A Guide for Lighting the Stage

Introduction

The aim of this guide is to help teachers better understand and explain the basic elements of stage lighting. This resource is intended to supplement existing teaching materials, providing additional information and relevant product examples to add colour to lessons and presentations. The content can be applied to a variety of venues, including school halls, drama studios, college and university venues, dance venues, village halls, arts centres, concerts and student television studios. The following chapters cover basic illumination techniques using the ColorSource family of products from ETC and provide a pathway towards more artistic lighting designs. The guide is supported by an optional set of posters, available from ETC (send an email to SchoolsUK@etcconnect.com to request a poster set).

Founded in 1975, ETC is a global leader in the manufacture of lighting and rigging technology for entertainment and architectural applications. ETC products are found in small and large venues worldwide. All ETC products are made to the same high standards, which is why they are used in so many professional and amateur venues. The ETC ColorSource family of equipment delivers LED lighting on a budget by offering high quality lighting, data distribution and power control in a plug-and-play format.

This guide will explain the reasons why lighting for the stage is such a key part of storytelling and keeping an audience engaged with a performance. It will also explain the parts of a lighting system, including the luminaires (also commonly known as lanterns or fixtures), power control devices and control desk (also known as a board or console).

Source Four ERS

Source Four PAR

Source Four Fresnel

ColorSource Consoles

ColorSource Spot

ColorSource PAR

ColorSource Fresnel

ColorSource CYC

ColorSource Linear

ColorSource ThruPower

Objectives

Overall objective: The teacher shall understand the reasons behind why we design light for the stage, the tools available to create lighting specific to the performance at hand, and the steps required to produce a lighting design for a performance and be able to explain these concepts to their students.

Chapter 1 / Section 1: Why do we light the stage?

This section explains the purpose of light on the stage, how it functions to help tell the story and how it helps to make the visual presentation of the performance more interