteristics as the arena. Its appeal as a performance space is its intimacy, with audience members viewing the performers from three sides. Any scenery that exists is located upstage so as not to interfere with audience sight lines, while the play's action takes place downstage on the thrust. Actor entrances are possible from upstage left or right or from the **vomitory entrances**, ramps that lead up to the front of the stage from beneath the audience. If the “voms” are used, steps are necessary along the front of the stage. In this way, rapid entrances can be made onto the stage and a director can use the steps to create levels.

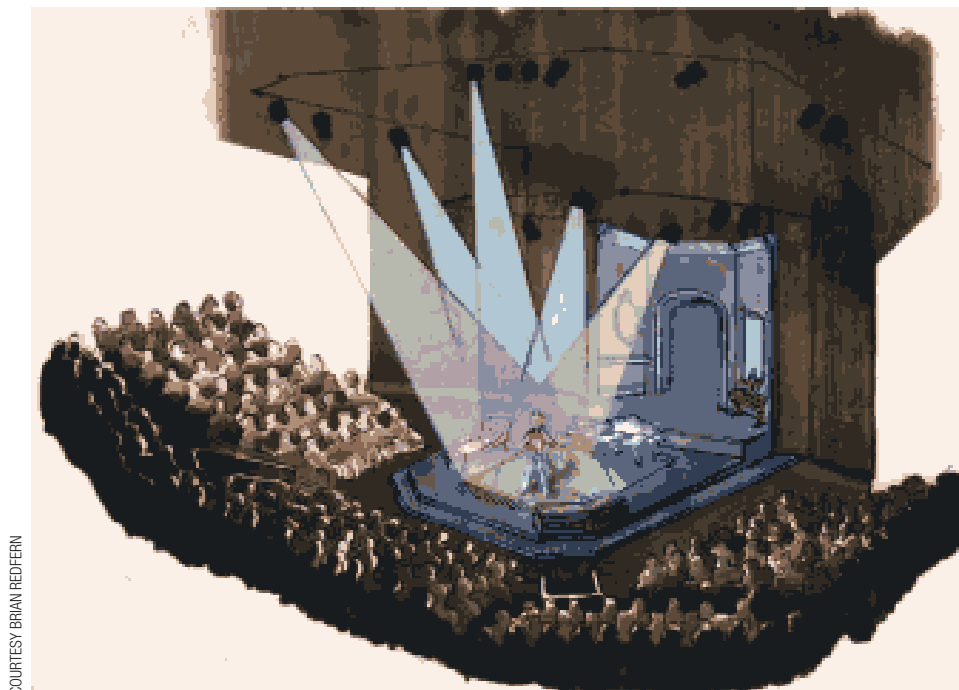
vomitory entrance In the thrust theatre, ramps serving as actors' entrances and exits that lead up to the front of the stage from beneath the audience.

The Theatre

Figure 24-13 is a perspective drawing of a thrust theatre showing lighting positions and other features of such an auditorium. Note that an actor playing downstage is seen from all sides by the audience, which wraps well around the thrust. As in the arena, side-light for some audience members is front-light for others.

Any theatre designed with a thrust stage must provide ample mounting positions for the lighting fixtures. The simplest way to do this is to hang a grid of pipes or other mounting structures over the entire stage and auditorium. It should extend in all directions at least as far from the edge of the stage as the height of the grid above the stage floor. There should be enough circuits on this grid to accommodate more than

24-13 Thrust Theatre Production



all anticipated fixtures. The need to hang lights in any location on the grid makes them difficult to mask. Today's audience has come to accept exposed lighting fixtures, particularly in arena and thrust theatres. Fixtures neatly cabled are seldom a distraction. Again, a tension wire grid offers an ideal solution. Another possibility for hanging positions is a series of ceiling ports that echo the shape of the thrust as indicated in our sample theatre. This provides for masking of fixtures as well as easy access via catwalks to the lights.

Placing a lighting boom in the vomms with a fixture shooting onto the stage creates an interesting and dramatic angle of light. Many thrust theatres have a balcony, the front rail of which provides a useful low-angle lighting position.

The spectators in the side seats particularly will find that the lenses of fixtures focused in their general direction are in full view. But as long as top hats are used, this should not be too much of an annoyance. Care must be taken to mask or frame off the upper part of the beams from such fixtures to be sure they do not glare directly into the eyes of those seated facing them. Fresnels, if used, should have barn doors.

Design Considerations

The arrangement of set pieces and properties often dictates how a thrust stage is best divided into lighting areas. Each area requires several fixtures focused on it from different directions. Top- or back-lighting is essential to set off the actor from the background. Care must be taken to avoid, as much as possible, light spilling into the audience. Blending and toning are best accomplished by the use of soft-beamed spotlights throwing color washes over large portions of the stage. Because of the steep audience rake, the stage floor becomes a major scenic element in most thrust houses. As in the arena, lighting color, texture, and composition are readily apparent on the floor (Figure 24-14).

Distribution A good thrust theatre offers many possibilities for fixture placement. Varying the angle of fixtures into an area provides good visual variety. However, because of spill into the audience, very low angles are possible only from the front. Therefore, a designer often treats an area with a low-angle front-light as well as color washes. Five to seven fixtures per area is not unusual in thrust lighting. The absolute minimum is three, but this provides for little or no variety.

Color As with arena staging, strong colors are not desirable on the thrust stage—although a designer can be somewhat bolder because of the one closed side. The use of very light tints, approaching no-color, has been a popular color system for the thrust. This look is generally sharp and dramatic. Another system calls for fixtures from the front to have very pale tints, with those on the side taking on stronger shades of the same basic colors. Color systems for the arena are also adaptable to the thrust. Color toning the floor is best done from back- or top-light and can add a great deal of variety to the stage picture.

Designing the Lighting

As can be seen in Figure 24-13, our sample production takes place in an interior setting with some furniture props downstage and with a level and an entrance upstage center. The light plot is designed for a comedy or a light drama with lighting angles standard for good visibility and colors chosen for their pale tints. We have divided the stage into seven areas, labeled I–VII. This will provide a bare minimum of coverage (see “variations” following). Figures 24-15 and 24-16 show the light plot and fixture schedule, respectively. Refer to these illustrations while reading the following pages.



PHOTO COURTESY RALPH FUNICELLO

24-14 Thrust Production Note the wonderful texture creating mood and composition in this production of *Henry IV* at The Lincoln Center Theatre, Vivian Beaumont Theatre. Directed by Jack O'Brien; scenery, Ralph Funicello; costumes, Jess Goldstein; lighting, Brian MacDevitt.

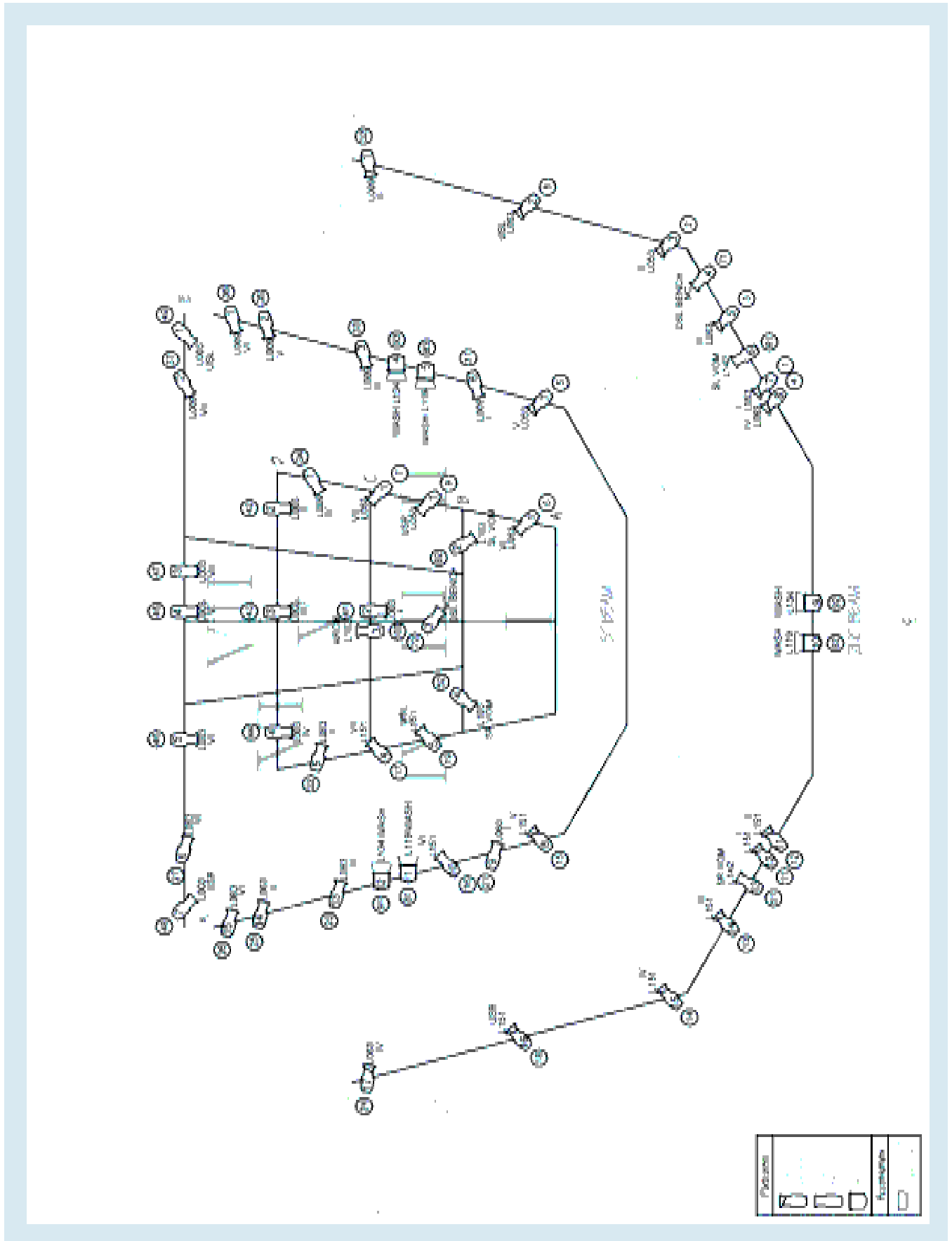
A Typical Lighting Area The color key in Figure 24-17 indicates the lighting for a typical area on the thrust. All fixtures are ellipsoidals to keep spill light into the audience at a minimum. Using Area III as an example, it is lit as follows:

- L053 (pale lavender) from the house-right front in a 26-degree ERS (2nd beam fixture #5)
- L009 (pale amber gold) from the stage-left side in a 36-degree ERS (1st beam #3)
- L151 (gold tint) from the house-left front in a 26-degree ERS (2nd beam #14)
- L063 (pale blue) from the stage-right side in a 36-degree ERS (1st beam #13)
- L003 (lavender tint) from the back in a 36-degree ERS (overthrust grid #D3)

Other Areas As in the arena, the outer areas on the thrust (I, II, and IV) are treated a bit differently. Those fixtures facing the audience would have their angles raised so as to avoid spill into the audience. In addition, owing to set and grid limitations, the two upstage areas will need to have a steeper back-light—almost a top-light.

Color With a minimum of five fixtures on each acting area and a color arrangement as shown in Figure 24-17, the designer has several options:

- The two warmes can act as key-light, with the cools filling.
- The two cools can act as key-light, with the warmes filling.
- Any one fixture (except the back-light neutral) can be lowered in intensity or dropped out completely, causing a color shift as well as a compositional change.



24-15 Thrust Production: Simplified Light Plot

COURTESY OF THE AUTHORS

POSITION	UNIT #	TYPE	FOCUS	LAMP	COLOR	CHANNEL	ACCESSORIES
BEAM 2	1	S4 26 DEGREE	II	575	L009	32	
	2	S4 26 DEGREE	USL	575	L063	8	
	3	S4 26 DEGREE	II	575	L063	2	
	4	S4 36 DEGREE	DSL BENCH	575	NC	71	
	5	S4 26 DEGREE	II	575	L063	3	
	6	S4 36 DEGREE	SL VOM	575	L142	51	
	7	S4 26 DEGREE	I	575	L063	1	
	8	S4 36 DEGREE	IV	575	L063	4	
	9	8" FRESNEL	COLOR WASH	1K	L134	92	10" BARN DOOR
	10	8" FRESNEL	COLOR WASH	1K	L119	82	10" BARN DOOR
	11	S4 26 DEGREE	II	575	L151	12	
	12	S4 26 DEGREE	I	575	L151	11	
	13	S4 36 DEGREE	SR VOM	575	L142	51	
	14	S4 26 DEGREE	II	575	L151	13	
	15	S4 26 DEGREE	IV	575	L151	14	
	16	S4 26 DEGREE	USA	575	L151	18	
	17	S4 26 DEGREE	IV	575	L063	24	
BEAM 1	1	S4 36 DEGREE	VI	575	L009	36	
	2	S4 36 DEGREE	V	575	L009	35	
	3	S4 36 DEGREE	II	575	L009	33	
	4	8" FRESNEL	COLOR WASH	1K	L134	93	10" BARN DOOR
	5	8" FRESNEL	COLOR WASH	1K	L119	83	10" BARN DOOR
	6	S4 36 DEGREE	I	575	L009	31	
	7	S4 26 DEGREE	V	575	L063	5	
	8	S4 26 DEGREE	V	575	L151	15	
	9	S4 36 DEGREE	I	575	L063	21	
	10	S4 36 DEGREE	VI	575	L151	16	
	11	8" FRESNEL	COLOR WASH	1K	L119	81	10" BARN DOOR
	12	8" FRESNEL	COLOR WASH	1K	L134	91	10" BARN DOOR
	13	S4 36 DEGREE	III	575	L063	23	
	14	S4 36 DEGREE	V	575	L063	25	
	15	S4 36 DEGREE	VI	575	L063	26	
GRID A	1	S4 36 DEGREE	VI	575	L063	6	
GRID B	1	S4 36 DEGREE	USR	575	L063	9	
	2	S4 36 DEGREE	SL VOM	575	L103	63	
	3	S4 36 DEGREE	DSL BENCH	575	NC	72	
	4	S4 36 DEGREE	SR VOM	575	L103	52	
	5	S4 36 DEGREE	USL	575	L151	19	
GRID C	1	S4 36 DEGREE	VII	575	L063	7	
	2	S4 36 DEGREE	I	575	L003	41	
	3	S4 36 DEGREE	ARCH	575	L103	100	
	4	S4 36 DEGREE	VII	575	L151	17	
	5	S4 36 DEGREE	II	575	L063	22	
GRID D	1	S4 36 DEGREE	IV	575	L009	34	
	2	S4 36 DEGREE	II	575	L003	42	
	3	S4 36 DEGREE	III	575	L003	43	
	4	S4 36 DEGREE	IV	575	L003	44	
GRID E	1	S4 36 DEGREE	USL	575	L003	49	
	2	S4 36 DEGREE	VII	575	L009	37	
	3	S4 36 DEGREE	VII	575	L003	47	
	4	S4 36 DEGREE	V	575	L003	45	
	5	S4 36 DEGREE	VI	575	L003	46	
	6	S4 36 DEGREE	VII	575	L063	27	
	7	S4 36 DEGREE	USR	575	L003	48	

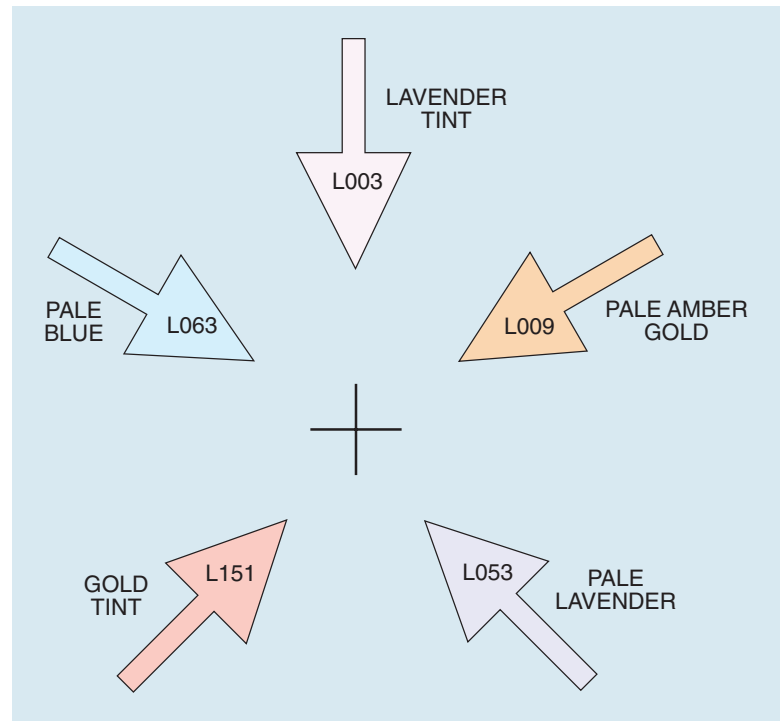
24-16 Thrust Production: Fixture Schedule

Color Wash A pair of 8-inch Fresnels light the entire set from the front to provide a tonal wash that can be varied by dimming the warm and cool fixtures to different readings. Another two pairs of 8-inch Fresnels located on either side of beam port #1 work with them. For the cool wash, an L119 (dark blue) is used, and for the warm wash, an L134 (golden amber). The golden amber has a warming effect on the rather cool blue, resulting in lavender tones when mixed properly.

Specials Several specials have been hung. The upstage left and right corners, which could be considered areas in themselves, are each covered by two fixtures from the front

plus a back-light. The vomitory entrances are lit from the audience side by 2nd beam fixtures #6 and #13 and from the stage side by overthrust fixtures #B2 and #B4. Overthrust fixture #C3, a 36-degree ellipsoidal, is framed to the upstage-center archway and colored in the versatile L103. Because it does not have its own area, the downstage-left bench is lit with two 36-degree ellipsoidals in no-color (2nd beam fixture #4 and overthrust fixture #B-C 3).

As noted, we primarily used ellipsoidal reflector spotlights in this plot because of good control over their beams. When practical, they are made soft-edged by shifting the lenses to throw the gate out of focus. If moving the lens barrel does not produce a soft enough edge, a light diffusion filter such as L256, L257, or L258 can be added. This reduces sharp beam edges that result in abrupt changes of intensity on the stage and the actors. Fresnel spotlights are used only when their spill light will not be a factor, as in our saturated color washes. Barn doors or top hats are suggested for all fixtures.



24-17 Thrust Production: Color Key Color key for the light plot in Figure 24-15.

Variations

As noted previously, seven areas is an absolute minimum. If the director chose to use the steps as an acting area, at least five additional areas would be necessary. The downstage right and left corners of the thrust would not be lit well and might require their own areas. Likewise, if much action took place upstage right and left, another two complete areas would be necessary. The production could require 16 areas plus specials.

If more than the minimum five fixtures per area is possible, an even greater variety of color and distribution could be achieved.

Color Multicolored back-light in the form of double-hanging or a scroller would add a great deal of variety to the stage pictures.

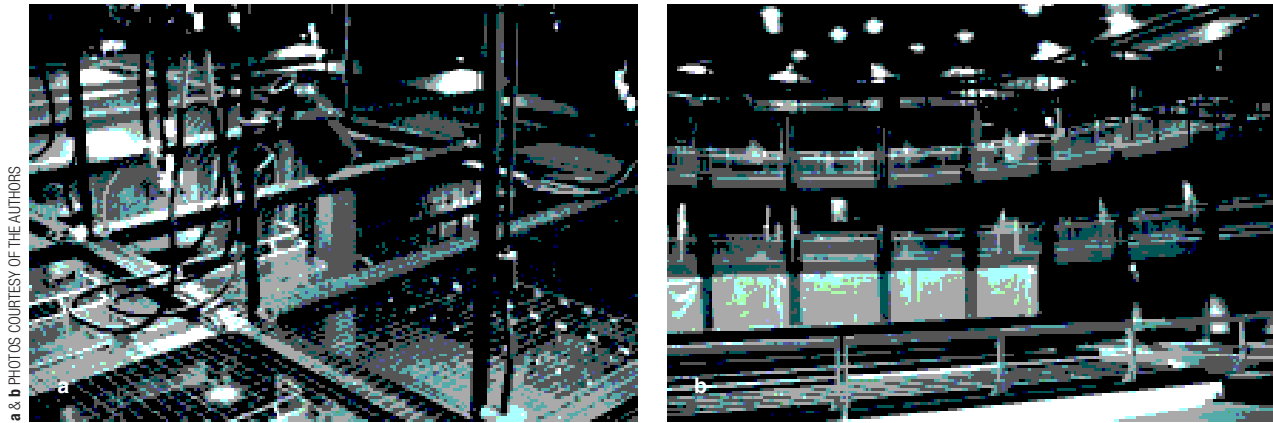
Side Angle For more dramatic productions, the vertical angle of the side-lights can be raised, with the following results:

- Sharper facial and body shadows resulting in a harsher look
- Spill into side audience seating is more controllable
- Area control is tighter

Texture Texture achieved by patterns or gobos can break up the sometimes flat and dull surface of the thrust stage. High side- or back-light is often a desirable angle for such treatment.

The Flexible Stage

Another form of performance space that should not go without mention is the popular “black box.” The traditional black box offers completely flexible audience and



a & b PHOTOS COURTESY OF THE AUTHORS

24-18 Tension Wire Grid

- a View from the grid of the Keck Theatre at Occidental College in Los Angeles. The woven cable grid is weight bearing and offers complete access to overhead lighting positions. This full-ceiling grid was installed by Hoffend & Sons.
- b View from the stage. The Keck is a unique courtyard theatre with a seating capacity of 475.

performance spaces; as such, black box seating can be set up in many configurations, each defining a unique playing space. Some common seating arrangements are as follows:

- One-sided, or full front (proscenium-type orientation)
- Two-sided, or corner staging
- Three-sided, or thrust staging
- Four-sided, or arena staging
- Aisle—with seats on two sides of a central aisle

Lighting the flexible space is not very different from lighting one of the several theatre forms previously examined except that the lighting positions are generally closer to the stage. To provide adequate lighting, a variety of hanging positions must be available. A cross-pipe grid over the entire space is a fair solution to the problem of flexibility. Such a grid allows lighting fixtures to be hung in any position and focused in any direction.

A better solution, as we have seen, is the tension wire grid (Figure 24-18). One-eighth-inch wire rope is woven in all directions, forming a weight-bearing surface on which an electrician can walk. Pipes supported from the ceiling are arranged to allow complete hanging flexibility with a minimum of time and effort. The lighting fixtures shoot through the thin wire mesh as shown in the photograph. This grid is ideal for the flexible space as well as extremely useful in arena or thrust situations.

Lighting for Dance

Dance is most often performed on a proscenium stage with a formal leg-and-border arrangement. At first glance, it would seem that dance requires the same sort of light that other forms of production do. There is, however, one important difference. When we attend a play, we are vitally interested in the faces of the actors to convey character, thoughts, and emotion. This is not as true in dance, particularly ballet, in which the position and movement of the dancer's body tell all. A knowledgeable dance patron will scarcely notice a dancer's face and will surely not concentrate on it. The primary concern is movement, revealed and emphasized by light.

Design Considerations

One method of emphasizing movement is to place the principal axis of light in line with the axis of movement. Thus, a ballerina spinning in a pirouette would have the light

hitting straight down on her or straight up from below. Although light from directly overhead tends to make the human body appear shortened, it remains a good way to accentuate the rapid turning of the dance.

Of course, it would be impractical, if not inappropriate, to attempt to emphasize every single movement of a dance. Fortunately, choreographers often establish several basic movement patterns and repeat them throughout a piece. These patterns support the theme of the dance piece, creating compositions that can be effectively reinforced by the lighting. In a concert made up of several pieces, lighting designers may provide specialized lighting for some of the most significant movement and more generalized lighting for the rest. A designer must attend as many rehearsals as possible and take careful notes before developing the light plot.

Dance Areas Unlike most dramatic productions, dance plots are not organized by lighting areas but arranged in a series of **dance zones**, areas that extend completely across the stage. Each zone is typically 5 to 8 feet deep, with the total number of zones determined by the depth of the dance space and the number of side entrances. A theatre's overstage lighting positions and masking legs also influence the number and placement of zones. A lighting boom is placed offstage left and right in each zone. In addition to zone lighting, a dance designer may provide diagonal lighting and numerous specials.

dance zones Dance lighting areas that extend completely across the stage; normally determined by placement of side-lighting booms and masking legs.

Side-Light When lighting a dramatic production, the designer usually begins with front visibility light and then moves on to side- and back-light angles. In lighting most dance, however, the designer begins with side-light. Side-lighting is the primary source of figure-modeling light (Figure 24-19). Although a typical theatrical light plot for the proscenium theatre has at least half of its equipment located front-of-house, dance plots often have three-quarters of their fixtures backstage. Extra cabling may be required if a theatre does not have the necessary number of circuits backstage for an average dance plot.

Distribution

Here are common mounting positions for dance lighting fixtures (almost invariably ellipsoidal reflector spotlights):



24-19 Dance Side-Light

PHOTO COURTESY YVONNE M. PORTRA

Front-Light Unlike theatre, dance uses front-light only under special circumstances or at low dimmer readings.

- Low front (30-degrees) tends to wash out body form; a little may be desirable for the sake of visibility and/or color washing.
- Medium-angle (45-degree) front-lights are mounted on a second balcony rail or in a ceiling position. Again, this does little for the body and casts shadows of ballet costumes on dancers' legs, although it can certainly be used as visibility light.
- Roughly at a 60-degree angle, high front is much more useful for theatrical presentation than for dance. This dramatic angle casts serious costume shadows on the legs of a ballerina, but it can be used in other types of dance to create mood.

Low Side For the low side position, lights are mounted very low on booms in the wings—less than a foot off the deck. This is an extremely valuable dance-lighting position—flattering to dancers because its light tends to lift the body. Low side-lighting fixtures are called “shin kickers” or “shin busters” for obvious reasons. They are normally clear or colored with very light tints. Their light can be shuttered off the floor surface in order to eliminate visible scallops from the beams. Gobos placed in low side fixtures enhance the sense of movement and add texture and mood to a scene. Fixtures can be focused so that patterns are visible only on the dancers and not on the floor.

Medium Side For the medium side position, lights are mounted on the boom about 8 or 10 feet above the floor in the wings. This may be regarded as the basic dance lighting angle. It throws a wash across the stage with little significant shadowing (Figure 24-20).

It may be desirable to mount an additional spotlight a few feet higher to carry across to the far side of the stage. A third fixture can be mounted a few feet lower to



COURTESY OF THE AUTHORS

24-20 Dance Lighting This scene from the Richmond Ballet Company's *Gloria* illustrates the effective use of side-light as a source. Artistic director, L. Stoner Winslett; lighting, R. Craig Wolf.

light the close side of the stage. In this case both long- and short-throw ellipsoidals are focused so that the center lines of their beams are parallel (see Figure 24-22 for details). Gobo patterns placed in this position shine on both the dancers and the floor.

High Side Light in the high side position comes from 15 to 20 feet high in the wings or from the ends of electric battens (such units are called **pipe ends**). If the chosen angle is too high, the light tends to push down on the dancers, making them appear squat. However, a 60-degree high side can be effective for a dramatic moment and is particularly useful in modern dance. Gobo patterns from high side fixtures read strongly on the floor.

Back-Light In the straight back position, light not only comes from above but also from behind the dancer. This is a very valuable position because it highlights the body in space, separating it from the background. Light from the back reads on the floor stronger than from any other direction (Figure 24-21).

Like the straight back position, diagonal back-light comes from above and behind the dancer, as well as from an angle to the side. Frequently, this is more desirable than straight back because it illuminates more visible surface area of the dancer's body.

Top-Light Down- or top-lights are mounted directly overhead, an effect that tends to push the body down. This position is useful only for specialized moments normally requiring isolation.

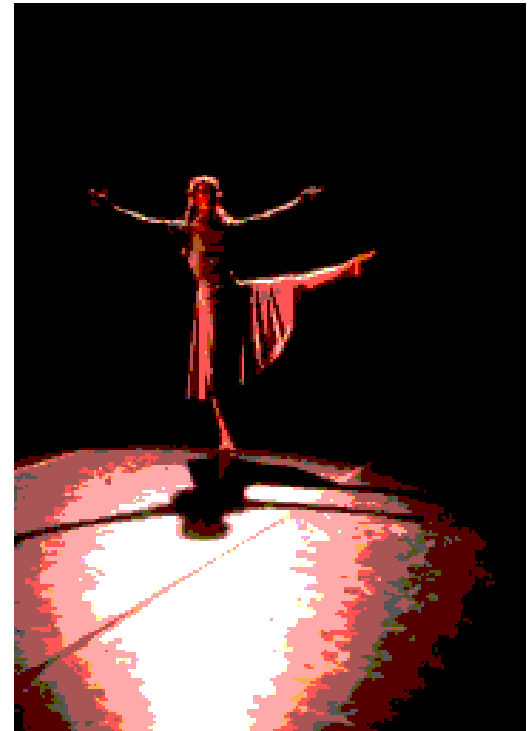
Follow Spots Light from a follow spot can come from various locations in the auditorium or from some onstage position. Such use must be kept unobtrusive and should be operated by an individual capable of making it so. Of course, in musical comedy, opera, and some classical ballet, blatant use of follow spots is accepted as traditional.

Dancers' Centering Light Dancers maintain balance by finding their "center." The lighting designer can help them by placing a **dance centering light** or *spotting light* in the auditorium. This should be a small 7½- or 15-watt red lamp located at head height, dead center at the rear of the auditorium or on a balcony rail.

Booms

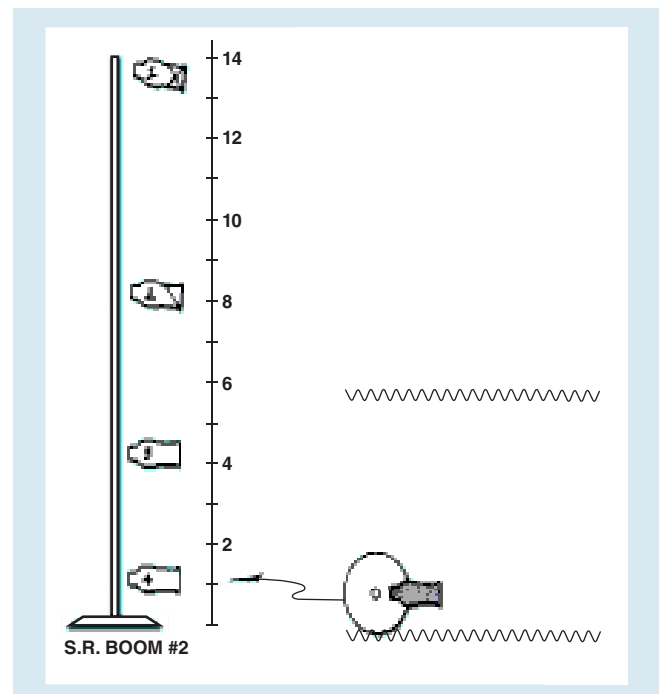
Low and medium side-lighting require floor stands or booms as hanging positions. A dance concert or ballet almost always calls for booms in each wing on both sides of the stage. This can total 12 booms for a large stage. It is traditional to hang lighting fixtures to the side of booms in the theatre, but for dance, they should be mounted straight out from the boom pipes. In this way, the boom will take up as little wing space as possible, allowing more space for dancer entrances and exits (often leaps into the wings). Figure 24-22 illustrates a typical dance boom layout.

Note that the boom is placed downstage in the wing. There are several reasons for this, but the most important is that the side-light then sufficiently wraps around the front of the dancer, avoiding a dark line down the front of the body.



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24-21 Dance Back Light Form-revealing back-light from a modern dance performance. Lighting by Craig Wolf.



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24-22 Basic Dance Boom Layout Fixtures are hung onstage from the boom to take up as little wing space as possible. Fixture 1 lights far stage-left in the second zone, whereas fixture 2 lights mid-stage and 3 lights close. Fixture 4 is a low-angle "shin."

pipe ends Fixtures clustered at the ends of light battens, providing high side-light.

dance centering light A small red light placed at dancer head height at the rear of the auditorium or on a balcony rail; serves to help dancers locate front. Also called *spotting light*.

Booms must be clean and safe, each with a safety tie from the top of the pipe to the grid. If the booms cannot be bolted into the floor, three or more sandbags must be placed on the bases to keep them from turning or moving. Cable to booms is neatest if run up the boom and onto an electric pipe for circuiting. However, many times, floor pockets must be used. If this is the case, run the cable straight offstage from the boom and then turn upstage or downstage to floor pocket locations. Cover the cable with carpeting and tape it securely to the floor.

Color Considerations

For most classical ballet, strong front colors are not desirable but a basic tint certainly is. Pale lavender is frequently used, but tradition may prescribe some other tint. Whatever color is selected becomes the neutral for the particular ballet. The other shades work in relation to it and, when blended together on the stage, approximate the neutral. Thus, if lavender is the neutral, a light rose next to it appears quite warm, and light blue appears cool. The rose and blue mix together to create lavender.

Figure 24-23 is a photograph from the classical ballet *La Sylphide*. Principal front-light colors are lilac (R55) and pale amber gold (R09). The cool-looking back-light is no-color blue (R60).

Designers can achieve a valuable effect by using advancing and receding colors to add apparent depth to the stage. The use of slightly cooler tints on the upstage dancers makes them appear farther away than they would otherwise seem. Likewise, warmer shades on the downstage dancers bring them even farther forward. Care must be taken in using this technique, however. The tints must not be so far apart that the dancers visibly change color as they move through the zones.



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24-23 Classical Dance The Richmond Ballet Company's *La Sylphide*. Staging, Frederic Franklin; lighting, R. Craig Wolf.



PHOTO COURTESY BILL KNOEPEL/GUY CAPI ASSOC.

24-24 Modern Dance A production shot from *Ballet on Broadway* produced by Ballet Theatre of Scranton. Choreographed by Joanne D. Arduino; lighting, Dennis M. Size.

As illustrated in Figure 24-24, modern dance requires color usage that is appropriately modern. Use of saturated colors, especially in side-light, is a common technique for expressing mood. At the same time, no-color light or cool tints are often chosen to express the sometimes dramatic nature of the dance. Color changers mounted in fixtures on the booms can provide needed variety for a performance comprising several dance pieces.

Cues

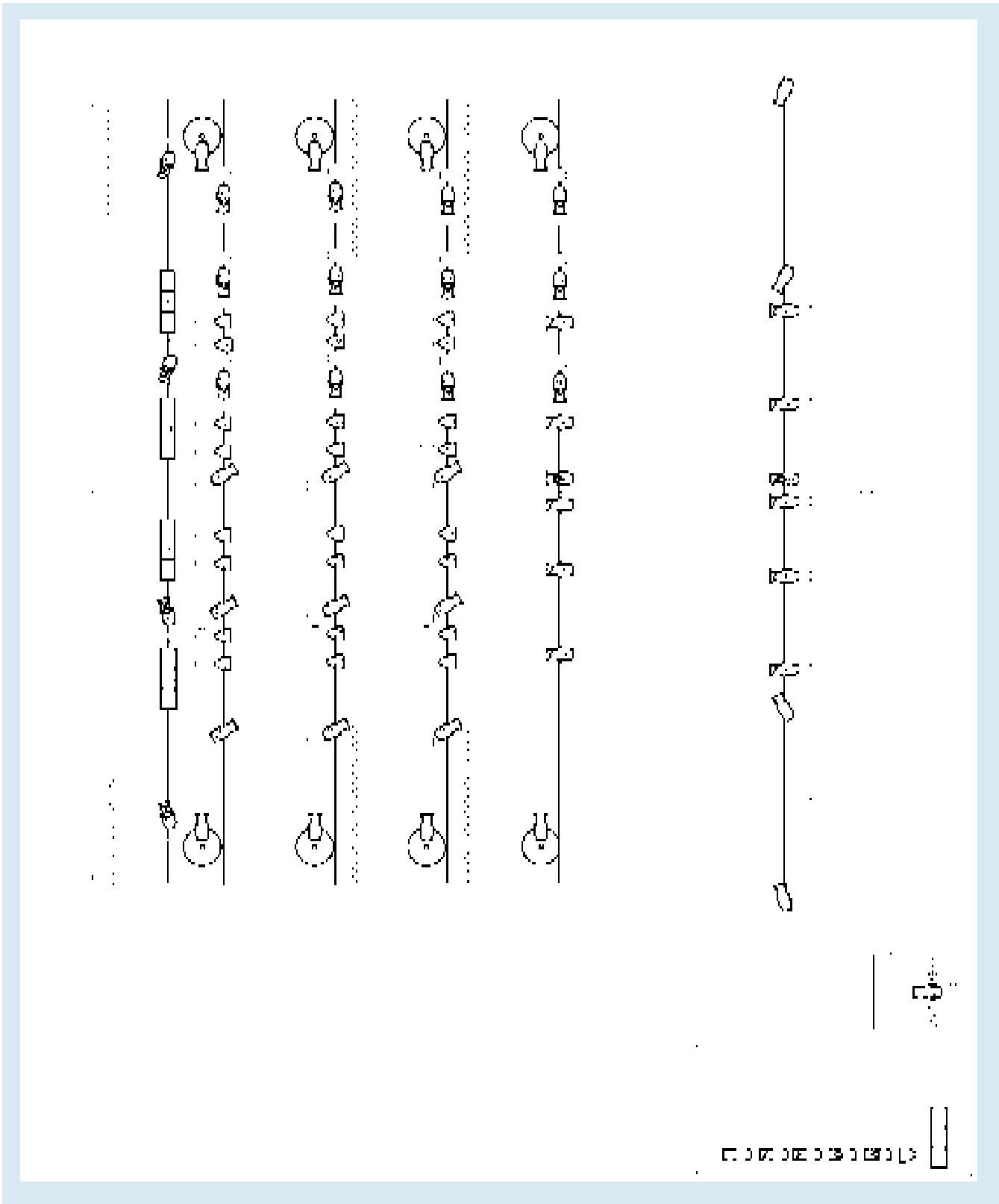
The rhythm of a theatrical production often dictates cue placement. This is even truer of dance. Movement nearly always corresponds to the music, and cues should do the same. The cues for a ballet should be called by the stage manager from the score. Obviously, the lighting designer should know the music very well before beginning the design. Cues for modern dance or pieces without scores may need to be called from the action. This requires that the lighting designer and stage manager become quite familiar with the movement. Attending preproduction rehearsals is imperative. Using a rehearsal video recording may also help the designer review and write cues with the stage manager.

A Dance Plot

Figures 24-25 and 24-26 are a sample light plot and fixture schedule for a dance concert consisting of three separate pieces. Each of the three is quite modern in style, but one has a classical influence with music by Tchaikovsky.

Physical Space The performance takes place in a small proscenium theatre with an opening that is 26 feet wide. Four zones are used because the depth of the space is 28 feet. The downstage edge of the dance floor ends at the plaster line so that side-lights located immediately upstage of the proscenium arch will be effective.

COURTESY OF THE AUTHORS



24-25 Modern Dance Concert: Simplified Light Plot A simplified light plot for a modern dance concert consisting of three separate pieces.

POSITION	UNIT #	CHANNEL	TYPE	FOCUS	LAMP	COLOR	TEMPLATE	ACCESSORIES
BEAM 1	1	91	S4 36 DEGREE		575	R39		
	2	91	S4 36 DEGREE		575	R39		
	3	1	S4 26 DEGREE		575	R05		
	4	2	S4 26 DEGREE		575	R05		
	5	81	S4 26 DEGREE	DSC SPECIAL	575	NC		IRIS
	6	3	S4 26 DEGREE		575	R05		
	7	4	S4 26 DEGREE		575	R05		
	8	5	S4 26 DEGREE		575	R05		
	9	82	S4 36 DEGREE		575	R339		
	10	92	S4 36 DEGREE		575	R339		
1ST ELEC.	1	51	S4 36 DEGREE		575	R61	G2	
	2	52	S4 36 DEGREE		575	R61	G2	
	3	6	S4 26 DEGREE		575	R05		
	4	53	S4 36 DEGREE		575	R61	G2	
	5	7	S4 26 DEGREE		575	R05		
	6	82	S4 36 DEGREE	CTR. SPECIAL	575	NC		IRIS
	7	8	S4 26 DEGREE		575	R05		
	8	9	S4 26 DEGREE		575	R05		
	9	10	S4 26 DEGREE		575	R05		
2ND ELEC.	1	54	S4 36 DEGREE		575	R61	G2	
	2	55	S4 36 DEGREE		575	R61	G2	
	3	11	S4 PAR MFL		575	R84		
	4	31	S4 PAR MFL		575	R321		
	5	56	S4 36 DEGREE		575	R61	G2	
	6	12	S4 PAR MFL		575	R84		
	7	32	S4 PAR MFL		575	R321		
	8	61	S4 36 DEGREE		575	R318		
	9	13	S4 PAR MFL		575	R84		
	10	33	S4 PAR MFL		575	R321		
	11	62	S4 36 DEGREE		575	R318		
	12	14	S4 PAR MFL		575	R84		
	13	34	S4 PAR MFL		575	R321		
	14	63	S4 36 DEGREE		575	R318		
3RD ELEC.	1	57	S4 36 DEGREE		575	R61	G2	
	2	58	S4 36 DEGREE		575	R61	G2	
	3	15	S4 PAR MFL		575	R84		
	4	35	S4 PAR MFL		575	R321		
	5	59	S4 36 DEGREE		575	R61	G2	
	6	16	S4 PAR MFL		575	R84		
	7	36	S4 PAR MFL		575	R321		
	8	64	S4 36 DEGREE		575	R318		
	9	17	S4 PAR MFL		575	R84		
	10	37	S4 PAR MFL		575	R321		
	11	65	S4 36 DEGREE		575	R318		
	12	18	S4 PAR MFL		575	R84		
	13	38	S4 PAR MFL		575	R321		
	14	66	S4 36 DEGREE		575	R318		
4TH ELEC.	1	60	S4 36 DEGREE		575	R61	G2	
	2	61	S4 36 DEGREE		575	R61	G2	
	3	19	S4 PAR MFL		575	R84		
	4	39	S4 PAR MFL		575	R321		
	5	62	S4 36 DEGREE		575	R61	G2	
	6	20	S4 PAR MFL		575	R84		
	7	40	S4 PAR MFL		575	R321		
	8	67	S4 36 DEGREE		575	R318		
	9	21	S4 PAR MFL		575	R84		

COURTESY OF THE AUTHORS

24-26 Modern Dance Concert: Fixture Schedule

POSITION	UNIT #	CHANNEL	TYPE	FOCUS	LAMP	COLOR	TEMPLATE	ACCESSORIES
	10	41	S4 PAR MFL		575	R321		
	11	68	S4 36 DEGREE		575	R318		
	12	22	S4 PAR MFL		575	R04		
	13	42	S4 PAR MFL		575	R321		
	14	69	S4 36 DEGREE		575	R318		
5TH ELEC.	1	70	S4 50 DEGREE		575	VARIOUS	G1	
	2	97	3 CELL SKY CYC		575	R41		
		98	3 CELL SKY CYC		575	R375		
		99	3 CELL SKY CYC		575	R357		
	3	71	S4 50 DEGREE		575	VARIOUS	G1	
	4	97	3 CELL SKY CYC		575	R41		
		98	3 CELL SKY CYC		575	R375		
		99	3 CELL SKY CYC		575	R357		
	5	97	3 CELL SKY CYC		575	R41		
		98	3 CELL SKY CYC		575	R375		
		99	3 CELL SKY CYC		575	R357		
	6	72	S4 50 DEGREE		575	VARIOUS	G1	
	7	97	3 CELL SKY CYC		575	R41		
		98	3 CELL SKY CYC		575	R375		
	99	3 CELL SKY CYC		575	R357			
SL BOOM 1	8	73	S4 30 DEGREE		575	VARIOUS	G1	
	1	121	S4 19 DEGREE		575	R53		
	2	141	S4 PAR MFL		575			WYBRON CXI
	3	111	S4 26 DEGREE		575	R53		
	4	101	S4 36 DEGREE		575	R53		
SR BOOM 1	5	131	S4 36 DEGREE		575	R60		
	1	171	S4 19 DEGREE		575	R302		
	2	191	S4 PAR MFL		575			WYBRON CXI
	3	161	S4 26 DEGREE		575	R302		
	4	151	S4 36 DEGREE		575	R302		
SL BOOM 2	5	181	S4 36 DEGREE		575	R60		
	1	122	S4 19 DEGREE		575	R53		
	2	142	S4 PAR MFL		575			WYBRON CXI
	3	112	S4 26 DEGREE		575	R53		
	4	102	S4 36 DEGREE		575	R53		
SR BOOM 2	5	132	S4 36 DEGREE		575	R60		
	1	172	S4 19 DEGREE		575	R302		
	2	192	S4 PAR MFL		575			WYBRON CXI
	3	162	S4 26 DEGREE		575	R302		
	4	152	S4 36 DEGREE		575	R302		
SL BOOM 3	5	182	S4 36 DEGREE		575	R60		
	1	123	S4 19 DEGREE		575	R53		
	2	143	S4 PAR MFL		575			WYBRON CXI
	3	113	S4 26 DEGREE		575	R53		
	4	103	S4 36 DEGREE		575	R53		
SR BOOM 3	5	133	S4 36 DEGREE		575	R60		
	1	173	S4 19 DEGREE		575	R302		
	2	193	S4 PAR MFL		575			WYBRON CXI
	3	163	S4 26 DEGREE		575	R302		
	4	153	S4 36 DEGREE		575	R302		
SL BOOM 4	5	183	S4 36 DEGREE		575	R60		
	1	124	S4 19 DEGREE		575	R53		
	2	144	S4 PAR MFL		575			WYBRON CXI
	3	114	S4 26 DEGREE		575	R53		
	4	104	S4 36 DEGREE		575	R53		
SR BOOM 4	5	134	S4 36 DEGREE		575	R60		
	1	174	S4 19 DEGREE		575	R302		
	2	194	S4 PAR MFL		575			WYBRON CXI
	3	164	S4 26 DEGREE		575	R302		
	4	154	S4 36 DEGREE		575	R302		
	5	184	S4 36 DEGREE		575	R60		

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24-26 Modern Dance Concert: Fixture Schedule (continued)

Distribution The plot shows a system of R05 front-light from the 1st beam and 1st electric. This is to provide a full-stage front wash if needed for visibility and will also likely see use in the curtain call. There is a system of stage-left high-side R61 with GAM # 714 "Sponge" gobo patterns to texture the stage and dancers from that side.

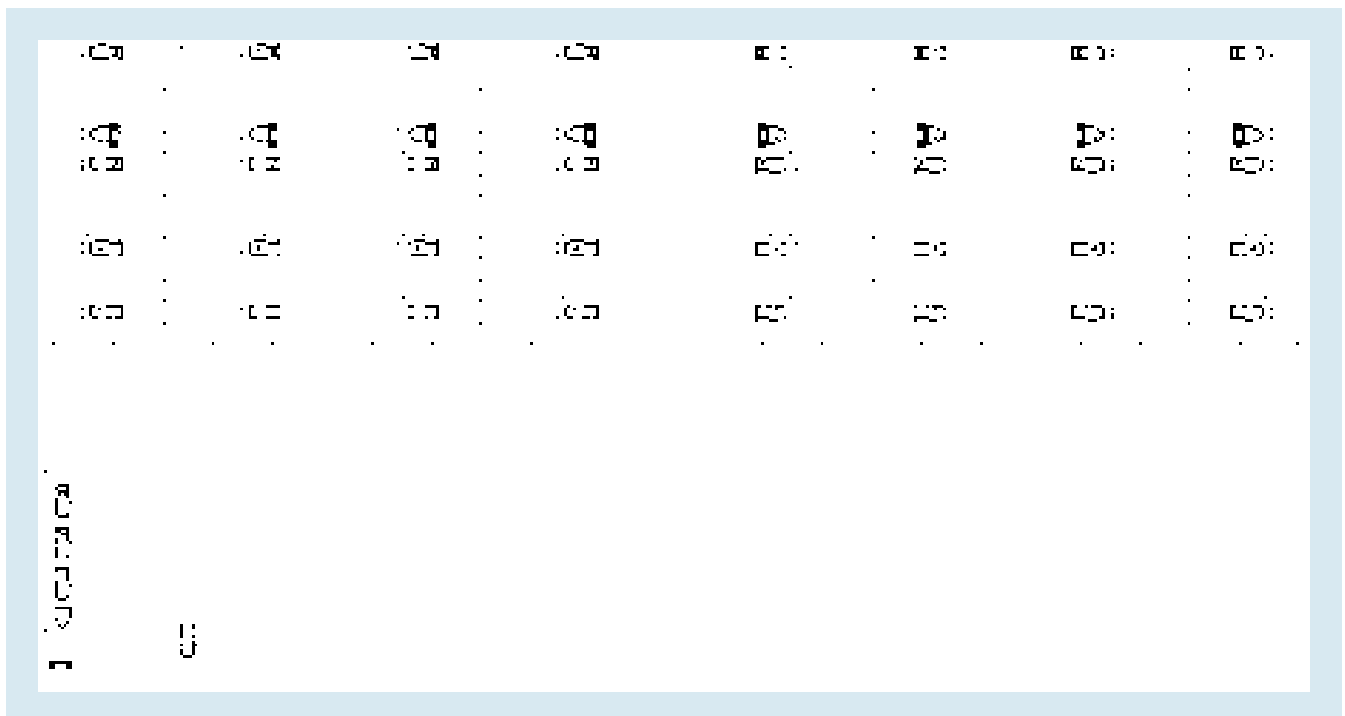
The remaining overstage fixtures are either back-light or specials. Two systems of Source-four PAR back-lights hang on electrics #2, #3, and #4. The two colors are fairly saturated and chosen to mix to create three, one for each dance piece. The PARs are hung four across the stage with their oval beams running up- and downstage.

The booms hold five fixtures each (Figure 24-27). The top ellipsoidal, a 19-degree, throws far across the stage and is focused a bit high to eliminate too much intensity buildup in the center of the stage. It receives top and upstage shutter cuts off the black masking legs. The mid-boom ellipsoidal, a 26-degree, is focused centerstage with slight shutter cuts both up- and downstage. The close ellipsoidal, a 36-degree, is focused to hit about 8 feet out from the wings and also receives an upstage shutter cut off the black legs. The 36-degree shins are tilted up just slightly and receive top and side shutter cuts. Finally, the medium PARs with scrollers are focused straight across the stage with their oval beams running vertically.

Color One bank of back-lights is colored in R84 (Zephyr Blue), a medium blue; and the second is in R321 (Soft Golden Amber), a golden-orange color. The two colors mix to a violet which works very nicely for the more classical piece.

A light tint of cool lavender (R55 - Lilac) is used in the stage-left side-light, while R302 (Pale Bastard Amber) is used stage-right. This technique offers a built-in warm and cool side, however slight. The scroller is generally used in more saturated colors that blend with the light tints of the other side-lights. The relatively cool R60 in the shins creates a harsher quality from the low side-lights.

Control For this dance concert, channels were assigned to provide independent control over nearly all fixtures. Note the channel layout for the booms, intended to make it easier to remember individual zones and functions.



24-27 Modern Dance Concert: Boom Plot

COURTESY OF THE AUTHORS

If fewer dimmers were available, some of the like-color back-lights could certainly be ganged, as could much of the front-light. If ganging the boom fixtures would be necessary owing to a lack of circuits, gang the close- and far-throw ellipsoidals on each boom. This allows for independent control over the mid-throw fixture. However, ganging the boom fixtures should be avoided if at all possible. Of course, one could gang like fixtures from one zone to the other, but this solution causes a circuiting nightmare.

Dance Design

Dance, in all its forms, is an exciting design experience. The principles of theatrical lighting apply, but more freedom for creativity and innovation commonly exists. It is not unusual for a dance lighting designer to be involved in the very creation of a dance piece, an involvement rare in the theatre. Working with choreographers is a joy, for they compose visually. Dance lighting seldom pays very much money, but the experience in terms of the art of lighting is well worth it.

Clearly, different types of stages as well as productions affect in many practical ways how designers develop ideas. In the next and final lighting chapter, we continue the discussion of designing for specific venues, starting with Broadway, and explore lighting design as a profession.

Lighting Design as a Profession

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This chapter gives special attention to lighting for the commercial theatre as well as theatre-related professions such as themed entertainment, concerts, architecture, television and film, restaurants, museums, industrials, and displays. It also includes interviews with several of this country's finest lighting designers.

Lighting on Broadway

New York's Broadway has always been, and still remains, the premier theatrical entertainment center of the United States. People come from all over the world to see Broadway productions. The level of competition for a designer in New York's commercial theatre is as high as it gets; equally great are the rewards for achievement. Although many practices are identical to those of any commercial theatre, some are unique to the Broadway stage.

The Broadway Lighting Designer

No designers work exclusively on Broadway. Despite the potential for high pay, there is not enough work to keep more than a handful of designers busy even on a part-time basis. New York-based lighting designers spend much of their time traveling about the country, working at regional theatres and other commercial venues. Many of these individuals spent years working as assistants to more established Broadway designers before they were rewarded their first Broadway show. Some of them designed off- and off-off-Broadway for many years, learning the ropes and meeting directors and producers.

A producer hires the artistic staff for a production, but the director is normally chosen first and often consulted; it is not unusual for the director to recommend a lighting designer for the show. Accordingly, the experience of having worked with many people on a variety of productions is essential to being hired for a Broadway show.

Before being eligible to light a show on Broadway or at many of the larger commercial theatres across the country, the designer must become a member of the **United Scenic Artists Union (USA)**, IATSE Local USA-829. This union represents professional scenic artists (painters); costume, lighting, scenic, and sound designers; projection designers (new category 2010); computer artists; graphic artists; and art department coordinators. It consists of one local union (829) divided into three regions: Eastern (New York City), Central (Chicago), and Western (Los Angeles).

There are two methods of membership application—as an established professional or by examination. Initiation fees for the professional are currently \$3,500; for those taking the exam, the cost is \$1,500. In addition, IATSE dues and fees are approximately \$300. Specific exam dates and requirements vary from region to region, but all regions

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For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

United Scenic Artists Union (USA) The American union representing professional scenic artists; costume, lighting, scenic, and sound designers; art directors; projection designers; computer artists; graphic artists; and art department coordinators.

DESIGNERS AT WORK ■ Donald Holder



COURTESY JONATHAN WEISS

Donald Holder is a New York–based theatrical lighting designer who has established a stellar career. He maintains a studio in New York and works in regional theatre, off-Broadway, and on Broadway. He has received Tony, Drama Desk, and Outer Critics Circle awards for his lighting of *The*

Lion King; a 2008 Tony award for *South Pacific*; and award nominations for *Movin' Out*, *Gem of the Ocean*, *A Streetcar Named Desire*, *Les Liaisons Dangereuses*, and *Ragtime*. He recently designed *Spider-Man: Turn off the Dark* (Figures 25-1 and 25-2) and enjoys working as the theatrical lighting designer for the television series *Smash*. Don's designs have been seen at most of the country's regional theatres, including the Goodman and Steppenwolf in Chicago, the La Jolla Playhouse and Old Globe Theatre in San Diego, Arena Stage, Harford Stage, ACT, and the American Repertory Theatre.

In addition to his theatre work, Don designs opera, does architectural and residential design, and enjoys working on new scripts.

Don grew up on Long Island, and his parents exposed him to New York theatre as a young boy. He always had a fascination for lighting and loved the theatre. However, his more practical side determined that he would attend college at the University of Maine and major in forestry. Of his college experience, Don says: "Of course, I immediately went and worked in the theatre 24 hours a day. . . . The faculty lighting/set designer there took me under his wing. . . . I learned from him that you could make a living and have a good, rich, happy life doing what you want to do—following your dream."

After graduation, Don worked several jobs while doing theatre. He eventually applied to Yale and was admitted into Jennifer Tipton's advanced lighting classes: "She gave me my first chance to light a production. Even [after] graduating, I was still worried about whether I could make a living in the profession. I remember I had the opportunity to take a job at New York City Opera or assist Jennifer off and on. It was a big decision for me. I turned down the job at the Opera and decided that I was going to be poor and assist. . . . That was a turning point for me—that I was finally willing to take the big step and go out and give it a shot. I think ultimately everybody has to make that commitment."

From then on, things began to fall into place. Don first worked with Julie Taymor on a production of *Titus Andronicus* for Theatre for a New Audience. It was a last-minute design and a difficult process, but he reports, "I really understood her style and her way of working because it was very much like mine in a way . . . and I respected her unrelenting push for perfection and her inability to accept the word 'no' . . . we became really good collaborators." About the collaboration on *The Lion King*, Don says: "I got involved before they even

officially hired a set designer—Julie had some basic ideas about the piece that I think informed all the other decisions. . . . When she pitched the piece [to Disney], she decided that she was going to tackle the hardest moments of the film—how to pull those moments off in the theatre—like the wildebeest stampede—and how to articulate Pride Rock. Those really informed the overall stylistic approach. . . . She had the courage and convictions to say: 'We want to keep the essence of what the story is and the characters, but we want to tell it in a completely different way and give the piece a completely new identity and a new life.'"

In terms of lighting, Don says: "She doesn't say 'This is what I want the lighting to be here and here and here'—you have to, as the designer, figure out what the overall shape of the piece will be and then be prepared for her reaction in the theatre—you have to make choices and be prepared to shape those and change them and be flexible because she tends to respond to what she sees."

Elaborating on the issue of collaboration, Don says: "Every director is a little different. . . . It's important that you come into the process with your own point of view about the piece—I think you need to know the script well enough that you have your own ideas about what the piece should or could be—and hopefully your ideas can inform the director's vision." In collaborating with scenic designers, Don notes: "Some scenic designers seek out your input early on and others don't at all. . . . If you don't protect the interest of the lighting in the overall approach, you can run into big difficulties. I think that the earlier you get involved, the better it is."

Don believes that he uses color in a spare, simple way: "I think as you get older, you get more comfortable with color but it's the most daunting. . . . The more I absorb the way light works in the world, a lot of questions get answered for me about how to use color." In terms of how he lays out a show, Don says: "What I first do . . . is figure out how I am going to carve out the space—in other words, create the light that separates the actor from the background—that gives a three-dimensional, sculptural context—create this living light in which the actors can exist. And that, to me, typically starts with side-light of some kind." Using *The Lion King* as an example, Don says, "*Lion King* is essentially a dance space—an open luminous box with luminescent cyc and legs that were intended to give the sense of an unending vista. . . . Dance is so integral to that space that it is essentially a dance light plot . . . it's so much about sunlight and about natural light. The systems of light, side-light in particular, are very much based on parallel construction—all the high side-light is very much in one angle."

In discussing light for a production style grounded in realism, Don says: "The light in nature, the rays of sunlight, are parallel. . . . To me, theatre is basically about humanity—it reflects the human condition—light is a subliminal, subconscious part of our world. . . . You need to put the play or the world in a context

DESIGNERS AT WORK (CONT.)

that [audiences] understand. . . . In order to understand how to interpret a moment through light, you have to understand how light functions in the world, and you have to start with that reference.”

Don offers the following wisdom to a person wanting a career in lighting: “The first thing I should say in terms of advice [is that] I think all this technology that we are being exposed to is [only] a means to an end—I think we can’t forget that what’s important is serving the piece, understanding the material, embracing the material, and being part of the overall vision. . . . All the technology out there is part of an ever-expanding palette, but you should not focus on that—that stuff you can always learn. My point is that, as a growing designer, you should learn about how to read a

play—learn how you fit into the rest of the world—read a newspaper every day—go to museums—become a fully rounded, fully informed member of society—understand history, understand art, understand literature. That’s infinitely more important than learning all the attributes of a moving light. [Young designers] should be getting a liberal arts education.” Don believes that there is no single path to follow when breaking into the business: “The important thing is to believe in yourself, work hard, be passionate about what you do, and never settle for second best—always do your best and realize that it’s a long, hard road. . . . It has to be the most important thing for you in your life—if it isn’t, then maybe you should consider what else would make you happy.”

require a rigid portfolio review. In New York, lighting-design applicants also complete a 45-minute practical exercise, which replaces the former 8-hour practical exam in testing the basic skills and concepts required of a lighting designer. Further information can be found on the USA website at www.usa829.org.

Membership in the union is often the first major hurdle faced by a young designer looking to work professionally. The portfolio-review and/or interview process is designed to eliminate individuals who the committee judge to be underqualified for membership in terms of the everyday skills and techniques required of professionals working in the commercial entertainment industry.

When working under a United Scenic Artists contract, a designer must receive a minimum fee. Established designers may ask for and often get a great deal more than this minimum. For example, a well-known designer may receive, in addition to a straight fee, a royalty based on a percentage of the gross receipts.

Equipment in the Broadway Theatre

Uniquely, the commercial theatres commonly referred to as “Broadway houses” have no lighting equipment of their own. There may be a dimmer for the house lights and wiring in conduit from backstage to front-of-house positions. A high-amperage company switch providing power for dimmers will be found close to the stage area. Everything else must be rented for the show: fixtures and their accessories, all control equipment and cable, dimmers and plugging boxes, cable sufficient to connect all fixtures to the dimmers, booms for offstage fixtures, work lights, and all special rigging supplies.

Equipment Rental and Shop Orders Because all expenses related to the production must be approved by the producer or business manager, the lighting designer must work within the figures that either has in mind. The normal rental contract calls for a payment of 10 percent of the value of the equipment for the first three weeks of the rental (e.g., an ellipsoidal reflector spotlight that costs \$400 rents for \$40 for the first three weeks). A lower percentage is charged for the next three weeks, and rental is further reduced for the remainder of the run of the production. Most producers ask for competitive bids from the few companies that rent lighting equipment for the stage. Others have a favorite rental house and always work with this same company. A producer may depend on the lighting designer to recommend a firm. The major rental and

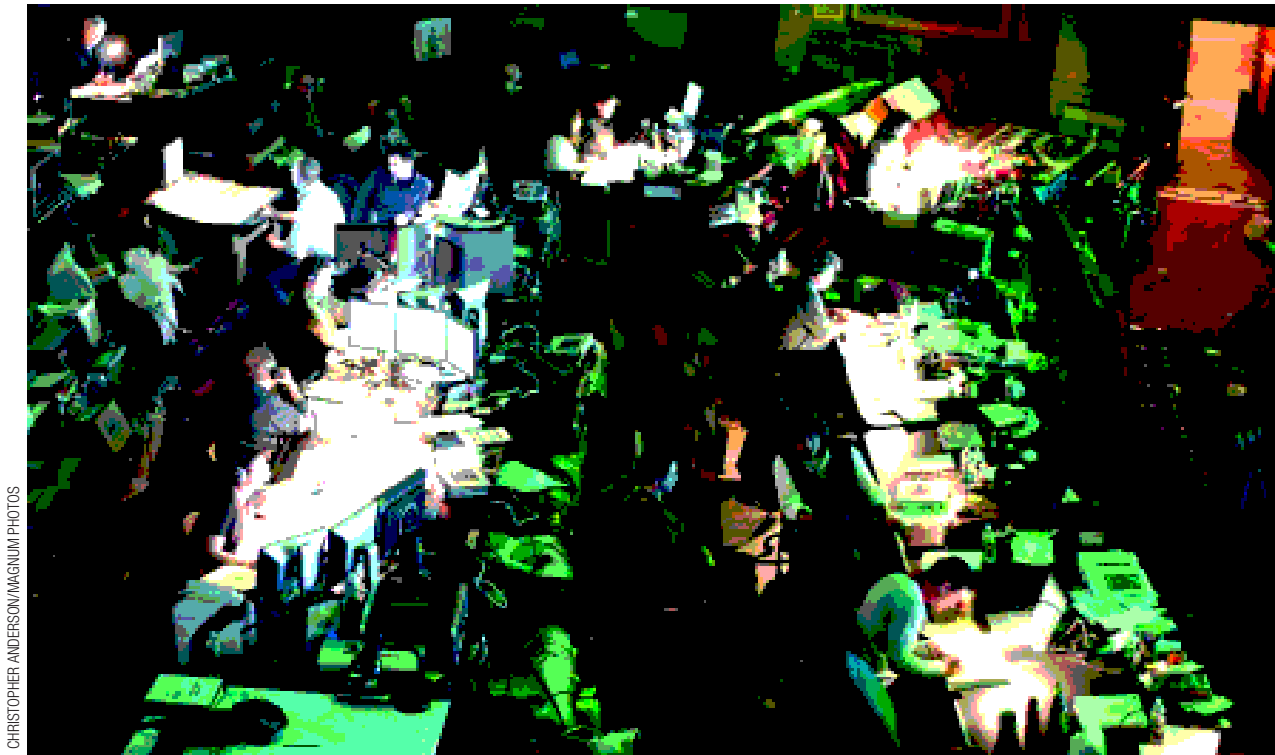
COURTESY OF SPIDER-MAN TURN OFF THE DARK/PHOTO BY JACOB COHL



COURTESY OF SPIDER-MAN TURN OFF THE DARK/PHOTO BY JACOB COHL



25-1 *Spider-Man: Turn Off the Dark*. Lighting by Donald Holder Music and lyrics by Bono and The Edge; book by Glen Berger, Roberto Aguirre-Sacasa, and Julie Taymor. Directed by Philip Wm. McKinley; scenery, George Tsypin; costumes, Eiko Ishioka; projections, Kyle Cooper.



CHRISTOPHER ANDERSON/MAGNUM PHOTOS

25-2 Production Tech Tables for *Spider-Man: Turn Off the Dark* The vast array of tech tables for the technical rehearsals of *Spider-Man* at the Foxwoods Theatre on Broadway.

supply houses in the New York area are PRG (Production Resource Group), 4wall Entertainment (Monachie, NJ), and SLD Lighting.

Even if the producer does not require competitive bids, the rental house must provide a cost estimate based on the equipment list called the *shop order*. This paperwork is generated by one of the various software programs as soon as the light plot is completed. It lists every piece of rental equipment in specific detail. It also specifies all necessary “perishables” (materials that will be used up and, therefore, must be purchased by the production), such as tape and tie-line (Figure 25-3).

After a bid is approved, the shop requires at least a week to gather and prepare the equipment necessary for a Broadway show. For a large show with specialized equipment such as projectors or unique light sources, much more lead time is needed. For this reason, the Broadway lighting designer must complete the plot several weeks earlier than a designer working primarily with in-house equipment.

The Light Plot

One of the challenges of designing on Broadway is that the designer may be able to see little, if any, rehearsal. The plot may need to be done before rehearsals even begin in order to allow time for bids and shop orders. However, the benefit of having free choice of fixtures and control is a Broadway design perk. Figures 25-5 and 25-6 on the following pages show the front-of-house and onstage light plots for the Broadway production of *Radio Golf* by August Wilson with lighting designed by Donald Holder (Figure 25-4). Figure 25-7 is the section and Figure 25-8 is the magic sheet for this production. The Cort Theatre is a medium-sized Broadway house seating 1,085 with a mezzanine and one balcony. Note that the first six electrics overstage have a rather high trim (31 and 36 feet) and are hung on walkable trusses for ease of focus and maintenance.



SARA KRULWICH/THE NEW YORK TIMES/REDUX

25-4 Radio Golf on Broadway *Radio Golf* by August Wilson on Broadway at the Cort Theatre. Produced by Jujamcyn Theatres, Margo Lion, Jeffrey Richards/Jerry Frankel, Tamara Tunie/Wendell Pierce, Feran Kirmser, Bunting Management Group, Georgia Frontiere/Open Pictures, Lauren Doll/Steven Greil and the August Wilson Group, and Wonder City Inc./Townsend Teague in association with Jack Viertel and Gordon Davidson. Directed by Kenny Leon; scenery, David Gallo; costumes, Susan Hilferty; lighting, Donald Holder.

Hiring Electricians

Even more significant than equipment rental costs are the wages paid to the electricians who set up and run the show. In New York and many commercial theatres elsewhere, these people must be members of the **International Alliance of Theatrical Stage Employees Union** (IATSE), commonly called the **IA**. Member electricians receive a substantial hourly wage, so prudent use of their time is imperative. The designer must understand and adhere to stringent regulations concerning working hours and conditions, which may vary from one local union to another.

Every large city across the country has its own IA local. The **union business agent** is the union's representative to the public. This individual negotiates labor needs with a producer and subsequently fills the crew call. Often one member of the crew is designated "union representative." This person is responsible for seeing that the rules and regulations of the union are followed and must report any violations to the business agent.

The electrician who works most closely with the designer is the **production electrician**. Hired by the show's producer, this person, who may or may not be a union member, works with the rental house and acts as a liaison between the producers and the IA union. Obviously, the choice of who will serve as production electrician matters a great deal to the lighting designer.

The Production Period

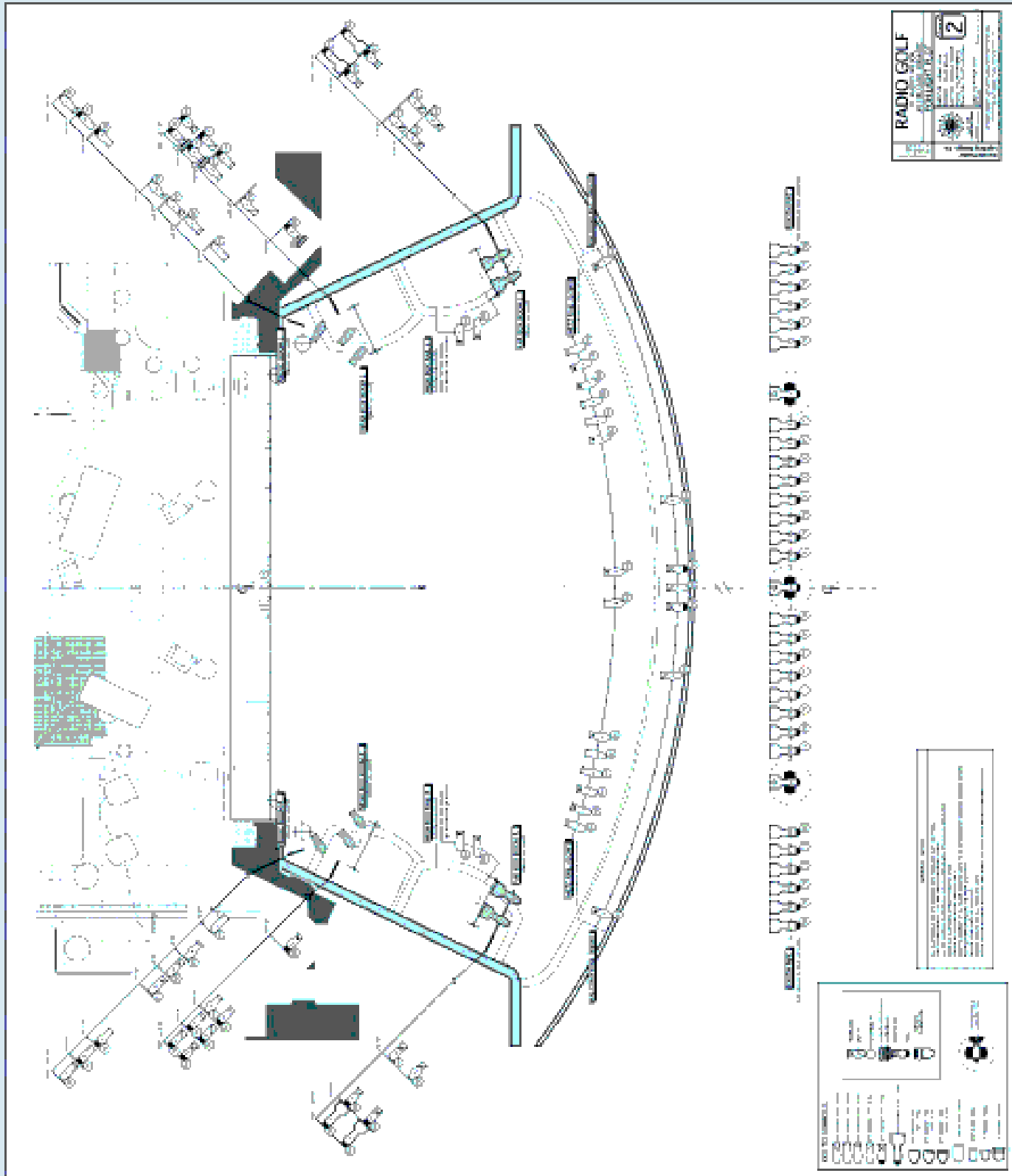
The biggest difference between designing for Broadway and elsewhere is *time*. Exciting, dramatic lighting such as that by Donald Holder for *Movin' Out* (Figure 14-12b) and Ken Billington for *Chicago* (Figure 25-9) requires extensive preparation and a lot of work—yet time available for the design period and production in the Broadway theatre is so compressed that only the best designers can survive. The familiar adage that "time is money" has never been more appropriate than when a designer is in the theatre with an IA crew. This is when superb preparation and an excellent production electrician really pay off. Figure 25-10 is a photograph of the load-in for *High Fidelity* at the Colonial Theatre in Boston; lighting by Ken Billington.

International Alliance of Theatrical Stage Employees Union (IA) The union representing stagehands and electricians.

union business agent A union's representative to the public; negotiates contracts and fills labor needs.

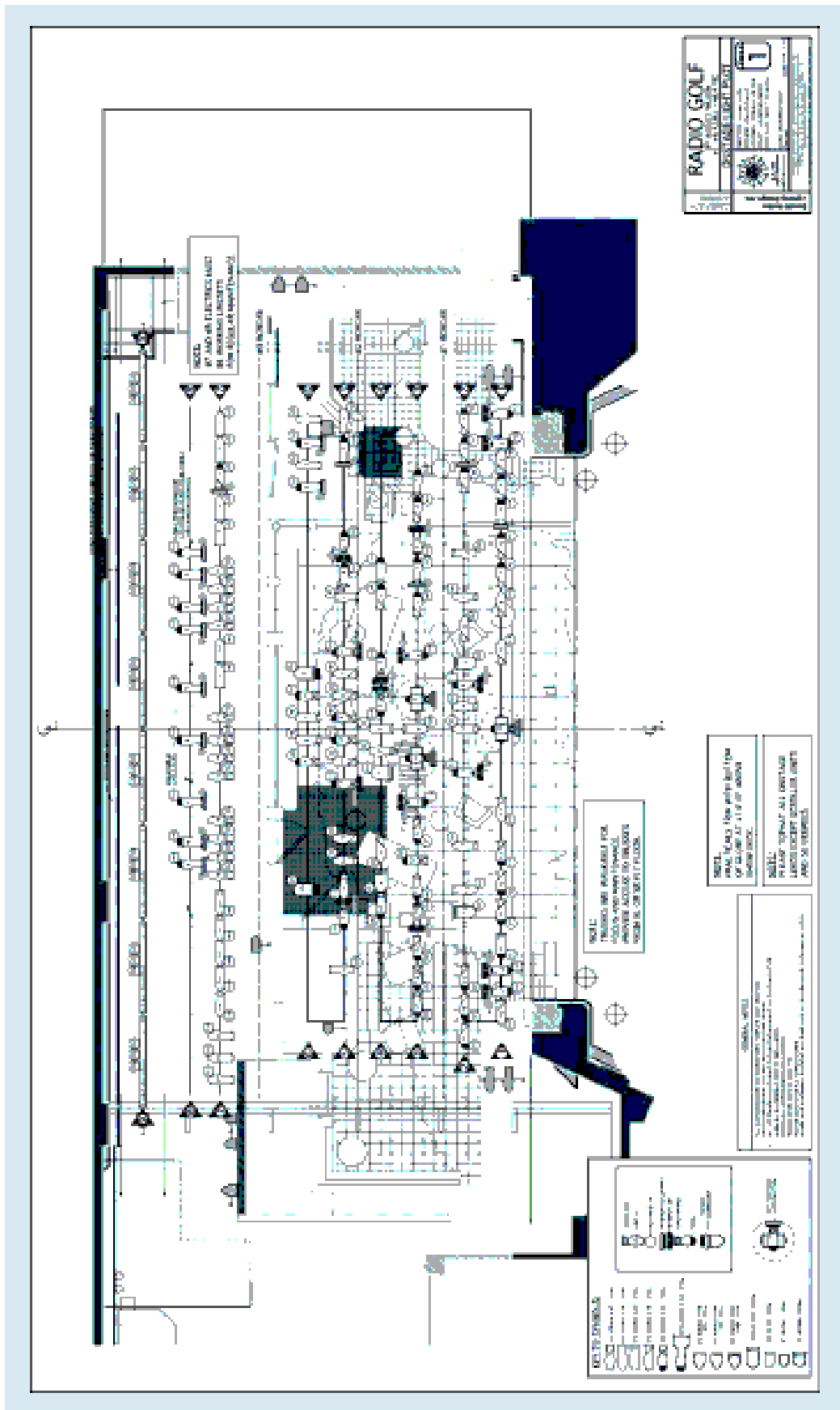
production electrician The electrician in charge and who works most closely with the designer.

COURTESY DONALD HOLDER

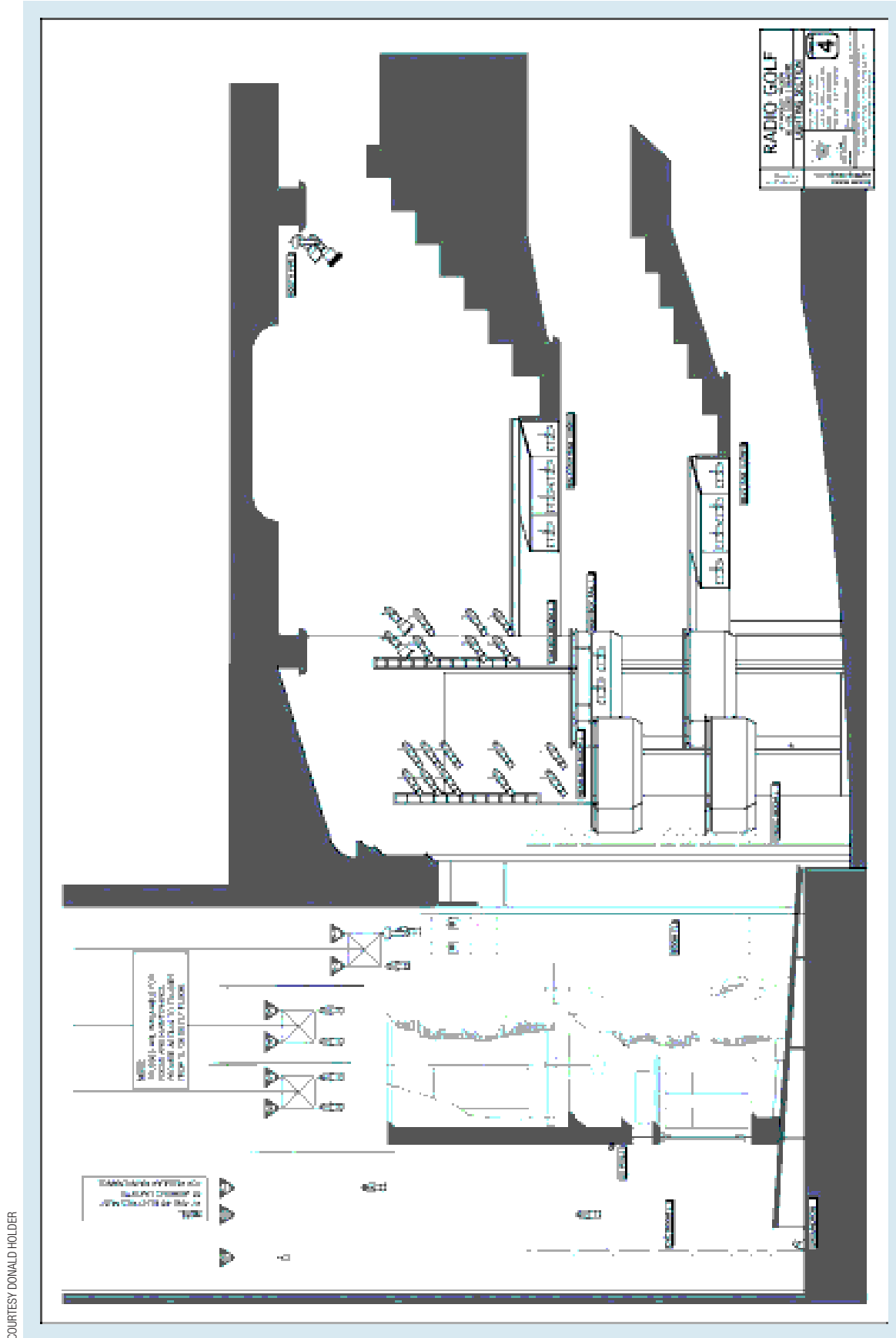


25-5 Radio Golf Front-of-House Light Plot The front-of-house plot for the Broadway production of August Wilson’s *Radio Golf*, designed by Donald Holder.

25-6 Radio Golf Overstage Light Plot The overstage plot for the Broadway production of August Wilson's *Radio Golf*, designed by Donald Holder.

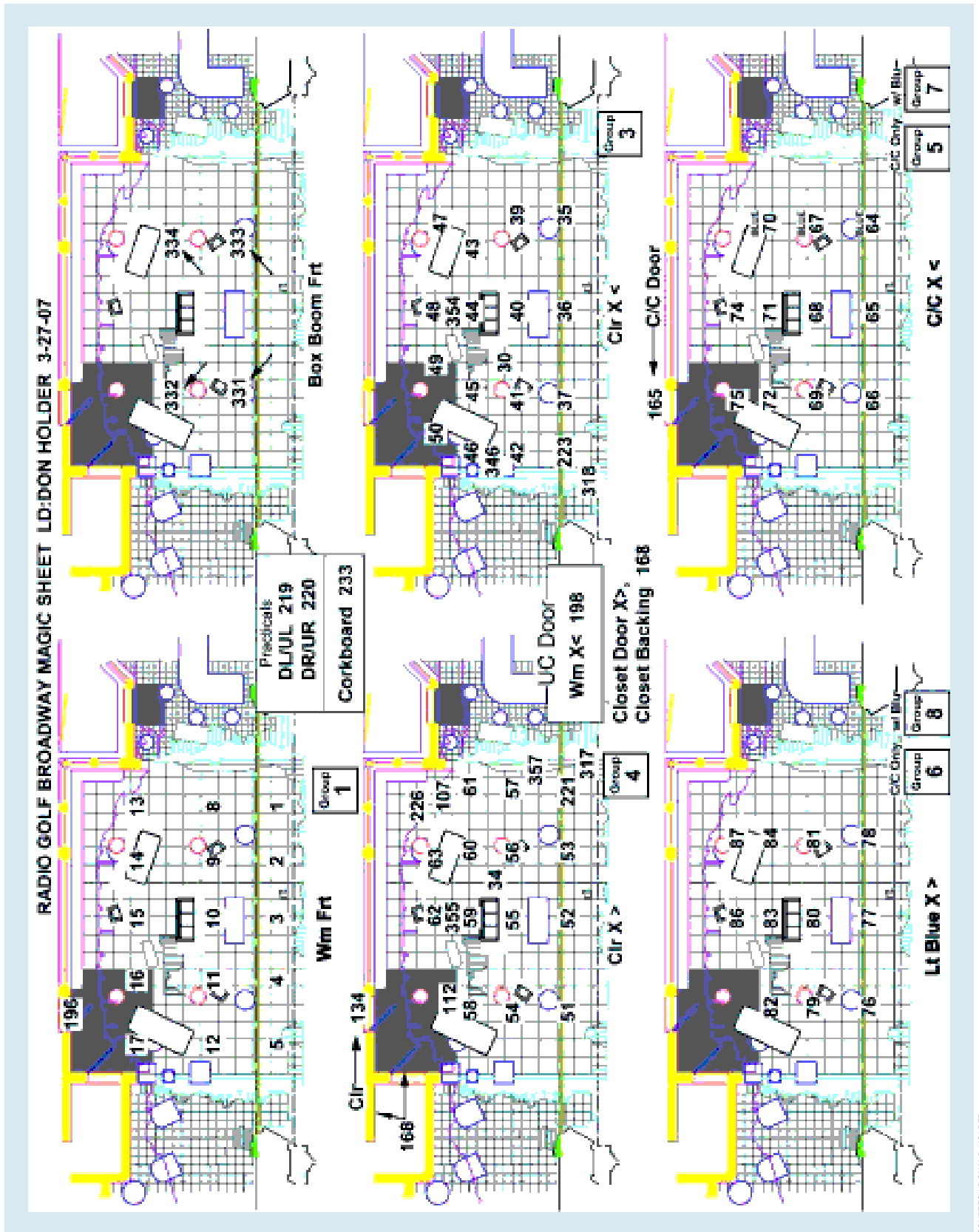


COURTESY DONALD HOLDER



COURTESY DONALD HOLDER

25-7 Radio Golf Lighting Section The section for the Broadway production of August Wilson's *Radio Golf*, designed by Donald Holder.



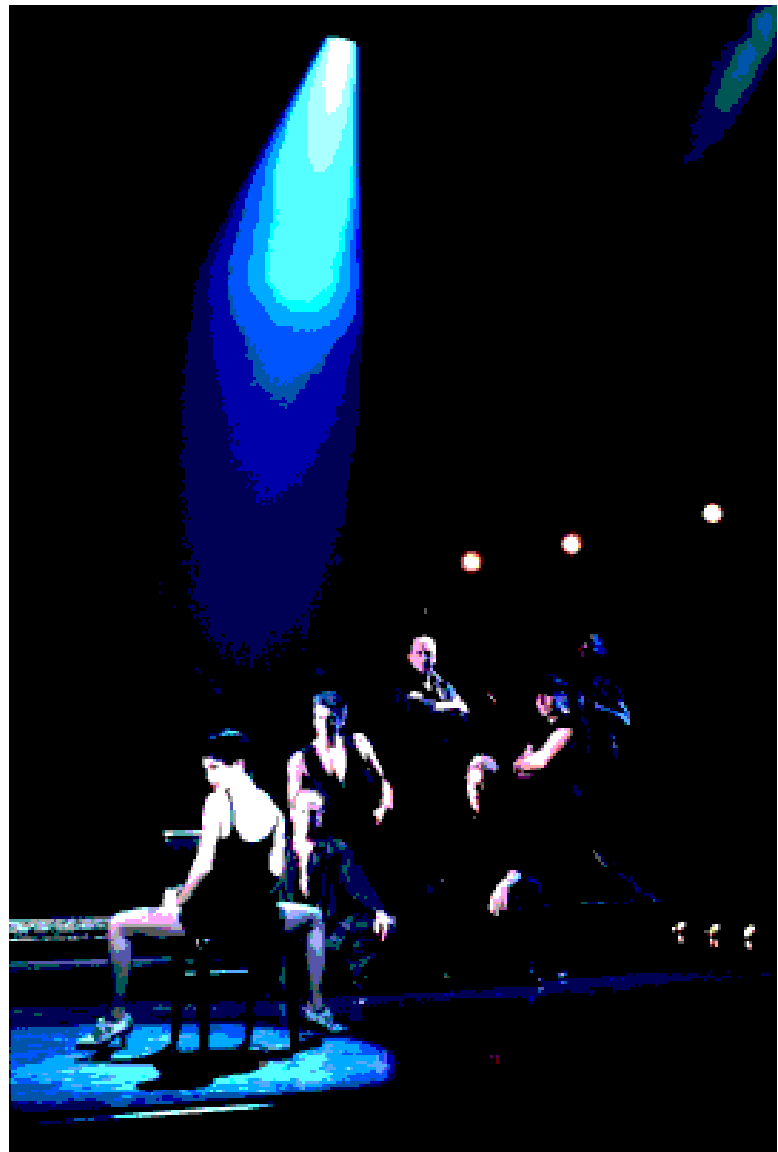
25-8 Radio Golf Magic Sheet The magic sheet for the Broadway production of August Wilson's *Radio Golf*, designed by Donald Holder.

COURTESY DONALD HOLDER

25-9 Broadway Lighting by Ken Billington Two photographs from the New York production of *Chicago* at the Shubert Theatre. Produced by Barry and Fran Weissler in association with Kardana Productions, Inc. Directed by Walter Bobbie; choreography, Ann Reinking; scenery, John Lee Beatty; costumes, William Ivey Long; lighting, Ken Billington.



COURTESY KEN BILLINGTON



COURTESY KEN BILLINGTON



PHOTO BY RALPH LARMAN, COURTESY KEN BILLINGTON

25-10 High Fidelity Load-In Lighting load-in for *High Fidelity* as seen from the balcony of the Colonial Theatre in Boston. Lighting designed by Ken Billington.

It should be expected that focus conditions will not be ideal. At best, a sound check will be going on simultaneously. At worst, carpenters will still be rigging scenery under a blaze of work light. The job must be done quickly to avoid overtime wages for the electricians on the work call. It must also be done absolutely correctly. A subsequent labor call to adjust focus means a ladder crew of four people, each hired for the union minimum of four hours.

According to union regulations, under no circumstances whatsoever may the lighting designer or an assistant handle any lighting equipment—one of the union electricians must be requested to do so. This applies even to such innocent actions as handing a wrench to its owner or steadying a ladder on which an electrician is working.

Moving the Show

The Broadway designer, more than any other, must know how to design a production for more than one space. Often a production premieres at one of the nation's regional theatres with the intent of then going to Broadway. Nearly all successful Broadway shows tour at some point after they have opened in New York. The lighting designer thus needs to be proficient at designing for more than a single theatre.

There are two types of Broadway tours. One is called a **national tour**, which plays for many weeks in a single large city. The second, the **bus-and-truck tour**, jumps from city to city, often playing a week but sometimes playing only one-night stands in each location.

National Tours A national tour settles into a major city. The actors get apartments, the IA crew is contracted for a long run, and the load-in period is at least several days.

national tour A tour that plays for a long run in a single city.

bus-and-truck tour A tour that plays short runs in numerous cities.

A light plot is usually designed for the specific theatre being used. The lighting designer normally attends technical and dress rehearsals, setting the look of the production before its run begins.

Bus-and-Truck Tours The light plot for a bus-and-truck tour must be designed to accommodate different types and sizes of theatres. Such a production inevitably carries less equipment than the Broadway plot specified. In response to time constraints, designers have developed various techniques to make setting up and focusing as easy as possible. The number of fixtures might be reduced and their type simplified. Lengths of pipe or track with fixtures already attached might be carried on the truck. Focus charts such as the one for the Broadway production of *Teddy & Alice* (Figure 25-11), as well as other time-saving devices, have been invented by designers and electricians who frequent the road.

Focus Charts A *focus chart* is a piece of lighting paperwork intended to record exact focus information for each lighting fixture in use by the touring production. It indicates exact focus location, usually using a grid method of notation. It also specifies shutter cuts and beam edge focus. Figure 25-11c is a sample page from the focus chart for the tour of *The Who's Tommy*; lighting by the late Chris Parry.

The Road Electrician If the designer is fortunate, an experienced head electrician will be assigned to the bus-and-truck production. This **road electrician** travels with the production and, along with the production stage manager, is responsible for making sure that the lighting is faithfully reproduced. Early consultation between the designer and the road electrician concerning equipment and methods of working can greatly enhance a production's success.

The designer must periodically drop in and check on a production during its run. If the lighting has slipped a bit from what was originally set, adjustments must be made.

road electrician An electrician for a bus-and-truck tour.

Designing for Regional Theatre

The middle years of the twentieth century will be remembered for the rebirth throughout the country of professional theatre, too long confined to New York and a few other large centers. Now it is a rare city that does not have at least one repertory or stock theatre, run by professional producers and directors and employing professional actors and designers.

Working in Regional Theatre

Nearly all regional theatres (called **LORT houses**, after the type of union contract issued to the actors) run apprentice programs, which seldom pay much but offer exceptional experience and valuable professional contacts. **Theatre Communications Group (TCG)** publishes a complete list of theatres and programs (www.tcg.org).

An enormous amount of exciting production is going on in regional theatre, using both national and local designers (Figure 25-12). More and more college students and graduates are working in these theatres on a full- or part-time basis. Opportunities abound for learning and making valuable contacts. The chances of assisting a designer or working on the staff are good for the talented and devoted theatre student. The first thing to do is send a résumé to either the production manager or artistic director of the theatre. Then telephone and request an interview—it is that simple. Do not be discouraged if you are turned down and seemingly ignored. These individuals are extremely busy, but you will get results if you are persistent. The following section provides an overview of lighting practices in this segment of the commercial theatre.

LORT houses Professional regional theatres; *LORT* stands for *League of Regional Theatres*.

Theatre Communications Group (TCG) A national service organization dedicated to assisting the not-for-profit theatre; publishers of *American Theatre* magazine and *ArtSEARCH*.

FOCUS CHART FOR: TEDDY AND ALICE

KEY TO ABBREVIATIONS

O.O.H. = Out of House
 O.O.P. = Off of Proscenium
 Off Prosc. = "
 H.H. = Head High (To Fingers with Hand Held Above Head)
 S.E. = Stage Edge
 A.A. = As Above (Same cuts as previous lamp)
 Δ = Angle Shutter
 L = Stage Left
 R = Stage Right
 @ = At
 F or FLD = Flood Focus for Fresnels
 SP = Spot Focus for Fresnels
 † SP = Lamp is † way from Full Spot in a Fresnel
 H = Hard Edge or Sharp in terms of focus of Leks
 S = Soft Edge or "Fuzzy" * * * * *
 M = Medium Edge
 CL = Center Line
 O.F. = OFF FEET

a

FOCUS CHART FOR: TEDDY & ALICE
 POSITION: UPPER BOX BOOM RIGHT.

CH/UNIT	PLUGGED BY	FOCUS	F	TYPE	COLOR	
11/1	0-2- -UBL: 7-8	D.L. SL OFF RENTAL SR -	* +4 @ 12L	S	6" x 16" IL LECO	02
11/2	0-1- UBL 7-8	D.L. SL Δ.A. SR -	* +4 @ 12L	S	11	35A
12/3	0-4- UBL 3-4	D.L @ L SL OFF RENTAL SR -	* +4 @ 4L	S	11	02
12/4	0-3- UBL 3-4	D.L @ L SL Δ.A. SR -	* +4 @ 4L	S	11	35A
13/5	-6- UBL 5-6	D.R @ L SL OFF (DOWN) SR -	* +4 @ 4R	S	11	02
13/6	0-5- UBL 5-6	D.R @ L SL Δ.A. SR -	* +4 @ 4R	S	11	35A
14/7	0-8- UBL 1-2	D.R. SL - SR O.O.P.	* +4 @ 12R	S	11	02
14/8	0-7- UBL 1-2	D.R. SL - SR O.O.P.	* +4 @ 12R	S	11	35A
78/9	10-11-12	(T) HOUSE FRONT SL O.O.P. SR -	* LEFT US OFF HANGER DS OFF FOOT	M S	11 T+S	CHA #240 REAR
78/10	9-11-12	(T) HOUSE FRONT SL - SR -	* SL OF CL US CLIPS HANGER DS O.F.	M S	11 T+S	4
7/11	9-10-12	(T) HOUSE FRONT SL O.O.P. SR -	* LEFT US OFF HANGER DS O.F.	M S	11 T+S	02 #244 LEAKS
79/12	9-10-11	(T) HOUSE FRONT SL - SR -	* SL OF CL US CLIPS HANGER DS O.F.	M S	11 T+S	11

POSITION & NO. UPPER BOX BOOM RIGHT
 PAGE NO. 1 OF 36

b

TOMMY - PINBALL "A" FOCUS CHARTS Page 1

Designer: Chris Parry
 Associate: David Grill
 PINBALL - FINAL CUT VERSION

Producer: ATP / Dodger / Pace
 Head Electrician: Steve Cooksey

Note: Asterisks indicate Replug Channels

Unit	Purpose	Type	Watts	Color	Dim	Chn
1	Door Frts	6x16	1kw	L201	79	(314)
	US	SR	Sf . . . Hd			
	DS	SL	Sp . . . Fl			
	TP	BT	Axis:			
2	Door Frts	6x16	1kw	L201	79	(314)
	US	SR	Sf . . . Hd			
	DS	SL	Sp . . . Fl			
	TP	BT	Axis:			
4	Frts CL	6x16	1kw	L203+R119	81	(6)
	US	SR	Sf . . . Hd			
	DS	SL	Sp . . . Fl			
	TP	BT	Axis:			
6	Frts CLC	6x16	1kw	L203+R119	83	(7)
	US	SR	Sf . . . Hd			
	DS	SL	Sp . . . Fl			
	TP	BT	Axis:			
7	Conductor	6x16	1kw	N/C	84	(3)
	US	SR	Sf . . . Hd			
	DS	SL	Sp . . . Fl			
	TP	BT	Axis:			

(continued on next page)

c

25-11 Focus Charts

- a Key to the focus chart for *Teddy & Alice*, designed by Tharon Musser.
- b Focus chart for *Teddy & Alice*.
- c Focus chart for *Tommy*. It was generated with a Lightwright® program.

a & b COURTESY THARON MUSSER
 c COURTESY THE ESTATE OF CHRIS PARRY

25-12 Regional Theatre Production

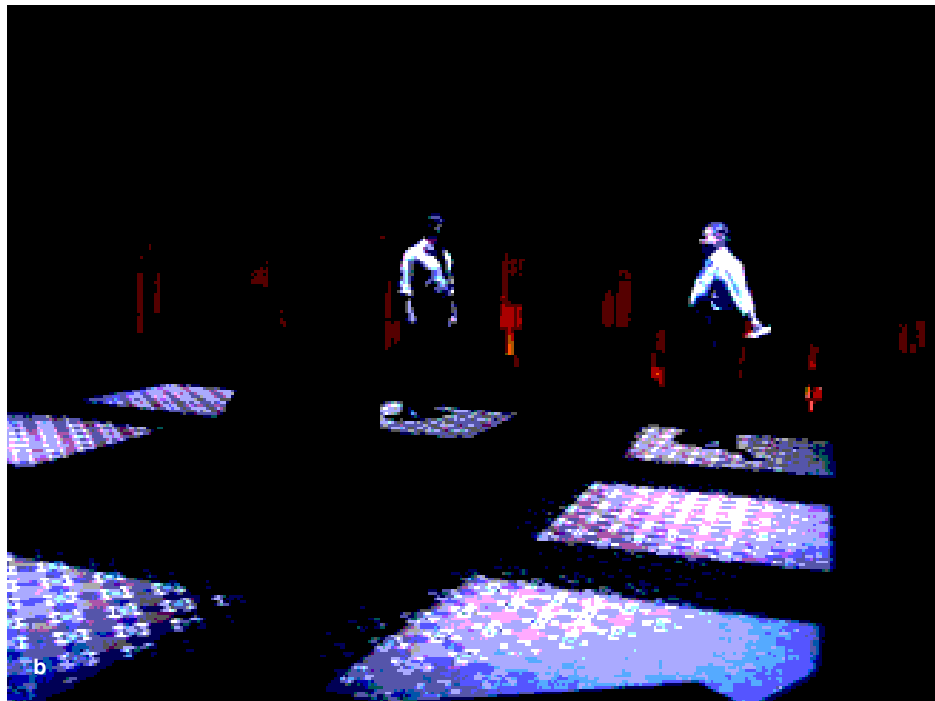
Death of a Salesman at Madison Repertory Theatre in Madison, Wisconsin. Directed by Richard Corley; scenery, Brian Bembridge; costumes, Sarah Reemer; lighting, Ann Archbold.

- a** Act I: Ben's first appearance; Charlie and Willie playing cards.
b Act II: Biff and Willie in the garden.

COURTESY ANN ARCHBOLD



COURTESY ANN ARCHBOLD



Regional Theatre Production

Many of the professional practices that apply to lighting design on Broadway are also standard for the country's regional theatres. However, accepted practice among the regional theatres also varies a great deal. Production schemes, ranging from repertory to stock, strongly influence how a lighting designer approaches his or her work. Work forces vary, with local IA union rules and regulations changing from city to city. Each theatre has its own in-house equipment, which may be radically different from one to the next. Budgets, technical production practices, and staffing are unique to each situation.

DESIGNERS AT WORK ■ York Kennedy



COURTESY KEVIN BERNIE

York Kennedy is a well-established regional lighting designer with his home base in Berkeley, California. The bulk of York's professional design work is in the areas of theatre and architecture. Among his many theatre credits are designs for San Francisco's

ACT (American Conservatory Theatre), The Old Globe Theatre in San Diego, South Coast Rep., The Alley Theatre, Dallas Theatre Center, Brooklyn Academy of Music, Berkeley Rep., the Goodspeed, and Seattle Rep (Figure 25-13). His architectural lighting credits include Landmark Plaza in San Francisco, Warner Bros. Movie World in Madrid, Misto Lino Retail Stores, LEGO Imagination Centers, and the Sendak Playspace in San Francisco's Sony Metreon. He has taught in several of this country's top theatre programs, is a long-time member of the United Scenic Artists, and is the recipient of numerous awards for his lighting designs.

York grew up in rural North Carolina with a family who appreciated the arts; his father was a high school drama teacher and his mother was a graphic artist. From a very young age, he was involved in theatrical production at his dad's school; he acted a bit, did technical work, and enjoyed being around theatre people. York began his college years at North Carolina School of the Arts but transferred to Cal Arts after his sophomore year. Having grown up in North Carolina, he wanted to expand his horizons, moving to California "to get exposure to as many forms of professional performance as possible: theatre, television, film, video design, concerts, and industrial design. I hadn't decided at that point whether to focus on theatre or work in some of the other areas. I wanted to 'open up' a little bit, I had been around the theatre my entire life." At Cal Arts, York discovered and fell in love with dance. He had been a musician during his high school years, and now he had found a wonderful art form that combined both music and movement with light. "I wanted to use my mind and work intellectually and visually in ways that heightened the movement. . . . I had been a musician and wanted to work with light in that kind of way. . . . I loved the collaborative, creative process. . . . I wanted to be designing and couldn't get enough of it."

After graduating, York moved to Los Angeles and was fortunate enough to be accepted as resident design assistant at the Mark Taper Forum. At the same time, he was designing for small Equity-waiver Houses in the greater Los Angeles area and working a bit in feature films. "I could drive well, so I would drive trucks for art directors. An art director would say 'go to Paramount, pick up these props, and bring them to the shoot.' That's how I survived." The resident assistant job at the Taper allowed York to work as an assistant to numerous well-known designers: "I started out assisting . . . extraordinary designers, and all incredibly different. . . . I loved being around creative, interesting people, I could never get enough of that." After working for a short time in Los Angeles, York joined

the designer's union, primarily to gain their health insurance benefit. Although working a good deal, York felt that his design process lacked the structure necessary to take it to a higher level: "I was an emotional thinker . . . expressive and dynamic, but it was chaos. . . . I needed to figure out how to harness all that energy—all of those ideas flying around in my head . . . so I became fascinated with structure." That led York to consider graduate school. Having earlier met Jennifer Tipton, he knew that she could teach him structure: "I never for a second regret spending that money or that time (on graduate school). I got what I wanted. . . . You've got to organize (light) and deliver it in ways that are meaningful and elegant and articulate. . . . It was all about learning how to read literature, break down a text, and tell a story in an articulate way with light . . . and learning how to collaborate with other designers."

After graduating from Yale, York spent a year in New York assisting and designing and learning more about the commercial theatre. He then moved back to California to work with Scott Feldsher, Robert Brill, and the people at San Diego's Sledgehammer Theatre. "It was life-changing—that was my company. I really wanted to work with them—I became their first resident lighting designer. It was a wonderful, small, and tight-knit group with a rich and exciting theatrical vocabulary. The company was loaded with incredibly bright people. We did a lot of new work—it was big and powerful and dynamic" (Figure 25-14). After a time, York found himself on the road most of the year, working at the various regional theatres across the country, "doing what I had always dreamed of doing, but still barely paying the bills." He moved to San Francisco and shared a studio for a time with friend and fellow lighting designer Peter Maradudin, but he was still traveling a great deal. "I had to get off the road. . . . I needed a home. . . . I couldn't live as a Bohemian all the time, I really needed some kind of foundation." He then met his wife-to-be, Susie, and took a teaching job at San Francisco State. At the same time, York began to do more architectural work. He also continued to travel about the country designing at regional theatres. After two years, York faced the fact that he needed to work less. "It was insane . . . but all of our mentors worked that hard. . . . It was sort of the model; that you had to keep a lot of balls in the air to survive. There is a kind of self-destructive mania forced upon us by the system that we have built a career in—on time, on schedule, on budget, faster—more projects to be able to survive." It is very difficult, but to maintain a career, a lighting designer must strike a balance between work that is greatly rewarding but pays little and that which brings in sufficient money.

In discussing the creation of his firm, York observes that it is very difficult to work outside the theatre or on large theatrical projects without the support structure that a firm offers—particularly if the work is architectural. "You can do more large-scale work and center your personal work efforts in a more creative way if you've

(continued)



PHOTO BY KEN FRIEDMAN, COURTESY YORK KENNEDY



PHOTO BY JASON BIEBER, COURTESY YORK KENNEDY

25-13 Regional Theatre Lighting by York Kennedy

- a** Tennessee Williams' *A Streetcar Named Desire* at San Francisco's American Conservatory Theatre. Directed by Richard Seyd; scenery, John Iacovelli; costumes, Ann Bruice.
- b** Shakespeare's *A Midsummer Night's Dream* at The Old Globe Theatre. Directed by Darko Tresnjak; scenery, Ralph Funicello; costumes, Paloma Young.



COURTESY YORK KENNEDY

25-14 Lighting by York Kennedy
A production of *Terminal Hip* at
Sledgehammer Theatre in San Diego;
Scott Feldsher, artistic director.

DESIGNERS AT WORK (CONT.)

got people backing you up. . . . Breaking down plays, talking with directors, pursuing new directors and projects, doing research on projects—that’s where my time should be spent and not in all the drafting.” He goes on to say: “I’ve kept it (my office) very small, intentionally so, in order to allow myself dexterity and flexibility in my career. . . . The trick is you can do bigger projects if you build the size of your firm . . . but at some point you become just a marketing machine and a business manager and no longer an artist and designer. It really is about being honest with yourself about what kind of work you want to be doing and what it will take to achieve that.”

When asked about his approach to a design, York says, “I really make sure I am asking strong, interesting, deep questions about every project I work on. . . . Those questions change depending on the circumstances and the medium. . . . That’s what I do—ask those questions of myself—I want to really explore every project.” As a designer, “you have to do the period research for a play, you study the social and political context of the play—what kind of people they were—how they live. . . . If you ask all those questions, then you know what the story is—on what levels can the light work to support and tell the story?” Light can illustrate “not just the emotional tone of a space but helps to tell us what kind of reality we are in—are we in a sort of normal reality or are we in a psychological landscape?” York’s research often includes looking at paintings and listening to music of the period. In addition, when doing Shakespeare, he finds that listening to one of today’s readily available very good recordings is extremely valuable: “I find hearing the language, the spoken verse, helps the music and imagery of the text come to life.”

In discussing design process, York observes that all members of the collaborative team need to bring something to the table: “Everyone of us has, hopefully, wonderful windows of perception into the

work. . . . That’s what makes this work worth doing, it’s hearing what they have to say around that table—you learn—you’re stimulated. . . . Then I go back and I start putting together everyone else’s ideas with mine and digesting that—trying to figure out how ideas that I had before make sense within this now larger and deeper and richer context.” In discussing working with scenic designers, York says that he loves to discuss how the play can happen on the set: “We talk about how to tell the story on that set.” The beauty of collaboration is that “it’s a group vision that will then be edited by the director—you’ve got to have the director to lead and guide and then edit . . . to harness all of that creative energy between all those interesting people.” York believes that a lighting designer must be like a chameleon, needing to “be able to shift or adjust your ideas and point of view—your ‘color’—to the environment at hand.” A designer’s work must never be so precious as to inhibit the collaborative, creative process.

Commenting on the state of the art, York says “Using our current consoles, operators certainly seem to be able to control the moving lights with increasing ease, and it is so wonderful now to have all the flexibility of the LEDs. I just did a project in Grace Cathedral in San Francisco with Anna Deavere Smith. Almost the entire inventory was either a moving light or an LED fixture that could also move. It was thrilling how we could just make the entire space morph from one color field into another—worlds of color that halogen lamps and filters were never able to achieve” (Figure 25-15). In reference to moving lights, York emphasizes that “the price-point still has to keep coming down, so that they can be completely integrated into the regional theatre, where so much work is developed. It is not only the initial cost of the fixture, but the day-to-day, show-to-show, maintenance costs that are prohibitive.

(continued)

DESIGNERS AT WORK (CONT.)

When asked about assisting and breaking into the business, York states that he thinks assisting “is one of the greatest ways to learn.” He recommends that before attending graduate school young lighting designers spend several years working in the field “to make sure it’s where their passion really lies . . . versus just diving right into a [very expensive] graduate program.” To be successful, lighting designers “must have a great curiosity for research, for seeking out meaning and questioning circumstances. . . . I think you need to have a passion for music, art, and literature as well as a passion for architecture—that will help you in theatre. You need to be very organized. You need to be

excited about developing and organizing intellectual ideas . . . But, first and foremost, I think you have to be a passionate storyteller—someone who’s excited about telling stories onstage—passionate about live performance.” York concludes: “There’s a level of kindness and generosity. . . . It works with openness—it goes with humility. . . . You need to come to the table with a lot of ideas and spunk and yet humility. . . . You need to stay kind but strong.” Finally, “you must commit to the work, to those around you, and to yourself. The work will be strong if you are doing that. This art form is too fragile—there is no room for half-hearted efforts.”



COURTESY YORK KENNEDY, PHOTO BY SCOTT WALL

25-15 Use of LED Sources Rich and vibrant color created by LED sources for *On Grace* at San Francisco’s Grace Cathedral. Performed and created by Anna Deavere Smith. Lighting design by York Kennedy.

business manager Person in charge of budgeting and all other financial matters, often including fund raising.

artistic director Person responsible for play selection, hiring of artistic staff, and sometimes fund raising.

Regional Theatre Staff Most regional theatres are nonprofit organizations run by a board of directors. This is a group of community leaders who have an interest in the arts but may know little or nothing about the actual operation of a theatre. The theatre’s **business manager** and **artistic director** are hired by, and directly responsible to, this board of directors. Each theatre has a permanent staff, the makeup of which depends on the unique needs of the individual theatre. There will most likely be a **production manager** and department heads, including an **electrics department head**, or *house electrician*. This person’s duties include maintenance of house equipment and working with a production’s lighting designer. In addition, this individual has a strong voice in determining load-in and running crew size as well as local interpretation of union rules and regulations.

Regional Theatre Designers A few regional theatres have staff designers, but most hire designers on a show-by-show basis. The way a lighting designer is hired is similar to Broadway practice, with the theatre’s artistic director acting as the New York producer. Some regional theatres hire only designers who are United Scenic Artist members, whereas others pay no attention to union membership. Most theatres have a list of favorite designers, although a production’s director can greatly influence this decision as well.

Designing for Repertory Repertory theatres have a unique scheme of production in which different shows are presented each day of the week. Traditional **repertory production** generally requires daily changeovers from show to show. It may involve as few as two or as many as eight individual productions. The lighting designer must develop a

repertory plot that serves as a basis for all shows, adding special instrumentation for each individual production. Repertory design requires much more equipment than is normal for a single production, and the demands of an individual show must often be compromised for the sake of the entire production scheme. Color changers, which assist in achieving visual variety, are an excellent equipment investment for the repertory theatre. Equally valuable are automated fixtures, which provide the designer with tremendous flexibility in repertory production.

Summer repertory—of Shakespeare or other classics, historical reenactments, and popular fare, especially musicals—has become a tradition in the United States. Designing for repertory theatre is an extremely valuable experience for any developing lighting designer.

Designing for Stock The vast majority of regional theatres produce their shows in a **stock** arrangement, running each production continuously for two to six weeks (summer stock productions may run only one week). Such a scheme requires rapid changeovers from show to show and normally a new lighting design for each production. The stock designer must be able to work quickly and efficiently, remaining one step ahead of the production schedule at all times.

Those theatres that run shows for more than three weeks often hire in their lighting designers for each production. Those operations with shorter runs may very well employ a resident designer. Either way, the lighting designer is always under a great deal of time pressure. Like repertory production, stock experience is invaluable for the beginning lighting designer.

What to Expect Some regional theatres have a stagehand contract with the local IA union, and just as many others have no union labor affiliation. In essence, the regional designer should expect to find a new situation and new challenges in each place he or she designs.

Most cities have their own IA local. As noted earlier, rules and regulations vary radically from local to local, as does the quality of work. The expertise of any local can be known only through previous experience or by word of mouth. Well before a production is mounted, the designer should carefully evaluate the potential workforce in addition to local rule idiosyncrasies.

As regional theatres have spread across the country, stage-lighting rental houses have grown in number as well. Some of these local businesses are surprisingly efficient and well-stocked. Others are woefully ill-equipped and lacking in knowledgeable personnel. The designer must anticipate the possibility of having to go to New York or some other major center for equipment needs, a situation that will surely affect budget and time considerations.

More important than commercial usage is the matter of professional standards. Designers should never consider going into any level of commercial theatre unless they plan to devote their total energy and ability to the routines and the problems that arise. Regional theatre is no place for the casual enthusiast or the dilettante, nor for the easily discouraged, the supersensitive, or the uncooperative.

Lighting for Opera

Lighting for the opera calls for a heightened theatricality, often combining techniques of theatre and dance. Traditional operatic scenery suggests reality but does so on a grand scale. Modern opera design often uses exaggerated techniques that suggest reality in a distorted manner, reminiscent of expressionism. Lighting may follow suit with saturated colors to produce a heightened sense of reality. Exaggerated angles and harsh colors may be used to produce stark images. Follow spots are frequently called for in opera production to separate lead singers from scenery and chorus.

Figure 25-16 shows photographs of the Opera Columbus production of Bertolt Brecht's *The Threepenny Opera*, composed by Kurt Weill. Figure 25-17 is the light plot for the production designed by Cindy Limauro. The theatre is Mershon Auditorium which seats 2,500 people with a proscenium opening 25 feet high and 54 feet wide and a single balcony. Figure 25-18 is the magic sheet for the production, and Figure 25-19 is a part of the designer's hookup.

production manager Person in charge of the day-to-day operation of the theatre and overseeing all production matters; often hires staff and works closely with the artistic director and business manager.

electrics department head Person in charge of all electrics and sometimes sound operations of the theatre; may be an IA union position; also called *house electrician*.

repertory production The process of presenting a different show each night, with the number depending on the size of the repertory.

stock production The process of running a single show for several weeks.

25-16 Opera Lighting by Cindy

Limauro The Opera Columbus production of *The Threepenny Opera* by Bertolt Brecht, music by Kurt Weill. Directed by Bill Fabris; scenery, Ken MacDonald; costumes, Christine Jordan.

- a** Act I, Scene 2: “Love Song” with Polly and Macheath.
- b** Act II, Scene 6: “Second Threepenny Finale” with full company.



PHOTO BY MATTHEW HAZARD; COURTESY CINDY LIMAURO

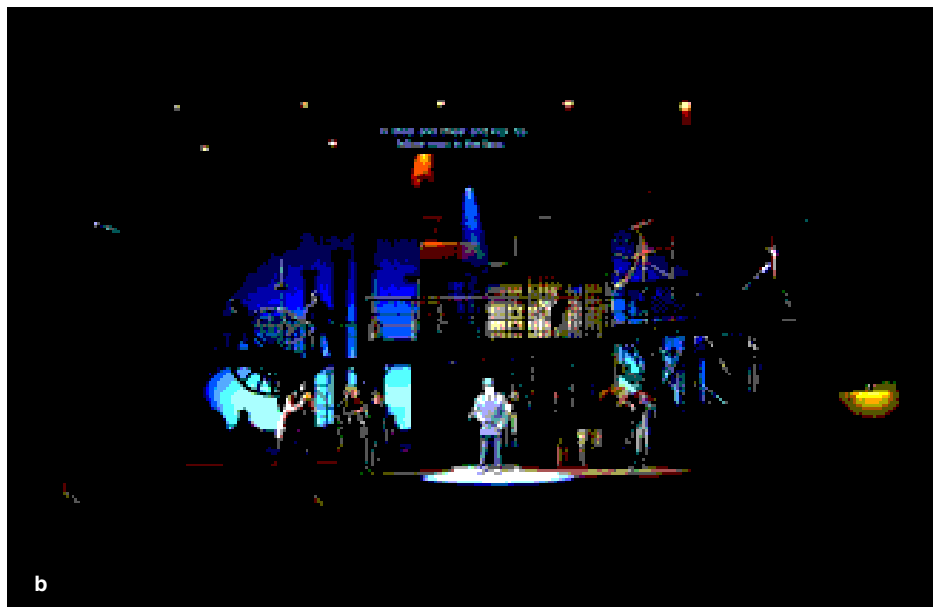
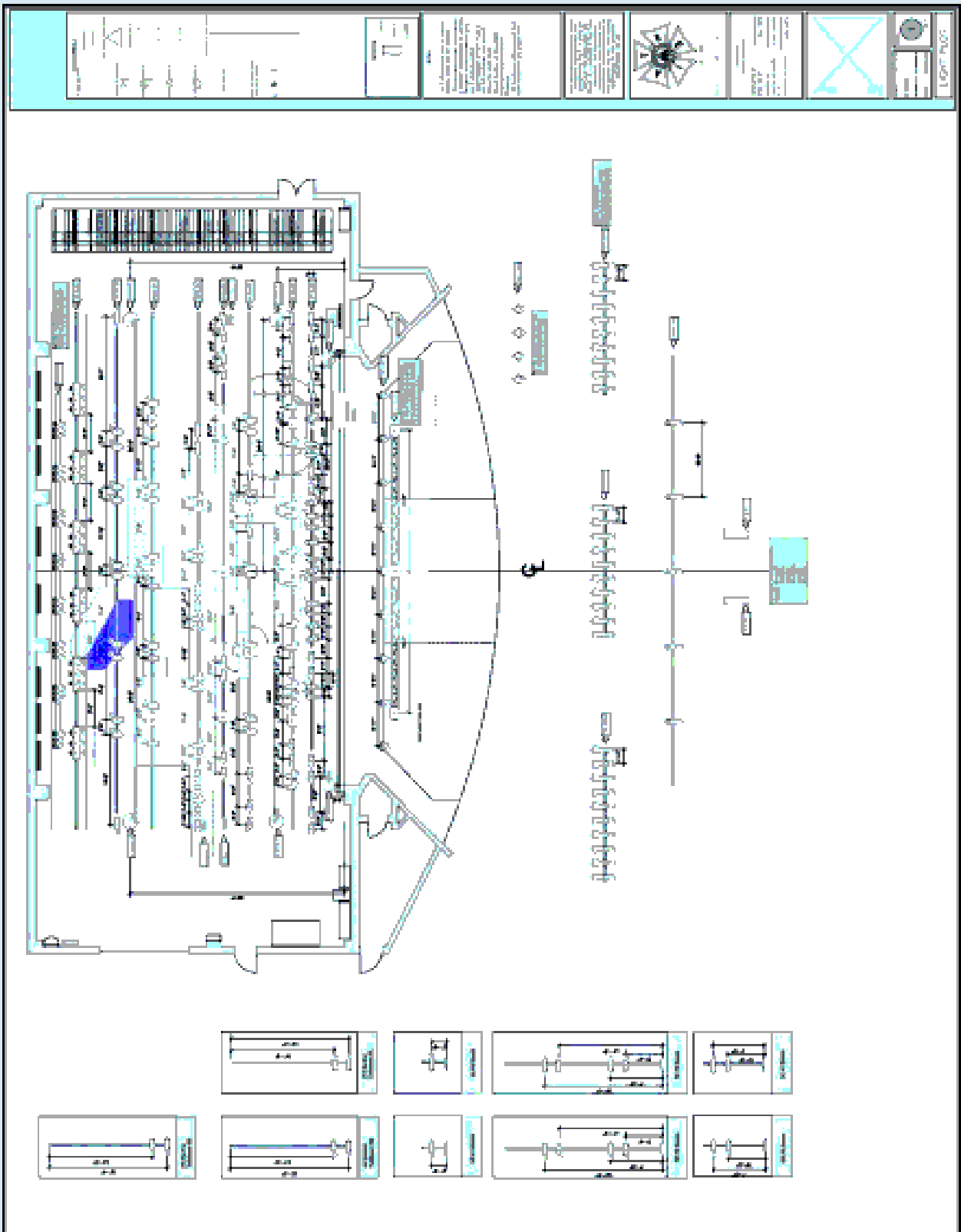


PHOTO BY MATTHEW HAZARD; COURTESY CINDY LIMAURO

Often referred to as a play with music, *The Threepenny Opera* was adapted by Brecht from John Gay’s *Beggar’s Opera*. Considered by many to have revolutionized the operatic form, *The Threepenny Opera* combines Brecht’s political wit with Kurt Weill’s music, reminiscent of 1920s Berlin dance bands and cabaret. The opera has three acts and several locations including the Peachum shop, a stable, a brothel, and the jail cell where Macheath ends up.

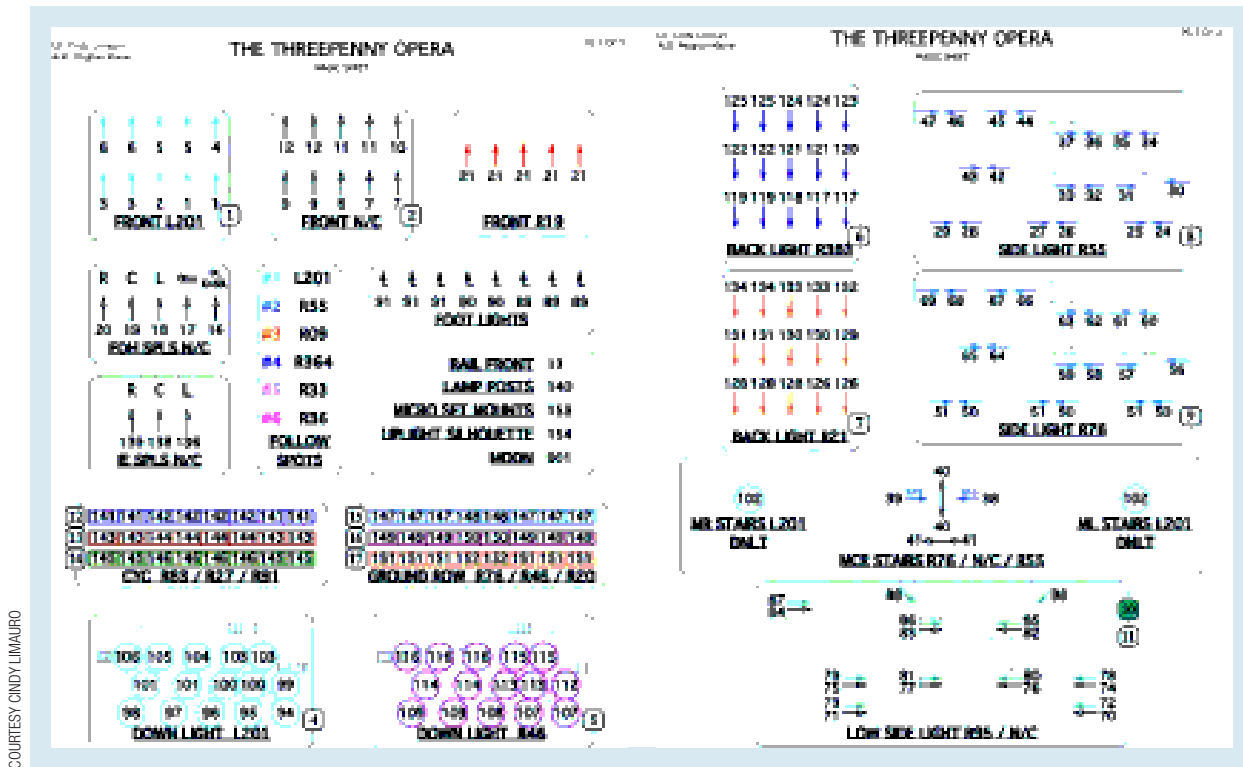
Lighting designer Cindy Limauro writes the following concerning the Opera Columbus production:

The inspiration for this production was German cabarets from the 1930s. The lighting is harsh, ranging from stark white and bleak to saturated color . . . Footlights and steep angles were used to accentuate the seedier side of life while low angles brought out the sculptural qualities. A hard-edged follow spot created isolation for individual characters singing about their situation.



25-17 Opera Light Plot The light plot for a production of *The Threepenny Opera*, produced by Opera Columbus. Lighting by Cindy Limauro.

COURTESY CINDY LIMAURO



COURTESY CINDY LIMAURO

25-18 *The Threepenny Opera* Magic Sheet The lighting magic sheet from *The Threepenny Opera*, designed by Cindy Limauro.

25-19 *The Threepenny Opera* Channel Hookup A page from the channel hookup for *The Threepenny Opera*, designed by Cindy Limauro.

3 Penny Opera CHANNEL HOOKUP

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Opera Columbus

Channel	Dim	Position	U#	Type & Accessories	Purpose	Type & Accessories & Watts
(1)		FOH COVE	3	Source 4 10deg	DL FRONT	Source 4 10deg 575w
		"	6	"	DCL FRONT	"
(2)		FOH COVE	18	Source 4 10deg	DC FRONT	Source 4 10deg 575w
(3)		FOH COVE	26	Source 4 10deg	DCR FRONT	Source 4 10deg 575w
		"	30	"	DR FRONT	"
(4)		FOH COVE	4	Source 4 10deg	ML FRONT	Source 4 10deg 575w
(5)		FOH COVE	8	Source 4 10deg	MCL FRONT	Source 4 10deg 575w
		"	17	"	MC FRONT	"
(6)		FOH COVE	24	Source 4 10deg	MCR FRONT	Source 4 10deg 575w
		"	28	"	MR FRONT	"
(7)		FOH COVE	1	Source 4 10deg	DL FRONT	Source 4 10deg 575w
		"	5	"	DCL FRONT	"
(8)		FOH COVE	13	Source 4 10deg	DC FRONT	Source 4 10deg 575w
(9)		FOH COVE	25	Source 4 10deg	DCR FRONT	Source 4 10deg 575w
		"	29	"	DR FRONT	"
(10)		FOH COVE	2	Source 4 10deg	ML FRONT	Source 4 10deg 575w
(11)		FOH COVE	7	Source 4 10deg	MCL FRONT	Source 4 10deg 575w
		"	14	"	MC FRONT	"
(12)		FOH COVE	23	Source 4 10deg	MCR FRONT	Source 4 10deg 575w
		"	27	"	MR FRONT	"
(13)		FOH BALCONY RAIL	1	19 Degree Strand SL	DL LOW FRONT	19 Degree Strand SL 575w
(14)		FOH BALCONY RAIL	2	19 Degree Strand SL	DCL LOW FRONT	19 Degree Strand SL 575w
		"	3	"	DC FRONT	"
(15)		FOH BALCONY RAIL	4	19 Degree Strand SL	DCR LOW FRONT	19 Degree Strand SL 575w
		"	5	"	DR LOW FRONT	"
(16)		FOH COVE	10	Source 4 10deg	DL SP	Source 4 10deg 575w
(17)		FOH COVE	12	Source 4 10deg	DCL SP	Source 4 10deg 575w
(18)		FOH COVE	16	Source 4 10deg	DC SP	Source 4 10deg 575w
(19)		FOH COVE	19	Source 4 10deg	DCR SP	Source 4 10deg 575w
(20)		FOH COVE	21	Source 4 10deg	DR SP	Source 4 10deg 575w
(21)		FOH COVE	9	Source 4 10deg	DL FRONT	Source 4 10deg 575w
		"	11	"	DCL FRONT	"

COURTESY CINDY LIMAURO

Working as a Lighting Designer

The theatre has always been the primary training ground for lighting designers. It remains so today, despite the diverse fields in which theatre-trained lighting designers work. Not only does the theatre teach the art of designing with light, it also teaches the art of collaboration. A background in theatrical lighting can form the basis of the skills and qualities needed for work in the fields of architectural lighting, themed entertainment, film and television, concerts, and industrials.

Rarely does a graduate from a theatre training program immediately get work as a designer. The old axiom that people have to “pay their dues” is still true—experience working in the field is a significant part of becoming a designer. Advanced computer drafting skills often prove to be of great value in gaining employment. Whether the work is theatrical, architectural, industrial, or themed entertainment, an aspiring lighting designer probably must live in or around a fairly large city. Some cities are known for certain types of work. Obvious examples are Los Angeles for film and New York for theatre. It is simply a matter of determining what field one wishes to pursue, getting proper training, and then going where major employers in that field are located.

Architecture

Architectural lighting is done by specialists who have backgrounds in design and engineering. Some very large architectural firms have their own lighting specialists on staff, but architects usually hire a lighting firm, such as Schuler Shook, who specialize in architectural lighting. Many architectural firms hire young people as apprentices.

DESIGNERS AT WORK ■ Robert Shook



COURTESY JENNIFER BARNETT

Robert Shook, IALD, LC, is a founding partner of the architectural lighting and theatre planning firm Schuler Shook (www.schulershook.com). Many of the partners of this firm began their careers as theatrical lighting designers

and continue to apply this background to the practice of theatre planning and architectural lighting design. Bob's theatre planning projects include the Victoria Arts Centre in Melbourne, Australia; the David H. Koch Theatre, Lincoln Center in New York; the McCaw Hall in Seattle; and the Victory Gardens Theatre and the Lookingglass Theatre, both in Chicago. His architectural lighting projects include Chicago's Millennium Park, the Art Institute of Chicago, Chicago Board of Trade, O'Hare International Airport, and Chicago's Shedd Aquarium. Figure 25-20 is a photograph of Pritzker Pavilion designed by Bob in Millennium Park.

Bob grew up in Louisville, where during his high school years, he was an usher at Actor's Theatre of Louisville and saw every show three or four times. Despite the fact that his love for theatre and architecture had been established, Bob went to Murray State University as a journalism major; but it did not last long: “By my second year of college, theatre was it. . . . From the beginning, light just

fascinated me. . . . I was always interested in light quality and light on stage.” After two years, Bob transferred to the Goodman School of Drama in Chicago—“a great place to get an education and practical experience” at the same time. Bob did his graduate work at Ohio University and, on receiving his M.F.A., immediately returned to Chicago: “The Chicago off-loop theatre movement was just getting started, and I was absolutely in the right place at the right time. . . . I loved working in small spaces. . . . Lighting for me was all about what light looked like on an actor's face—there's nothing more important than revealing an actor with light. . . . I loved working with actors—I would go to rehearsal all the time. I loved the rehearsal process—I loved sitting over in a corner and seeing how a scene develops—I would do all of my design work sitting in a rehearsal hall watching the director and the actors work—there is so much energy in the room and you're really sensing what's going into that scene—and I'm designing it as they're talking about it.”

He also gained important foundation experience by working in the industry: “Of course, nobody could make a living just doing lighting design, so I worked for a while at Grand Stage Lighting . . . getting a little bit of ‘behind-the-scenes’ in terms of the lighting-supply side of things. I worked for a couple of years at a large television studio in Chicago and learned a lot about lighting for

(continued)

DESIGNERS AT WORK (CONT.)

video, and then I went to work for a while at Art Drapery Studios, a rigging company, and learned a lot about stage rigging. I also saw, coming through that office, theatre designs that had been done by consultants—and I started learning what theatre consultants did—that’s where I taught myself how to read architectural drawings. I began to realize that the perfect thing for me was theatre, lighting, and architecture—[that] drove me in the direction of theatre consulting and architectural lighting.” Although Bob never apprenticed or worked in an architectural firm, he says that it “would have been a good idea—I applied to a firm that I wanted to work for, but they weren’t hiring. So, after a while, I decided that I could take a stab at this myself.” Bob began doing small projects as a theatre consultant and, later, as an architectural lighting designer. In 1982, Bob met lighting designer Duane Schuler, who was lighting opera in Chicago. In 1986, Schuler Shook was born. Today, they have a total staff of thirty-five, with offices in Chicago, Minneapolis, Dallas, and Melbourne, Australia.

Bob explains that the firm is pretty much equally divided between theatre consultants and architectural lighting designers and that he is “one of the few people in the firm who actually has a foot on both sides.” Most architectural firms do not maintain lighting designers on their full-time staff, instead electing to hire designers on a project-by-project basis from a firm such as Schuler Shook. Undoubtedly, the founders’ grounding in theatrical design influenced the firm’s belief that “an open collaborative process is the key to successful design.”

Regarding the process involved in a typical architectural lighting project, Bob says, “The first thing we do is to have a sit-down meeting with the architect and, if possible, someone else [such as the owner] who may have a slant on this project. That meeting, in our view, is just to get [the architect’s] take on ‘What is this building about?’ . . . ‘What was behind your ideas to have gotten this far?’ It’s a process, in my view, of getting into the architect’s head—understanding what he is doing with this space so that we can try to come to some idea of what the lighting should be like—what the quality of light should be in the space.” Next, the firm receives a set of architectural plans: “Everybody in the architectural market these days is working in AutoCAD—that makes it very convenient because there’s one standard.” They study the plans “looking for opportunities—‘Where are the (lighting) opportunities in this space?’”

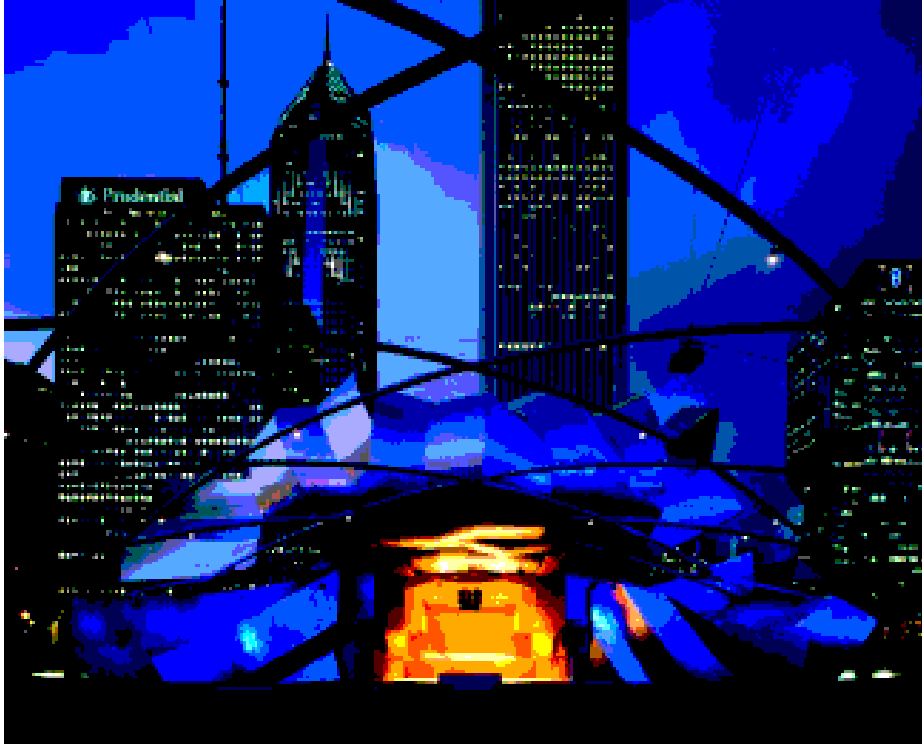
Bob continues: “Then, in our office, we have a studio process. . . . Everybody has an opportunity to sort of lob ideas in. . . . It’s just a big brainstorming session.” Then Bob and the project designer consider options for the lighting—developing them on presentation boards created from archived images or the architect’s drawings. Photoshop is a useful tool at this stage. Meetings go back and forth between the lighting designer and the architect and, finally, fixtures are chosen and

lighting plans are developed: “We produce, in our office, what we call ‘lighting layouts’ . . . to distinguish them from actual working drawings. . . . The architect will incorporate our drawings into the reflected ceiling plans, which show the location of the fixtures, and our information will also get passed on to the electrical engineer, who will add conduit and wiring and circuitry and that kind of information. Then, from that point on, we are reviewing what the architect and the electrical engineer are drawing.”

In discussing training and breaking into the architectural lighting business, Bob says, “I have found that it’s a relatively difficult transition to make from theatrical lighting to architectural lighting. The advantage of having a theatrical lighting background and doing architectural lighting is that you’re aware of the dramatic possibilities of light and you are very aware of how light behaves. . . . When you are working in a dynamic environment like the theatre, you are making those [light behavior] decisions every second; when you are working in an architectural environment, it’s all about planning.” He believes that there are two other areas that one must deal with in making a transition from theatre to architecture: “Actually knowing the equipment . . . learning your tools . . . it takes a long time to do that . . . [and] the third area, to me, is learning how to work with an architect.” While collaborative skills learned in the theatre are extremely important, Bob feels that “if you are going to work in the architectural field, you have to like architects. You really have to understand where they’re coming from, you have to put yourself in their shoes, you have to understand ‘Why did they design this space the way they have?’ You have to figure out ‘If I were the architect, how would I design the lighting for this building?’”

He goes on to say: “There are schools that are training people [specifically] to be architectural lighting designers. . . . They are almost all architectural engineering programs—and so you’re really coming out of it from an engineering background—which is kind of a side-door to architectural lighting. And theatre might be another side door. And, in fact, the best of all possible worlds is if you had an office that was populated with about half theatre people and half engineering people—very interesting process.” Bob explains that most offices try to “free up” those people with engineering backgrounds, while “the people that come at it from a theatre background, they need more of a technical engineering grounding: understanding how to read a photometric chart, how to run calculations, and how to draw an architectural detail.”

Here is Bob’s advice to theatre-trained designers who want to work in the architectural lighting field: take independent courses sponsored by local chapters of the Illuminating Engineering Society (IES) and learn to use AutoCAD, because “when you start you are going to be doing a lot of drafting.”



25-20 Architectural Lighting by Robert Shook Pritzker Pavilion in Millennium Park, Chicago.

SCOTT McDONALD © HEDRICH BLESSING

Individuals with theatre backgrounds are particularly welcome because they have been trained to think both creatively and practically and because they work well with other people. Chicago, Los Angeles, San Francisco, and New York are hubs of architectural activity. The ability to draft with CAD is of particular advantage in landing a job in the architectural world.

The **Illuminating Engineering Society (IES)** is a national organization made up primarily of architectural lighting engineers and designers. The principal function of this organization is to provide its members an outlet for discussion and the dissemination of up-to-date information on architectural lighting. The IES is also concerned with providing better training in architectural lighting. They have an online job listing, and local chapters offer beginning and advanced classes that can greatly help one gain industry-specific information (www.iesna.org).

Illuminating Engineering Society (IES)

An organization made up primarily of architectural lighting designers and engineers; publishes the IES handbook and offers courses in architectural lighting.

Television and Film

As in architecture, many lighting directors for television and film were trained in the theatre. Television and film lighting is a highly competitive field; however, one can gain entry into the industry by beginning as an apprentice or assistant. Los Angeles and New York are the major film and television centers, although most other large cities offer ample television opportunities. Some universities, such as San Diego State, offer a theatre major with a film or television minor. Most colleges and universities offer some film and television course work.

The **National Association of Broadcasters (NAB)** holds an annual convention that attracts television workers from across the country. It is a good place to meet people and learn more about the field—and perhaps find a job (www.nab.org).

National Association of Broadcasters (NAB)

An organization of individuals involved in television production.

25-21 Television Lighting by Dennis

Size Fox News Channel's Studio H, New York City.



COURTESY/RAEFORD DWYER

DESIGNERS AT WORK ■ Dennis Size

COURTESY JESS T. REINHARDT

Dennis Size is a principal designer with The Lighting Design Group, a major broadcast lighting design firm on the East coast (www.ldg.com). His personal television credits include designs for *Good Morning America*, *Live with Regis & Kathie Lee*, *20/20*, *All My Children*, *Ryan's Hope*, *The Montel Williams Show*, *The Oprah Winfrey Show*, *Martha Stewart Living*, *Ellen*, *Dr. Oz Show*, *The Chew*, *Dick Clark's Rockin' New Years Eve*, *the 2012 Republican National Convention*, and *All My Children*. He has received four Emmy awards (*Ryan's Hope*, *Oprah Winfrey*, *Centerstage*, and *All My Children*) as well as numerous nominations. Figure 25-21 is a photograph of Fox News Studio H in New York and Figure 25-22 is the light plot designed by Dennis for that studio.

Dennis studied theatrical design at the University of Scranton and in the M.F.A. program at Penn State. At that time, many of the major television networks had a "vacation relief program" in which designers were trained to take over the lighting of an ongoing production when the staff lighting director was on vacation. Through a series of fortunate circumstances, Dennis received the opportunity to work on ABC's popular *Ryan's Hope*. After a dozen years of

refining his craft, Dennis established himself among the most sought after television lighting designers in New York. He describes his initial work in television as a "means of supporting my theatrical lighting habit" and continues to this day to design and teach design, not only for television but also for the stage.

Although Dennis believes that "the most important thing is his training as a theatrical lighting designer," he also makes it clear that television and theatre lighting have their differences. Television lighting is commercial. Dennis bemoans the fact that "you have to efficiently use all of your design skills and abilities to make it happen in an eight-hour day. God forbid you end up creating overtime." Time in the studio is so compressed that there is little margin for error and there is seldom a sense of collaboration. The television designer needs to think like a director: "I have to design everything as though I am directing it. . . . We have to direct the attention at exactly what the audience needs to see. If the shot is a close-up of somebody's face and it is important to see the reaction in the eyes, you want to make sure that there are not shadows on the face, distracting wrinkles, or anything that takes the attention away from the story the eyes are telling." The good television designer knows exactly what is needed for the specific program: "Nine times out of ten on talk shows or news programs

DESIGNERS AT WORK (CONT.)

[the producers] are ‘content’ people—they don’t get involved with the visuals—that’s why you’re being hired—they hire the design team to come in and create the proper look for them that makes the intended statement.” The producer is concerned with content and whether the director is shooting the visuals properly.

Dennis goes on to tell about creating the lighting for an ABC late night news program. The typical news shows of the day tended to have uninteresting, flat lighting. However, the director of this particular show did not want that look because “it’s late at night and people are working—they are prepping the news for the day—the janitors are going to be coming through—we’re shooting 360 degrees and we’re going to see behind the scenes. So I threw all sorts of patterns around the room to texture the atmosphere dramatically—it made the two anchor people in the center of this cavernous space pop out—we used the qualities of white light and shadow and texture. They loved it—to me it was just another little theatrical thing.” The word soon got out and Dennis moved from show to show applying his theatrical talents. His lighting “tells a story.”

Dennis’s use of follow spots to key-light and fill in the faces of television actors is wonderfully theatrical. This technique was born with his first redesign of *The Oprah Winfrey Show*: “They wanted Oprah to go everywhere. We were talking about individual areas, we were talking about many lights into areas from every angle, the set was going to be on air casters, they were going to be able to lift the whole set up and move it to different parts of the studio. . . . I loved the idea of lighting the whole space—we used color changers and patterns and texture—it was textural space that had a lot of color quality to it. Oprah then became an issue: ‘How do you light this woman to go anywhere?’—you follow her. When I brought up the word [*follow spot*], people in television looked at me like I was nuts.” The idea was to locate seven very tightly irised and softly focused follow spots around the space that would fade up and down as Oprah moved and turned from camera to camera. Dennis used 10-degree Source Fours, usually running at only 30 percent. “The concept of the show was to really fill her face with a soft glow at all times so wherever she moves around that set there is an ethereal pool of light moving with her. . . . This way you are highlighting just her face and making her look perfectly elegant.”

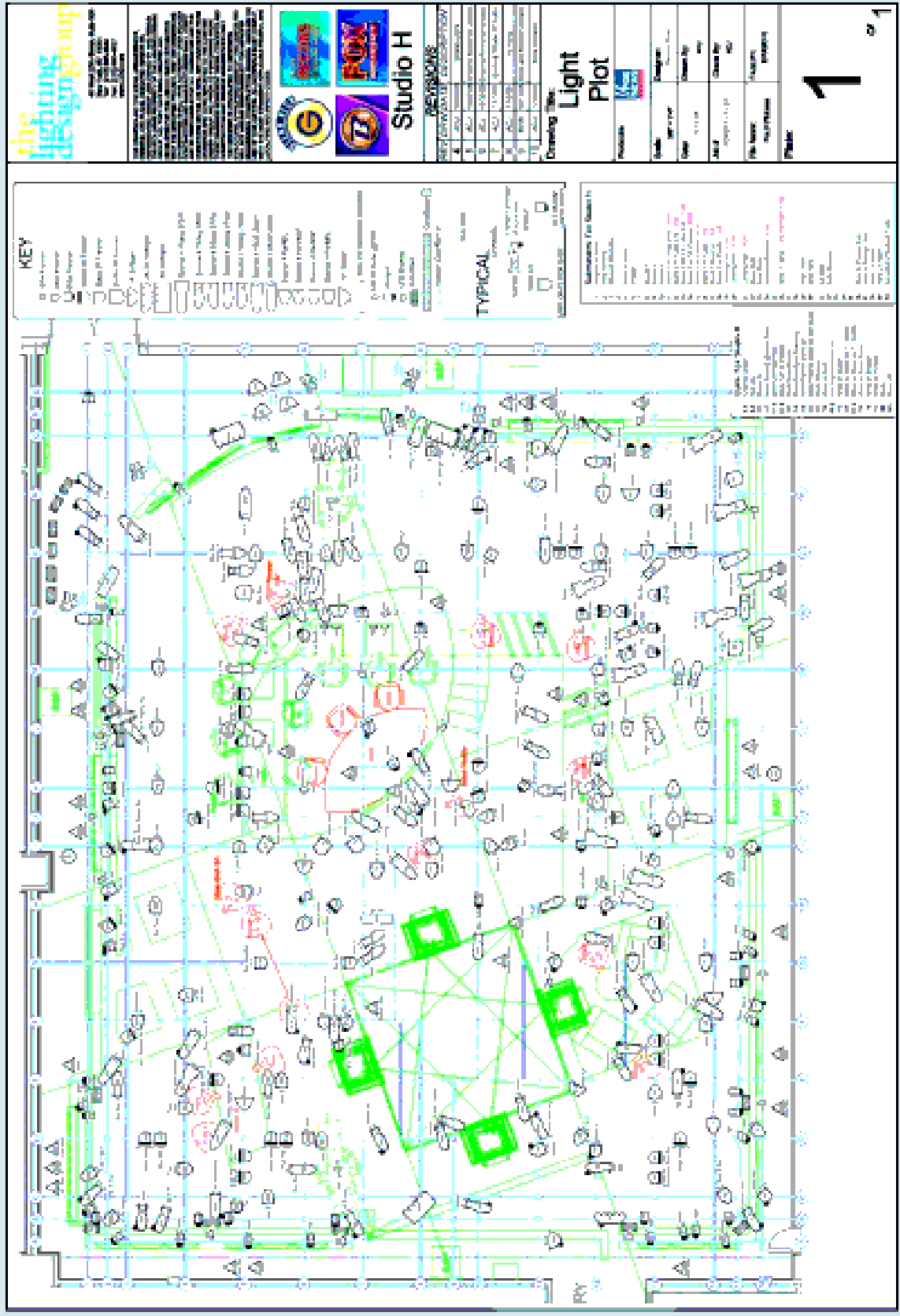
A fundamental element of Dennis’s lighting is tight control: “You want to be able to control the light—I think that’s the key. . . . That’s all I did at ABC when they said ‘We want his style.’ My style was just to put the light where it is needed, and nowhere

else. You know, if you want to light the walls and make them look good, don’t put that 2K Fresnel so it washes both the person and the wall.” As a result, a typical Dennis Size studio hang contains a large number of LeKos (ellipsoidal reflector spotlights) used not only as set lights but also as key-lights.

In reflecting on his start in television lighting, Dennis says of *Ryan’s Hope*: “I was lucky enough to fall into something that fit my design aesthetic like a glove. If I had been thrown into something like the sports department . . . I would have been trained by people who only cared about getting enough lumens on somebody’s face to get a picture—and that’s a problem. I ended up putting in about fourteen years on soap operas doing dramatic presentations.” After that, Dennis moved on to special events for ABC, where he found greater design challenges. In 1977, Dennis left ABC and joined Steve Brill, who had designed for NBC, and formed The Lighting Design Group: “At that time there were only about eight people on staff—now we number 40—between our production staff and our designers.” In discussing how the firm works, Dennis explains that, even though the basic look of a show has been designed, “every day you’re redesigning—you’re setting something new—you’re deciding what the look of the show that day is going to be. . . . To maintain our standards, we like one of our own lighting directors to be on a show.” As part of his job as vice president of design, Dennis supervises the design team. He makes sure that the right designer gets placed on the right show.

In terms of breaking into the industry, Dennis says, “People coming out of school just aren’t trained in television lighting—they’re trained in lighting design and I think that’s great because you can adapt it, but . . . the company can’t afford to train people. So what I usually do is have people come and observe me and our other designers, and then we’ll hire them for a while as an intern—we started an internship program many years ago. We also created an assistant designer position . . . who does the drafting and works with/for the staff designers.” So, the necessary skills are sounding rather familiar:

- Excellent people skills (first and foremost)
- A solid basic training in theatrical lighting
- Drafting and visualization skills such as Photoshop
- Knowledge of new technology—especially energy efficient light sources
- A strong desire to work in the industry



25-22 Fox News Channel's Studio H Light Plot The light plot designed by Dennis Size for Fox News Channel's Studio H in New York.

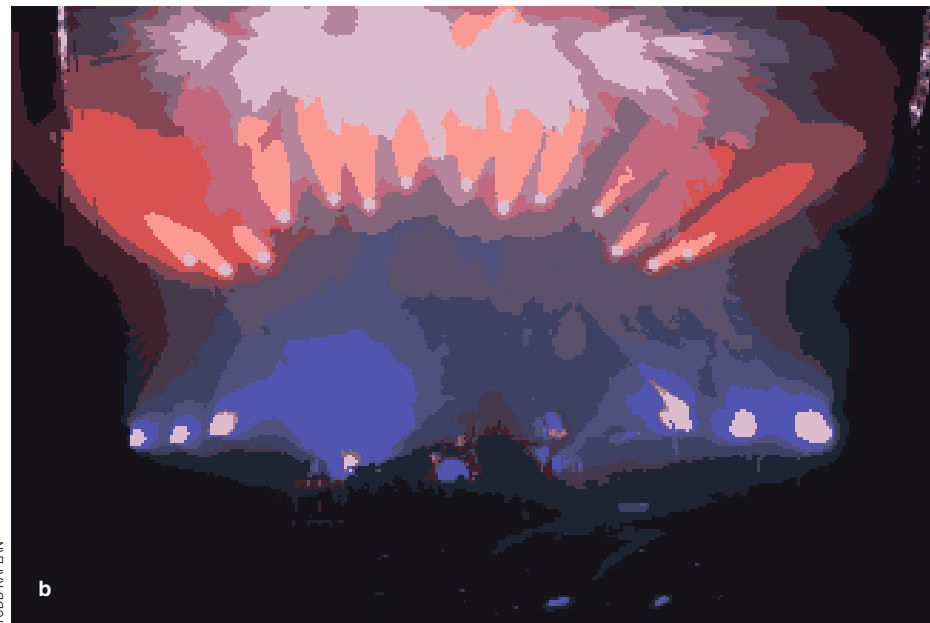
COURTESY LIGHTING DESIGN GROUP

Concerts

Concert lighting grew out of the need for special illumination for touring rock concerts. In the beginning, a band member was in charge of the lighting—often nothing more than a few PARs providing a wash of color on the stage. However, things changed quickly as bands realized the dramatic effect color and light had on their audiences. Special lighting and effects soon became a necessity. New methods of touring lights were developed, and the PAR-64 fixture became an industry standard. More recently, concert lighting provided the theatre with a whole new generation of automated fixtures (Figure 25-23).



TODD KAPLAN



TODD KAPLAN

25-23 Concert Lighting Automated Fixtures A Monsters of Folk concert at the Academy of Music in Philadelphia. Lighting director, Marc Janowitz.

- a** Automated fixtures lighting the band.
- b** Automated fixtures after flyout.

DESIGNERS AT WORK ■ Marc Janowitz



COURTESY RICHARD TERMINÉ

When asked, Marc Janowitz will explain that his vocation is a production designer for live events: concerts, theatre, performance art, and the occasional DVD. The fact is that he's a concert designer—plain and simple, that's his passion—and he's in the

midst of a very exciting career. Currently the production designer for My Morning Jacket, Monsters of Folk, TV on the Radio, and Flight of the Conchords, Marc has also worked with Dr. Dog, Passion Pit, Matisyahu, Blue Man Group, and Cirque du Soleil among others. His firm is Marc Janowitz, LLC (marcjanowitz.com), and he operates out of New York.

Typically Marc's responsibilities include the creation of lighting, video, scenery, and effects for his clients. At the mid-level concert industry in which Marc currently does most of his work, "there's usually only one set of designer eyes that is hired in, and it usually starts with a lighting designer. As such, you end up being responsible for everything visual that is presented on stage. As lighting designer, you are creating an environment that is the sole visual representation of the music—the sole visual playground for the band . . . It becomes a unified vision." Marc thinks of video and projection as an extension of his lighting. If a client wants very specific video content, he often enlists the services of a video designer, preferring to work with people "who are very cinematic—they're really filmmakers . . . It's easy to find and download stock video content . . . eye candy . . . really what you want in a collaborator for a videoscape is someone who has a cinematic vision." He goes on to say that when using video, "I'm creating a visual picture: using the imagery to portray the *visceral* story of the music—not the *literal* story of the music." Indeed, Marc Janowitz is a production designer. Here's a brief look at how he got there.

Marc grew up in Peekskill, New York, just up the Hudson River from New York City. He became interested in the technical aspects of theatre early, while still in grade school. His sixth grade English teacher happened to also be in charge of the school play. As a result, everyone in her class had to partake in the production, including Marc. Because he couldn't stand the idea of being in front of an audience, Marc chose stagecraft and soon migrated to lighting. Through arts camp and an active high school theatre program, he gained even more experience. While still in high school, Marc got his first professional work—running follow spot at the local roadhouse for a Christmas special: "I spent all my free time trying to do whatever I possibly could to enhance my knowledge and experience and my contacts." He soon was working as a stagehand at the local Broadway roadhouse as well as the occasional concert at Giants Stadium: "It was an amazing experience; it exposed me to how real productions

were done at a time when I was still able to go off on my own and experiment with ways to integrate that into my own self as a designer." It was at this point that Marc began to realize that there were really two paths that he could follow: "one more orientated toward technical execution and the other more in the creative and specification and deciding what things look like . . . I tried to pursue them simultaneously so that one would inform the other." Upon graduating from high school, Marc headed to Boston to attend Boston University, at first as a theatre major, but eventually earning a bachelor's degree in philosophy. He soon found himself working local calls all over New England. The Boston theatre community was a relatively small one—everyone knew everyone else and jobs were often had by referral from friend to friend.

The next significant event in Marc's career journey was to shape his life more than any other: Blue Man Group opened a show in Boston. "They came to Boston to open their second show. Their first show was the one in New York that's still there, at the Astor Place Theatre. The Boston theatre community rallied together to put that show in; these were the same people that I had been working with all through college." Marc resisted making the commitment to full-time technical work on the show, but then he went to see a performance: "It was mind-blowing, magic. It wasn't just that the show was cool and funny or that the production was really well thought out. The lighting was actually quite low tech; that's part of what appealed to me—what they were able to achieve visually and the through-line of how it all worked together." He took the board operator job that had just opened up while still finishing up his senior year of college. A year later, Blue Man Group opened a third show in Chicago, and Marc was asked to act as assistant lighting designer. "At the time, development for a Blue Man show could go on for a year or longer . . . They wanted to take over the theatre . . . They wanted to be fully installed from the outside of the building to the lobby all the way through the backstage experience. The creators of the show were still very much involved at the time—they were still performing. They were in the rotation of the cast; they would be up there on stage and come out into the house in blue makeup, dripping in paint, and look at light cues."

Marc left Blue Man after the Chicago opening and drove to Las Vegas to join the crew installing *O* for Cirque du Soleil. "In that time, my knowledge of how lighting systems go together and how creative processes can work increased exponentially." Marc recognized his fortune in working with such great production companies as Blue Man Group and Cirque du Soleil: "I recognize that I have been extremely lucky; not everybody gets those opportunities. But also I believe that, in a lot of ways, you create your own luck: it is recognizing the opportunities as they come along and going for it—not being afraid to take risks."

DESIGNERS AT WORK (CONT.)

Marc returned to Blue Man Productions as Marc Brickman's associate designer in order to develop their touring company: "Unlike most people's, my first tour was seven trucks, five busses, a massive set, video and lighting design—and it all came out of our office." Marc was lighting director on the tour working with a large number of very experienced personnel, some of whom were almost twice his age: "That's when I began to realize that your learning process never stops. You never pass up an opportunity to learn, and your ability to deal with people is as important, if not more important, to being successful in this industry than is your talent, or your knowledge of equipment, or your anything else . . . Designers who work a lot are people-people: they get along with the managers, they get along with the directors, they get along with the agents and producers—they are people that others want to have around and collaborate with."

When visiting Marc in his Brooklyn office, it is evident that he is indeed a people-person. He is currently chief lighting designer for his firm. Although he still goes out on the road, more often than not he works on creating a design for a music group along with an assistant who will later act as lighting director for their tour—the person on the road with the band. Marc's niche is working with "indie" music groups: "Bands that are hard-touring acts that care a lot about what they're doing . . . When they call me it's usually the first time that they're going to make an investment in their look . . . One of the major challenges in that is they often don't have the time or money to do full technical or production rehearsals . . . Most of the time we don't assemble a show until the tour happens: we will build the system in the shop, we'll make it as easy to tour as possible, and we will pre-program the show using ESP Vision or one of the other available programs out there" (Figure 25-24.) That places a great deal of responsibility on the shoulders of Marc's assistant, the lighting director. "I very carefully choose who my lighting director/programmer is going to be because they're going to be the ones who are really doing the cueing and growing the design on a regular basis . . . A concert tour show grows and develops over time and the lighting must too." A good lighting director "needs to understand your aesthetic because they're representing your thing, but they need to also have their own; they need to be intelligent and creative, and they need to understand how to meld the two worlds. They're in a very tough world because they've got their own thing, they've got what the band wants to do, they've got what management is saying, and then they've got someone like me sitting back and saying 'no, that's not what it's meant to be.' It's a very small list of people that I can count on to integrate all those things." Marc acknowledges that he, as lighting designer, gives up much of the control over the final product. He emphasizes that "there is a high level of trust, communication, and loyalty that you need to find in a lighting director because you are giving up that control, but you are doing it with

trust . . . You can't just grab someone and say 'here's a plot, this is kind of what it's about, go with it'—you have to choose carefully, you have to foster their knowledge, you have to over-explain to them what your intentions are as a designer . . . At this level—and most of the kids who want to be a concert designer are going to work at this level for a long time—you're always going to be short on time, you're always going to be short on budget, you're never going to have a production rehearsal that's really substantial enough to do what you want to do, so you better make sure that whoever is representing you is given as much information to succeed as possible." At the same time Marc is touring with a show, he says that he is actively "collecting people. I never pass up the opportunity of finding out what someone is about, what they really want to be doing. I don't forget them. I take their information and when I get a certain client I look at what their budget range is, what the system is going to be like, what level of experience is needed to take the show out. I look at potential assistants very carefully, and believe it or not, probably the most important consideration is how they interact socially."

When asked about the business, Marc says: "One has to learn about the business. If you don't have an understanding of how the business works, of how your business works, you're going to be taken advantage of—it is the entertainment *business* . . . You have to protect your interests." Marc emphasizes that contracts and letters of agreement are essential to a designer's well-being. He goes on to say that "you've got to place the 'preciousness' of your art in the back seat to your ability to navigate the industry and the people and the technical challenges and the restrictions."

In discussing aspects of designing in the concert world, Marc says: "You have to find things inherent in the band—in the music, in their personality, in their perception. They're what you use as departure points for your design . . . You have to completely immerse yourself in the music the second you see even the possibility that you might be working for a band." Marc says that "rarely, if ever, do I learn lyrics to a song—somehow my ear doesn't click into the words when they're being sung. Music comes to me more like flavors in a way, a very visceral experience that in my mind translates into color, texture, direction, intensity, and motion." He warns that it's easy to fall into the trap of approaching a concert design knowing ahead of time what technology you are going to use and letting that knowledge dictate the design: "You have to imagine, for just a second, that you need to light this band with twelve PAR cans. How are you going to do it? You get to the essence of it . . . The first thing that is most important about lighting any band is you've got to know the music. You've got to have an understanding of where those changes are and when you have twelve PAR cans, all you can do is make sure that the changes happen at the right place—at that point it doesn't matter what it changes to."

(continued)

25-24 Concert Lighting Process—Marc Janowitz

- a** Concept rendering for TV on the Radio concert.
- b** TV on the Radio at Ryman Auditorium, Nashville, TN. Lighting/production designer, Marc Janowitz; lighting director, Ben Silverstein; associate designer, Ben Price.

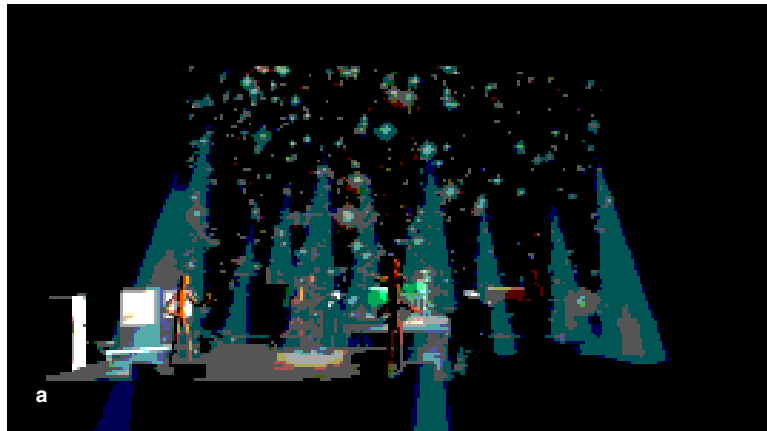


IMAGE COURTESY MARC JANOWITZ



RODERICK TRESTRAIL II

DESIGNERS AT WORK (CONT.)

Approaching a design, Marc stresses:

- It starts with the music and the performance; go to YouTube and see what the band's energy is like in a live situation.
- Identify the scale of the tour: what are the sizes of the venues?
- Look at album art—you immediately get a sense of the band's visual styles and aesthetic.
- Spend some time talking to the band about what they like—they created this music after all.
- Talk to the band's manager; you need to make responsible financial decisions and the manager knows what can be afforded. Remember: it is a business.

Marc notes that “my lighting often responds to what the front-of-house audio engineer is doing in some respects, because he'll

focus in on something that the keyboard player is doing, and it will make me focus in visually on some concentrated sound from that part of the stage” (Figure 25-25).

Marc is glad to have his theatre background. He feels that “you develop a certain type of aesthetic and a level of sensitivity and a way of collaborating in theatre that is infinitely helpful in concert work.” The discipline of theatre training teaches a designer that “the design pack you put out—the plots you put out, how you do them—is all a reflection of who you are and how you approach your work.”

Finally, Marc advises: “Love what you do. With a very few exceptions, we don't get rich in this business. We don't do it for the money. I do it because I love it; I can't imagine doing anything else. If you don't have that kind of core connection to it, then it may not be worth the sacrifice.”

A concert lighting director tours with the band, running the lighting console for each performance. Being a part of a concert tour is an extremely valuable experience for any young lighting designer. Such tours hire electricians and, in addition, it may be possible to assist the designer. Jim Moody, who was trained as a theatrical designer, has written an informative book on concert lighting that

PHOTO BY RICHARD TERNINE, COURTESY MARC JANOWITZ



a

25-25 Concert Lighting by Marc Janowitz

- a My Morning Jacket at Madison Square Garden.
- b TV on the Radio at Ryman Auditorium in Nashville.

RODERICK TRESTRAL II



b

anyone interested in the field should read. It is listed in the additional reading list at the back of this book.

Themed Entertainment

The rise in popularity of themed entertainment has made this another lucrative field for lighting designers. Theme parks are often owned and run by large corporations such as Disney and Universal. In this case, one should apply to the human resources department for a position. If at all possible, find out exactly who does the hiring and contact that person directly. Assuming there is work, lighting designers trained in the theatre are welcomed at these large entertainment conglomerates. At times, small firms consisting of one or two designers are contracted to do the lighting for a specific theme park or attraction. When the work comes along, these firms need help to get the job done. Sending a résumé and requesting an interview could lead to a good job and provide exceptional experience. Remember that volume of work for the smaller firms varies a great deal. Do not give up if nothing is available immediately. Be persistent without being a nuisance.

Lighting Dimensions International (LDI) holds a national conference each November, which many lighting designers in diverse fields attend. Such conferences offer a way to meet people and learn more about the various aspects of lighting design (www.ldishow.com). The **Themed Entertainment Association (TEA)** publishes a directory of firms working in the industry and has an online job board (www.teaconnect.org).

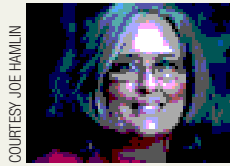
Lighting Dimensions International (LDI)

Group that publishes *Live Design* magazine and holds an annual convention for individuals working in the entertainment industry.

Themed Entertainment Association

(TEA) An organization representing creators, developers, designers, and producers of compelling places and experiences including themed entertainment.

DESIGNERS AT WORK ■ Lynda Montgomery



COURTESY, JOE HAMLIN

Lynda Montgomery is a principal lighting designer for Walt Disney Imagineering. The Disney organization has several divisions that are concerned with entertainment design, each one of them unique.

The Entertainment Division is responsible

for live shows in the parks and often hires designers on a show-by-show basis. Disney Theatrical is responsible for live theatre on- and off-Broadway. Imagineers are permanent staff designers who create—“from concept through construction—all Disney theme parks, resorts, attractions, cruise ships, real estate developments, and regional entertainment venues worldwide.” Lynda explains that Imagineering is responsible for “anything a park’s guest sees—the attractions, landscaping, walkways, rest rooms.” One of Lynda’s recent designs is the exciting “Twilight Zone Tower of Terror.” We were able to catch up with her between Paris trips where she is putting the finishing touches on “Tower” for Disney Studios there.

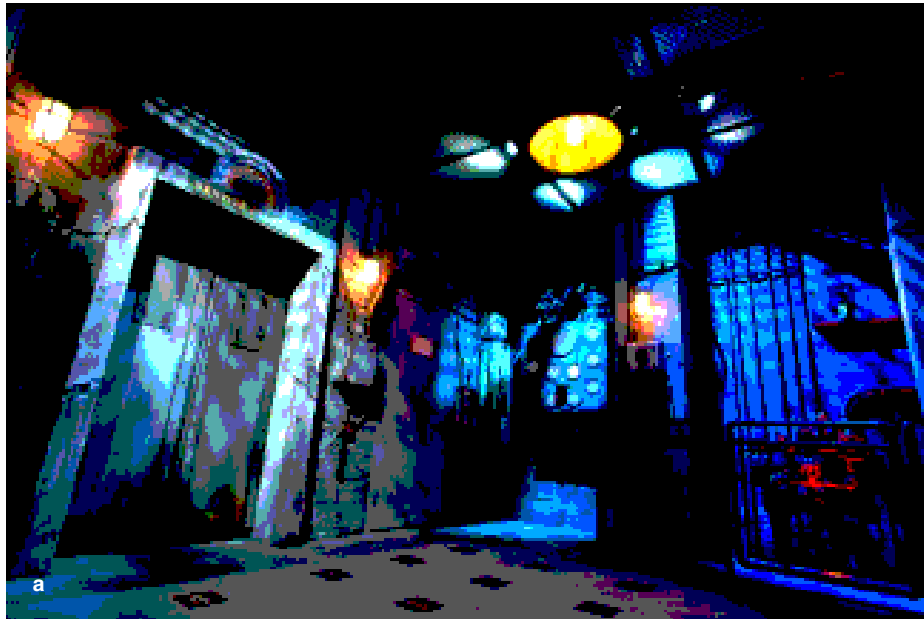
Lynda’s fascination with technical theatre and, more specifically, lighting began in high school when one of her teachers showed her how to use the control board: “All it was was a line of striplights with three colors—red, green, blue—I mixed the colors, and it was over. The bug had bit me.” Like many others, Lynda entered college thinking that she would study something sensible—she intended to be a veterinarian. But she kept walking past the college theatre building thinking how much she would like to be in there. Finally, she gave in and switched her major to theatre and has never looked back. She received a B.A. in Theatre Design from San Diego State University in 1990. In her senior year there she and a friend were fortunate enough to land a job working on the rehab of an attraction at Universal Studios in Hollywood. They enjoyed the work, learned a lot, did a good job, and heard that Disney was hiring. Lynda was offered an internship with Walt Disney Imagineering two weeks before she graduated.

Her formal internship with Disney lasted several months. It was a time for both parties (employee and employer) to decide whether each had made the right decision. Following that trial period, she became an associate lighting designer with duties that primarily involved field work installing other people’s designs. These, of course, were the formative years—when Lynda learned process and procedures of designing and installing major theme park attractions. She says: “The theme park industry involves a different kind of lighting but also a lot of theatre lighting. You get to do everything—from rest rooms to roller coasters to theatre shows. The variety of it keeps you interested—I still learn something new every day.” She worked in this capacity nearly ten years, getting small design assignments such as rehab of “The Hall of Presidents” in Florida’s Magic Kingdom park but primarily assisting other designers; she emphasizes that “assisting the older, more experienced designers was invaluable.”

Lynda was subsequently promoted to lighting designer, several years later to senior lighting designer, and she is now a principal lighting designer. Associate designers at Walt Disney Imagineering still work under another lighting designer; lighting designers normally get their own projects; principal designers are assigned large projects and sometimes responsibility for an entire park.

Lynda installed the original “Tower of Terror” in Florida and then went on to design and install similar attractions in California (Figure 25-26) and Paris. The Roosevelt Hotel in Hollywood was the inspiration for the look of Disney’s hotel. “Tower is a great themed attraction—it takes you back in time to a different era—the Golden Age of Hollywood.” She explains that a project happens in two stages: design and instillation. The design stage is very similar to theatre in that it involves a detailed script, collaboration with fellow designers and technicians, and working drawings. She elaborates: “It always starts with a story—what are we trying to tell the audience—a place, and a time—we are transporting our guests to a different time and place and immersing them in it.” In the case of “Twilight Zone Tower of Terror,” the creative team consisted of the art director, the show producer, the interiors person, the scenic designer, the architect, the lighting designer, audio, media, special effects, and props. Lynda enjoys the collaboration and notes that “the sound motivates the lighting in Tower—I don’t move a single light without an audio cue.” She goes on to explain that lighting architecture is a big part of the job: “It’s a challenge both technically as well as artistically . . . really the architectural stuff is all theatrical—it’s all angles and color, the mood you are trying to convey—it’s just a different fixture that you are using.” For a new attraction, there are often several mock-ups done during the early phases of the project. The drawings stage is full of collaboration with art directors and production designers as well as architects, interior designers, graphics designers, and electrical engineers. “You basically have to design and build a building with the intent of doing a show inside—we are one of the few disciplines that work on both the facility and the show—we do all the architectural lighting.”

Instillation is a very proactive job. The designer is in the field looking at everything as it happens. The designer works with contractors, first locating the lighting (“sprinklers, speakers, and lights all want the same real estate—that’s why you have to be proactive—you need to make sure that your stuff gets put where you want it—location is very important, especially in architectural lighting”) and then focusing, coloring, and programming. A difference between themed entertainment and most theatrical lighting is that all control needs to be specified. The number of dimmers, where they go, and the specifics of the control system all need to be worked out. Lynda says that one of the nice things about working for Disney is that, unlike many consultants, she gets to install her own work: “To me, if you don’t get to do that part of it, there’s no fun—you get to realize



© DISNEY

a

25-26 Themed Entertainment Lighting by Lynda Montgomery

- a A view of the hotel service elevator in the “Twilight Zone Tower of Terror” at Disney California Adventure.
- b The boiler room in Disney California Adventure’s “Twilight Zone Tower of Terror.”



© DISNEY

b

DESIGNERS AT WORK (CONT.)

your own work, much like the theatre.” The whole process may take up to four years for a large project.

When asked what advice she would give a young person looking for a job in the industry, Lynda said: “Be persistent without being annoying. Be respectful.” Of her Disney job, she recalls: “I managed to get a hold of the phone number of the manager of lighting and I spoke with her directly. That was a big help. I had the interview, and it went well. I sent her a thank-you card for the interview and then she called me and hired me.” In

addition, in order to succeed “you have to know your stuff technically because, chances are, when you come out of school you are going to be somebody’s assistant . . . you are going to be asked to draw, to do AutoCAD, to do a fixture schedule . . . as someone’s assistant you can learn so much—and that’s how you will meet your contacts.” Lynda reminds the young designer to “keep your integrity—it’s a small community—it doesn’t seem like it, but it is—be respectful—being respectful is really important. I’ve gotten a long way by listening and being respectful.”

Industrials and Trade Shows

Lighting for industrials and trade shows can be a lucrative business. It is primarily done by firms that have gained reputations over the years for this type of design work. These firms are contracted by industry giants such as General Motors and IBM to design and execute the lighting for their product shows. The scope of this design work varies from relatively direct and simple illumination to extremely complex and spectacular productions. Figure 25-27 shows a good example of corporate theatre by ShowTec (www.showtec.com).

Industrial lighting firms are always looking for people with lighting design talent to apprentice and learn more about the business. Such firms are generally located in larger cities and can be found in a phone directory. Prospective designers can call and ask for the name of the individual who accepts résumés.

The Theatre

Working your way up to designing in the theatre is a slow and sometimes frustrating process. Normally, producers will not hire a designer until his or her work has been seen. The paradox is this: How can someone see your work if you cannot get hired? You must

25-27 Corporate Theatre by ShowTec Petco's Annual Manager's Meeting near Washington, DC

- a** Photo of frame and fabric construction ribbon set pieces before projected imagery.
- b** Set pieces with video projections, using 2 Catalyst Pro Media Servers and an Encore Video Switching System with cueing from Wholehog III Show Control.

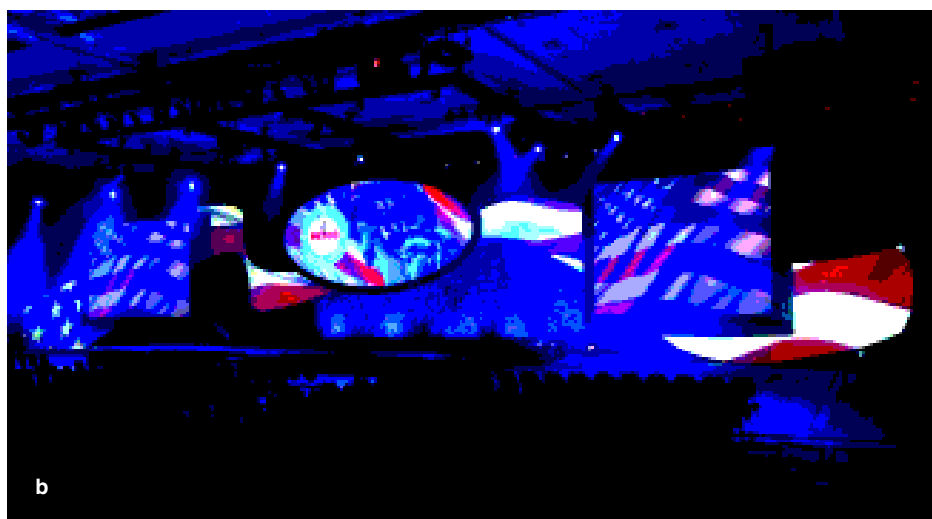


PHOTO COURTESY JONATHAN MARTIN/SHOWTEC

PHOTO COURTESY JONATHAN MARTIN/SHOWTEC

be prepared to design for little or no money at first. This also means that you will need another job. In fact, most theatrical lighting designers work in other fields. Your first choice for nondesign work should be doing something else in the theatre. Stagehands and electricians are always needed, and some get paid good wages. Assisting more experienced designers is of great advantage. Such work allows you to stay close to the theatre and meet people who may offer you work in the future. Create a good website, build up a résumé, and distribute it frequently.

The **United States Institute for Theatre Technology (USITT)** is the American association of design and production professionals in the performing arts. It sponsors an annual conference, usually held in March, which is invaluable for meeting other designers, keeping up with state-of-the-art techniques and equipment, and learning more about the art of design through the numerous workshops offered. USITT also provides a job placement service at its national conference as well as online job postings. Membership is inexpensive for students and reasonable for others. For information, go to www.usitt.org.

ARTSEARCH is a national publication listing available positions primarily in the theatre arts. You may subscribe to this TCG (Theatre Communications Group) service at www.tcg.org.

The theatre is a wonderful place to work because theatre people enjoy what they are doing. It does not take too long to discover whether or not you are cut out for a career in the theatre. But remember—if you think you are, be persistent. It will pay off!

United States Institute for Theatre Technology, Inc. (USITT) The association of design, production, and technology professionals in the performing arts and entertainment industry.

ARTSEARCH A nationwide listing of available theatre jobs; published by Theatre Communications Group.



PART IV | SOUND FOR THE THEATRE

26 | Sound and Music in the Theatre

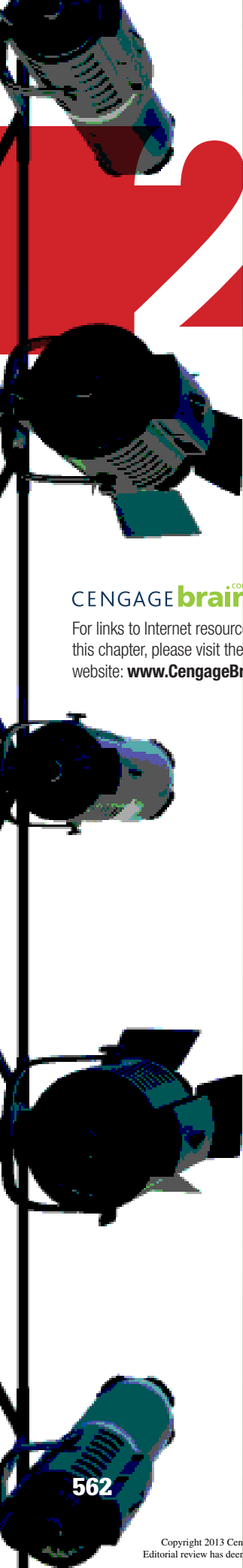
27 | Sound Systems and Equipment

“ Music expresses, at different moments, serenity or exuberance, regret or triumph, fury or delight. It expresses each of these moods, and many others, in a numberless variety of subtle shadings and differences. It may even express a state of meaning for which there exists no adequate word in any language.

”

Aaron Copland

What to Listen For in Music



26

Sound and Music in the Theatre

CENGAGE **brain**.com

For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

The use of sound and music in theatre is not new; its origins go back to primitive rituals that combined dramatic action with music and dance. However, sound as a separate theatrical design element on a par with scenery, costume, and lighting is a fairly recent development. Not so many years ago, theatre sound was primarily made up of mechanical effects supervised by the properties department; sounds requiring electricity, such as bells and buzzers, were relegated to the lighting and electrics department.

With the advent of high-fidelity recording and playback equipment in the 1960s, sound reproduction became a practical, albeit cumbersome, tool for the theatre. The next decade brought about more sophisticated equipment for recording and playback. The synthesizer, a revolutionary electronic keyboard developed by Robert Moog, could reproduce a multitude of musical sounds. Digital technology followed, introducing DAT (digital audio tape) recorders, hard disk recording, sampling, CDs, and DVDs. The venerable audio tape is now a thing of the past, having been replaced with recordable CDs and DVDs, Blu-ray, flash drives, and computer hard disk storage.

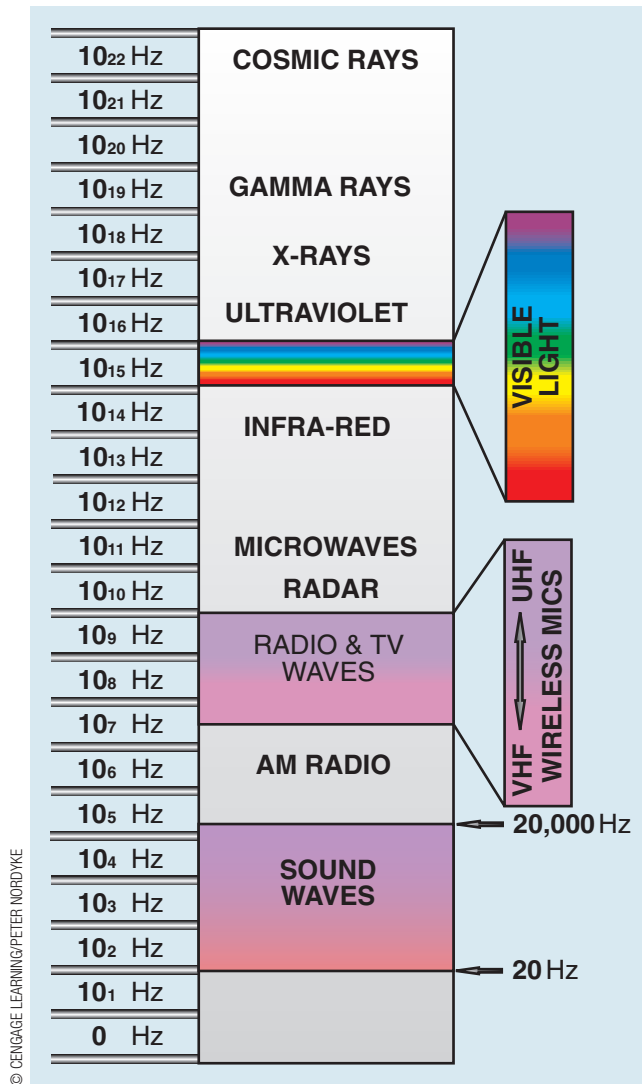
We recently have witnessed yet another technological revolution in the area of sound processing: modern computer software has replaced traditional hardware in nearly every aspect. Today's sound designer/technician works his or her magic on a computer equipped with digital sound editing software. As a member of the design team, the sound designer offers exciting potential for enhancing live theatrical production.

Fundamentals of Sound

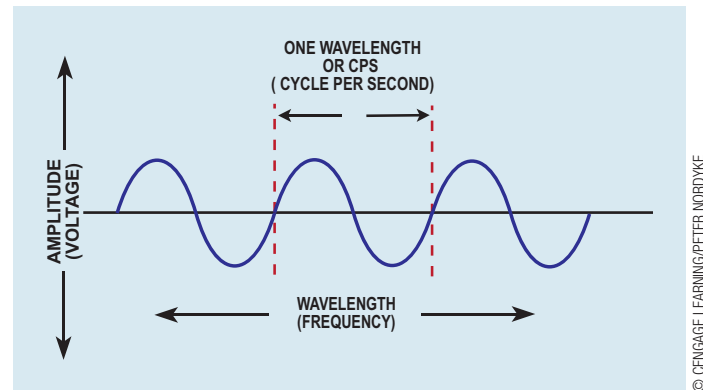
We are constantly surrounded by sound. The brain controls what we hear, through its remarkable ability to focus on a particular sound or reject it in order to concentrate on something else. As the composer Aaron Copland indicates on the previous page, music affects us emotionally. It can heighten or relieve tension. In the theatre it can alter our perception of dramatic action. And, because of its temporal nature, music can alter our perception of time. The responsibility of the theatrical sound designer is to manipulate music and sound to enhance the effect of dramatic action.

The Phenomenon of Sound

We are most familiar with sound as air waves or vibrations within a certain range on the electromagnetic spectrum (Figure 26-1). However, nearly all of us have experienced hearing under water, which illustrates that sound moves more or less easily through nearly all materials. In fact, sound moves slowly through air compared with most other mediums—only about 1,130 feet per second (approximately 1 foot per millisecond). It



26-1 The Electromagnetic Spectrum The normal range of human hearing is generally 20 to 20,000 hertz (cycles per second).



26-2 Visual Representation of a Sound Wave

follows that sound cannot travel through a vacuum because nothing exists from which waves can be created.

Sound is produced when a body at rest is made to vibrate, causing pressure waves to move in all directions from the source. The rate and the amount of vibration play an important role in what we hear. For example, when a harp string is plucked, it is pulled in one direction and rebounds past its original resting place. Molecules in the air mimic the movement of the string, thereby creating sound waves. How far and how fast the string moves determine the height and the length of the sound wave, respectively. This can be illustrated in graphic form as a series of cycles (Figure 26-2).

As sound waves move through the air, they diminish in height (loudness or **amplitude**), but the wavelength itself (**frequency**) does not change. Some surfaces tend to absorb sound waves, while others reflect them. If a sound is reflected several times before being absorbed, **reverberation** occurs. Finally, the sound may reach a receptor, such as our ears.

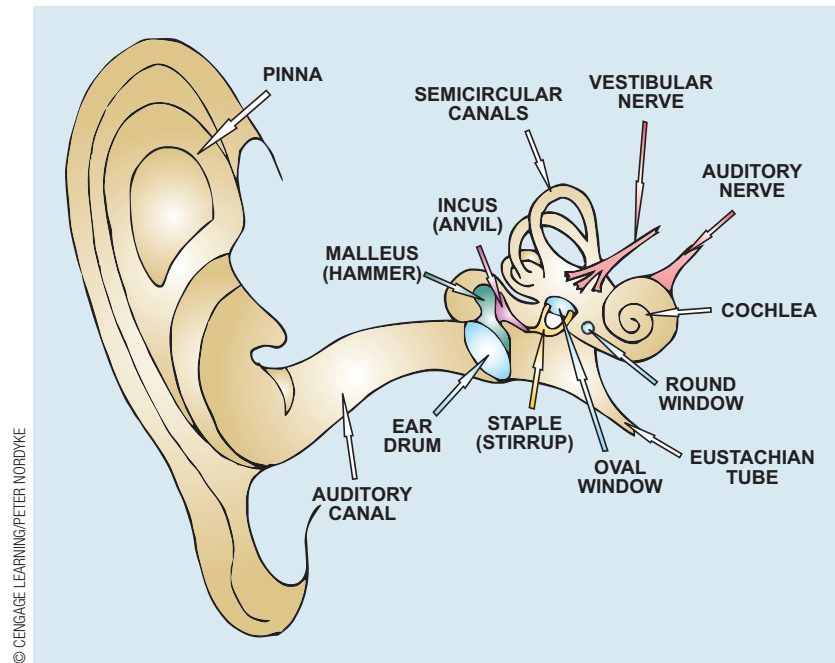
The Ear As shown in Figure 26-3, the ear is made up of several parts. The *pinna*, or outer ear, acts like an antenna to collect sound waves and direct them into the *ear canal*. The pinna also helps one locate the direction of a sound. The ear canal terminates at the *tympanum*, or eardrum, which vibrates in reaction to the sound waves. The middle ear contains three tiny *ossicles*, or bones (commonly referred to as the *hammer*, *anvil*,

amplitude Measured in decibels (dB), amplitude is synonymous with *volume* or *intensity*. Amplitude is determined by the height of a sound wave.

frequency The rate at which a sound vibrates, measured in cycles per second or hertz (Hz). The length of a sound wave determines frequency. A sound's frequency determines its pitch.

reverberation The combination of multiple blended sound images caused by reflections from walls and other surfaces. If reverberation time is long enough to discern individual sounds, then it is referred to as an *echo*.

26-3 The Human Ear



and *stirrup*), that take up and intensify these vibrations. The fluid-containing *cochlea*, or inner ear, houses the many nerve endings that receive pressure from the vibrations through tiny, hair-like cells. Responding to the pressure, these nerves send electrochemical signals via the auditory nerve to the brain for interpretation. Much important input concerning loudness and frequency is gathered in the cochlea; however, the brain alone selects and analyzes sounds.

Measuring Sound

To describe a given sound, one needs a technical vocabulary that defines the components specifically enough to be meaningful. Although very few sounds are made up of a single frequency, all sounds can be broken down into their various component frequencies and amplitudes.

hertz A unit of measurement used to identify the frequency of a sound. Hertz (Hz) are equal to cycles per second or CPS.

decibel A measurement of sound intensity, the decibel (dB) describes a ratio of two quantities. One decibel is a measurement of electrical or acoustic power equal to $\frac{1}{10}$ of a Bel (a unit named after Alexander Graham Bell).

sound pressure level (SPL) The measurement of acoustic pressure level in decibels.

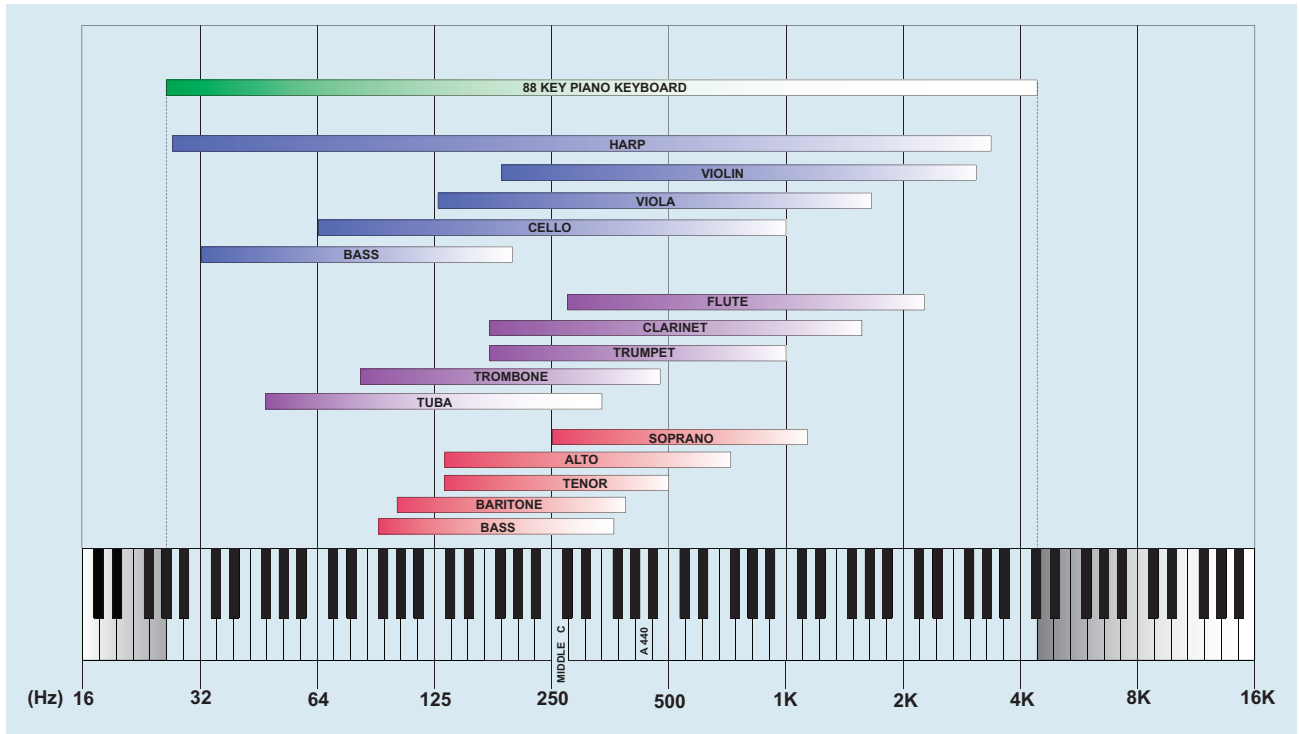
threshold of hearing Normally defined as 0 dB SPL, this equates to the quietest sound that the ear can discern.

dynamic range The difference, measured in decibels, between the quietest and the loudest portion of a segment of sound. In a live situation, this usually is the difference between the loudest portion and the noise floor of the theatre.

Frequency The length of a sound wave is defined according to its *frequency* in time and is measured in cycles per second, or **hertz** (Hz). There is a direct relationship between *pitch* and frequency: the high-pitched sounds from a flute have high frequencies (shorter waves); the low-pitched sounds from a cello exhibit low frequencies (longer waves). Frequency is the main characteristic that allows us to discern one sound from another. The normal human ear can hear frequencies from 20 Hz to 20,000 Hz (representing wavelengths from approximately 56 feet to $\frac{2}{3}$ of an inch long). Figure 26-4 shows some common frequency ranges for musical instruments and the human voice.

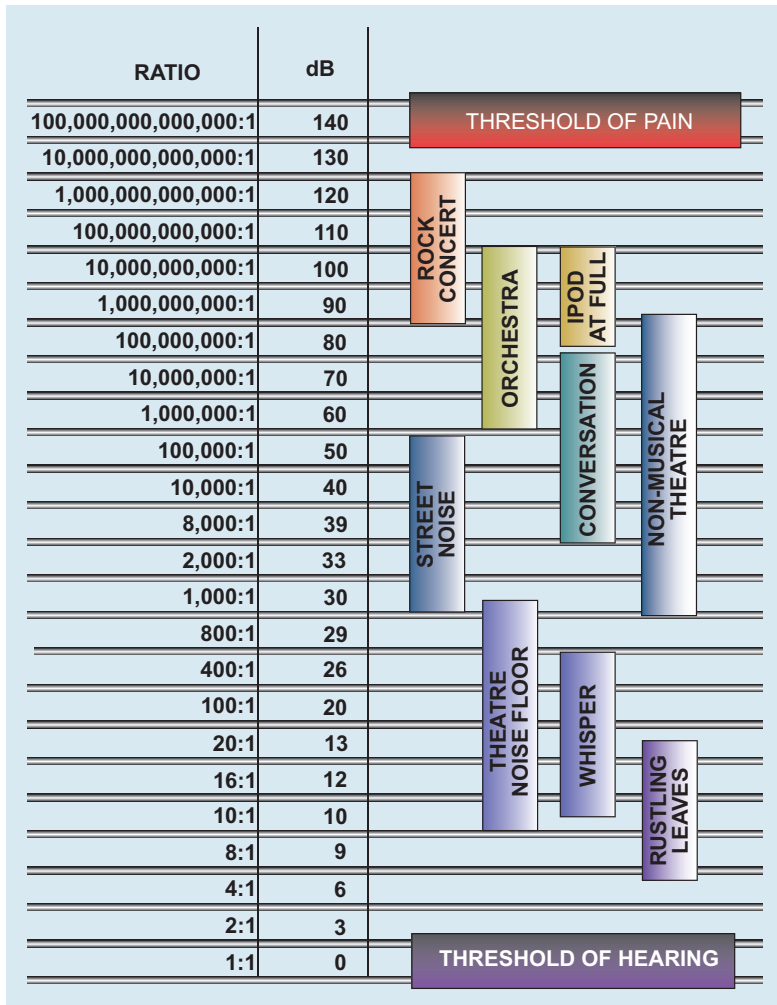
Amplitude The height of a sound wave is called its *amplitude*, which is synonymous with the volume or intensity of sound. The most common measure of amplitude is the **decibel** (dB), with 1 dB being the smallest difference that can be distinguished by the normal human ear. The decibel measurement is not on a linear scale, however; it is instead a ratio of two intensities. The next chapter provides more on decibel levels.

Here are some important terms and concepts concerning the volume of sound. **Sound pressure level (SPL)** is a standard measurement of loudness that uses decibel values (Figure 26-5). **Threshold of hearing** refers to the quietest sound human beings can hear, or 0 dB SPL. The **dynamic range** of a sound is the difference between its smallest



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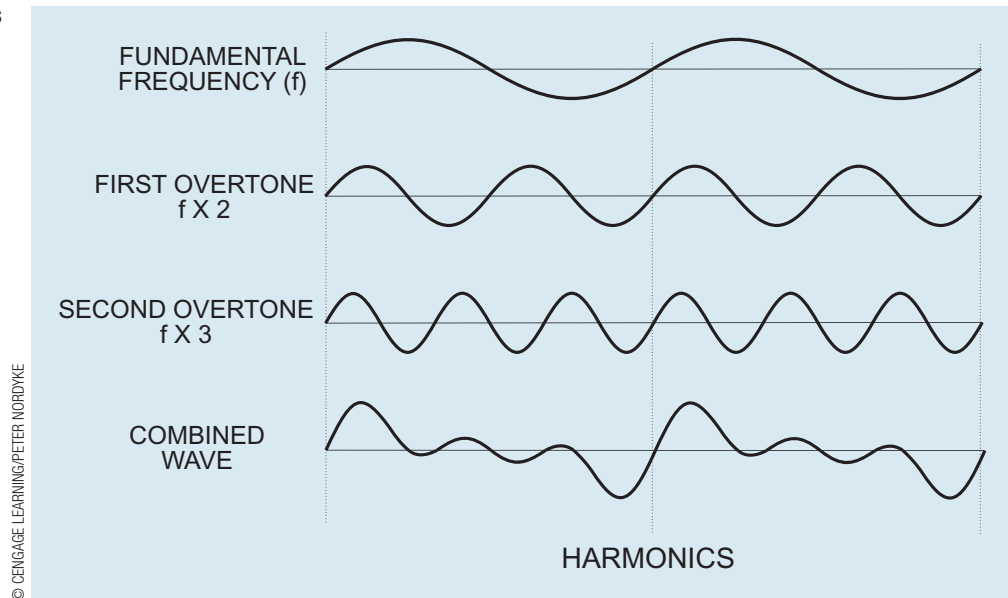
26-4 Frequency Ranges A comparison of musical sounds and their frequency ranges.



26-5 Sound Pressure Levels (Loudness) A range of sound pressure levels between 0 dB, the threshold of hearing, and 130 dB, the threshold of pain. Increasing the sound pressure 100 times (100:1 ratio) is equivalent to a 20 dB increase in SPL.

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26-6 Harmonics



and greatest amplitudes. In live situations, dynamic range is the difference between the ambient sound of a theatre auditorium (referred to as the “noise floor”) and the loudest sound level. Finally, it is important to remember that sound intensity drops off by the square of the distance from the source (*inverse square law*).

Harmonics As stated earlier, a sound consisting of a single frequency is unusual in nature. Most sounds produce a primary frequency aptly named the *fundamental frequency* as well as a number of subsequent frequencies called *overtones* or **harmonics**, which are multiples of their fundamental frequencies (Figure 26-6). For example, the violin may produce a fundamental frequency of 440 Hz, (A above middle C), but its sound also contains frequencies of 880 Hz, 1,760 Hz, 3,520 Hz, and so on. We hear the fundamental frequency best because it is usually the lowest pitch of them all as well as the loudest. Harmonics are present in all complex sounds and contribute greatly to the uniqueness of a sound.

harmonics The overtones that are created when a note is played on a musical instrument. Normally, these are multiples of the fundamental frequency.

timbre The tonal quality of a note, sung or played on a musical instrument, that includes the fundamental frequency of the note combined with all the harmonics (overtones) created. Timbre is what distinguishes the sound of two different musical instruments playing an identical note at the same volume.

Timbre The quality of a sound that makes it unique is referred to as its **timbre**. Timbre is the distinction in sound between two different musical instruments playing an identical note at the same volume. As stated, harmonics is an important part of timbre. However, the distinctiveness of a sound is also determined by the sound’s *resonator*. The sound of an acoustic guitar is dependent on its construction. Likewise, each human voice sounds a bit different because of the individual make-up of a person’s anatomy.

Perception

Sound and vision are the tools we use to recognize our surroundings. Vision is unidirectional, whereas sound perception is omnidirectional. By a process of *triangulation*, our two ears give us the ability to roughly locate the sound of, say, a chirping bird. We then use amplitude, time differences, and phase shifting to give us more information about the sound. This is referred to as **binaural localization**. Because of the placement of our ears, localization of a sound on the horizontal axis is much easier than the vertical.

binaural localization Using our two ears to locate a sound, primarily by noting which ear receives the sound first.

To learn how to manipulate sound effectively, the theatrical sound designer must be acquainted with additional principles of sound perception concerning distance and loudness, masking, recognition, and reverberation.

Distance and Loudness The inverse square law tells us that the loudness of a sound decreases significantly over distance (doubling the distance = $\frac{1}{4}$ the volume). In addition, air absorbs sound energy. The higher the frequency, the greater the absorption. As a result, distant sound is not only softer than close sound, it also lacks higher frequencies.

An experiment by Harvey Fletcher and W. A. Munsen in 1933 showed another important feature of loudness perception over distance. They discovered that the frequencies we hear best are between 2,000 and 4,000 Hz and that this midrange acuity becomes more pronounced as loudness decreases. In other words, distant and quiet sounds are perceived as having limited dynamic range—their lower and higher frequencies are not heard as well. It follows that our brain's most accurate indication of the distance of a sound is through frequency identification. The sound designer needs to capitalize on these factors when preparing distant sounds for theatrical playback.

Masking The blocking of one sound by another is referred to as **masking**. This phenomenon occurs when one sound or event demands our attention to such a degree that it negates other sounds or events. Sound masking is most often the result of a louder sound taking over quieter sounds, but masking may also occur if a sound is unusual or out of place.

masking When one sound or event demands our attention to such a degree as to negate other sounds or events.

At equal volumes, a lower frequency masks the frequency just above it. This is significant, especially when a designer makes selections for *underscoring* (music playing under dialogue). Masking may occur if underscoring frequencies are lower and adjacent to those of the dramatic dialogue.

Recognition As we have seen, decreasing the amplitude of a sound does not by itself give the sound a sense of distance. Likewise, merely increasing the amplitude does not necessarily allow people to hear a sound better. Recognition of a sound depends on the interaction of its *duration*, *familiarity*, and *volume*. A sound must last long enough to be understood. Familiar sounds are the most easily recognized. And, to a point, a louder sound is more readily perceived than a softer one. When making sound effect choices, the designer must take all three of these factors into account.

Reverberation Our ears receive sound waves both directly from a source and reflected off various surfaces. As we have seen, these multiple reflections are known as *reverberation*. One of the primary means we have of identifying our immediate surroundings is an analysis of the relationship between direct and reflected sound. Remember that our ears receive a reflected sound *after* the original. The brain then compares the reflected waves with the original in terms of timing and quality and forms a “picture” of our environment for us. For instance, if the delay between direct sound and reflected sound is long and the sound has not been greatly muted, our environment is felt to be cavernous. A sound is perceived as “rich” if it contains a certain degree of reverberation; it is flat or “dry” if it does not. The sound designer can manipulate the mood of a sound or a piece of music through frequency as well as reverberation control.

Acoustics

Acoustical measurements of a room or a theatre indicate how that specific space responds to sound. The study of **acoustics** is a subject of its own; here we discuss the basic factors that are most significant to the sound technician and the designer.

acoustics The scientific study of the total effect of sound, especially as produced in an enclosed space. In the theatre, this may relate to reflection, absorption, and creation of harmonics that characterize a theatre's reverberant field.

Acoustical Reverberation A major element in acoustical study, *reverberation* must be controlled for sound to be heard well. As noted earlier, too little reverberation makes a room sound “dead,” lacking in richness and fullness; too much causes complete lack of intelligibility. In a performance space, the key to good sound is directly related to the reflective qualities of the room; however, the matter is complicated by the fact that the

ideal reverberation time for speech is not the same as that for music. Between .8 and 1.4 seconds of reverberation time is preferable for the speaking voice. Musical instruments require more time for their sounds to blend well—from 2 to 3 seconds. *RT60* is a measurement of reverberation time; it is the length of time it takes a sound level to drop 60 dB.

Reflective Surfaces Because sound emanates in all directions from a source, it is reflected by many different surfaces in a typical theatre. Scenery onstage as well as the walls, floor, and ceiling of the auditorium all reflect sound. If the side walls of an auditorium are parallel to each other, sound is bounced back and forth between them, creating reverberation that may destroy intelligibility. A hard, flat ceiling can act as a valuable sound reflector, but a convex ceiling serves better because it disperses the sound more evenly.

To control reverberation, acousticians treat walls and ceilings with absorptive materials. They carefully design the shape and the interrelationship of the walls and ceiling and pay close attention to the *rake* (slope) of audience seating, the seats themselves, and floor treatment. Still, there remain several uncontrollable variables, such as number of people in the seats (people absorb sound), scenery on the stage, and quality of sound reinforcement. Large multipurpose auditoriums are built with adjustable ceilings and side walls that either increase or decrease reverberation time in order to accommodate both speech and musical instruments.

Recent developments in acoustical analysis software have made a big difference in how much influence a sound designer can exert over a space. Programs such as SIM 3 from Meyer Sound or EASE from Renkus-Heinz create sophisticated acoustic simulators capable of analyzing how sound from various speakers reacts in a given space. ODEON from Odeon A/S is room acoustics modeling software used by architects and acousticians to solve acoustical problems before a building is ever built (Figure 26-7).

Sound in the Theatre

Several tasks are involved in theatrical sound: the designer is concerned with the recorded music and effects used to enhance the overall production, the reinforcement of the actor's voice as well as the theatre's communication systems. The designer also may be called upon to design the sound system itself. Occasionally, different people are employed for each of these responsibilities, but it isn't unusual for a single sound designer to be asked to accomplish all of these tasks. In addition to the performer's natural voice, sound in the theatre can be divided into four functional categories:

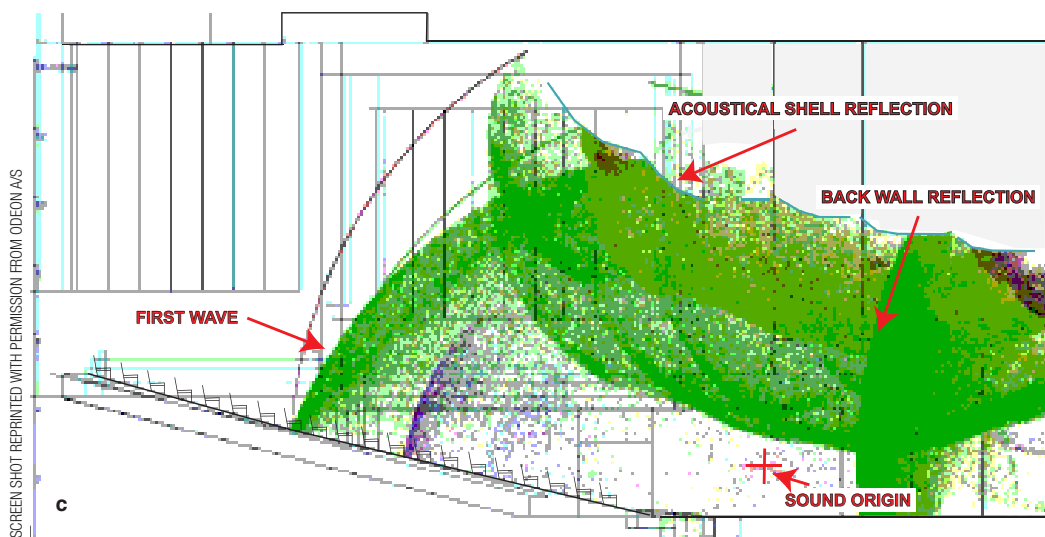
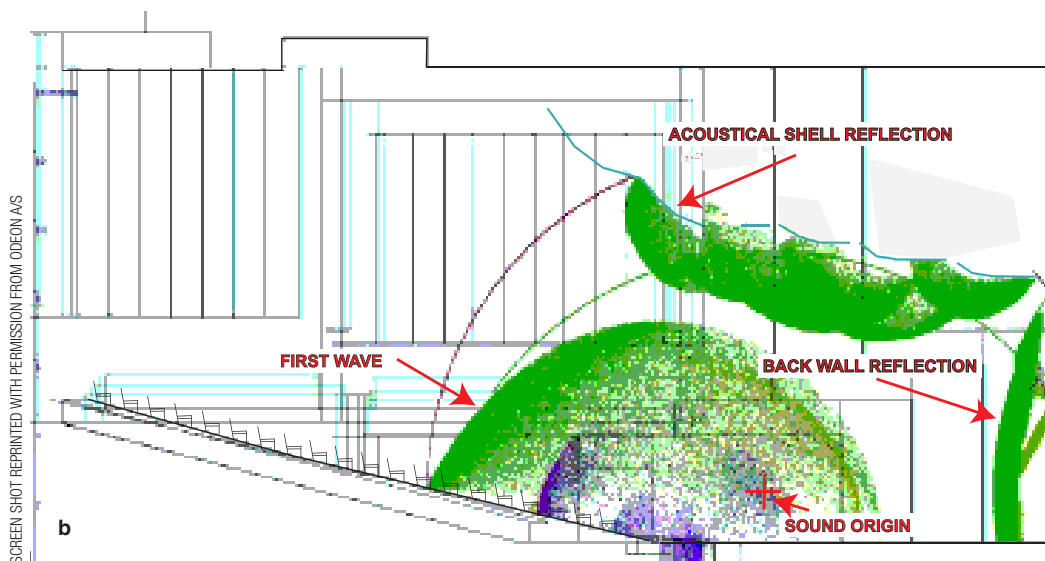
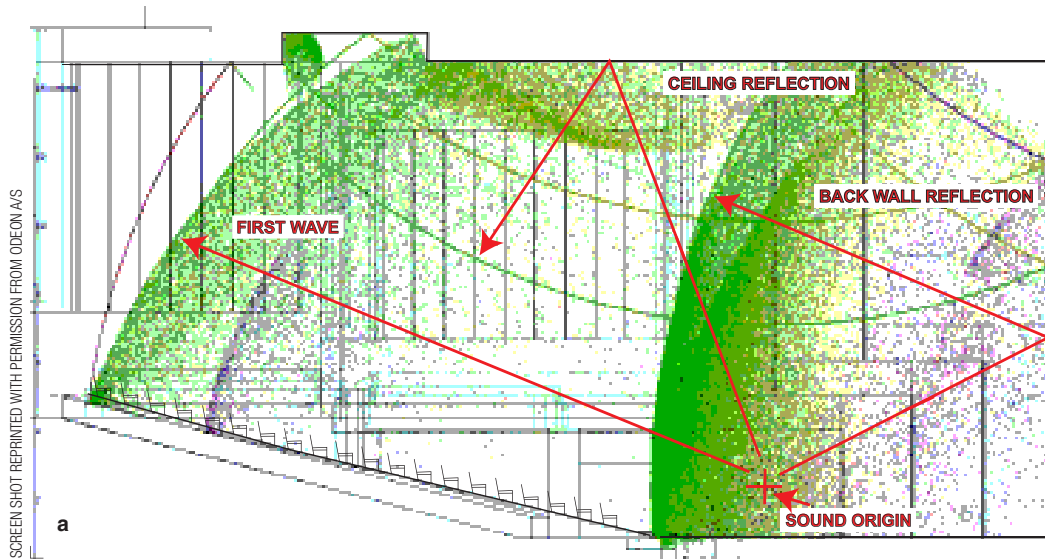
- Production design
- Reinforcement
- Audio communications
- System design

Production Design

Theatrical sound design's most creative task is analyzing a script and creating the sound for a production. The designer has the responsibility of becoming extremely familiar with the script, determining when and where to use sound, researching and finding the appropriate sounds, and organizing them for production playback. Recent developments in sound editing software have greatly increased the creative potential of the theatrical sound designer. Today, anyone with a computer and a bit of software can easily edit sound as well as compose music. More on the subject of production design is found in the section of this chapter titled, "Sound Design for the Theatre."

26-7 Acoustical Models

- a** Large auditorium with no acoustical baffles. Illustration indicates long reflection times (echoes) and loss of intelligibility.
- b** Convex acoustical baffles reflect the original sound, shortening the reflection time.
- c** Reduced reflection times lead to blending of the sound waves and increased intelligibility.



Reinforcement

reinforcement The electronic amplification of actors or musical instruments onstage. Typically used to do the following: (1) Help the audience hear the actors. (2) Blend and balance the vocals and the musical instruments in a musical theatre production. (3) Add an effect or change the quality of a voice.

The most equipment-intensive of sound tasks, **reinforcement** is the amplification (and sometimes processing) of a live sound. In the theatre, such sounds are most often, but not restricted to, performers' voices or musical instruments. What makes amplification tricky is the usual desire to maintain as natural a sound quality as possible. Reinforcement is typically necessitated by either poor room acoustics or the desire to balance two or more sounds. Musical theatre is an obvious example because balancing an orchestra and a singing voice is often a necessity. Larger theatres commonly require reinforcement; however, theatre audiences have become so used to amplification that they have come to expect it in all but the most intimate venues.

Vocal Amplification Greater emphasis on amplification in the theatre has required that sound designers become proficient in using a wide variety of reinforcement equipment and techniques. Wireless microphones amplify a single actor's voice, sophisticated mixing equipment provides for complex balancing of sounds, and digital delay units make sure that the sound reaches the audience at the proper time.

In dealing with sound reinforcement, the designer must always remember that our perception of where a sound comes from is overwhelmingly based on where we hear the sound from first, which in live theatre should be the actor, not a loudspeaker. In fact, this first arrival is so strong that sound coming from a loudspeaker can be up to 10 dB louder than the sound coming directly from the actor and an audience member will still perceive the sound source as coming from the stage. Called the **Haas Effect**, this is the guiding principle in dealing with speaker placement and use of electronic delays in the theatre. If a loudspeaker is closer to the audience than the actor is, the loudspeaker signal must be delayed.

Haas Effect Localization of a sound is primarily dependent upon the location of the first sound to reach our ears.

foldback system Typically a separate set of amplifiers and speakers placed to direct their sound to the actors/singers so they can hear the orchestra and themselves. Also placed in the orchestra for musicians to hear themselves and the actors/singers.

A sound designer may also amplify sound so that performers can hear it. Such an arrangement is called a **foldback system**. It consists of speakers that allow performers to better hear recorded or live music as well as themselves. Individually controlled speakers, called either foldback or monitor speakers, are placed so as to direct their sound to the performers. Foldback systems may also be necessary for certain players in the orchestra to hear themselves as well as for the conductor to hear the singers and/or musicians. Due to specialized requirements, each foldback system needs to be controlled and mixed separately from the others and from the main audience sound system.

Live Music There is no substitute for the magic and excitement of live music in the theatre. Although live music is certainly not limited to the musical theatre orchestra, a full orchestra tends to have the most elaborate electronic sound requirements. There are occasions when the live musical requires no electronic treatment of sound at all, but these tend to be the exception rather than the rule.

Traditionally found in a pit located at the front of the stage, the musical theatre orchestra of today may just as likely be found backstage behind a scrim, or on a side stage, or on the stage itself. However, moving the orchestra is often fraught with problems, including sound. Individual musical instruments, instrumental sections, or even the entire orchestra may need to be miked in order to provide sound that is properly balanced with that of the performers. Even a small orchestra requires a great deal of physical space that must include room for music stands and lights, details that might fall under the auspices of the sound department. As mentioned earlier, *foldback speakers* may also be necessary for certain parts of the orchestra to hear themselves or the singers.

The Conductor An orchestra's conductor often has no special sound requirements, with the possible exception of foldback speakers as well as necessary communications (discussed later). It may seem obvious, but the conductor must be able to see the stage, and the actors and musicians must be able to see the conductor. These seemingly minor details can require extensive treatment, often demanding closed-circuit video.

A single camera set up to cover the stage can suffice for the conductor equipped with a small video monitor. A second camera focused on the conductor, along with several large monitors situated about the stage or on a balcony rail, may be necessary to enable the performers to see the baton. If this is the case, sufficient light must be cast on the conductor to accommodate a video signal.

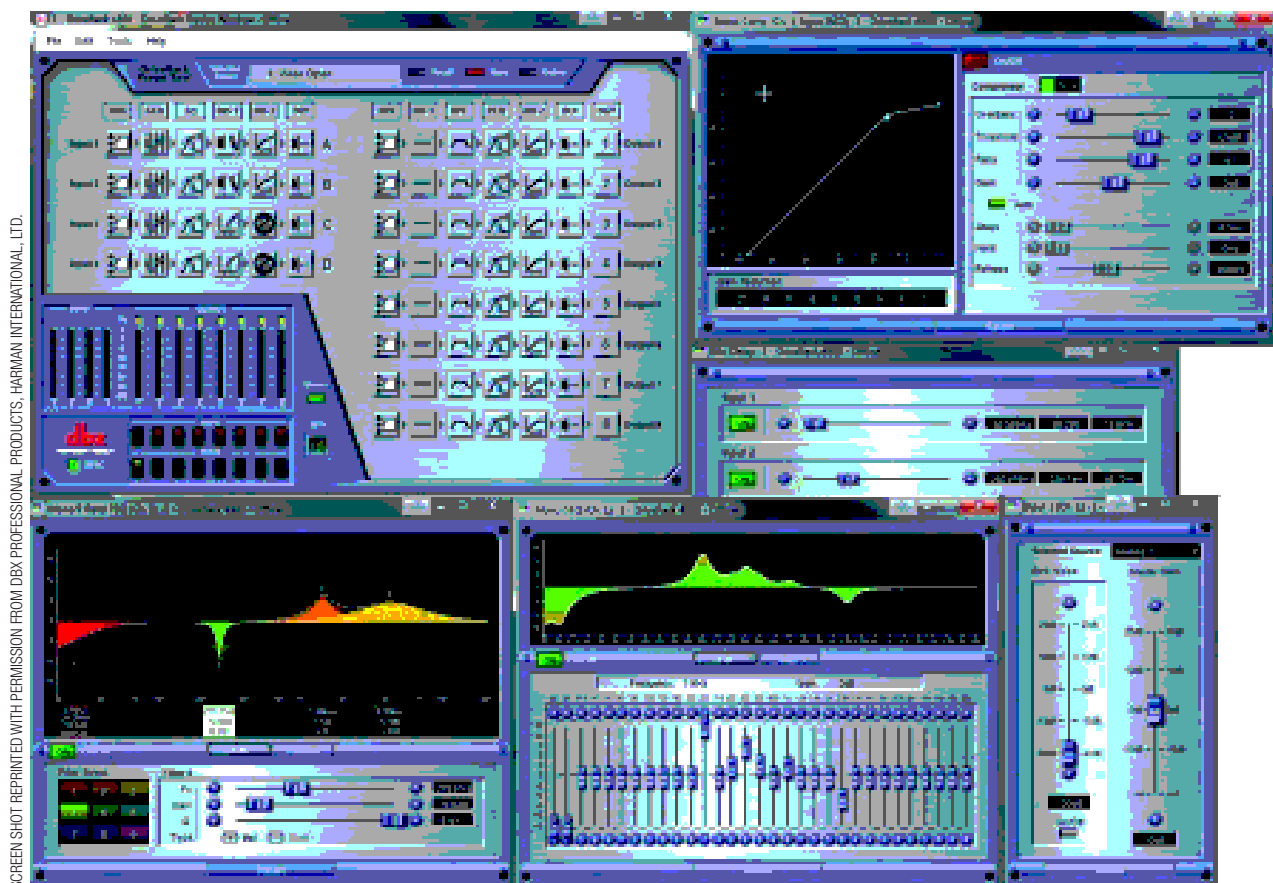
Requirements for a musical theatre reinforcement system will most likely change for every production. The design of such systems involves speaker selection and placement, microphone selection and placement, and a sophisticated mixing control console that must be located in the auditorium. The mixing console operator must hear what the audience hears.

Live Sound Processing The act of treating sound with electronic equipment in order to change its quality is called **processing**. Extremely valuable in both production design and reinforcement, processing used to involve routing the sound through numerous pieces of equipment such as effects processors, compressor units, or equalizers. Today, we employ specialized signal-processing equipment, either as an outboard addition to an analog mixer or built into a digital mixer, to adjust all parameters of the audio signal. In addition, software such as Graphi-Q2™ from Sabine or DriveRack® from dbx can perform sophisticated acoustical feedback analysis and adjustment to dynamically set filters and significantly increase a system's potential gain before feedback (Figure 26-8).

An **equalizer** is a particularly useful processing tool. Depending on the circumstance, both the female and male voice, as well as most musical instruments, can benefit from proper and judicious *equalization*—a process of electronically boosting or cutting selected frequencies. Because of their particular acoustics, many auditoriums require

processing Altering the audio signal in a nonlinear fashion. Equalizers, effects units, and compressors are examples of signal processors.

equalizer An electronic device that alters a specific frequency or frequency range. The two most common types are graphic and parametric.



SCREEN SHOT REPRINTED WITH PERMISSION FROM DBX PROFESSIONAL PRODUCTS, HARMAN INTERNATIONAL, LTD.

26-8 Sound Processing Screen shot of System Architect software controlling dbx DriveRack® hardware which combines many signal processing tasks.

26-9 Audio Communications

- a Clear-Com wired headset.
- b Belt pack.
- c Digital wireless belt pack with headset.
- d Hand Set.
- e System receiver.



PHOTO COURTESY CLEAR-COM, AN HME COMPANY

equalization in order to control undesirable resonant frequencies. An equalizer will often be found as an integral part of the reinforcement system. (This tool will be discussed in greater detail in the next chapter.)

Audio Communications

Production Headsets Many people scattered all over the theatre need to be in constant touch with the stage manager and one another during a performance. A flexible and reliable system of audio communication is therefore crucial. Usually, such a system is built into the theatre. If not, a portable system is necessary, and the sound technician may have to attend to it. Headsets are the most common and useful system, and several companies manufacture a sturdy and reliable product (Figure 26-9).

Certain locations in the theatre are best served by speaker stations as well as headsets. These include the fly rail and loading dock, where stagehands cannot wear headsets, and perhaps soundproof booths such as the lighting control booth. Wireless as well as wired headset systems are available. Obviously, not being attached to a wire is a big plus for users such as backstage personnel, but this system's cost and maintenance is greater than that of conventional headsets.



SOUND ADVICE ■ Headset Suggestions

- A system with more than one channel is often very useful, sometimes imperative.
- Use headsets with one earphone rather than two, so that live sound can also be heard (an exception might be in high-volume situations such as rock concerts).
- Always have working spare headsets and the belt packs that power them available and readily accessible.
- Treat headsets with the care and respect they deserve—they are fragile instruments.
- Know what to do if headsets fail—have a backup system.

Assistive-Listening Devices Many larger theatres have a built-in audio system designed to assist audience members who have special hearing needs. This system is normally completely separate from the other stage audio systems, having its own input microphones, amplifiers, and transmitters. An audio signal from the stage is sent to an infrared or radio frequency (RF) transmitter that, in turn, sends a signal to special headsets being worn by the hearing-impaired.

System Design

Designing a sound system involves selecting the proper equipment for the task at hand. It may be as simple as choosing whether or not an equalizer is required or as complex as specifying all equipment to be rented. This is one reason why the sound designer must be very familiar with individual pieces of equipment, from playback units to speakers, and how they function. More on system design follows in Chapter 27.

The Tools of Sound Design

The building blocks of any sound design are the tools with which the designer works. The script and the approach to the production, as developed by the design team, determine the choice of these tools, including the following:

- Composed and processed sound
- Music and underscore (live or recorded)
- Sound effects and environmental sounds (live or recorded)
- Speaker placement

Composed and Processed Sound

Some of the greatest potential for creating exciting music and effects falls under the category of composed and processed sound. The production and manipulation of sound as a design tool has been made possible by technological advances beginning with the *synthesizer*, followed by *samplers* and *digital effects processors* and, most recently, *computer compositional software*.

Synthesizers and Samplers The most common type of synthesizer is either an electronic keyboard or computer software that can simulate an array of sounds, including those of various musical instruments. Synthesizers come in a variety of types and price ranges, one type primarily intended for performance and another for production. *Digital samplers*, as the name implies, record and manipulate digital **samples** of a sound. Some of the new keyboards/digital workstations can act as both synthesizer and sampler and use computer algorithms to model acoustical instruments with much of the subtlety of the instrument itself played live. The possibilities are almost endless as the sound designer learns to use this equipment to produce and/or alter sound to fit the mood or style of a production.

Compositional Software Loop-based software such as Sony's ACID Pro (Figure 26-10) allows a designer with little or no musical instrument skills to compose music. This software is based on libraries of prerecorded sound "loops" that are designed to seamlessly repeat themselves as long as required. Using a multitrack environment, the designer can choose a sound and place it on one of the tracks; another sound can go on a second track, and so forth. By combining tracks and sound loops, a complex score can be created with relative ease. Because the loop files contain tempo, time signature, and pitch information, any of these can easily be changed. In addition, each track has its own volume, panning, and

sample Taking a "snapshot" of an analog waveform and assigning it a numerical value. The number of times per second that an analog to digital converter (ADC) freezes and assigns a numerical value to the signal (voltage) is the sampling rate. A 16-bit stereo sampling rate of 44.1 thousand times per second is referred to as CD quality.

26-10 Created Sound Effects Loop-based sound composition software allowing for time-based music creation.



SCREEN SHOT REPRINTED WITH PERMISSION FROM SONY ELECTRONICS INC.

effects envelopes, allowing control of these features. While there are numerous loop libraries available, a designer can also create unique original loops.

Processed Sound Samplers, digital effects processors, and computer software offer many ways to alter sound in order to create a particular effect. One of the most popular is *pitch shifting*, the process of speeding up or slowing down a recorded sound in order to change its quality. As a sound is slowed, its pitch is lowered, resulting in a “bigger” sound; for instance, a small engine can be made to sound like a huge turbine by slowing the playback speed. This was the primary reason for having a variable-speed tape machine in the sound studio of the past.

Other valuable techniques are mixing *sound on sound*, playing back in the *reverse direction*, *filtering* using an equalizer or equalization software, and adding *echo* or *reverb*. Sound-on-sound mixing through the use of multitrack recording and editing software can be quite subtle, adding a “richness” to the sound; alternatively, its effect can be quite abstract and bold.

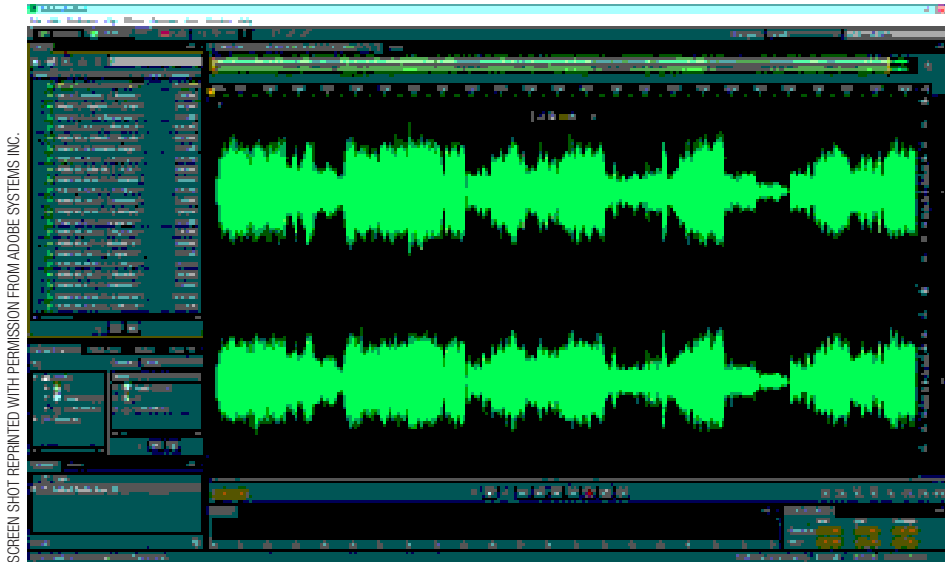
Using *equalization* to filter sound can reduce or eliminate low frequencies, conditioning a piece of music to serve as underscoring. It can add as well as subtract hiss and noise in a recording, and it can subtly adjust the quality of a music selection or sound by attenuating (turning down) or boosting certain frequencies.

Editing Software For most editing requirements, a computer with various audio software applications has replaced the need for vast amounts of hardware. Available software such as Pro Tools® or Adobe® Audition® (Figure 26-11) enable the sound designer to import sound and alter it with the stroke of a mouse. Waveforms can be viewed, processing performed, and effects created in an astonishingly short time. Learning curves vary, but elementary programs are extremely simple to learn. In fact, most of today’s new computers come with some form of sound hardware and software.

Multitrack editing software allows the designer not only to record and play multiple tracks simultaneously but also to individually modify each track in several different ways:

- **Amplitude.** Used to adjust volume or normalize the level across a track or in an **envelope** and add dynamic processing, such as limiters, compressors, and expanders.
- **Delay Effects.** Adding such effects as echo, reverb, chorus, and multipath delays to a track.

envelope Traditionally, the dynamics of an individual sound from a musical instrument in terms of attack, decay, sustain, and release. Contemporary usage: the window used to dynamically alter a sound track over time.



26-11 Editing Software Waveform and multitrack editing software.

SCREEN SHOT REPRINTED WITH PERMISSION FROM ADOBE SYSTEMS INC.

- *Filters.* Using graphic, parametric, or other dynamic equalization.
- *Restoration.* Removing pops and clicks from old recordings. Removing tape hiss from reel-to-reel or cassette recordings. Restoring tracks that are clipped from excess volume when they were recorded.
- *Time and Pitch.* Adding such effects as Doppler shift, pitch bending, changing pitch, and time stretching.

All these techniques can be achieved by using the proper editing software, including the following:

- *Avid.* Pro Tools (complete music production system), www.avid.com
- *Sony.* Sound Forge (digital audio production suite), www.sonycreativesoftware.com
- *Adobe.* Audition (integrated audio recording, mixing, editing, and mastering), www.adobe.com

Music

Most of today's productions use either live or recorded music to enhance the performance. This music may be either found or composed by the sound designer.

Incidental Music Preshow music is played as an audience enters the theatre. Selection of this **incidental music** is never left to chance, for the designer would be wasting a great opportunity to put audience members in the proper frame of mind for the upcoming performance. Preshow music can establish the period of the ensuing production, comment on the action that is about to take place, or hint at the style of the production. In addition, a particular type of sound (electronic music, for instance) used elsewhere in the production can be introduced at this time in order to acclimate the audience to the sound.

In making selections from existing music, the designer must proceed with great caution. Music carries with it associative memories that stick with people for a long time—sometimes all their lives. Richard Strauss's "Also Sprach Zarathustra" (used in the film *2001: A Space Odyssey*), the much-played 1812 Overture by Tchaikovsky, and almost any Beatles tune are just a few examples of music that would have to be used with great care. Most designers like to work with original music in order to avoid audience associations. Teaming up with a composer or using composition software, such as Sony's ACID Pro, Ableton's Ableton Suite™, or Cakewalk® SONAR™ X1, are highly recommended in situations where music will play a major emotive role in the production.

incidental music Music that occurs other than during the actual play, such as before and after the show or at intermission.

change music Music used to cover the time and possibly the noise of a scene change.

underscoring Playing music or other sound “under” dialogue in order to affect mood or comment upon the action.

effects Music or sounds that are prerecorded and played back during a scene, such as that from an onstage phonograph or radio.

Change Music Music accompanying a well-choreographed scene change can make a potentially painful experience pleasurable. Yet, music used solely for covering changes (and nowhere else in the production) may appear obvious and out of place. Of course, this **change music** must be as carefully selected as any other. The designer may select the music to reflect on the scene just past or to set the tone for the one to come. He or she must always remember to allow for greatly varying scene change lengths from performance to performance.

Underscoring As mentioned earlier, the powerful technique of **underscoring** involves playing music or other sounds during character dialogue. It is perhaps the trickiest way to use music in a production. The danger lies in competing with the spoken word to the extent of distraction or masking. In addition, the technique itself, which is used commonly in television and film production, can become obvious and ridiculous. The camera focuses an audience’s attention to a much greater degree than theatre does, where the normal field of focus is considerably broader. Therefore, the designer must approach underscoring in the theater with particular care and consideration. Many stage directors may at first find underscoring distracting to the point of being unacceptable as a technique. However, it can be used effectively if the sound designer introduces the music at low levels using limited dynamic range and remembers the principles of masking. Underscore music or sound should be added to the rehearsal process as early as possible to allow actors to adjust to its presence and tempo.

Effect Music When music is used as an **effect** (motivated by a radio playing, a piano in the sitting room, or a jazz combo across the street), selections require careful attention as to their appropriateness. Being true to the *source* of the music, as well as the style and period of the play, is critical. For example, a jazz combo playing onstage will exhibit a great deal of dynamic range and sound quite different from that same combo heard on the radio or even across the street.

Sound Effects

Although one could argue that *any* use of sound in a stage production is an effect, it is helpful to consider most music and processed sound to be separate from effects. Sound effects can be found prerecorded, be self-recorded, or be created. Sources of sound effects are only as limited as the designer’s imagination.

Prerecorded Sound Prerecorded sound effects can be downloaded from the Internet or found as libraries on CDs. Several of the better sound effect libraries that sell prerecorded effects include these:

- *Sound Ideas*. SFX Library; www.sound-ideas.com
- *The Hollywood Edge*. SFX Library; www.hollywoodedge.com
- *The Sound Effects Shop*; www.soundeffectsshop.com
- *Valentino*. SFX Library; www.tvmusic.com

Here are a couple of websites that also offer downloadable sound effects:

- *Sounddogs*. www.sounddogs.com
- *Soundsnap*. www.soundsnap.com

Music stores carry various small collections, which are the least expensive, although their quality varies. The purchase of an effects library represents a significant investment, but the ready availability of effects is an absolute necessity for even a modest production studio. Although the Internet and a computer with composition software, along with synthesizers and samplers, have elevated sound production to new heights, they have not negated the value of an effects library.

Other sources of prerecorded effects might be local radio stations or professional recording studios, where both the quality and cost will be high. Become familiar with the studio nearest you; its personnel are usually audio experts and can offer great assistance.

Self-Recorded Sound The sound engineer can also directly record environmental sounds, the playing of musical instruments, and the human voice. Recording on location can be fraught with problems that range from special equipment demands to the need for sound isolation. Although not to be totally avoided, this technique of sound gathering should never be left to the last moment, and a backup plan is advisable. Studio work is much safer, and a wide range of recordings can be accomplished in a well-equipped studio space.

Created Effects Created effects, by far the most interesting, offer great potential for exciting design results. Found objects such as pieces of metal, noise-making machines, and everyday things such as squeaky screen door hinges all have possibilities for interesting effects. Sound designers investigate objects made up of as many different materials as possible (tin interacting with fiberglass or metal tubes striking glass, for example) and imagine how each sound might be used—they also keep a written record of their findings. Finally, the possibilities for creating sound by using a computer with software such as the earlier mentioned ACID Pro or SONAR are endless.

Speaker Placement

The final tool available to the sound designer is control over how the sound will reach the audience. Although the selection of speaker type (discussed in the next chapter) significantly affects a sound's quality, the placement of speakers matters even more than the type. Recall that the location of our ears gives us greater horizontal than vertical sensitivity to the direction of a sound source. Therefore, principles of sound reinforcement state that speakers should be located above the stage in order to maintain a proper directional sense of the performer. This is a good rule to remember, but it may not always apply to performance music and sound effects.

For effects that have a distinct source (for example, a gutted radio prop located onstage), the speaker should be located inside or as close as possible to the object. Speakers come in a variety of sizes, and good sound is being reproduced from some very small speakers these days—so locating the speaker right onstage is usually achievable. Distant effects can often be helped by speakers aimed in some direction other than at the audience. The theatre's grid and auditorium ceiling are also valuable speaker positions.

Many sound designers like to hang their speakers above the stage. This is desirable for a variety of reasons: clearing valuable deck (stage floor) space, keeping sound cable in the air (off the floor), and providing source direction. If plans include hanging speakers, the scenic and lighting departments must be advised well in advance; they also need that air space and, if consulted, will be less likely to place a black border immediately downstage of the speaker position. A valuable rule of thumb is that a speaker must be able to “see” the audience in order to deliver good sound.

Finally, flexibility of speaker placement is absolutely necessary for good production sound. Although not true for reinforcement, playback requires that the designer have the ability to place speakers in any position.

Sound Design for the Theatre

The best design in the theatre is a result of good collaboration. The production sound designer should be involved in the collaborative process from the start. This is when the style of production is determined, a factor that will heavily influence sound decisions; this is when the scene designer can be made aware of special sound needs such as

speaker placement; and this is when creative ideas can be shared with the director and other designers. Like the lighting designer, the sound designer normally has a bit more time to develop his or her ideas than do the scenic or costume designers. This means that the sound designer may have the luxury of attending rehearsals before final design decisions must be made.

Functions of Sound Design

The design of musical and audio effects for theatrical production is certainly the most creative and perhaps the most important function of sound in the theatre. Such design requires that a person have a strong background in general theatrical production, a good knowledge of sound equipment, and an interest in and familiarity with music and sound. In addition, music composition skills are a big plus. The ways sound design can contribute to theatrical production fall into three categories:

- Evoking atmosphere or mood
- Reinforcing the action
- Commenting on the action

Evoking Atmosphere or Mood One familiar way sound can evoke a specific atmosphere or mood is by using environmental sounds in a realistic manner. Such use can help to establish *locale*, *environmental conditions*, *period*, and *time of day*, as well as mood. Examples abound: bright chirping of birds for a cheerful morning scene, ominous rolls of thunder preceding a storm, or sad notes of a lone violin. Although it must be handled with some degree of caution, realistically motivated sound is one of the easiest to use because of the audience's inclination to readily accept such sound.

The designer can also use either nonrealistic or unmotivated sound to evoke an atmosphere or mood. *Unmotivated* sound has no apparent source; *motivated* sound does, such as recorded music coming from an onstage piano. Musical underscoring is often unmotivated and while it can be extremely effective in any style of production, a subtle touch is required.

A designer must never forget the power of silence. The impact of establishing an atmospheric sound, such as crickets chirping, then suddenly cutting off the sound can be more dynamic and effective than any other device.

Further examples of the use of atmospheric sound are pre- and postshow music and incidental or change music. The selection of such music depends completely on the style of production as determined by the director and artistic team during their early collaborative meetings.

Reinforcing the Action Using sound in a realistic manner to reinforce the action of a play helps to keep the audience informed of current or upcoming events. Sound coming from a television just switched on is an example, as is the ringing of a telephone or the sound of an approaching delivery truck. Such sounds are not chosen arbitrarily because the designer must remain faithful to the period and style of the production. And, even though the sound is primarily reinforcing the action of the play, there is often room for comment. The sound from the television may have a sharp and nagging tone, the telephone ring may be insistent, or the delivery truck may screech to a halt to express urgency. These sounds usually fall into the category of effects.

Commenting on the Action The designer can comment on an action by using sound in a symbolic manner. Such usage may or may not be motivated, and a wide variety of approaches might be taken. For example, a tympani roll on the entrance of a character in a certain type of production might be either comic or sinister depending on its treatment, and comic music playing under a serious scene will certainly affect an audience's

reaction to the scene. Underscoring serves as a powerful technique for commenting on the action. In every case, however, the designer must be extremely sensitive to the stylistic approach of the production and be sure that the sound is in every way appropriate.

The Sound Designer and the Design Team

Several references have been made to qualities that a designer of sound for the theatre should possess: a working knowledge of theatre production in general and sound production specifically; a passion for music, with interest in all types and periods; a technical knowledge that provides understanding of the equipment involved in sound production; and a keen environmental awareness that facilitates design creativity. In addition, every designer in the theatre must have the ability and the desire to share in the design process—to be a member of a design team. Of all the arts, theatrical design is unique in its collaboration. Relating to other designers and their ideas in a positive manner is not only exciting but also forms the very basis of collaboration.

The sound designer is involved with the production and the production team from their inception. An approach to a production is the result of script analysis, research, and design meetings with all the designers, the director, and perhaps the playwright. This approach is the product of much thinking and input; it will guide the manner in which the story will be told—including, but not necessarily limited to, which period, thematic elements, and production style will predominate. From this information will grow design ideas that will be unified by the fact that each stemmed from a common approach. Only then will the sound designer be ready to begin the exciting process of making specific choices.

The process of sound design can be broken down into four stages:

- Script analysis and research
- Preproduction
- Sound plot
- Production

Script Analysis and Research

Design for the theatre always begins with the script because it embodies the playwright's ideas on which all production choices are based.

Script Analysis The first time a designer reads a script, it should be read as if it were a novel. This reading allows the designer to take in the play without the distraction of design considerations. This is a very important reading, for it will form the basis of the emotional reaction to the script. The instincts gained from this initial reading will often have great influence on subsequent decisions. This reading should be completed before the first design meeting.

A second reading is done with the designer paying attention to specific production elements that may relate to the eventual design. This is where location, time of day, period, and environmental concerns are noted. It is a good idea to write down these items for future reference.

The third reading is necessary to gain specific information concerning sound for the production, including:

- *Sound cues specifically called for in the script* (often referred to as *intrinsic cues*). These are often motivated cues and include such things as a telephone ringing, radio playing, or dog barking.

- *Cues indicated by the playwright's notes, stage directions, or character dialogue.* These are often environmental sounds that the designer may or may not end up finally using in the production. Examples include the sound of rain if it is storming outside, the breaking waves of the nearby ocean, or a stage direction that a truck pulls up outside. There is a fairly important distinction between playwright's notes and stage directions. Stage directions are usually based on the design of the original production of the play and are often taken from the stage manager's book. Actual playwright's notes reflect the viewpoint of the author and should be given utmost consideration. Unfortunately, it is sometimes difficult to tell the difference between one and the other.
- *Cues that are primarily intended to enhance the mood of the production.* These cues could be either motivated or not. Underscoring is the best example of such a cue.

The information gained from this third reading should be carefully noted. It will form the basis of the forthcoming *sound score*. It is best to complete this reading after the preliminary design meeting when you have a better idea of your director's intentions.

Research Research involves much more than searching for music called for in the script. It involves learning more about the location of the play, its specific environment, and its time period. The difference between an adequate design and a great design is often determined by the extent of research put into the project. Research takes time, but the payoff is significant. A designer must learn how to research; such training is an important part of the curriculum of any good design program.

Location and environment can greatly affect sound choices. It is not difficult to find visuals of a certain country, landscape, or city. This visual information will inform later design decisions. The period in which the production is set will undoubtedly influence the ultimate style and quality of the sound. Period research, an essential step toward any good sound design, must take place as soon as possible because a sound score cannot be developed without proper research. Of course, films and actual period music are good research sources, but the designer should also consider reading about the period, reading books from the period, and looking at art and photographs from the period. Photographic records of architecture, clothing, and interiors will be a tremendous aid in discovering the feel of the times.

Design Meetings Design meetings are, first and foremost, a time to listen. Discover how the director and other members of the design team have reacted to the script. Share your reactions with them. In a successful design meeting, you will soon discover what is important to the director.

Much of the initial design meeting is devoted to the script. However, you should find out about more mundane things such as your budget, the venue's equipment list, production calendar, and any anticipated need for vocal reinforcement. Early design meetings allow each member of the team to present his or her own ideas and react to others. More technical concerns such as speaker placement and rehearsal CDs can be brought up at later meetings.

The Sound Score The early sound score (Figure 26-12) consists of a nontechnical written description of what the sound might eventually be like. It reflects how you as the designer are envisioning each cue in terms of mood, style, and period. This valuable paperwork may help in presenting ideas to the rest of the production team, but more importantly, it acts as an initial outline of the final sound design. Although there are no set rules concerning what information the score must contain, here are some things that should be included:

- The *number* of the sound cue
- Script location
- A *complete description* of the cue in terms of its content, mood, style, and other information, perhaps including special treatment

SOUND SCORE 12TH NIGHT		
SOUND DESIGN: JEFF LADMAN		
NO.	PAGE	DESCRIPTION
1	1	Extension of boat entrance as Viola leaves the boat and steps foot onto the Illyrian soil.
2	1	Viola moves farther onto Illyrian soil.
3	2	Strain of music from Orsino's group in the distance. It is coming from the portable gramophone, but will open out more generally as they come onto the stage. Will need to be timed to end. Something exuberantly romantic.
4	3	Orsino's "love" music, repeat of section of previous.
5	3	Exit of Orsino as group moves away and exits. In the same vein as preceding. Might be the beginning of the piece to which we only heard the later part.
6	4	Pull down on Viola/Orsino motif that runs through the show.
7	15	Toby entrance music with cart, et. al. ("Arise, Arise") Music is coming from the jukebox, as the cart, then opens up to a more general sound.
8	15	Olivia mourning music (interrupts or overlaps the preceding). A kind of dirge that needs to cover a cross-over by Olivia and her entourage. Will be interrupted by a large belch from Sir Toby in the middle of it. So, may need to be constructed in two parts.
9	21	Live dance cues.

SOUND DESIGN: JEFF LADMAN

26-12 Sound Score Sample from a sound score. The score helps the designer formulate and present early sound ideas to the director and other designers.

A great deal of thought goes into the creation of a sound score, with all decisions being based on the script, your research, and the production approach.

Preproduction

Once the sound score is complete, the designer may start to collect the required music and effects as well as begin the recording process. The time required for this work varies greatly, depending on the complexity of the design. The designer must allow at least three weeks before technical rehearsals begin; however, complex production designs may take several months to complete.

Master Computer Files As sounds are found, they should be stored in a *Master Folder* and carefully labeled for content. This folder will store all sound and music being considered for the production. Further “generations” of a sound can be stored in other folders as the designer works toward the final product.

The Director's CD As soon as a significant amount of sound has been collected, the designer burns a CD for the director containing representative selections of music and sound effects. The purpose of this **director's CD** is to gain imperative feedback concerning the style and mood of the selections as well as their appropriateness to the production. This is also a good time to attend rehearsals to get a better feeling for the atmosphere created by the actors, the pace of the production, and overall directorial intent. Keeping in close contact with the director and the stage manager of a production in rehearsal just makes good sense.

director's CD Selections of possible sound cues for the director to evaluate.

rehearsal CD Sound effects or music given to the director or stage manager for use in rehearsal; useful for timing or giving the actor a chance to work with underscoring, songs, or sound effects before technical rehearsals.

The Rehearsal CD A director may need a **rehearsal CD** well in advance of the actual show sound in order to coordinate actor timing or familiarize the actors with particular sounds. This CD is particularly useful for sounds with which the actors interact (such as a door bell or telephone ring) as well as underscoring. Necessary sound and music should be recorded onto a CD for ease of playback and should contain sound that is as close to the final product as possible. Preparing a rehearsal CD can prove to be of great advantage to the sound designer, often cutting hours off a technical rehearsal.

Sound processing such as equalization or digital reverberation treatment should happen next, followed by the building of the show CD or computer files. However, before the final show sound can be created, the designer must produce a sound plot.

Sound Plot

sound plot The actual working list of the cues for a production; normally includes cue numbers, speaker assignments, fade times, and so forth.

Another planning tool for the designer, the **sound plot** is similar to the sound score, but it is much more detailed and technical (Figure 26-13). This paperwork is preliminary to a sound cue list and helps the designer make decisions concerning playback. Components and format can vary, and some playback software will generate sound plots. However, every sound plot should include the following information:

- Sound cue number
- Script page number
- Cue description and length
- Playback device information
- Speakers in use

This is the design step where the designer plans exactly how the production sound will be run: how many and what kind of playback devices are necessary, exact speaker requirements and type of control, how many cues there will be, and how long each one should last. Often the stage manager can help and should at least be consulted for last-minute changes from rehearsals. Formulating the sound plot will give the designer enough information to proceed intelligently with the creation of the final show sound

SOUND PLOT 12TH NIGHT												
SOUND DESIGNER: JEFF LADMAN												
CUE NUMBER	PAGE NUMBER	DESCRIPTION	LENGTH	PLAYBACK DEVICE	FADE TIME ↑ ↓	SPEAKER ASSIGNMENT & LEVEL						NOTES:
						HOUSE LEFT	HOUSE RIGHT	USL	USR	GRAMOPHONE	CART	
1	1	Boat entrance FADE IN	2:34	CD #1 TRACK 1	↑ 0:05	∞	∞	-10	-10	∞	∞	As scene fades up and viola is on boat
2	1	fade to house speakers		CD #1 TRACK 1	↑ 0:10	-20	-20	-10	-10	∞	∞	Viola moves onto land
3	1	FADE OUT		CD #1 TRACK 1	↓ 0:05	∞	∞	∞	∞	∞	∞	20 sec. after cue 2
4	2	Gramophone FADE IN	5:21	CD #2 TRACK 1	↑ 0:10	∞	∞	∞	∞	+15	∞	Starts just before lights fade up
5	2	fade to house speakers		CD #2 TRACK 1	↑ 0:20	12:31 AM	-35	∞	∞	+20	∞	As Orsino's party enters
6	3	FADE OUT		CD #2 TRACK 1	↓ 0:15	∞	∞	∞	∞	∞	∞	As Orsino starts to leave
7	3	Orsino's love music	2:15	CD #1 TRACK 2	0:00	-10	-10	-15	-15	∞	∞	w/ light cue - start of scene
8	3	FADE DOWN house speakers		CD #1 TRACK 2	↓ 0:15	∞	∞	-15	-15	∞	∞	As Orsino's party moves away
9	4	FADE LOWER		CD #1 TRACK 2	↓ 0:15	∞	∞	-25	-25	∞	∞	After exit fade down US - play to end of track
10	15	FADE IN Toby's music	4:39	CD #2 TRACK 2	↑ 0:10	∞	∞	∞	∞	∞	+10	Toby's entrance w/ cart
11	15	FADE OUT		CD #2 TRACK 2	↓ 0:00	∞	∞	∞	∞	∞	∞	Music cut on Toby's belch

SOUND DESIGN: JEFF LADMAN

26-13 Sound Plot Sample from a sound plot. The plot is generated to help the designer make decisions about playback.



26-14 QLab Screen shot of QLab audio and video playback software.

and cue list, but the final sound design must never be attempted without finishing this paperwork. Here are three popular suppliers of playback hardware and software:

- *Meyer Sound*. LCS Series™, Matrix3™ Audio Show Control System; www.meyersound.com
- *Stage Research*. SFX™ (Theatrical playback and show control software for Windows OS); www.stageresearch.com
- *QLab* (Theatrical playback and show control software for Macintosh OS); www.figure53.com (Figure 26-14).

In addition, if sound requirements are complex, with many overlapping cues, it is advisable to do additional charts (sometimes referred to as *worksheets*) detailing in a time line each cue playing.

Production

If the sound for a production is complex, a rehearsal with or without actors solely dedicated to sound is necessary. If not, sound can first be played in the technical rehearsal. Either way, the sound designer needs to have several details taken care of prior to this time. Cues should be written into the stage manager's script several days before the technical or sound rehearsal(s). Because the director may wish to be present at this session, it should be scheduled well in advance. Each of the stage manager's cues should have a specific call placement so that changes made later can be done in an exact manner.

Pre-Tech Cueing and System Check It is wise for the sound designer to take a quiet moment in the theatre before the first sound or technical rehearsal and set preliminary sound levels for each cue, checking speaker functions at the same time. (An audience will absorb roughly 3 dB of sound, a factor that the designer must allow for.) This is also a good time to brief and check out the operator on



SOUND ADVICE Design Steps

1. Script reading/analysis and collaborative meetings with director and design team to determine production style, period, and mood.
2. Research and study resulting in sound score.
3. Collection and storage of music and sounds.
4. Creation of a director's CD and attending rehearsals.
5. Creation of a rehearsal CD, if necessary.
6. Development of the sound plot.
7. Creation of the final show sound and cue list.

the equipment, allowing plenty of time for problem solving. If the headset communication system is the responsibility of the sound department, the sound designer should find out the number and location of headsets from the stage manager and prepare and check out the equipment. Leaving these details for the day of the technical rehearsal is a serious mistake and will waste much time. Good preparation and planning is never more evident than at the technical rehearsal; every effort should be taken to make this experience a painless one.

Sound Rehearsal The sound designer should arrive a bit early for the sound or technical rehearsal and be sure that the sound operator and the equipment are ready to begin on time. Every sound cue should be run under performance conditions so that its length and level can be properly judged. The designer sits at the “tech” table and makes sure that both the stage manager calling the cues and the operator take careful notes of all changes. Nothing is more frustrating than mistakes being repeated because changes were not properly noted. The entire crew (including the designer) needs regular breaks to do their jobs well.

Dress Rehearsals/Previews Often the designer will need to make adjustments after the technical rehearsal and before the dress rehearsals begin. These changes will usually be minor if everything has gone well, but they may require a great deal of studio time if there are problems. The corrected sound must be ready for first dress, so planning ahead is important. Once the dress process has begun, sound problems must be dealt with while the run goes on. The sound designer may not stop a dress rehearsal for a problem unless it is an emergency. If changes are being made during previews, as is often the case with new scripts, the sound designer must plan on being in attendance. He or she must make sure to touch base with the director, stage manager, and operator after every rehearsal. A backup of the final show sound must also be readily available in case of emergency.

The Run Before each performance, the sound operator needs to check the entire system to ascertain that everything is in proper working order. It is good practice to record a series of sounds or music that can be used as preshow tests; this recording can be programmed as cues and played before the house opens. Each speaker should be tested individually, and a show cue should be run to check volume levels.

As this chapter has shown, designing sound for the theatre involves many specialized areas of knowledge as well as an ordered collaboration with other designers. The next chapter discusses in detail the equipment used for sound design in the theatre.

Sound Systems and Equipment

Mastering the art of theatrical sound, like other aspects of design, involves not only artistry but also technology. The functions of various software and equipment and how they interrelate matter a great deal to the sound designer/technician. Technology has driven the evolution of theatrical sound design—what follows is a closer look at that technology.

The Sound Systems

Music and sound play several different roles in the theatre, and the requirements of a sound system vary with each role. Here we discuss the three theatrical systems:

- Recording system
- Playback system
- Reinforcement system

Each of these systems requires an **input source**—anything that sends a sound signal to the system. There are two technologies used to transmit a sound signal through a wire: *analog* and *digital*. Although the two cannot be used interchangeably, an analog signal can be converted to digital and vice versa by means of an analog/digital (a/d) or a digital/analog (d/a) converter.

As we have seen, sound waves flowing through the air create a pattern analogous to the vibration of their source (as in the harp string). If received by a microphone, a copy or *analog* of these waves can be reproduced electronically and sent through a wire to a recording device. Owing to their relatively low voltage and current, **analog signals** are quite susceptible to induced noise and interference. However, in *digital reproduction*, the direct action of a sound wave is not recorded; instead, the electrical analog of the wave is measured, and that measurement (a numerical representation of the wave) is recorded. In this process, an analog signal is converted to a rapid series of on-or-off (binary) pulses. Called **digital signals**, these pulses can be read, recorded, and manipulated with great precision, resulting in more flexible and accurate storage and reproduction.

A further advantage of digital technology is as a communication protocol between different pieces of equipment. For this to happen, various manufacturers had to agree on a common digital “language.” *Musical Instrument Digital Interface*, or **MIDI**, was born out of this need. MIDI is the standard protocol for digital communication between one component and another. As the name implies, MIDI was originally developed for musical instruments, but today people use it in much broader ways. For example, *MIDI Show Control* enables computers with MIDI ports to “speak” to lighting control consoles, sound systems, and automation devices.

CENGAGE **brain**.com

For links to Internet resources pertaining to this chapter, please visit the book's companion website: www.CengageBrain.com.

input source Any device that sends an audio signal to the sound system.

analog signals Audio information represented by a continuous variable measurement of physical quantities such as length, width, voltage, or pressure. An analog audio recording is a continuous curve, as opposed to a digital recording, which is based on discrete samples.

digital signal Audio information represented by multiple binary (on-or-off) measurements. An analog wave form is measured or *sampled* many times. The aggregate of those values represent the wave form.

MIDI Musical Instrument Digital Interface is a standard for representing musical information in digital format. Through MIDI Show Control, its use has been expanded to include communication and the control of all types of theatrical equipment.

transducer A device such as a microphone or speaker that converts input energy of one form into output energy of another. In the case of a microphone, it transduces acoustic energy in the form of sound pressure waves in the air into electrical energy.

mixing board A device used to preamplify, combine, and adjust sounds from a variety of sources and assign them to various outputs. A mixing board usually includes some provision for limited equalization along with supplying phantom power to devices that require it. Also known as a *mixer*. A digital mixer also converts analog signals to digital and allows for more advanced signal processing.

The Recording System

A theatrical recording system is used to record and process voice, music, and sound effects intended for use in a production. Modern recording systems have numerous input sources either connected to an analog mixer and sent to an analog/digital interface or, if already digital, connected directly to the interface, which has software-emulated mixing. The recording system is best located in its own studio, one that has been adequately sound-proofed for live recording.

Input Sources for Recording Input sources for the recording system can be categorized as follows:

- Microphones
- Digital optical media (CD, DVD, Blu-ray)
- Digital nonvolatile memory (flash drive, mp3 player, iPod)
- Analog media (recording tape, records)
- Electronic keyboards or other electronic instruments
- Computer stored or synthesized audio

Specialized *microphones* used for recording come in various types, depending on the specific application. A microphone is a **transducer** because it receives acoustic sound waves and converts them to an analog electrical signal. As noted earlier, the electrical signal produced by a microphone is not powerful; it has quite a low voltage. Therefore, the wires carrying this signal must be adequately shielded from other electrical interference, and the signal must be either converted to digital or electronically boosted to a higher level (called *line level*) before being processed.

Optical media store sound waves in digital form on a disk such as a CD, DVD, or Blu-ray. Tiny divots representing a binary code are etched in the surface of the disc; they can then be read by a laser for playback. Current optical media used for theatrical sound recording include the CD (compact disc), DVD (digital video disc), and Blu-ray (blue laser disc).

Although generally replaced today by optical media or solid-state storage, *recording tape* provided a common input source because of its ability to store and play back sound. The tape's film is coated with ferrous oxide particles that can be magnetized, allowing the storage of either analog or digital signals. The most universal types of tape media used for analog recording were reel-to-reel or the cassette, with digital DAT (digital audio tape) being used for some field recording.

There remains some music that can be found only on vinyl discs or *phonograph records*. Therefore, a good recording studio will still have a turntable available for the rare occasion when only a phonograph record will do the job. Sometimes audio designers want to record and play back the unique sound of a phonograph record.

Keyboards, such as *synthesizers* and *samplers*, can generate a vast array of sounds. Sampling keyboards record or “sample” a sound, allowing instant access for editing and processing. Digital samplers can record and store these sounds for subsequent playback and therefore function as an input source. A synthesizer can also act as an input source. It can produce a wide range of sounds, either imitating other instruments or creating unique new sounds.

The final input source is the *computer*. A computer equipped with the proper software can function as a synthesizer or sampler. It can store *loop libraries* as well as other sound libraries. It can also access the Internet, a vast source of sound and music. Today's computer is the most versatile of input sources.

Recording Mixer/Computer Interface The purpose of the recording mixer (Figure 27-1) is to receive input sources, combine them, and send the mixed signal on to a computer that converts the audio to digital and stores it. These **mixing boards**



PHOTO COURTESY MOTU, INC.

27-1 Recording Mixer/Computer Interface The MOTU 896 mk3, an 8-channel mixing interface allowing either microphone or line-level signals to be directly recorded into a computer.

have input jacks for both microphone and line-level signals. They are able to provide minor equalization as well as volume control over the signals. Many recording mixers also double as a professional-grade computer audio interface, converting the audio to digital and passing it through a **FireWire** or USB cable directly into a computer for storage.

Computer Of course, a computer's hard drive readily stores recorded sound in a digital format. In addition, when equipped with selected software, the computer allows a designer to edit a piece of sound by displaying its specific audio waveform on a monitor; the visual waveform can then be cut and pasted in any manner. In addition, complex processing can be performed on this waveform, including adding such effects as equalization, reverb, pitch shifting, noise reduction, and compression. The computer also provides potential for recording and mixing of multiple waveforms that can be stored and used as multitrack playback files in production or mixed down to new stereo playback files. Finally, the system archives the finished sound onto a storage device such as a hard drive, CD, or DVD.

FireWire Apple's name for the IEEE 1394 interface. A serial bus interface standard (connector, cable, protocol) similar to USB for transmitting and receiving data.

The Playback System

The *playback system* takes the sound prepared by the recording system and puts it in a format suitable for production playback. It must be able to store a great deal of music and sound, providing instant access to each cue for production playback. For many years, this task was accomplished by bulky reel-to-reel tape decks or even less-desirable cassette players that fed their sound to a *mixer*, which subsequently sent it to amplifiers and speakers.

Two types of playback systems are in common use today:

- Input sources connected to a playback mixer
- Computer playback system

Input Sources Connected to a Playback Mixer Today's playback input sources include CDs, DVDs, Blu-ray, computer hard drives, and possibly MP3 players or iPods. These storage devices take sound processed for playback by a computer and store it in a form that is easily retrieved for production playback. Sound is then routed through a mixing board located in the sound booth and run by the sound operator.

27-2 Playback Mixer Sixteen-channel Soundcraft FX16ii playback mixer.

PHOTO COURTESY SOUNDRAFT, HARMAN INTERNATIONAL INDUSTRIES, LTD.



The mixer in a playback system serves mainly to combine or “mix down” several input signals and route them into one or more output channels. The mixing console provides volume control as well as some equalization for each of the line-level input signals (Figure 27-2). A physical playback mixer is ordinarily unnecessary when using computer software that performs the same functions.

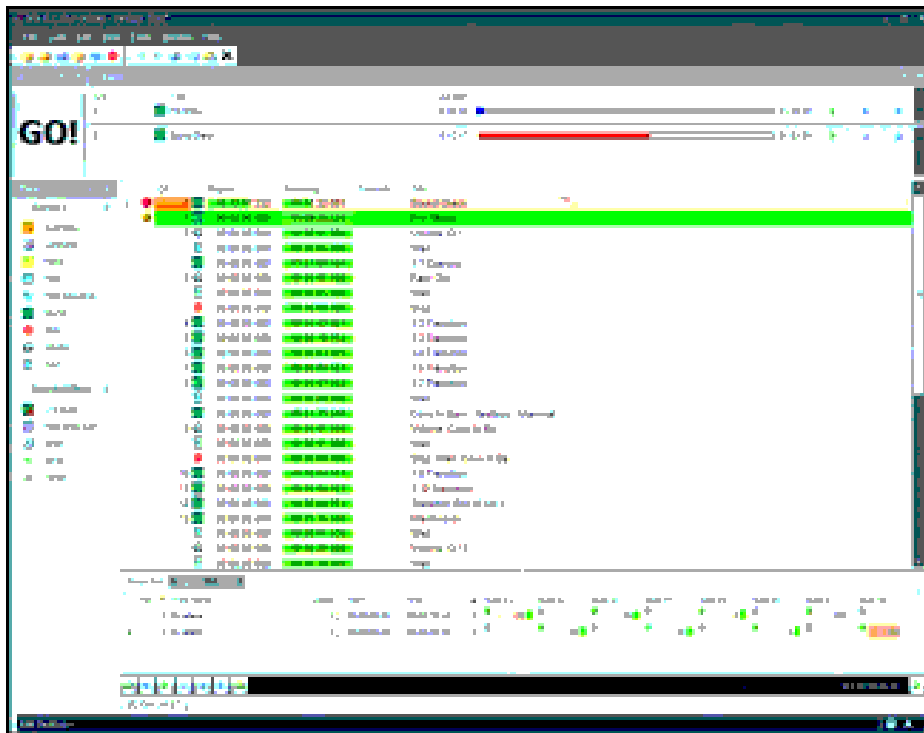
Computer Playback System Equipped with appropriate software, the computer provides the same functions that the input sources just discussed do when connected to a mixer—and more. Such software programs include SFX from Stage Research, Inc. for Windows OS; QLab from figure 53; LLC from Macintosh OS; or CueStation software and D-Mitri Digital Audio Platform from Meyer Sound. The computer’s hard disk stores the production sound as well as all necessary cue information. The system acts much like a lighting control board, with the sound cue sheet displayed on the monitor and the operator pushing “go” for a cue to begin. Fade rates, volume levels, and speaker assignments are recorded and automatically played back with each cue (Figure 27-3).

Speakers in the Playback System As discussed in Chapter 26, a theatrical playback system requires great flexibility in terms of speaker selection and location. Because a theatre audience expects sound effects and music to come from their apparent source, speaker placement is critical to good sound design. Specific selection criteria will be covered later in this chapter, but concern for placement should be utmost in the designer’s mind from the beginning of the process.

The Reinforcement System

A theatrical *reinforcement system* is used to amplify, process, and mix vocals, live music, and sound—principally actor’s voices and orchestral music. This system is generally made up of microphones as input sources connected to a *reinforcement mixer* that, in turn, is connected to amplifiers and speakers. Theatrical reinforcement can be fairly simple or extremely complex. Broadway musicals routinely mix more than 100 inputs and outputs with sophisticated computer controls. This is a huge number of audio signals to access, control, and mix down to output channels.

Reinforcement Input Sources As stated, the vast majority of input sources in a reinforcement system are *microphones*. Some signals will likely come from traditional



27-3 Playback Monitor Screen Screenshot from Stage Research, Inc. SFX theatrical playback and show control software.

SCREEN SHOT REPRINTED WITH PERMISSION FROM STAGE RESEARCH, INC.

wired microphones placed onstage, backstage, or in the orchestra. These mikes may take the form of *floor microphones* used onstage for general vocal reinforcement, *stand mikes* used backstage or in the orchestra for vocal or musical instrument pickup, or specialized musical instrument microphones used to amplify the orchestra. In musical productions, the performers will likely wear miniature *wireless microphones*, with their audio signal sent through the air by a transmitter to a receiver and then through wires to the mixer. In addition to microphones, input sources may include “*direct boxes*” or other line-level inputs from the orchestra. Playback system inputs such as a CD or a computer can also be routed through the reinforcement mixer.

The Reinforcement Mixer The primary difference between a recording or a playback mixer and a reinforcement mixer is that the latter normally has a greater number of input and output channels and more sophisticated control. However, both do the following:

- Boost a microphone-level signal to line-level
- Mix down (combine) several input signals
- Adjust volume levels
- Provide some tone control
- Route the signal through various processing equipment such as equalizers, compressor/limiters, effects processors, feedback eliminators, and so forth (integrated in digital mixers)
- Send the final signal to selected amplifiers and speakers

The reinforcement mixer (Figure 27-4) is located in the auditorium, usually toward the rear of the main floor, so that its operator can hear exactly what the audience is hearing. The operator “rides” the sound levels—bringing up a mike when needed, taking it out when not required, and balancing the sounds from more than one microphone or other input source. More sophisticated playback mixers are digital and include internal signal processing functions. They also offer several forms of control



PHOTO COURTESY SOUNDRAFT, HARMAN INTERNATIONAL INDUSTRIES, LTD.

27-4 Reinforcement Mixer Soundcraft Vi6 digital reinforcement mixer.

including MIDI-Mute groups, which provide computerized control over many input channels, allowing “presets” and cues to be written, stored, and played back similar to how a lighting control console functions.

The reinforcement mixer contains many output channels so that specialized sound mixes can be sent to different locations. The main speaker system is the primary location, which may include house right, center, and left speakers; subwoofers; and down-fill, front-fill, and under-balcony-fill speakers. Other destinations could be sound effect or surround sound speakers; a variety of *foldback* locations, including the stage itself, the orchestra, and the conductor; the *stage monitor* system with speakers located in the dressing rooms, green room, and elsewhere; and perhaps the *assistive-listening* system.

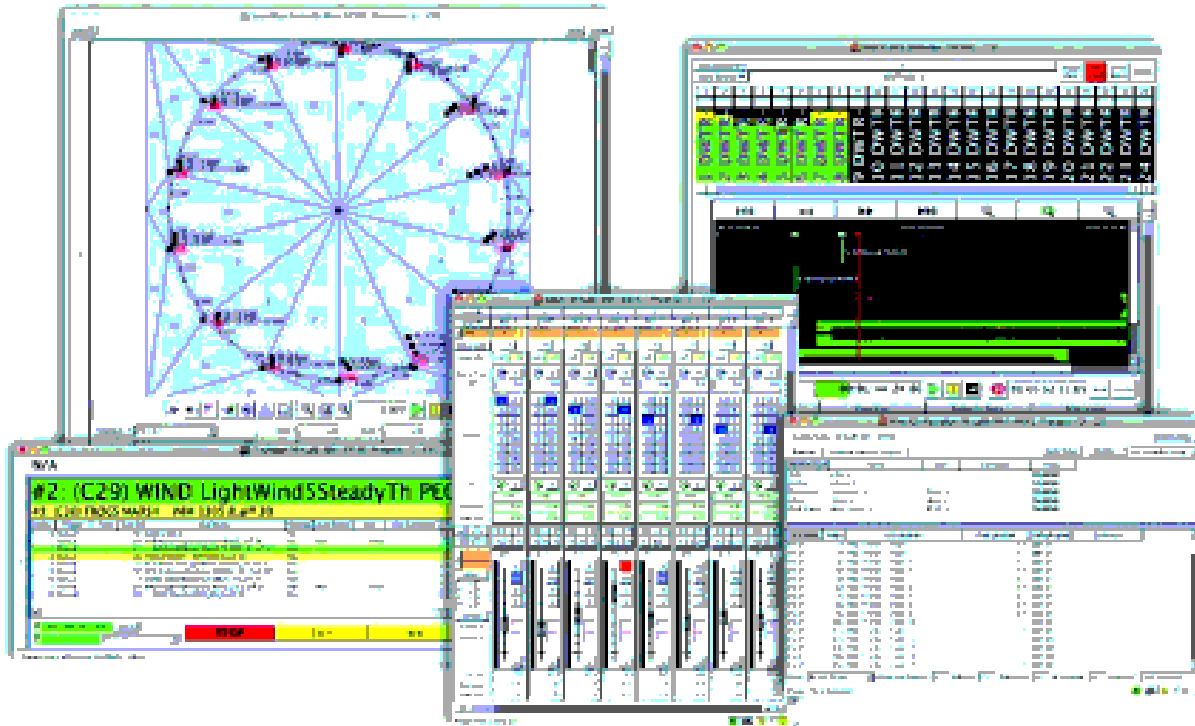
Combination Systems

To save money and space, a smaller theatre company may combine equipment used for recording, playback, and reinforcement. Examples include using a sound computer both for processing and playback, using a single multipurpose mixer for both playback and reinforcement, and using processing equipment such as an equalizer for recording as well as playback. Such systems may benefit from an electronic patch system or a **patch panel**, both of which provide flexibility in connecting one piece of equipment to another.

patch panel A matrix of plug points used to interconnect various pieces of audio equipment. Usually divided into rows of inputs and outputs, the patch panel provides an organized central location for their routing.

The traditional patch panel provides convenient routing of analog signals from one component in the system to another. It comprises a confusing-looking collection of jacks that allow an operator to connect any input source into any signal-processing unit. Depending on the needs of the job at hand, a CD’s output could be patched into a computer or the mixer or into another recording device. The patch bay is made up of single $\frac{1}{8}$ - or $\frac{1}{4}$ -inch-diameter jacks that are labeled by function. For instance, “MIX 3 IN” translates to “mixer channel number 3 input.” Once the purpose of a patch panel is understood and the various pieces of equipment in the system are known, using it becomes a fairly easy task.

Compared with the patch panel, an integrated audio show control system saves time and space. Besides patching, such a system provides volume control, signal processing, and sophisticated routing for each of the input and output signals, easily panning any sound between any number of speakers. Software such as CueStation (shown in Figure 27-5) can provide 72 tracks of simultaneous hard disk audio playback and recording.



COURTESY MEYER SOUND LABORATORIES, INC.

27-5 Integrated Audio Show Control Meyer Sound CueStation software and D-Mitri hardware allow control over microphones and audio playback with real-time placement of sounds throughout the stage and house.

The Equipment

The sound designer or technician must have enough knowledge of how and why a piece of equipment works to make intelligent choices about using or specifying equipment. The following section describes in detail the functional aspects of input, processing, and output equipment.

Microphones

As stated earlier, microphones convert sound waves into electrical energy for transmission to another location. By their nature, microphones are analog devices. If their low, **mike-level** signals are not converted into digital, they need to be boosted to a higher power level called **line level** before they can be processed. This is normally accomplished by a **preamplifier**, or “preamp,” located in the mixer. If the mixer is digital, the mike-level signal will be converted to digital.

As Figure 27-6 shows, microphones come in a variety of sizes and shapes. The handheld *vocal microphone* (Figure 27-6a) is a good choice for multipurpose use, although most tasks are performed best with specialized mikes. As one might expect, a vocal microphone is particularly sensitive to frequencies in the vocal range. The sound produced by a large, handheld vocal microphone is unique because it has a specialized frequency response and boosts low frequencies.

The *instrument microphone* (Figure 27-6b) is engineered to have a “flat” frequency response, meaning that it responds fairly equally to all frequencies.

General area reinforcement uses surface-mounted or **boundary microphones** placed along the front of the stage. Two types of boundary microphones manufactured by Crown International are the pressure zone microphone or PZM (Figure 27-6c) and the phase coherent cardioid or PCC (Figure 27-6d). An important difference between these

mike level Signal voltage levels from a microphone to a mixing board, normally in the millivolt (thousandth of a volt, or mV) range.

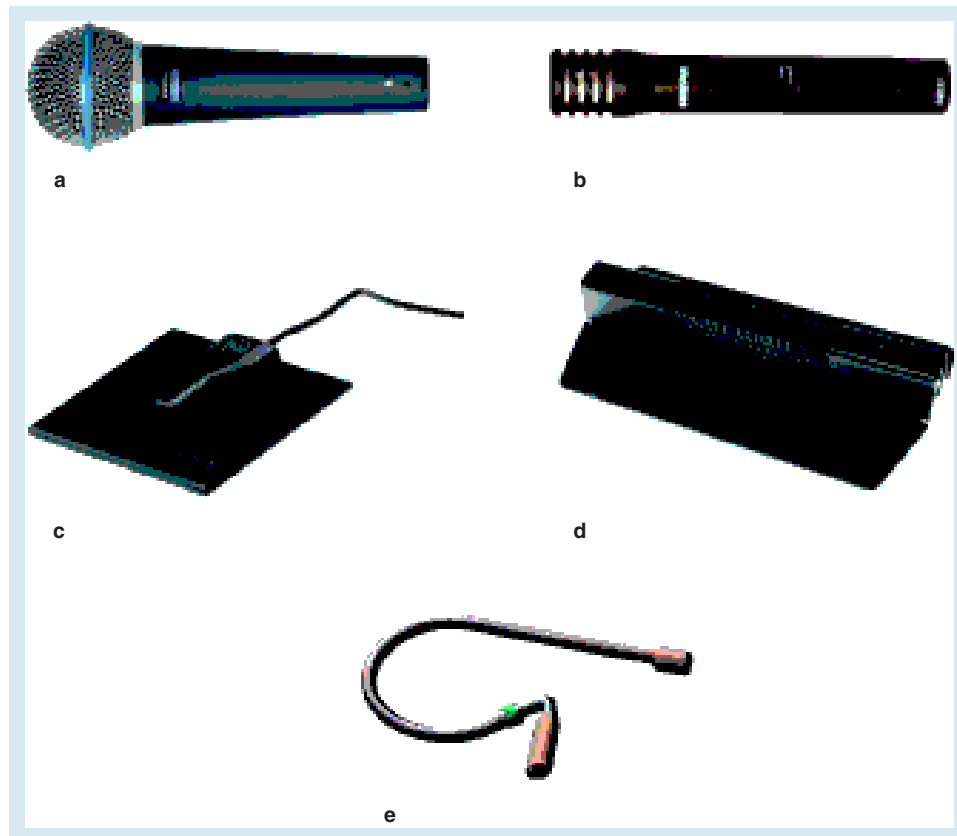
line level Signal voltage levels from various pieces of audio equipment to speaker amplifiers; ranging from 77.5 millivolts to 24.5 volts, with 4.5 volts across 600 ohms equal to 1 watt.

preamplifier The first circuit encountered by the sound signal from a microphone into the mixing board, it amplifies the microphone level signal to line level.

boundary microphone A microphone placed extremely close to and facing a flat (boundary) plate. Rather than responding directly to pressure in the air, this microphone picks up pressure variations from the air gap between the element and the plate.

27-6 Microphones

- a** Shure Beta 58a handheld dynamic vocal microphone.
- b** Shure SM137 condenser-type instrument microphone.
- c** Crown PZM (pressure zone microphone). A condenser microphone with a typical hemispherical pickup pattern.
- d** Crown PCC (phase coherent cardioid) condenser boundary microphone with a half-cardioid pickup pattern.
- e** Countryman E2 Earset subminiature electret condenser microphone—one of the types commonly used in wireless microphone systems.



a & b COURTESY SHURE, INCORPORATED. USED WITH PERMISSION.

c & d COURTESY CROWN AUDIO, INC.
e PHOTO COURTESY COUNTRYMAN ASSOCIATES, INC.

dynamic microphone A microphone housing an element that consists of a diaphragm directly coupled to a coil of wire that moves back and forth in a magnetic field. As the air pressure moves the diaphragm, the coil's movement in the magnetic field induces a flow of alternating electricity in the microphone cable that is analogous to the alternating waves in the air.

condenser microphone A microphone housing an element consisting of two metallic-coated plates separated by a small volume of air. The top plate, which is charged with an electrical voltage, acts as a diaphragm. Its movement back and forth (changing the distance of the air gap between the two plates) alters the electrical charge induced in the back plate. Because of the very low voltage generated, all condenser microphones require an internal amplifier as well as a source of power—either a small battery or phantom power from the mixing board.

phantom power Power for condenser microphones supplied through the microphone cable from the mixing board.

two microphones is that the PZM accepts sound from all directions, whereas the PCC rejects sound from all directions but one.

Specific reinforcement of selected performers is accomplished by using *personal microphones*, either handheld or miniature (Figure 27-6e). The popularity of wireless miniature microphones has grown as they have become more dependable and cost-effective. If of good quality and properly used, modern wireless microphones work well for most stage reinforcement applications.

Microphone Types Most microphones are categorized in two ways:

1. How they perform the task of changing sound into electrical energy
2. Their pickup patterns

Although there are many types of microphones, in the theatre we are primarily concerned with only two: the *dynamic* microphone and the *condenser* microphone.

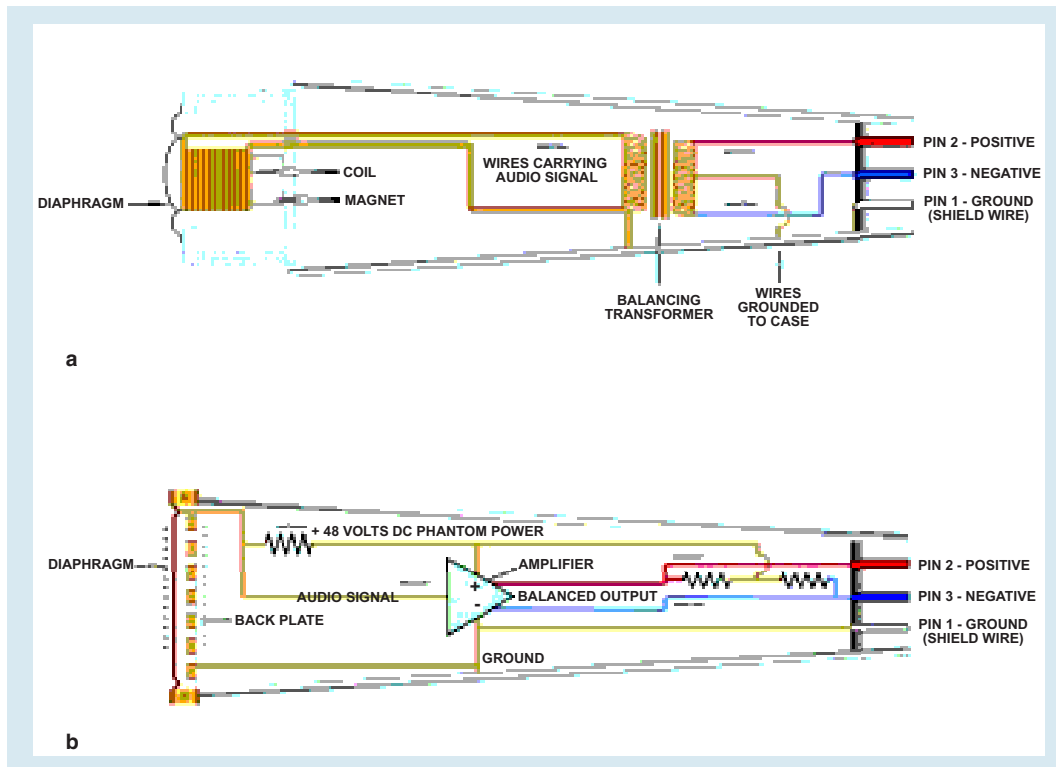
The **dynamic microphone**, short for “dynamic moving coil,” uses a diaphragm, similar to the eardrum, to receive sound waves (Figure 27-7a). This vibrating diaphragm causes movement of a metal coil inside a magnetic field, which in turn generates an electrical signal—an *analog* of the sound waves. Probably the most common microphone, the dynamic can be designed with any sound pickup pattern. It is the least fragile and can be of excellent quality.

The **condenser microphone** receives sound waves on electronic plates that generate a signal (Figure 27-7b). However, so little initial signal power is created that a small amplifier must be located nearby. The amplifier, housed in the microphone, may be powered by a DC (direct current) power supply in the form of a small battery, or more likely, by an electrical power supply from the mixing board, referred to as **phantom power**.

Although it is the highest quality available, the condenser microphone is also more delicate and expensive than the dynamic. Because of its added sensitivity, the condenser

27-7 Dynamic and Condenser Microphones

- a Dynamic.
- b Condenser.



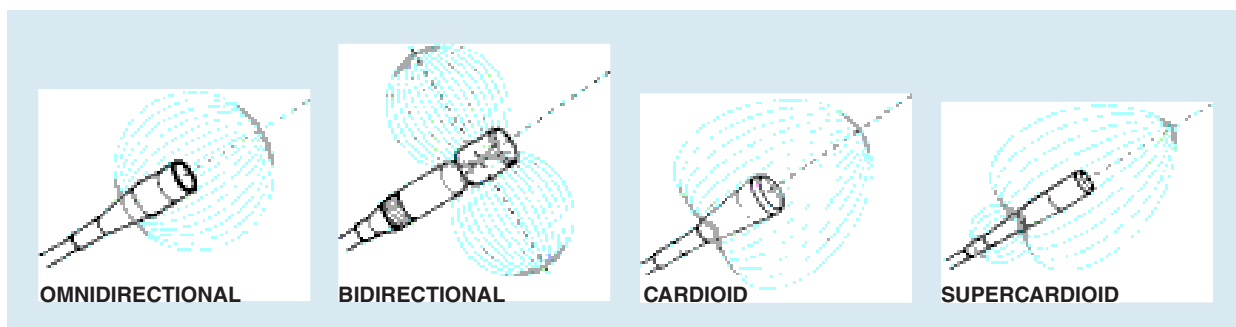
a & b © CENGAGE LEARNING/PETER NORDYKE

microphone is normally chosen for more demanding or critical sound tasks. Because the condenser can be made significantly smaller than the dynamic, it is the only type used for miniature microphones.

Microphone Pickup Patterns A microphone without a restricted pickup pattern receives sound equally from all directions. Such a microphone located on the floor at stage front would receive direct sound from a performer’s voice, bounced sound from the floor, and sound from the orchestra and audience. Restricted pickup patterns help a microphone be more selective. Figure 27-8 illustrates four common pickup patterns: omnidirectional, bidirectional, cardioid, and supercardioid.

As the name implies, an *omnidirectional* pattern microphone receives sound from all directions. This pattern is used for body mikes, monitor mikes, and pressure zone microphones (PZMs), as well as in situations where all sound is required, such as group recording. **Feedback**, in which sound from a speaker is picked up by a microphone and continuously reamplified, can be a particular problem with this pattern. (See “How to Control Feedback” near the end of this chapter.)

feedback An audio loop created between a microphone and its speaker. As a speaker’s volume is increased, a point is reached where sound from the speaker entering the microphone is greater than the original sound from the actor. This “loop” then becomes self-feeding (hence, *feedback*), locking onto in-phase frequencies and amplifying them uncontrollably.



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27-8 Microphone Pickup Patterns The choice of pickup pattern is determined by the specific task.

A *bidirectional* pattern looks like the figure eight. It works well in recording two-person interviews or in any other situation in which the desired sound comes primarily from two opposite directions.

A *cardioid* pattern is the most useful for general theatrical applications. Rejection of sound increases as one moves around the microphone and is most effective at the rear, lessening the possibility of feedback. When placed in close proximity to a sound source, a directional microphone exhibits increased low-frequency response, a phenomenon known as **proximity effect**.

proximity effect The increase in low-frequency response when a microphone is placed very close to the sound source. This is an inherent characteristic of directional microphones and is usually associated with singers using handheld microphones.

For long-range directional pickup, the *supercardioid* pattern is desirable. This pattern is used by the phase coherent cardioid (PCC) microphone, which is commonly placed along the downstage edge of the apron and is used for general vocal pickup.

Wireless Microphones A microphone without the nuisance of a cable is very desirable, particularly for vocal reinforcement. The wireless microphones shown in Figure 27-9 are actually miniature FM radio stations. In the case of the miniature wireless, the tiny body mike is wired to a low-power transmitter worn by the performer. This transmitter sends a radio signal of specific frequency to a receiver located offstage. The receiver picks up only that frequency and sends the analog-converted signal through a wire to the sound system for amplification. The transmitter and receivers can be made to operate on a variety of matched frequencies in order to isolate one microphone from another when several are in use.

This type of system is fairly delicate, and the better ones are expensive. However, the negatives are outweighed by the convenience of the system and the quality of its sound reproduction. Performers often wear the tiny omnidirectional microphone over the ear or on the forehead at the hairline, with the wire running through the hair and down the back. This technique, as opposed to the familiar clipping onto a piece of clothing, avoids noise created by the clothing and prevents variation in sound level as the head turns from side to side. Another option is for the performer to wear a headset-type miniature microphone (Figure 27-9c). The armature allows the microphone capsule to be placed close to the performer's mouth, providing the sound of a large vocal microphone while

27-9 Wireless Microphones

- a Handheld wireless microphone.
- b Body-pack wireless transmitter.
- c Wireless headset microphone.
- d Wireless microphone dual diversity receiver.



a-d COURTESY SHURE, INCORPORATED. USED WITH PERMISSION.



SOUND ADVICE ■ Microphone Care

To perform well over their life span, microphones need to be properly cared for.

- Never blow into a microphone to test it.
- Store microphones in a cool, dry cabinet on a padded shelf or in their cases.
- Do not thump or bang microphones on a hard surface.
- Always clean wireless microphone capsules with alcohol after each performance to remove corrosive salt, sweat, and tape glue.

minimizing feedback. In this case, a cardioid pickup pattern is used to reject sounds other than the performer's voice and to take advantage of the proximity effect to increase base response.

The sound designer must work closely with the costume department when using wireless body mikes; the placement of relatively bulky transmitters can be tricky, and the costume department can offer invaluable assistance. For further information on the use and care of wireless equipment, see the "How to Work with Wireless Microphones" section at the end of this chapter.

Optical Playback

The audio world received the compact disc with open arms for a variety of reasons. Disc players are simple to use, may be controlled remotely, and allow quick and easy access to tracks. The CD is the most common recordable media because its playback device, the CD player, is universally available. However, DVD and Blu-ray disks can store more information than CDs because stored data is closer together and on multiple layers, rather than only on the surface.

Flash Memory and Hard Disk Playback

Flash memory, a nonvolatile computer memory, and portable hard drives (either standard or solid state) are becoming one of the easiest ways to record, transport, and playback all types of computer files, including audio (Figure 27-10).

Compressed Sound One of the most popular ways to obtain music today is over the Internet, but it must be remembered that most downloaded music will be in a *compressed format*.

Compression of sound in order to allow for greater storage capacity is not a new idea; a standard for compressed audio was adopted in 1991 by the Moving Picture Expert Group (MPEG) and has been evolving ever since. Two of the more popular formats are MP3 (short for MPEG-1 Layer 3) and M4a (short for MPEG-4 AAC) used to compress audio files found on the Internet. Both types of compression remove sounds that theoretically would be masked and, therefore, not perceived by the human ear. Compressed music is good for research and personal listening; however, the compression becomes more apparent when the music is played on theatrical quality sound systems. It is always best to use the highest quality source material, preferably uncompressed.

The Computer

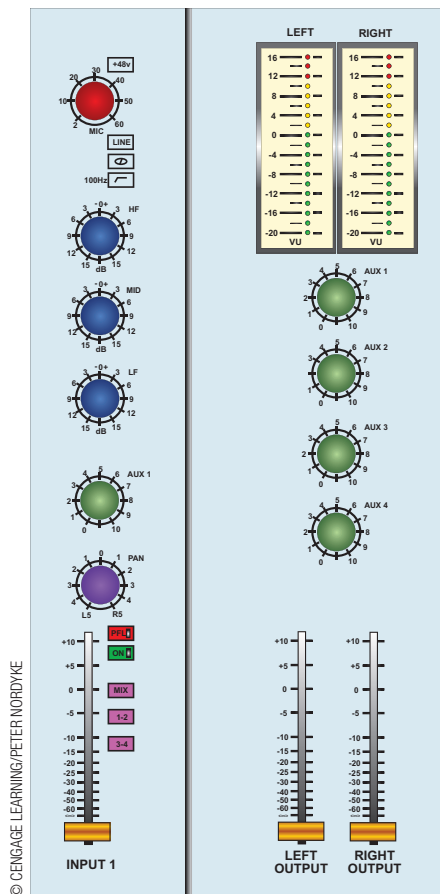
As noted, the computer has replaced numerous pieces of audio equipment once found in the theatrical sound studio. Computers have not only lowered the cost of sound processing but also greatly reduced the editing time involved in creating sound effects and music for a theatre production.



COURTESY SONY ELECTRONICS, INC.

27-10 Portable audio recorder Sony PCM-D50 Linear PCM (pulse code modulation) Recorder which records uncompressed stereo audio to flash memory.

flash memory Nonvolatile computer memory that can be electrically erased and reprogrammed. Primarily used in memory cards, USB flash drives, and other portable memory devices.



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27-11 Mixer Signal Path Drawing illustrating the sound signal path of a single input through the mixer.

trim pot Also referred to as *input level*, *input gain*, or *pad*, it is a sound mixer's volume control over the input signal.

pan pot The potentiometer that controls the left/right assignment to a sound mixer's output bus.

signal processor Hardware or software that alters an audio signal in a nonlinear fashion, such as an equalizer or reverb unit.

Modern computers are capable of audio editing and playback; however, there are some basic requirements that should be noted. Working with multiple audio tracks and signal processing requires processor speed and plenty of RAM to stream playback without skips or delays. In addition, a professional-quality audio interface is necessary for all but the most basic audio playback. Interfaces come in various configurations, depending on the number of inputs and outputs and the type of connection to the computer: either a card that fits into the computer or a FireWire or USB external connection. Multitrack recording requires many inputs; and for theatrical playback, a large number of outputs is necessary. Finally, an audio computer must have adequate hard disk space. A second hard disk drive dedicated to sound recording and playback is recommended. Then the primary hard disk can be used for the operating system and programs. Make sure to keep the hard disk clutter-free, organized, and defragmented for trouble-free operation. Last but not least, back up everything and keep your primary theatre playback computer off the Internet and running only the software it needs!

With appropriate software, the editing computer may also be used as a playback device for theatrical production. For processing, the computer has sampling software, synthesizer software, loop-based software, and editing software. For playback, it acts as a control system for the sound operator.

Mixers

The duties of a mixer can be performed either by computer software or a hardware mixing console. Both digital and analog mixers are available in a wide variety of styles depending on function. As mentioned earlier, theatrical mixers may need to serve several purposes—studio recording, show playback, and in-house reinforcement mixing. Mixer capacity is specified in terms of input and output channels; 8 to 12 channels in and 2 channels out is a minimum requirement; 16 to 48 inputs, with 8 to 16 output channels, is more normal.

The mixer is a complex piece of equipment. It must control a large number of inputs and direct them to various output channels. In an analog mixer, each input channel has a line-level as well as a low- or mike-level input. Because the power of a microphone's signal is relatively slight, an analog mixer contains preamplifiers that take these low-level signals and increase them to the higher line level.

The low-level microphone input is wired directly to a preamplifier located within the mixer (Figure 27-11). The sound signal then travels to an input attenuator, or **trim pot**, used to adjust the volume level, and on to equalizer controls. Next is another fader, called a **pan pot**, that determines how much volume will be routed, by switches, to the selected output channels. Yet another fader masters the level of the selected output channel. Finally, the VU meter registers the resulting sound. An operator can monitor the sound either completely mixed just before the VU meter or unadulterated just before the input fader (called PFL or pre-fade listen).

Auxiliary feeds for processing equipment are standard on many mixers. A mixer can be custom designed for a particular use.

Signal Processors

Signal processors alter sound in a nonlinear manner, unlike amplifiers, which change the amplitude in a linear fashion. They include multi-effects processors, compressor/limiters, and delay units as well as equalizers. Like mixing, processing functions can be performed either by hardware components or by computer software.

Equalizers An equalizer serves three basic functions for theatrical sound in doing the following:

1. In the recording system, processing sound to make its effect more appropriate to the action
2. In a playback system, altering voice, music, or sound frequencies to improve tone quality
3. Adjusting selected frequencies of an output source in accordance with room acoustics or for the control of feedback

Although a mixer provides some degree of equalization through its tone controls, an equalizer allows for much more precise adjustment of specific frequencies.

Two main types of equalizers exist: *graphic* and *parametric*. The graphic type has sliding faders permanently assigned to frequency bands that are typically between one-third and one octave in width. The parametric type allows the operator to select specific frequencies for control and to adjust the band width individually. Each type serves well in particular applications. If an equalizer is used only to adjust room acoustics, for example, it should be of the parametric type and be left alone to do its job. However, equalizers used to control tone quality will need to be adjusted according to each task. In this case, an easily accessible graphic equalizer is preferable.

Modern pieces of equipment such as the Sabine GRAPHI-Q2 (Figure 27-12) combine graphic and parametric equalization into a single unit. In addition, the GRAPHI-Q2 offers compression and delay features. Equalization is a very important technique for reinforcement, recording, and playback.

Other Processing Equipment *Multi-effects processors* are particularly valuable because they can perform a wide variety of processing tasks. They can alter sound in varying degrees—from making it richer by adding a slight amount of reverberation to giving it an echo (repetition of a whole sound). In addition, they can provide pitch shifting, flanging, auto-pan, and so on. *Compressor/limiters* are used to ensure that a sound signal does not “over drive” an amplifier and speaker. They either compress or limit the dynamic range of an audio signal as needed. *Delay units* were mentioned previously in conjunction with the need to delay sound from speakers to the audience. They are important in maintaining the actor as the source of the sound in the theatre.

Amplifiers

Line-level voltage must be increased to **speaker-level** for a loudspeaker to work (in technical jargon, to “drive” the speaker). Therefore, an amplifier matched to the loudspeaker’s power rating is assigned to each speaker in the system. Rack-mounted amplifiers are commonly placed in the ceiling of an auditorium between the sound control booth and the majority of the speakers. However, it is becoming more common to see a factory-installed amplifier contained within a speaker cabinet.

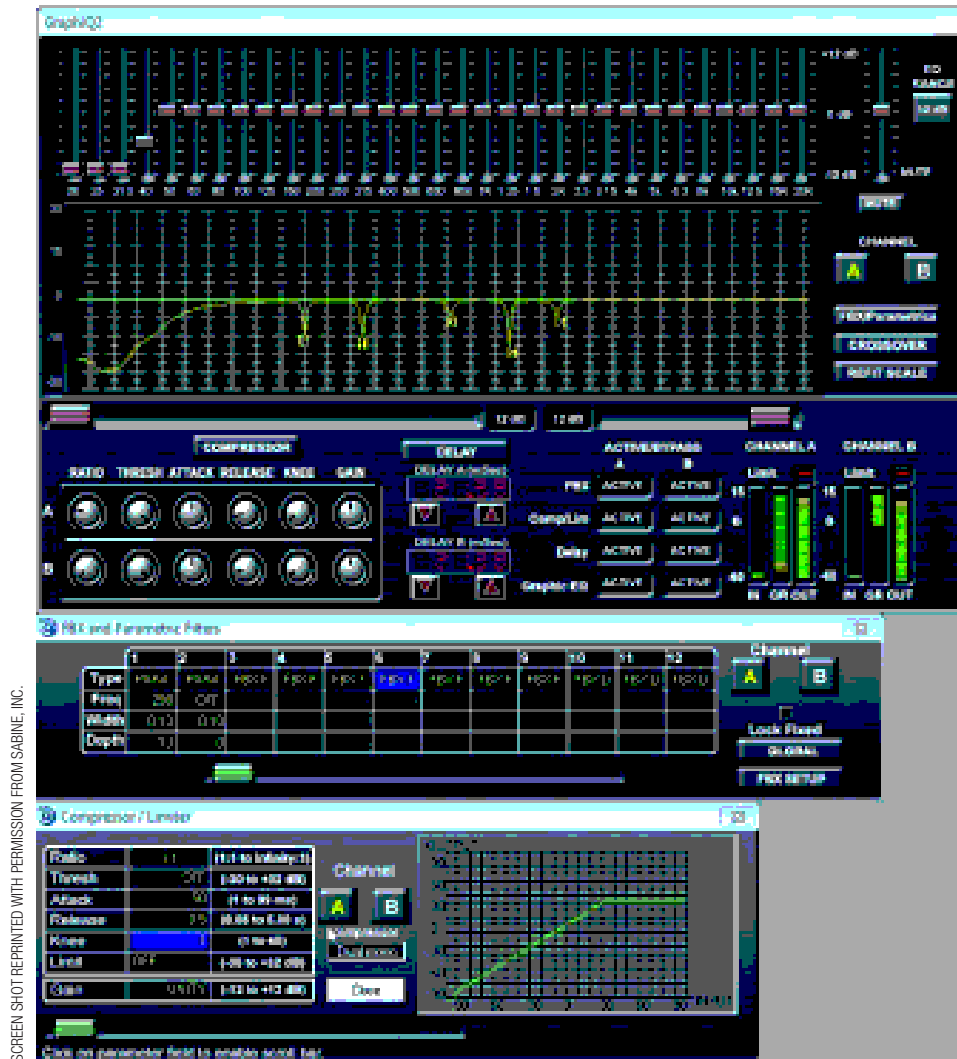
Power amplifiers have come a long way since the days of metal boxes filled with glowing tubes. However, one thing has not changed: amplifiers and speakers must be compatible. Proper matching involves a speaker’s **impedance** (similar to resistance in a DC circuit, measured in ohms) as well as its RMS power rating. **RMS** (root mean square) is a way of describing the power or wattage capacities of amplifiers and speakers. Under normal conditions, an amplifier’s RMS power output (measured in watts) should never be less than the speaker’s continuous power rating; most professionals recommend amplifiers rated at least one and a half times the speaker’s RMS power rating. Underpowering a speaker can cause distortion and excessive clipping that can destroy a speaker as easily as overpowering it can. Although loudspeakers can have impedances varying from

speaker level Signal voltage level from an amplifier to its speaker. Twenty-four and a half volts and up is enough to drive a speaker.

impedance The measurement of resistance in alternating current circuits, including audio signals. It is used in speaker specifications (typically 4 to 16 ohms) and in sound equipment input and output specifications.

RMS Root mean square is used to give an average power value to an alternating current or audio circuit as it would compare with that of a direct-current circuit. RMS can be used to describe both peak (instantaneous) values as well as the more useful continuous power output.

27-12 The Equalizer The Sabine GRAPHI-Q2 dual-channel computer-controlled equalizer combines feedback eliminator, graphic and parametric equalization, and compressor and delay functions.



2 to 30 ohms (most common are 8 and 16 ohms) and amplifiers usually are designed for loads of 4, 8, or 16 ohms, they must be matched for proper sound reproduction. It is highly recommended that a theatrical sound system have compatible amplifiers permanently assigned to each speaker.

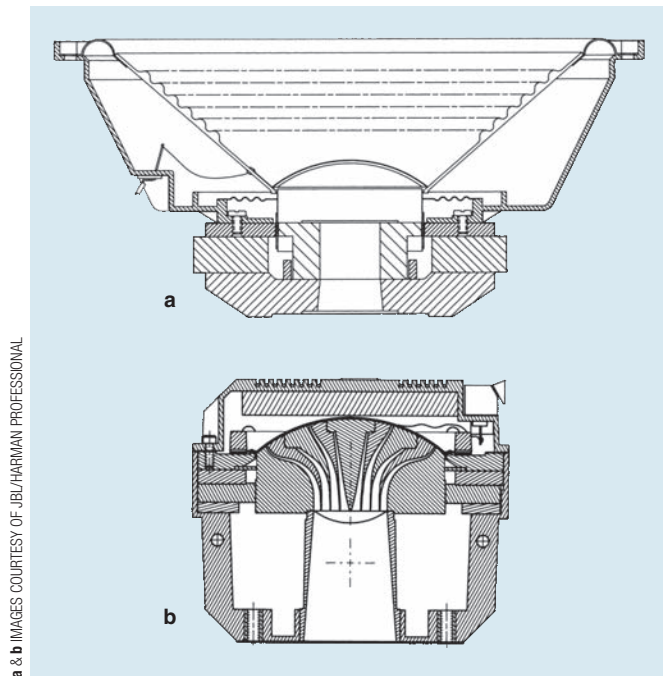
Loudspeakers

Like microphones, loudspeakers are specialized and come in a wide range of sizes, types, and prices. They receive the sound signal from the amplifier and transduce it back into pressure waves that we can hear. The more accurately a speaker performs this task, the better it is for theatrical use; quality varies greatly.

Speaker Types There are two different speaker components within a theatrical loudspeaker:

- The *cone speaker* (Figure 27-13a)
- The *compression driver speaker* (Figure 27-13b)

In both cases, a moving diaphragm generates pressure waves. The larger cone speakers have a plastic or fiber diaphragm, whereas compression drivers have a diaphragm made of a stiff material such as aluminum or titanium. A metal diaphragm is more



a & b IMAGES COURTESY OF JBL/HARMAN PROFESSIONAL

27-13 Sectional Drawings of Two Speaker Types

- a Cone-type low-frequency driver.
- b High-frequency compression driver without its horn.

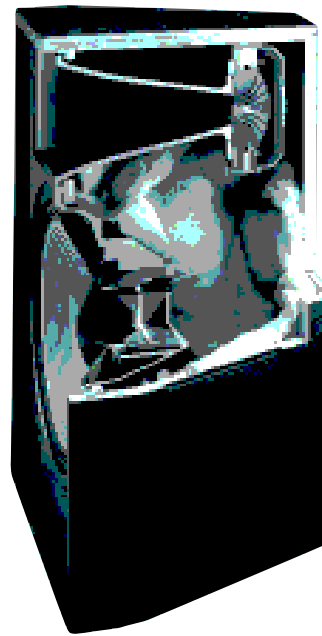


IMAGE COURTESY OF JBL/HARMAN PROFESSIONAL

27-14 Compression Driver with Horn

Cutaway of a JBL Array Series loudspeaker with a biradial horn and a 14-inch low-frequency woofer.

capable of producing sounds in the higher frequencies; a cone speaker is better for lower frequencies. A horn such as that shown in Figure 27-14 is usually coupled with a compression driver to control the sound dispersion. The extent of directionality depends on the shape and the size of the horn, which can be designed for specific tasks. (See “How to Select and Place Speakers” at the end of this chapter.)

Most speakers will be enclosed in a cabinet, which plays a significant acoustic role in the sound production (Figure 27-15a). Housed in the cabinet is a **crossover network**. This electronic device receives the sound signal from the amplifier and separates the frequencies into ranges acceptable to the individual speakers. Low frequencies are handled by the *woofer*, a large cone whose size is determined by the sound volume and frequencies it is required to generate—the more volume and the lower the frequencies, the larger the cone diameter. Although a midrange speaker may be included in the cabinet, the middle and high frequencies are normally handled by a single compression driver.

As mentioned earlier, the current trend is toward **self-powered speakers** (Figure 27-15b and c). These speakers, which provide separate amplifiers tailored for each speaker component, receive a line-level signal for audio and 120-volt power. The amplifiers also add sophisticated signal processing to achieve a flat frequency response. Such a system eliminates the possibility of mismatching amplifiers with speakers.

With the advancements in compact self-powered speakers, many system designers have gone back to using the **line array** model of speaker configuration (Figures 27-16a and b). Line arrays were first described in 1957 and use the principle of constructive and destructive interference to control the directionality of low to mid frequencies. This can be a huge advantage in projecting sound over distance and, more importantly, controlling unwanted echo and reverb. First used in large-scale touring productions, line arrays in more compact form are finding their way into smaller venues and theatres.

crossover network An important speaker element, this electronic device is used to divide and route frequency bands to the appropriate speaker component—either as a passive set of electronic components located inside the speaker cabinet or as an active electronic device that divides a line-level signal into frequency bands and sends them to separate power amplifiers.

self-powered speakers Speaker cabinets that contain power amplifiers and processing circuits that exactly match the speakers in the cabinet. Only an AC power supply and line-level audio signal are needed, eliminating many outboard components.

line array A group of speakers arranged in a vertical stack, closely spaced and operating in-phase and with equal amplitude. Line arrays allow for very directional control of mid to low frequencies over long distances through the use of constructive and destructive interference.



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a



COURTESY MEYER SOUND LABORATORIES, INC.

b



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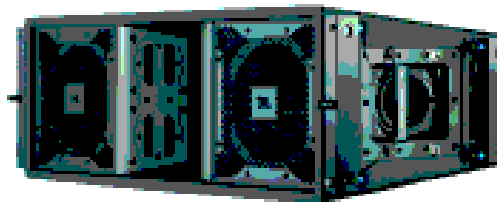
c

27-15 Speaker Systems

- a Renkus-Heinz CFX-121 full range non-powered speaker with internal passive crossover.
- b Meyer Sound UPA-1P self-powered two-way speaker.
- c Meyer Sound USW-1P self-powered subwoofer.

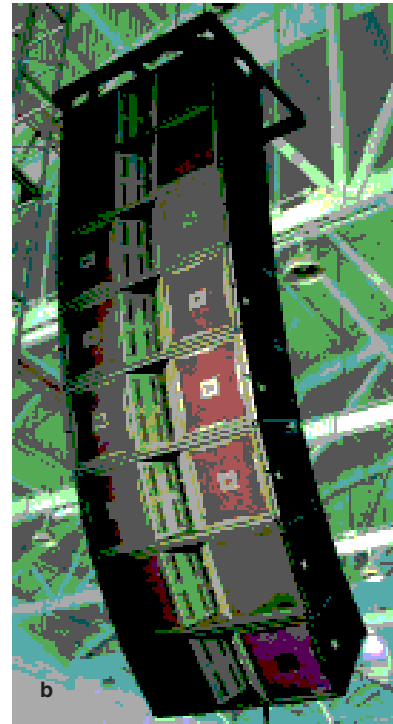
27-16 Line Array Speakers

- a JBL VerTec Series line array speaker element.
- b JBL VerTec Series line array forming a focused-wave front.



a & b IMAGES COURTESY OF JBL/HARMAN PROFESSIONAL

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Essential Sound Design Skills

This section covers “how to” instructions for several tasks essential to sound design:

- How to do wiring and use connectors
- How to work with digital audio
- How to make live recordings
- How to work with wireless microphones
- How to control feedback
- How to select and place performance microphones
- How to select and place speakers

How to Do Wiring and Use Connectors

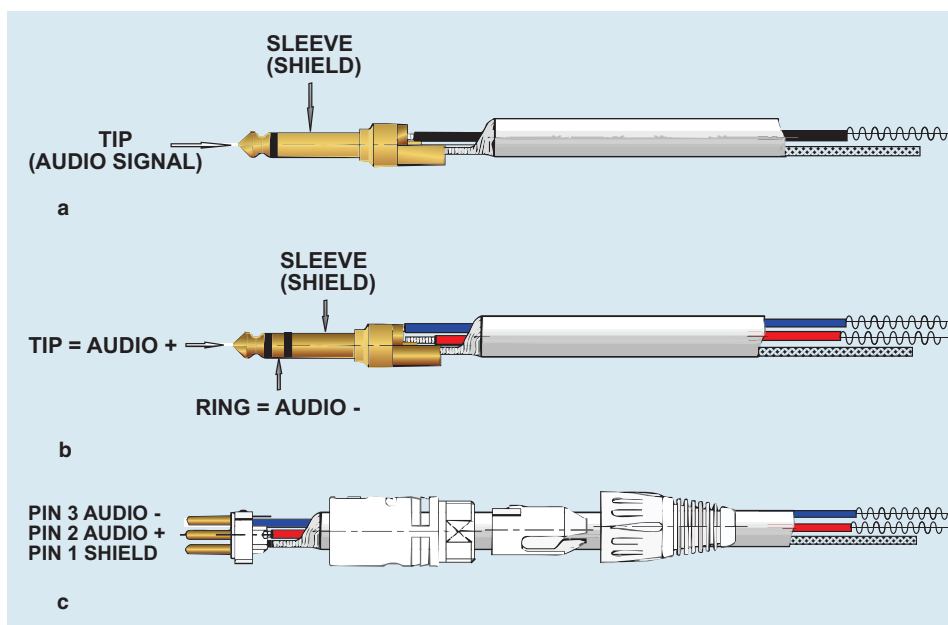
The power of sound signals varies in voltage from low-level mike signals (less than 1 volt) to high-voltage speaker lines (up to 70 volts). Wiring and connectors must be appropriate for the task they are to perform.

Balanced and Unbalanced Lines Two types of wiring are used to send an analog signal from one piece of audio equipment to another: balanced and unbalanced lines. An **unbalanced line** is a cable made up of a single conductor with a metallic shield wrapped around it (Figure 27-17a). The single conductor is the positive wire, while the shield acts as both the zero-volt reference and the ground. A **balanced line** has two conductors with a shield (Figure 27-17b and c). These negative and positive conductors carry the signal, while the shield acts as a ground.

Unbalanced lines are less expensive but are subject to electrical interference. They are typically used in consumer equipment to carry a signal from one piece of equipment to another. Balanced lines are used for microphone lines and other long runs of cable. It is most desirable to have the entire system balanced, as is the case in professional systems. Even with a completely balanced system, however, it is best to keep audio cable away from higher-voltage electrical lines (such as lighting cables), which produce a magnetic field that can interfere with the sound signal.

unbalanced line The audio signal is carried on a single center-conductor in a shielded cable. This method is used primarily for consumer electronics and is very susceptible to noise and interference.

balanced line The audio signal is carried on two wires in a shielded cable, with one signal being 180 degrees out-of-phase from the other. Sometimes called *differential input*, this input signal is read only in terms of the difference between the two wires; therefore, any noise induced on both of the wires will be ignored. Balanced lines are standard in professional equipment and can be used for very long cable runs.



27-17 Balanced and Unbalanced Lines

- a** An unbalanced line with a 1/4-inch phone connector.
- b** A balanced line with a 1/4-inch phone connector.
- c** A balanced line with an XLR connector.

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Speaker Lines Connections from amplifiers to speakers deserve special attention because of the relatively high voltage requirements. If the distance from amplifier to speaker is short, common 14 gauge wire is fine. However, if the run is long or several speakers are being driven, wire gauge may need to be increased to ensure that the speaker or speakers receive adequate power.

Connectors Figure 27-18 shows some common connectors associated with professional audio equipment. The RCA phono connector is used only for unbalanced signals and is often found on consumer equipment. The ¼-inch phone connector can be either balanced or unbalanced and is typically used for line-level devices. It is less desirable than the XLR connector because it does not lock in place and does not at first make a complete connection when plugged in. An XLR connector is a much better choice. It locks, has good strain relief, and makes a clean connection. However, XLR connectors cannot handle the higher voltages of speaker lines.

Because of their higher voltage and current, professional speakers should have specially designed connectors used with them. Two common connectors are the Neutrik speakON™ connector (Figure 27-19) and the comparable Switchcraft HPC-Series connector. Developed by Neutrik specifically for speakers, these connectors lock in place, allow for quick disconnect, handle high current, and are available in 2-, 4-, or 8-contact versions for multiple speaker connections. Some speakers still come equipped with ¼-inch phone jacks—they are to be avoided.



a-c PHOTO COURTESY NEUTRIK USA, INC.

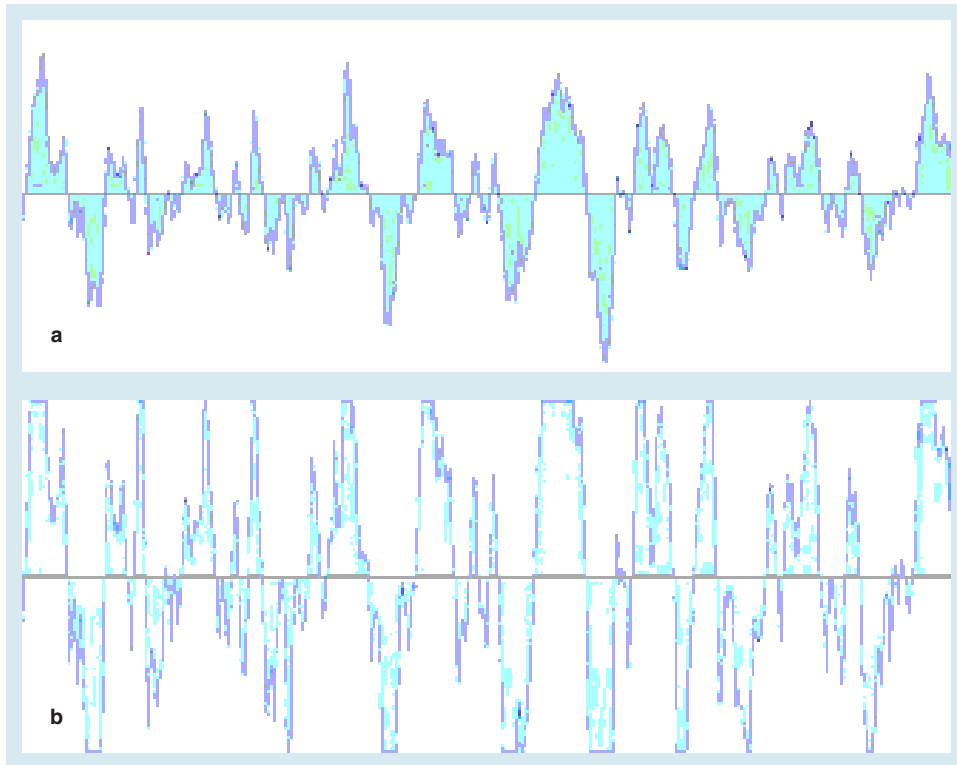
27-18 Audio Connectors

- a Unbalanced RCA phono connectors and jack.
- b Unbalanced and balanced phone connector.
- c Balanced XLR connectors.



COURTESY NEUTRIK USA, INC. SPEAKON IS A REGISTERED TRADEMARK OF NEUTRIK.

27-19 Speaker Connectors Neutrik speakON™ high current, locking speaker cable connectors.

**27-20 Digital Sampling**

- a** Screenshot of a sampled wave form.
b Screenshot of the same wave form showing digital clipping causing distortion.

a & b © CENGAGE LEARNING/PETER NORDYKE

How to Work with Digital Audio

Digital audio is a numeric (binary) representation of sound. When an analog signal is changed into digital by an analog to digital (a/d) converter, the device is measuring how high the signal (voltage) is at a given moment. This is called *sampling* (Figure 27-20a).

Sampling To represent an analog waveform accurately in binary terms, a great number of samples must be taken: a minimum of 44,100 per second, the sampling rate of a commercial CD. This number is derived from the **Nyquist sampling theorem**, which states that one must sample an analog signal at twice the rate of the highest frequency in order to reconstruct that signal accurately. The quality of a digital reproduction, then, depends largely on adequately high sample rates and resolution.

The accuracy of each sample is further determined by the number of values assigned to each—this is referred to as the **sampling resolution**. High-quality audio samples assign 65,536 different values (2^{16} , which is equivalent to 16 bits, or 2 bytes). The value of each sample may be recorded and stored in a computer's hard drive. One minute of CD-quality audio comprises

$$60 \text{ seconds} \times 2 \text{ bytes (16 bits)} \times 44,100 \text{ samples per second} \times 2 \text{ tracks (stereo)}$$

The current trend in studios is to record in 24- or 32-bit files at up to 196 kHz sampling rates. This allows for much more headroom and more accurate high-frequency response when multiple tracks are processed and mixed down.

Digital Clipping and Aliasing When converting an audio signal from analog to digital, one must consider the problem of **digital clipping**. Note that in Figure 27-20b the tops of the waveforms have been clipped off. This clipping happens when the input voltage exceeds the maximum numeric value that the a/d converter can assign, resulting in the same number being used over and over again until the voltage drops back below the maximum level. This digital distortion is very noticeable and almost impossible to remove after the fact. Recording at the highest possible volume (voltage) produces the

Nyquist sampling theorem Accurately reconstructing an analog sound signal in digital form requires that it be sampled at twice the rate of the highest frequency.

sampling resolution The number of different values available to assign to a digital audio sample. Resolution directly affects the quality of sound reproduction.

digital clipping In sound recordings, a harsh distortion caused by inaccurate digital recording of frequencies beyond the sampling range or volume above the maximum numerical value of the a/d converter.

aliasing In sound recordings, a distortion caused by a sampling rate below the Nyquist frequency.

best resolution. However, a ceiling exists that reflects the highest sampling number available. Above this ceiling, clipping occurs.

Aliasing is another severe form of distortion. It is the result of a sampling rate below the Nyquist frequency. Analog-to-digital converters should use low-pass filtering to remove all signals above the sampling rate, and higher sampling rates should be used to limit distortion from aliasing at higher frequencies.

How to Make Live Recordings

Live recording of a synthesizer or other electronic equipment is simply a matter of patching its output into the recording device, but recording sounds with a microphone is another matter entirely. The microphone input should be routed through a mixer and then into a recording device, allowing the operator volume control and mixing control. In most instances, it is safest to record “flat” (without equalization) and make adjustments later. The recording studio normally should be quite “dead,” with walls and floors covered with absorbent material (carpeting works well). In addition, any ambient sound must be eliminated.

In recording, remember to set up the mixer with the proper gain structure. Beginning at the pre-amp, turn the gain up until a good hot signal is obtained, but not so loud that it starts clipping (usually indicated by a red light). Next, run the individual faders up toward 0 dB. Finally, adjust the output to the recording device. Having the input too low at the start only means that the volume will have to be boosted later, resulting in more noise and a less accurate recording.

Ample time must be allowed for any recording session. Before the “talent” arrives, all equipment should be checked to be sure that it is in good working order. Make a recording of the room to see what you hear; a sample of this recording can later be used to filter out any constant background noise. Do not be afraid to experiment; mistakes often reveal valuable techniques. Try a variety of different microphones as well as placements. Remember that microphones (especially omnidirectional ones) pick up *everything*, including the sound of the equipment, computer, and ventilation fans. At the end of your recording session, take a moment and listen to the recording before you send the talent home.

To keep unwanted noise at a minimum, sound engineers often place a microphone close to the sound source in live recordings. In doing so, they must pay attention to the *proximity effect*. Because various frequencies can differ greatly in wavelength, a directional microphone placed less than 2 feet away from a source will exhibit an increase in low-frequency response. The results can be balanced by using an equalizer.

In addition, close-up recording accentuates sounds that otherwise would be indistinguishable. A good example of this effect is the squeak of a guitar string as the musician’s finger moves. Such sounds are nearly impossible to process out of a finished recording. Recording engineers must give special consideration to this problem.

When recording the speaking or singing voice, either a directional or an omnidirectional microphone may be used. The directional mike eliminates more ambient sound while the omnidirectional mike provides more “presence” and is less likely to “pop.” Place the microphone 6 to 12 inches away from the person being recorded and run a series of tests with the talent talking into the mike. Use a pop filter in front of the mike if needed. If the dynamic range of the recording is too great, use a compressor to limit the peaks and avoid clipping.

If it is possible to record in a studio or other quiet place, use a studio condenser microphone for the best sound quality. These mikes offer extreme dynamic range and frequency response, producing the best possible recordings (Figure 27-21a).

The effect of distant sound is best achieved with the person off-axis or to one side of a directional mike; it can also be added later with equalization and reverberation.

Recording a group of voices can be done with a single omnidirectional mike. If stereo recording is necessary, try a stereo microphone or two directional mikes crossed, as in Figure 27-21b.

How to Work with Wireless Microphones

Available either as handheld or as miniature body mikes, wireless microphones are a major element of any reinforcement system. In addition to understanding wireless technology, the sound designer must take care to observe several practices that improve wireless use.

Sound Quality Miniature wireless microphones are available in two types: omnidirectional and cardioid. Selection depends on where the performer wears the microphone. In most cases, the omnidirectional type is chosen for theatre use because the mike is placed on the performer's head. Unfortunately, problems with sound quality, feedback, and interference are more common with omnidirectional pickup patterns.

Sound quality lacks proximity effect and selected frequency response exhibited by cardioid microphones. Some degree of equalization should be used to offset this effect.

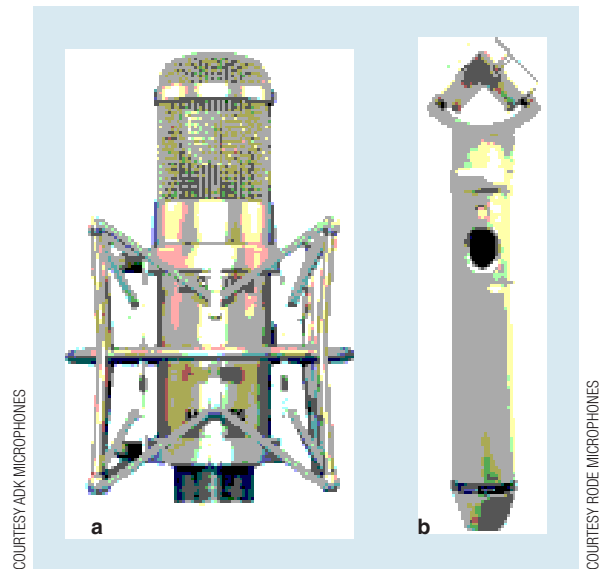
Comb filtering is another concern. When two microphones at approximately the same volume level come closer than about three feet apart, constructive and destructive phase shifting begins to occur. If one graphs this out, the filtering looks like the teeth of a comb. To minimize this comb filtering when two actors are playing close together, the operator should take out one of the two microphone levels or at least attenuate it by a minimum of 10 dB.

Attaching the Body Mike The body mike is attached either at the hairline or over the ear. When attaching the mike over the ear, a metal support must be used to hold the mike cable and capsule in place. Any malleable metal with a rubberized coating will do, such as solid-core copper electrical wire with rubber coating. With tape, attach the mike cable to a 3- or 4-inch length of the wire, allowing the mike capsule to extend beyond the end of the support wire by an inch or so. Then bend the wire over the performer's ear and tape it to the skin behind the ear using clear medical adhesive tape. Additional tape may be necessary, but attempt to keep the mike capsule slightly off the surface of the performer's skin to avoid excess moisture. Microphone capsules that are designed with integrated over-the-ear wires can also be purchased. Use bobby pins to attach the mike at the hairline. If this proves too unstable, try attaching a more substantial clip to the mike cable and then to the hairline.

In either case, the mike cable can be run down the back of the performer to the bodypack transmitter. The costume shop can help to provide a fabric pouch to hold the transmitter. The pouch may be attached to the costume itself or to the body of the performer with an elastic strap.

Transmitting Frequencies Whether handheld or miniature, care must be taken in selecting the transmitter frequencies of wireless microphones to avoid interference from other broadcasting. A good solution is to use vacant VHF (30 to 300 megahertz) or UHF (300 to 3,000 megahertz) television channel frequencies, which can be specified when purchasing a new wireless system.

Another potential problem is **intermodulation**, the complex relationship between a frequency and its harmonics. When using multiple wireless microphones, intermodulation will render many of the available frequencies useless. Most wireless systems come with several preset groups of frequencies that have been carefully selected to work well with each other by manufacturers using sophisticated computer programs.



27-21 Recording Microphones

- a** ADK Model TC large-diaphragm condenser microphone suitable for studio-quality recordings.
- b** Rode NT4 stereo condenser microphone.

intermodulation Additions to a processor's original audio signal produced within the components themselves.

Attempting to integrate two systems manufactured by different companies can lead to interference difficulties; in this case, the designer must pay particular attention to the assigned frequency groups. If a problem still exists, he or she may have to go to the manufacturer's website to obtain compatible frequency numbers.

Receiver Placement Proper placement of the wireless receiver is essential for good sound quality.

- Place the receiver or run the antennas as close to the transmitter as possible. Many designers choose the orchestra pit or just offstage for receiver placement.
- Try to ensure that the antenna of the transmitter is not under any metal part of the costume and is straight and not coiled in any way.
- Do not place the receiver antenna close to metal or other dense material.
- Avoid placing the receiver near computers or other RF-generating equipment.

Maintenance Try to keep the miniature microphone capsule dry—sweat from the performers can significantly reduce the life of the capsule. Keep the backpack transmitters dry by using medical sheaths specifically made to cover wireless transmitters and microphones. Inspect microphones after every performance, and do a thorough test before each performance. It is good practice to replace backpack batteries before each performance.

How to Control Feedback

As we have seen, *feedback* is the annoying sound produced by a reinforcement system amplifying a certain frequency or frequencies over and over again. Usually, this condition occurs when a microphone is placed too close to a speaker cabinet or if its gain is increased too much. Sound from the microphone is sent to an amplifier and then to the speaker. If the sound from the speaker becomes as loud as that from the performer using the mike, it will be picked up by the microphone and reamplified. In this event, a sound loop occurs, resulting in feedback. There are several ways to stop feedback, listed here from most to least obvious:

1. Turn down the gain from the loudspeaker.
2. Move the microphone further away from the loudspeaker and/or place the performer's mouth closer to the microphone.
3. Use a more directional microphone and/or loudspeaker.
4. Use a parametric equalizer to attenuate those frequencies that are feeding back. Under normal conditions, one or several frequencies will be causing the sound to feed back. If these frequencies are identified by an analyzer, an equalizer can be employed to eliminate the problem.

How to Select and Place Performance Microphones

Whether recording in a studio or working with live microphones on stage, there are two rules of thumb that should be remembered:

1. In placing microphones, the distance between one microphone and the next should be at least three times the distance between the microphone and the performer or musical instrument (3:1 rule). This will reduce unwanted phasing.
2. Doubling the number of microphones turned up on stage reduces the overall system gain before feedback by 3 dB.

Vocal Other than body mikes, the best solution for vocal microphone selection and placement in the reinforcement system is floor mikes placed downstage in the footlight

position. The best microphone for this task is the supercardioid PCC-type with rear sound rejection. Position the mikes about 15 feet apart, keeping in mind that an odd number of mikes is best so as to provide a center position. They will be effective approximately 15 to 20 feet upstage.

Difficult-to-reach positions often require some theatrical ingenuity. Mounting a PCC- or PZM-type microphone on the scenery can effectively solve a tough reinforcement problem. Suspending a small condenser mike above the playing area is another possible solution.

Keeping the number of live microphones in use to an absolute minimum is imperative in order to maintain greater gain before feedback. A good operator never has a microphone turned on if it is not needed.

Musical The sound from any electronic musical instrument should be fed into the mixer by means of a **direct box**. Sometimes referred to as a DI box (direct injection box), this small electronic circuit makes it possible for the signal from the instrument to go directly into the microphone input of the mixer.

Most other instruments can best be miked by placing a directional microphone as close to the sound source as possible. In addition, special microphones are manufactured for musical instrument pickup. Some are standard microphones and others, called *contact microphones*, react to sound vibrations. A PZM mounted inside a partially closed piano lid produces good sound. Manufacturers' catalogs provide additional information on the various microphones made for musical pickup.

direct box Also referred to as a *DI box* or *direct injection box*, this device takes an unbalanced line-level signal from an electronic musical instrument such as an electric guitar or synthesizer and provides an isolated, low-impedance, microphone-level signal to a mixing board.

How to Select and Place Speakers

Selection Speaker selection is determined by application. Low-frequency sounds produced by the woofer are fairly nondirectional owing to their long wavelengths. However, the higher frequencies produced by the compression driver can be made directional with the aid of a horn. Horns are available with various directionality, normally indicated by dispersion angle in degrees.

If the speaker is in a small black box theatre and close to the audience, a wide ($90^\circ \times 90^\circ$) speaker is desirable in order to evenly cover the maximum number of seats. Larger theatres require a narrower dispersion ($40^\circ \times 60^\circ$ or $40^\circ \times 90^\circ$) to keep the sound directed at the seating and off of the walls and ceiling. The more focused the sound is on the seating, the more control the designer has over unwanted echo and reverb. In addition, focusing the sound helps reduce system feedback. This is particularly significant in musical theatre, where directing the sound to the audience and keeping it off the stage is a must for feedback control.

Theatre speakers should be able to produce 115 dB of sound pressure level without distortion, have as wide and flat a frequency response as possible, and be kept to a minimum physical size. All this translates into money. Theatre companies pay top dollar for their speakers. Because speakers are the weakest link in the audio system, they must be of the highest quality.

Power Ratings As noted, speakers have an RMS power rating usually measured at 8 ohms. The RMS rating serves as a guide to the speaker's performance in terms of volume. However, some speakers are more efficient than others. Rather than rely on RMS figures alone, sound engineers compare them with the speaker's efficiency as indicated by sound pressure levels published by the manufacturers (SPL at 1 meter with 1-watt input).

Phasing When hooking up speakers, one needs to ensure proper electrical phasing. This simply means that one must always pay attention to the positive and negative connections from amplifier to speaker, never crossing them. Doing so will cause the diaphragm of one speaker to move in, while that of the other moves out, potentially canceling sound.



SAFETY PRACTICE

Speaker Rigging Safety

Rigging in the theatre is potentially dangerous and should only be carried out by qualified personnel. Speakers are no exception. NEVER HANG A SPEAKER THAT IS NOT RATED BY THE MANUFACTURER FOR OVERHEAD USE. Never hang a speaker from its handles. Always use rated hardware and industry-standard safety factors when rigging speakers. If you don't feel qualified, seek the help of the theatre's rigger or technical director.

Placement As we have seen, it is best to place reinforcement loudspeakers above and just in front of the performer. However, other locations may be necessary if the designer wishes to approximate the direction of a sound source. Physical limitations of the performance space may also compromise speaker placement.

If stereo sound is required, two speakers separated by some distance will be necessary. This can be achieved by placing speakers above and to each side of the performer, perhaps with a fill-in center speaker. Be aware that this arrangement may be fine for sound effects and music but will cause the spoken word to be less intelligible.

Speakers for the arena stage should be located as close as possible to center, above the performance space, pointing out toward the audience. The dispersion pattern of the high-frequency horns should be narrow enough to direct the sound to the audience and not to the acting area. If such an arrangement causes feedback, the speakers will have to move toward the audience until the problem is alleviated.

Glossary

- a vista** In view of the audience.
- ACN** Architecture for Control Networks is a stage lighting protocol designed to replace DMX, improving two-way communication and signal reliability.
- acoustics** The scientific study of the total effect of sound, especially as produced in an enclosed space. In the theatre this may relate to reflection, absorption, and creation of harmonics that characterize a theatre's reverberant field.
- adapter** A special cable with different types of connectors on each end; allows a fixture with one type of connector to be plugged into a circuit with a different type of connector.
- aliasing** In sound recordings, a distortion caused by a sampling rate below the Nyquist frequency.
- alternate position** Any secondary position of a piece of scenery, drafted in dotted line.
- alternating current (AC)** An electric current that periodically reverses direction of flow.
- alternator** A simple alternating current (AC) generator.
- amber drift** The color shift of an incandescent lamp as it is dimmed.
- ampere** The measurement of flow rate of electrons (current) through a conductor. Also used to indicate the capacity of a circuit or a conductor.
- amplitude** Measured in decibels (dB), amplitude is synonymous with *volume* or *intensity*. Amplitude is determined by the height of a sound wave.
- analog signals** Audio information represented by a continuous variable measurement of physical quantities such as length, width, voltage, or pressure. An analog audio recording is a continuous curve, as opposed to a digital recording, which is based on discrete samples.
- analogous** Using any three adjacent hues on the color wheel.
- ANSI lamp code** A system for identifying lamps that uses a different three-letter code for each lamp.
- apron** The area of the stage just in front of the proscenium arch; synonymous with *forestage*.
- area lighting** An organizational method of lighting in which lighting areas are assigned throughout the acting area and fixtures are focused on those areas in the same ways, thus providing consistency in lighting the actors as they move about the stage. Also called *area method* and *area system*.
- arena seating** Also referred to as *stadium seating*, whereby the slope of the audience seating is quite steep; most often found in arena and thrust theatres (as well as in sports stadiums).
- arena theatre** A theatre space in which the audience encircles the acting area; sometime referred to as *theatre-in-the-round*.
- artistic director** Person responsible for play selection, hiring of artistic staff, and sometimes fund raising.
- ARTSEARCH** A nationwide listing of available theatre jobs; published by Theatre Communications Group.
- Austrian drape** Sometimes referred to as a *brail curtain*; a curtain that is rigged with a series of vertical drawlines that lift at the same time and at the same speed.
- automation** A programmable interface allowing for many variables, including timing, acceleration, speed, and location with limit.
- auxiliary view** A drawing done in addition to the standard top, front, and side of the orthographic projection, in which an angled surface is rotated to reveal true length measurement.
- axis** Any device moving a piece of scenery.
- backstage** All the area upstage of the proscenium arch; often used synonymously with *offstage*.
- balance** Equalization of visual weight or opposing forces within a composition.
- balanced line** The audio signal is carried on two wires in a shielded cable, with one signal being 180 degrees out-of-phase from the other. Sometimes called *differential input*, this input signal is read only in terms of the difference between the two wires; therefore, any noise induced on both of the wires will be ignored. Balanced lines are standard in professional equipment and can be used for very long cable runs.
- barn door** An accessory for the Fresnel spotlight that attaches at the color-frame holder and allows for linear beam-shaping from four sides.
- baseboard** Piece of molding at the bottom of a wall that protects the wall from chair legs slid against it; also used as a device to move our eye from the horizontal surface of the floor to the vertical surface of the wall.
- batten** Pipe batten; horizontal pipe hung from a line set of a fly system.
- batten tape** Strips of paper or cloth attached to a lighting batten to assist in the hanging and circuiting of fixtures.
- beam edge** In a spotlight beam, the point where the light drops off to 50 percent of maximum intensity.
- beam port** Lighting positions located in the ceiling particularly in proscenium houses used primarily for front-light.
- bevel** Any cut in the same direction as the grain of the wood.
- binaural localization** Using our two ears to locate a sound, primarily by noting which ear receives the sound first.

- black box theatre** A theatre that is usually small and that allows flexibility in the arrangement of audience to acting space; so named because the walls are usually painted black.
- blind** A window covering used to block out light. There are various types, the most common being Venetian blinds and roller blinds. Also called a *shade*.
- board foot** A measurement of lumber equivalent to a board 1 inch thick and 1 foot square.
- boomerang** A rolling platform, usually with several levels, that allows scenic artists to work on several areas of a drop simultaneously when painting vertically.
- booms** Vertical hanging positions for lighting instruments. Portable types often consist of 1½-inch black pipe screwed into a heavy base. Also called *lighting trees*.
- border** Overhead masking, usually in reference to opaque black fabric, hanging from a batten and running laterally across the stage.
- boundary microphone** A microphone placed extremely close to and facing a flat (boundary) plate. Rather than responding directly to pressure in the air, this microphone picks up pressure variations from the air gap between the element and the plate.
- box boom** A vertical hanging position for lighting equipment, located in the sidewalls of the auditorium close to the stage. Named after the placement of light booms in audience side boxes, these positions create a low to medium side angle a bit to the front of the performer.
- breasting** Moving a hanging unit of scenery away from its working position to make room for (usually) another piece of scenery or an electric (a pipe used for lighting instruments).
- bridling** Extending the line set by adding a length of pipe and tying it diagonally to the lifelines.
- broad** A rectangular floodlight that produces a bright and fairly even wash of light.
- bulb** The sealed glass enclosure of a lamp. Also called the *envelope*.
- bus-and-truck tour** A tour that plays short runs in numerous cities.
- business manager** Person in charge of budgeting and all other financial matters, often including fund raising.
- C-clamp** A clamp, shaped like a C, that is used to attach a lighting fixture to a pipe batten.
- cable** Temporary stage wiring—normally 20-amp capacity to match stage circuits.
- carriage** The supporting structure of a staircase tread.
- cartooning** The drawing, usually in charcoal, of a paint elevation on a drop or flat.
- casket lock** A two-piece locking device incorporating a rotating wedge that pulls both pieces together and locks them with one turn of an Allen T-wrench. Also called *coffin lock*.
- ceiling beam** or **port** A slot cut in the auditorium ceiling, providing a position for hanging and focusing front-lights.
- chair rail** Piece of molding, usually about 3'-0" above the floor to protect the wall (both plaster and wallpaper) from the back of a chair sliding against it.
- change music** Music used to cover the time and possibly the noise of a scene change.
- channel** The dimmer controller in a memory.
- channel** or **dimmer parking** A lighting control-board feature in which the intensity level of a channel or dimmer will not be recorded in a cue.
- chroma** The purity of a color or the amount of adulteration (neutrality); often referred to as *intensity* or *saturation*.
- circuit** An established path of electrical flow.
- circuit breaker** A switch that automatically opens if the current exceeds a circuit's capacity.
- color boomerang** A device, located in the front of the barrel of a follow spot, that holds several color filters, allowing for quick color changes.
- color interaction** How the perception of a color is influenced by the presence of another color.
- color modification** The alteration of a surface's color by colored light.
- color rendering index (CRI)** A measure on a scale of 0 to 100 of how accurately a light source reveals the color of an object.
- color temperature** A measurement in degrees Kelvin (K) of the color of light emitted from a source. Stage-lighting instruments with incandescent lamps have a color temperature of about 3,200 K; candlelight is a warm-colored 1,800 K; and arc light is a cool-colored 6,000 K.
- common neutral** A neutral wire serving two or more hot wires.
- company switch** A switch, commonly found backstage in theatres, that supplies high amperage power for touring dimmers.
- complementary hue** One of two hues directly opposite each other on the color triangle or color wheel.
- composition** The organization of design elements into a unified form. Light reveals composition.
- condenser microphone** A microphone housing an element consisting of two metallic-coated plates separated by a small volume of air. The top plate, which is charged with an electrical voltage, acts as a diaphragm. Its movement back and forth (changing the distance of the air gap between the two plates) alters the electrical charge induced in the back plate. Because of the very low voltage generated, all condenser microphones require an internal amplifier as well as a source of power—either a small battery or phantom power from the mixing board.
- condensing lens system** The first lens or set of lenses in an image projector; the condensing lens(es) concentrate the light from the source onto the slide.
- conductor** Materials that allow the free motion of a large number of electrons.
- cones** Light receptors located in the retina that are sensitive to color.
- connectors** Electrical plugs.
- contactor** An electrically operated device in which a small switch controls a larger, remotely located switch.
- continuity tester** A piece of testing equipment that supplies a low-voltage current in order for an electrician to ascertain whether a circuit is complete or broken.

- contour curtain** A curtain that is rigged with several separately operated drawlines that can create a variety of shapes when the curtain is open.
- contrast** In scenery, dissimilarity of forms used to create interest. In lighting, a difference in color, intensity, or distribution.
- control** The degree to which a designer can isolate a specific section of the acting area. Control depends on dimmers and lighting area size.
- cornice** Piece of molding at the top of a wall, most often the largest in scale, used to move our eye from the vertical surface of the wall to the horizontal surface of the ceiling.
- cross-fade** The process of bringing up one group of lights while dimming out another.
- crossover network** An important speaker element, this electronic device is used to divide and route frequency bands to the appropriate speaker component—either as a passive set of electronic components located inside the speaker cabinet or as an active electronic device that divides a line-level signal into frequency bands and sends them to separate power amplifiers.
- cue** The movement of light from one stage “look” to another. A cue is usually assigned a specific number.
- cue insertion** The ability to insert a new lighting cue between two existing cues in the cue list.
- cue linking** A feature that allows the linking of one lighting cue to another out of normal cue-list order.
- cue sheets** A list of a production’s lighting cues in numerical order.
- cutting plane** An imaginary line along which an object is sliced, allowing the viewer to see inside; typically used in reference to a plan or a section view of an object.
- cyclorama** Historically, a curved hard background. Today, the abbreviation “cyc” is used for any sky drop.
- dado** Notch cut into a board, allowing a second piece to fit into it.
- dance centering light** A small red light placed at dancer head height at the rear of the auditorium or on a balcony rail; serves to help dancers locate front. Also called *spotting light*.
- dance zones** Dance lighting areas that extend completely across the stage; normally determined by placement of side-lighting booms and masking legs.
- dark set** A special lighting cue for the sole purpose of allowing changes in automated fixture attributes, such as to cause color changers or automated fixtures to change their color or focus without being seen.
- dead haul winch** A winch that lifts a load that has not been counterweighted.
- decibel** A measurement of sound intensity, the decibel (dB) describes a ratio of two quantities. One decibel is a measurement of electrical or acoustic power equal to $\frac{1}{10}$ of a Bel (a unit named after Alexander Graham Bell).
- dependent door** A door in which the reveal structure is a part of the flat or wall that frames it.
- design approach** The idea, or the visual theme, of design.
- devised piece** The way in which the story will be told, is discovered through the rehearsal process rather than from a written text. This process involves all members of the company—director, actors, and designers.
- dichroic reflector** In a theatrical spotlight, a glass reflector with a dichroic coating, which allows some wavelengths of light to pass through while reflecting others.
- dichroics** Glass color filters that reflect rather than absorb unwanted wavelengths.
- digital clipping** In sound recordings, a harsh distortion caused by inaccurate digital recording of frequencies beyond the sampling range or volume above the maximum numerical value of the a/d converter.
- digital projectors** A projector that receives a digital signal and transforms it into an image to be projected onto a screen by means of an objective lens system.
- digital signal** Audio information represented by multiple binary (on-or-off) measurements. An analog wave form is measured or *sampled* many times. The aggregate of those values represent the wave form.
- dimmer-per-circuit** A dimming system that permanently assigns an individual dimmer to each lighting circuit in the house.
- direct box** Also referred to as a *DI box* or *direct injection box*, this device takes an unbalanced line-level signal from an electronic musical instrument such as an electric guitar or synthesizer and provides an isolated, low-impedance, microphone-level signal to a mixing board.
- direct current (DC)** An electric current flowing in one direction only.
- director’s CD** Selections of possible sound cues for the director to evaluate.
- distributed dimming** Placing groupings of dimmers directly on electric pipes near the instruments rather than in a remote location.
- distribution** The specific manner in which light falls on a surface— influenced by the direction, quality, and texture of the light itself.
- DMX universe** One universe of DMX consists of 512 discreet control channels.
- DMX-512** A standard communication protocol for lighting-control systems.
- documentary projection** Projection that supports and comments on the action.
- douser** A mechanical device, commonly found in follow spots, used to dim the light. Sometimes spelled *dowser*.
- downstage** Direction toward the audience.
- drop** A large piece of fabric that is dyed, painted, or otherwise treated to create a background.
- dry-brushing** Pulling the brush across wet paint in such a way that the bristles of the brush leave a streaky brush stroke.
- dutchman** A thin strip of fabric used to hide the joint on the face of two adjacent flats.
- dynamic microphone** A microphone housing an element that consists of a diaphragm directly coupled to a coil of wire that moves

back and forth in a magnetic field. As the air pressure moves the diaphragm, the coil's movement in the magnetic field induces a flow of alternating electricity in the microphone cable that is analogous to the alternating waves in the air.

- dynamic range** The difference, measured in decibels, between the quietest and the loudest portion of a segment of sound. In a live situation, this usually is the difference between the loudest portion and the noise floor of the theatre.
- e-stop** A button or switch that interrupts the motion of a moving scenic unit outside of the cueing parameters.
- effects** Music or sounds that are prerecorded and played back during a scene, such as that from an onstage phonograph or radio.
- electrical solenoid** An electromagnet that can be used for remote control of special effects.
- electrics department head** Person in charge of all electrics and sometimes sound operations of the theatre; may be an IA union position; also called *house electrician*.
- electromagnetism** The creation of an electromotive force (voltage) through the use of a generator.
- electrons** Negatively charged particles that orbit the nucleus of an atom.
- elevation** A view of an object in which the line of sight of the viewer is perpendicular to the object, sometimes referred to as a projection.
- elevator** A mechanism built to move an actor or scenery vertically; an elevator is a permanent part of a theatre, as opposed to a lift, which is a temporary structure built for the same purpose; compare *lift*.
- ellipsoidal reflector** A reflector cast in the shape of part of an ellipsoid, which reflects light back to its secondary focal point; found in ellipsoidal reflector spotlights.
- ellipsoidal reflector spotlight (ERS)** Stage-lighting fixture that uses an ellipsoidal reflector. The ERS is the most efficient and versatile fixture in use today. It creates a concentrated, sharp light and has a built-in beam-shaping capability.
- emphasis** Visual prominence using the elements and principles of design to guide the viewer to a specific area of the design.
- envelope** Traditionally, the dynamics of an individual sound from a musical instrument in terms of attack, decay, sustain, and release. Contemporary usage: the window used to dynamically alter a sound track over time.
- equalizer** An electronic device that alters a specific frequency or frequency range. The two most common types are graphic and parametric.
- Ethernet** A universally used digital communications protocol capable of carrying numerous DMX signals at the same time.
- extended apron** An apron that projects out into the house.
- extruding** Squeezing molten metal through a shaped aperture to form a shape such as a rod or a tube.
- facings** The edge of a platform or stair tread, used to hide the structure decoratively.
- false proscenium** A neutral frame, most often black, that either reduces the opening of the proscenium arch or alters its shape.
- feathering** Pulling the brush from a wet painted surface to a dry one so that the stroke ends in a featherlike pattern.
- feedback** An audio loop created between a microphone and its speaker. As a speaker's volume is increased, a point is reached where sound from the speaker entering the microphone is greater than the original sound from the actor. This "loop" then becomes self-feeding (hence, *feedback*), locking onto in-phase frequencies and amplifying them uncontrollably.
- feeder cable** High-amperage flexible cable used to connect portable dimmers and other equipment to a theatre's power supply.
- field edge** In a spotlight beam, the point where the light drops off to 10 percent of maximum intensity.
- filament** A thin piece of tungsten that glows and emits light from within a lamp.
- fill-light** The secondary source of light in a composition. An important factor in visibility, fill-light is often thought of as bounce light or shadow.
- fire curtain** A fireproof wall-like structure that is built to drop quickly in the event of a fire so that it encloses the entire proscenium opening, separating the stage house from the auditorium.
- FireWire** Apple's name for IEEE 1394 interface. A serial bus interface standard (connector, cable, protocol) similar to USB for transmitting and receiving data.
- fit** Flat brush with a long handle; varies in size from ½ inch to 3 inches.
- fixed caster** A caster that allows movement in only two directions.
- fixture schedule** A lighting chart that is arranged by fixture location and number and that lists a variety of fixture information.
- flash memory** Nonvolatile computer memory that can be electrically erased and reprogrammed. Primarily used in memory cards, USB flash drives, and other portable memory devices.
- flash pot** A device made to hold and ignite a highly explosive powder for onstage special effects.
- floating** Lifting a wet drop off the floor by blowing air underneath while the paint is wet.
- flood focus** The largest of the variable beam sizes of a Fresnel spotlight.
- fly rail** Any part of a fly system where the lines are moved in and out and locked into place; also referred to as *locking rail*.
- fly space** The space above the set.
- focal length** The distance between the center of a lens and its focal point.
- focal point** Center of interest.
- focal point of lenses** The point at which parallel rays of light converge after passing through a lens.
- focal point of reflectors** The specific point at which a light source must be placed in relationship to the reflector in order to achieve the desired reflective pattern.
- focus chart** Charts containing focus information for all fixtures in a production; used to reproduce the focus accurately.

- focusing** The process of aiming and adjusting lighting fixtures to suit the needs of an individual production. Focusing is normally done by the lighting designer and a crew of electricians.
- fog juice** The liquid used in fog and smoke machines.
- foldback system** Typically a separate set of amplifiers and speakers placed to direct their sound to the actors/singers so they can hear the orchestra and themselves. Also placed in the orchestra for musicians to hear themselves and the actors/singers.
- follow cues** An important lighting control function that allows one cue to follow another automatically with a single press of the “go” button.
- foot-candle** A measurement of intensity of light reflected off a surface. Average stage brightness is approximately 70 foot-candles.
- footing** Using a foot to prevent a flat from sliding in the process of walking it up.
- footlight** Low-angled light sources often placed at the front edge of the stage apron—at the “feet” of the actors.
- forging** Stamping metal into a shape.
- free electron** An electron removed from its atom, providing the means of electrical flow.
- frequency** The rate at which a sound vibrates, measured in cycles per second or hertz (Hz). The length of a sound wave determines frequency. A sound’s frequency determines its pitch.
- Fresnel fixture** Named after the inventor of its lens, the Fresnel is a theatrical fixture with a spherical reflector and the ability to change beam size. It produces a soft, even field of light.
- frost** A plastic light-diffusion medium.
- fullness** The effect achieved by gathering or pleating a given width of fabric into a narrower width. For example, a 10’-0” wide drape at 100 percent fullness would need 20’-0” fabric width.
- gate** In an ellipsoidal reflector spotlight, the position at which shutters, iris, and gobos are located. The gate is also close to the reflector’s secondary focal point, where the light rays cross.
- gauge** A measurement of the diameter of a wire; directly relates to the wire’s capacity.
- gels** A short name for color filters; derived from the word *gelatin*.
- gelstring** A series of plastic color filters taped together and rolled to form the scroll of a color changer.
- generator** A device that creates an electromotive force (voltage) by moving a conductor within a magnetic field.
- genre** A general category, such as farce, mystery, and tragedy, distinguished by form, style, content, and other characteristics.
- glass curtain** A sheer or translucent fabric used to allow light inside a room and not allow a viewer from outside to see inside.
- glazing** Painting a transparent or semitransparent layer on top that subtly tones a surface or provides a finish (such as gloss, semi-gloss, or matte).
- gobo** A pattern, normally cut into a thin stainless steel plate, which is placed at the aperture of an ERS to project an image.
- Golden Section** Also called the Golden Mean; a ratio, such as in a rectangle, in which the short side to the long side is the same as the long side is to the sum of the short and long sides, approximately 3:5.
- gradation** Transitional steps in a sequence used to create emphasis and a feeling of movement in a design.
- ground plan** A cutaway view of a set from a horizontal cutting plane 3’-0” above the stage floor; essentially the top view of the set in an orthographic projection.
- ground row** A row of striplights located upstage and used to illuminate the background from the bottom. A *scenery ground row* is a horizontal masking device used to hide the lighting ground row.
- grounding** A safety feature in modern wiring. A third wire acts as the ground wire, providing an electrical path of low resistance in case of a short circuit.
- groups** Similar to lighting submasters in that any number of individual channels can be assigned to one group master. Submasters can also be assigned to groups.
- Haas Effect** Localization of a sound is primarily dependent upon the location of the first sound to reach our ears.
- hanging cardboards** Pieces of cardboard onto which a section of the light plot has been attached; used to assist in the hanging and circuiting of fixtures.
- hanging chart** A chart included on the ground plan and section that indicates the placement of each piece of scenery that hangs or flies from a batten, including line set number, distance from the plaster line, and trim.
- harmonics** The overtones that are created when a note is played on a musical instrument. Normally, these are multiples of the root frequency.
- harmony** A pleasing or congruent arrangement of scenic forms, creating an aesthetic unity, often achieved through repetition.
- hertz** A unit of measurement used to identify the frequency of a sound. Hertz (Hz) are equal to cycles per second or CPS.
- hidden outline** The outline of an object that is hidden from view, drawn in dotted line.
- HMI and HTI** Two types of metal halide arc lamps commonly used in follow spots and automated fixtures.
- Hollywood flat** A flat in which the framing members are on edge; the corners of the flat are end to face (as opposed to end to edge).
- hookup** A lighting chart that is arranged by dimmer or channel number and that lists a variety of instrument information.
- hot wire** The conductor that carries electricity to the place of work.
- hue** The name of a color; scientifically, the color’s wavelength or position in the spectrum.
- IGBT dimmer** A modern electronic dimmer. The Insulated Gate Bipolar Transistor is the electronic component that controls the current.
- Illuminating Engineering Society (IES)** An organization made up primarily of architectural lighting designers and engineers; publishes the IES handbook and offers courses in architectural lighting.

- image projectors** A projector that focuses light onto a slide or moving film by means of a condensing lens system. The resulting image is then projected onto a screen by means of an objective lens system. Also called a *slide projector*.
- impedance** The measurement of resistance in alternating current circuits, including audio signals. It is used in speaker specifications (typically 4 to 16 ohms) and in sound equipment input and output specifications.
- in-trim** Position of scenery as it should be when in use: the “in” position.
- incandescent filament lamp** A glass bulb enclosing a tungsten filament that emits light when an electrical current is passed through it.
- incidental music** Music that occurs other than during the actual play, such as before and after the show or at intermission.
- independent door** A door that is a completely separate unit from the flat or wall into which it will be fit.
- infrared** Light energy with wavelengths just longer than the longest visible wavelengths (red)—literally “below red.”
- input source** Any device that sends an audio signal to the sound system.
- insulator** Materials that have few free electrons and therefore resist the flow of electricity.
- integrated projection** Projection that interacts with the action as an integral part of the production scheme.
- intermodulation** Additions to a processor’s original audio signal produced within the components themselves.
- International Alliance of Theatrical Stage Employees Union (IA)**
The union representing stagehands and electricians.
- iris** A device, located at the gate of an ellipsoidal reflector spotlight, that makes the beam’s circumference larger or smaller.
- jack brace** A triangular structure used to support or brace a vertical flat.
- jewel lighting** An early Broadway technique of lighting involving the use of a low-angled source from the balcony rail in combination with lights from each box boom.
- jib camera** A camera mounted on a tripod, usually counter-weighted, that allows it to move vertically, horizontally, or in combination.
- Kelvin (K)** A temperature scale used to identify the color of a light source.
- kerf** Thickness of the cut made from a saw blade.
- key-light** The primary source of light in a composition—normally the brightest. Key-light may imitate a motivational source.
- keystone** Distortion of an image owing to projection at an oblique angle to the screen.
- ladders** Hanging positions for lighting instruments that derive their name from the fact that, with vertical uprights and horizontal “rungs,” they look like ladders. They may be permanently fixed or, more likely, able to be hung in a variety of positions.
- lamp** A light source consisting of a filament, a bulb, and a base.
- lay-in brush** Brush, usually 3 to 4 inches wide, used for painting large areas; often used for base coating, spattering, and other such techniques.
- LCL (light center length)** The distance from the center of a lamp’s filament to some predetermined place in its base.
- LED** Light emitting diode; a special diode that can be designed to produce light of various colors.
- leg** Side masking, usually in reference to opaque black fabric, hanging from a batten and running vertically to the floor.
- lens tube** The housing for the objective lens(es) of a projection system. The housing is normally interchangeable to provide a variety of beam spreads.
- level/rate wheel** A wheel or touch pad that can control individual lighting channels, groups of channels, or an entire cross-fade.
- libretto** The text or dialogue of an opera.
- lift** A mechanism built for a specific production to move an actor or scenery vertically; compare *elevator*.
- liftline** The line running from the batten through the loft blocks (pulley) and the head block (group of pulleys) on top of the arbor in a fly system.
- Lighting Dimensions International (LDI)** Group that publishes *Live Design* magazine and holds an annual convention for individuals working in the entertainment industry.
- lighting rehearsal** Moving cue-to-cue through a production’s lighting looks with the director and stage manager—hopefully with actors in costume, but without other tech—takes place before the technical rehearsal.
- lighting storyboard** A series of value sketches or color renderings depicting the quality of light for the various “looks” of a production.
- lighting system** An arrangement of lighting instruments of similar type, color, and/or direction that produces a specific lighting “look.” A system may be used alone or in combination with other systems.
- lighting truss** Metal tubing, often aluminum, welded together in a crossing pattern for strength; used to support lighting equipment.
- limit switch** A device that, when tripped by a moving scenic unit, will cause the movement to stop.
- line** A straight geometric figure consisting of a series of points that has direction, length, and width, although the width is often so narrow it is usually not recognized.
- line array** A group of speakers arranged in a vertical stack, closely spaced and operating in-phase and with equal amplitude. Line arrays allow for very directional control of mid to low frequencies over long distances through the use of constructive and destructive interference.
- line level** Signal voltage levels from various pieces of audio equipment to speaker amplifiers; ranging from 77.5 millivolts to 24.5 volts, with 4.5 volts across 600 ohms equal to 1 watt.
- line set** A group of three or more lines using the same counterweight to lift a batten or unit of scenery.

- liner** Narrow, long-handled brush (often $\frac{1}{4}$ inch) used for details, most often in painting molding.
- lining** Using a small brush to paint lines, most often in painting highlight and shadow in painted molding.
- loft block** Any block, or pulley, placed in the grid.
- loose-pin hinge** A two-piece hinge in which the pin can be removed.
- LORT houses** Professional regional theatres; *LORT* stands for *League of Regional Theatres*.
- lumen** A unit of measurement of the intensity of a light source.
- magic sheet** Custom-designed paperwork used to assist the designer in setting and adjusting light levels; also called a *cheat sheet*.
- masking** Any piece of scenery that is used to complete the stage picture and prevent the audience from seeing the backstage area; also when one sound or event demands our attention to such a degree as to negate other sounds or events.
- media server** Software or a dedicated computer that allows for complex playback of media.
- MIDI** Musical Instrument Digital Interface is a standard for representing musical information in digital format. Through MIDI Show Control, its use has been expanded to include communication and the control of all types of theatrical equipment.
- mike level** Signal voltage levels from a microphone to a mixing board, normally in the millivolt (thousandth of a volt, or mV) range.
- mini-plot** A very abbreviated light plot showing one typical lighting area for a given look in the production.
- ministrips** Striplights using MR-16 lamps.
- miter** Any cut across the grain of the wood.
- mixing board** A device used to preamplify, combine, and adjust sounds from a variety of sources and assign them to various outputs. A mixing board usually includes some provision for limited equalization along with supplying phantom power to devices that require it. Also known as a *mixer*. A digital mixer also converts analog signals to digital and allows for more advanced signal processing.
- monochromatic** Using only one hue, black and white, and the complement to reduce the chroma.
- mood** The quality of a play that, when properly transmitted, creates a state of mind or emotional response in the audience.
- motion profile** The speed, distance traveled, acceleration, and deceleration of a scenic unit.
- motivated lighting** Lighting sources arranged to duplicate the effect of a specific source such as a chandelier.
- motivational lighting** The theatrical use of light based on an actual source or sources.
- mullions** Interior window-framing pieces.
- mult** Short for multi-cable. A single stage-lighting cable normally containing 18 conductors used to get circuits to temporary lighting positions.
- multipart cue** Several cues running together at different speeds that are handled as one cue by the control board.
- nanometer** A measurement in billionths of a meter used to define certain wavelengths (colors) of light.
- National Association of Broadcasters (NAB)** An organization of individuals involved in television production.
- national tour** A tour that plays for a long run in a single city.
- negative space** The space between two or more forms.
- neutral wire** The conductor that carries electricity back to the generating plant.
- nominal size** The rough-cut size of a piece of lumber as milled before being planed to working size.
- nonmotivational lighting** Light used as a pure element of design, without reference to any actual sources. Often such use is based on the designer's emotional reaction to the script.
- nonrepresentational** A form of art that is abstract and ornamental, not based on real-life objects and shapes.
- nosings** The projecting edge of a stair tread and top of stair riser; often refers to any molding hiding the intersection of tread and riser, particularly if the tread itself does not project.
- nucleus** The positively charged center of an atom; composed of protons and neutrons.
- Nyquist sampling theorem** Accurately reconstructing an analog sound signal in digital form requires that it be sampled at twice the rate of the highest frequency.
- objective lens system** The second lens or set of lenses in an image projector; the objective lens system receives the image of the slide and transmits it to the screen in a size determined by the spread (focal length) of the lens.
- offstage** (1) Direction away from the center of the stage. (2) The stage areas to the right and left of the set.
- ohm** The measurement of a conductor's resistance to the flow of electrical current.
- Ohm's law** A circuit's amperage is equal to its voltage divided by its resistance (measured in ohms). Used to calculate resistance.
- optics** Reference to the optical features of a stage-lighting fixture—most significantly, the reflector and lens or lenses.
- orthographic projection** A straight-line projection drawing of an object showing three views, typically the top, the front, and the side.
- out-trim** Position of scenery when it is not in use: the "out" position.
- overdrapery** Draped or gathered fabric, usually heavy and opaque, used as a decorative window treatment. Sometimes permanent, sometimes functional, it is often used in conjunction with a glass curtain.
- pallet** A wagon with a very low profile; also called a *skid*.
- pan pot** The potentiometer that controls the left/right assignment to a sound mixer's output bus.
- PAR fixture** A lighting fixture using the parabolic aluminized reflector lamp. It produces a strong and harsh beam of light that is oval with soft edges. Its field is rather uneven.
- parabolic reflector** A reflector cast in the shape of part of a parabola, which reflects light in parallel rays; found in PAR fixtures.

- parallel circuit** A type of electrical circuit in which portions of the total current flow through the various elements simultaneously.
- parquet** A geometric or mosaic pattern in a wood floor.
- patch panel** A flexible system allowing the connection of any stage circuit to any dimmer; used in non-dimmer-per-circuit systems; also, a matrix of plug points used to interconnect various pieces of audio equipment. Usually divided into rows of inputs and outputs, the patch panel provides an organized central location for their routing.
- pegging** Method of attaching two pieces of wood by inserting a small wooden dowel (peg) into a hole drilled into both pieces.
- phantom power** Power for condenser microphones supplied through the microphone cable from the mixing board.
- picture rail** Piece of molding that is used to hang pictures.
- pin connector** A stage connector with round brass pins that slide into holes in the receptacle.
- pinrail** The steel rail on which lines in a hemp system are secured, often by the use of belaying pins.
- pipe ends** Fixtures clustered at the ends of light battens, providing high side-light.
- pipe pocket** A casing sometimes stitched to the back at the bottom of a drop into which a chain or pipe can be inserted for weight.
- plano-convex lens** A lens with one flat (plano) side and one outwardly curved (convex) side; found in ellipsoidal reflector spotlights.
- plaster line** Imaginary line on the upstage edge of the proscenium arch.
- plotter** A mechanical drawing machine used to draft light plots and technical drawings from digital files.
- point cue** An additional lighting cue that is assigned a decimal point number placing it between two whole-numbered cues.
- pounce** A drawing, done on Kraft paper, that has been perforated in order to transfer it to the scenery to be painted.
- power formula** $\text{Wattage} = \text{amperage} \times \text{voltage}$.
- preamplifier** The first circuit encountered by the sound signal from a microphone into the mixing board, it amplifies the microphone level signal to line level.
- preset** The name given to a lighting look—especially when the preset system is used.
- preset console** A control system with at least two rheostats or controllers per dimmer located on the control console. One set of controllers can be preset for the next lighting look, while the other set represents what is “live” onstage.
- preset sheets** A means of recording channel levels for each lighting cue in a production.
- primary hue** One of three hues that are used to mix all other hues. In pigment the primary hues are red, yellow, and blue; in light they are red, green, and blue.
- priming brush** Wide brush (6 inches is common) used for covering very large areas.
- processing** Altering the audio signal in a nonlinear fashion. Equalizers, effects units, and compressors are examples of signal processors.
- production electrician** The electrician in charge and who works most closely with the designer.
- production manager** Person in charge of the day-to-day operation of the theatre and overseeing all production matters; often hires staff and works closely with the artistic director and business manager.
- profile piece** A flat piece of scenery that follows the outline of an object, such as a tree, hill, or fence.
- programming** The process of inserting cues or presets into a lighting control console.
- proportion** The size of a form relative to another form.
- proximity effect** The increase in low-frequency response when a microphone is placed very close to the sound source. This is an inherent characteristic of directional microphones and is usually associated with singers using handheld microphones.
- purchase line** Rope used to move a batten up and down in a counterweight system.
- quartz strips** Striplights using long quartz lamps.
- rabbet** Wide groove cut into the face of a board, allowing another board to fit into it.
- rag painting** Using a lightly crumbled up piece of fabric dipped in paint and softly rolled or used in place of a sponge (also called *rag rolling*).
- rails** Top and bottom horizontal framing members of a flat.
- RDM** Remote Device Management is a stage lighting protocol intended to allow two-way communication between a control console and a remotely-controlled device.
- refraction** The bending of light rays as they pass through mediums with different densities, as in a light beam traveling through air bending from its original track when it goes through glass.
- rehearsal CD** Sound effects or music given to the director or stage manager for use in rehearsal; useful for timing or giving the actor a chance to work with underscoring, songs, or sound effects before technical rehearsals.
- reinforcement** The electronic amplification of actors or musical instruments onstage. Typically used to do the following: (1) Help the audience hear the actors. (2) Blend and balance the vocals and the musical instruments in a musical theatre production. (3) Add an effect or change the quality of a voice.
- repertory production** The process of presenting a different show each night, with the number depending on the size of the repertory.
- representational** A form of art that directly relates to real or lifelike objects.
- reveal** The frames of an opening in a flat to indicate the thickness of the wall, usually 1 x stock.
- reverberation** The combination of multiple blended sound images caused by reflections from walls and other surfaces. If reverberation time is long enough to discern individual sounds, then it is referred to as an *echo*.
- rhythm** Patterns of repeated visual movement.
- riser** Vertical surface of a step, often referred to as *facing*.
- RMS** Root mean square is used to give an average power value to an alternating current or audio circuit as it would compare with

that of a direct-current circuit. RMS can be used to describe both peak (instantaneous) values as well as the more useful continuous power output.

road electrician An electrician for a bus-and-truck tour.

rods Light receptors located in the retina that are sensitive to intensity.

roll drop A drop wrapped around a long horizontal roller (usually like a big blind); also called an *oleo drop*.

roundel Round glass color filters made to fit into striplights.

sample Taking a “snapshot” of the analog waveform and assigning it a numerical value. The number of times per second that an analog to digital converter (ADC) freezes and assigns a numerical value to the analog signal (voltage) is the sampling rate. A 16-bit stereo sampling rate of 44.1 thousand times per second is referred to as CD quality.

sampling resolution The number of different values available to assign to a digital audio sample. Resolution directly affects the quality of sound reproduction.

scale The size or mass of a form.

scoop Ellipsoidal reflector floodlight used to create a bright, even wash of light.

SCR dimmer A modern electronic dimmer. The silicon controlled rectifier (SCR) is the electronic component that controls the current.

scrim An open-weave fabric used in the theatre for its transparent properties.

scroll work Curved, detailed design resembling a rolled piece of paper.

scumbling Intermixing of two or more colors on the scenery in a random pattern, allowing some areas to blend.

secondary hue One of three hues produced by mixing any two primaries. In pigment, they are magenta, orange, and green; in lighting they are cyan, yellow, and magenta (CYM).

section A view of the stage, auditorium, and scenery from one side, as if cut across vertically at the center line.

self-powered speakers Speaker cabinets that contain power amplifiers and processing circuits that exactly match the speakers in the cabinet. Only an AC power supply and line-level audio signal are needed, eliminating many outboard components.

series circuit A type of electrical circuit in which current passes through the various elements successively. If one element fails, the current will stop.

service power Refers to the type of wiring system providing electricity to a user as well as its amperage.

set line The edge of the set farthest downstage, usually parallel to the plaster line.

shade Darker value of a hue.

sheave Pulley; the part of a block that rotates.

sheet metal Piece of metal that has been rolled into a flat sheet, thinner than plate.

shop order A contract for the rental of lighting equipment and accessories that lists, in detail, all the equipment to be rented for a production; used for bidding purposes and ordering.

short circuit An accidental path of low resistance, allowing an abnormally large flow of current; usually caused by improper wiring or broken insulation.

show control Using a computer to control the timing of two or more stage movements (light, scenery, sound, effects).

show deck A floor or deck built for a specific production, including all necessary mechanics for moving scenery.

show portal A decorative frame designed for a particular production and used either to pull together multiple sets visually or to help establish the character of the production.

shutter The part of a door that opens and closes.

shutters Moveable metal plates, inserted at the gate of an ellipsoidal reflector spotlight, that allow the beam to be shaped in a linear manner from any of four directions.

side-arm An accessory valuable for hanging lights on booms or other vertical positions.

side cove A vertical slot cut in the side wall of the auditorium to provide a hanging location for side-front light.

side stage The area right and left and in front of the proscenium arch; sometimes used as acting area.

sightline Line of sight from an audience seat to a point onstage.

signal processor Hardware or software that alters an audio signal in a nonlinear fashion, such as an equalizer or reverb unit.

sinewave dimming Use of IGBT electronics to reduce the height of the electrical sinewave, resulting in lowered voltage to the lamp.

single-source lighting Creating the quality of one distinct source of illumination by clustering several lighting fixtures together or by using one large, bright source.

site-specific Theatre produced using a found space that is uniquely perfect for a particular production.

sky-drop A backdrop that is not painted with anything representational. Sometimes called a *cyc*.

soft patch An electronic patching system present in most lighting consoles that allows the connection of any control channel to any dimmer/circuit.

sound plot The actual working list of the cues for a production; normally includes cue numbers, speaker assignments, fade times, and so forth.

sound pressure level (SPL) The measurement of acoustic pressure level in decibels.

splattering Method of applying painted texture by sharply tapping a loaded brush against the heel of the hand, leaving droplets of pigment on the work.

speaker level Signal voltage level from an amplifier to its speaker. Twenty-four and a half volts and up is enough to drive a speaker.

specials Lighting fixtures used in addition to the regular production lighting.

spectral distribution The radiant power emitted by a light source at each wavelength over the visible spectrum—normally shown in graph form.

spherical reflector A reflector cast in the shape of part of a sphere, which returns light back to its focal point; found in Fresnel spotlights.

- split cross-fader** Two faders: one assigned to those lights going down in intensity and the other assigned to those lights going up in intensity. This tool allows for variation in up and down fading times.
- sponging** Using a sponge to apply paint.
- spot focus** The smallest of the variable beam sizes of a Fresnel spotlight.
- spotline** (1) Line rigged specially for one production; not part of the standard rig of the theatre. (2) A single rope and pulley used in remote position on the grid; often used to fly scenic pieces that are not parallel to the plaster line.
- stage circuit** Permanent stage wiring — normally 20-amp capacity.
- stage left** Direction to the actor's left as he or she faces the audience.
- stage right** Direction to the actor's right as he or she faces the audience.
- staging** The arrangement of actors in the environment, creating stage pictures that help to tell the story of the play.
- stiffener** Usually a 1 × 3 or 1 × 4 used horizontally on edge to keep several flats in place, most often on the same plane.
- stiles** Vertical framing members of a flat.
- stipling** Using the tips of the brush to apply paint in an up-and-down motion.
- stock production** The process of running a single show for several weeks.
- storyboard** A series of sketches that provide a moment-by-moment view of a scene, act, and so forth.
- striplight** A row of lamps in a single housing used to create a wide and even wash of light; commonly used to illuminate backdrops.
- submaster** The name given to a single lighting master controller to which any number of individual control channels has been assigned.
- swivel caster** A caster that allows movement in any direction.
- tableau curtain** Two overlapping panels of fabric that are rigged to pull open on a modified (curved) diagonal.
- tandem head block** A grouping of pulleys that carry the lines from individual blocks to the arbor in a counterweight system and to the pinrail in a hemp system.
- tenon** A projecting member in a piece of wood or other material for insertion into a mortise to make a joint.
- tertiary hue** Any hue that is the result of mixing a primary hue with a secondary hue. In pigment, there are six possibilities: blue-green, yellow-green, yellow-orange, red-orange, red-violet, and blue-violet.
- Theatre Communications Group (TCG)** A national service organization dedicated to assisting the not-for-profit theatre; publishers of *American Theatre* magazine and *Art SEARCH*.
- Themed Entertainment Association (TEA)** An organization representing creators, developers, designers, and producers of compelling places and experiences including themed entertainment.
- three-phase system** A 120/208-volt AC electrical wiring system consisting of four wires: three hot and one neutral. Also known as the *four-wire system*.
- three-wire system** A 120/240-volt AC electrical wiring system consisting of three wires: two hot and one neutral.
- threshold of hearing** Normally defined as 0 dB SPL, this equates to the quietest sound that the ear can discern.
- thrust stage** A stage in which the acting area juts out into the audience; it usually has audience on three sides.
- tight-pin hinge** A hinge in which the center pin cannot be removed.
- timbre** The tonal quality of a note, sung or played on a musical instrument, that includes the fundamental frequency of the note combined with all the harmonics (overtones) created. Timbre is what distinguishes the sound of two different musical instruments playing an identical note at the same volume.
- tint** Lighter value of a hue.
- toggles** Internal framing members of a flat, usually horizontal but sometimes vertical.
- top hat** An accessory particularly useful with the Fresnel spotlight that attaches at the color-frame holder and reduces spill and glare from the fixture's lens.
- tracking** An operational mode in which a channel or dimmer level remains the same in all lighting cues until told otherwise.
- transducer** A device such as a microphone or speaker that converts input energy of one form into output energy of another. In the case of a microphone, it transduces acoustical energy in the form of sound pressure waves in the air into electrical energy.
- transformer** A device used to increase or decrease the voltage of alternating current (AC).
- translucency** A fabric that can be either opaque or translucent, depending on how it is lit.
- trap** Any hole in the stage floor.
- traveler** Any curtain that is drawn in a horizontal direction; also called a *draw curtain*.
- tread** Horizontal surface of a step.
- trim** Height of something above the stage floor; to hang pipes or scenery above the stage floor.
- trim clamp** A two-piece metal clamp that is used to bind together the lines in a hemp system, for ease of operation. Also referred to as a Sunday.
- trim pot** Also referred to as *input level*, *input gain*, or *pad*, it is a sound mixer's volume control over the input signal.
- triple-swivel caster** Also called a *zero-throw caster*; a caster mounted on three wheels around a central point for easy turning.
- tripping** Picking up the bottom of a drop as well as the top when there is not enough room to fly it completely out.
- true length line** A line in a drafting in which the measurement on paper is the actual length of the line of the object.
- truss** A framework of wood or metal that uses triangles and is therefore considerably stronger than a simple beam.
- tungsten-halogen lamp** An incandescent lamp with a halogen-family gas sealed within its quartz-glass envelope. Also called a *quartz lamp*.

- twist-lock connector** A stage connector that provides a sure connection by means of prongs that lock within the receptacle.
- two-fer** A special cable that allows for the plugging of two lighting fixtures into one circuit.
- two-wire system** A 120-volt AC electrical wiring system consisting of two wires: one hot and one neutral.
- ultraviolet** Light energy with wavelengths just shorter than the shortest visible wavelengths (violet)—literally “beyond violet.”
- unbalanced line** The audio signal is carried on a single center-conductor in a shielded cable. This method is used primarily for consumer electronics and is very susceptible to noise and interference.
- underscoring** Playing music or other sound “under” dialogue in order to affect mood or comment upon the action.
- union business agent** A union’s representative to the public; negotiates contracts and fills labor needs.
- unit setting** A setting based on the retention or the reuse of certain elements of scenery for more than one scene.
- United Scenic Artists Union (USA)** The American union representing professional scenic artists; costume, lighting, scenic, and sound designers; art directors; projection designers; computer artists; graphic artists; and art department coordinators.
- United States Institute for Theatre Technology, Inc. (USITT)** The association of design, production, and technology professionals in the performing arts and entertainment industry.
- upstage** Direction away from the audience.
- valance** The uppermost decorative frame of a window drapery treatment. Sometimes a valance is draped fabric, as in a swag, or a hard surface either painted or covered with fabric.
- value** The presence of white or black in a color; the lightness or darkness of a color.
- value sketch** A sketch that emphasizes the light and shadow of a set.
- variable area lighting** Large as well as small lighting areas are arranged throughout the acting area. The small areas offer great control and are used in conjunction with the larger areas.
- variation** Slight or major changes in the elements or principles of a form that prevent monotony.
- voltage** or **electromotive force (EMF)** A difference in potential—the force that causes free electrons to move in a conductor.
- vomitory entrance** In the thrust theatre, ramps serving as actors’ entrances and exits that lead up to the front of the stage from beneath the audience.
- wainscoting** Any wood lining on a wall, usually seen in the form of paneling.
- wash lighting** Use of general illumination to cover the entire acting area; this technique offers little, if any, control.
- watt** The measurement of the electric power rate, or the rate at which work is done through the use of electricity.
- wet-blend** To blend two or more colors on the scenery while they are wet.
- winch** A hand-cranked or motor-driven drum rigged with a cable that is used to move scenery.
- window sash** Frame that contains the panes of a window.
- wings** Vertical masking pieces on the sides of a proscenium stage. The name is derived from “wing and border” scenery. Wings also refer to the offstage right and left spaces in the proscenium theatre.
- xenon short-arc lamp** A bright arc lamp with xenon gas sealed within its envelope; develops high pressures within the bulb.
- yoke** On a lighting fixture, the U-shaped part that holds the C-clamp and allows the fixture to tilt.
- zoom profile** A profile spotlight with movable lenses that provide an adjustable beam diameter.

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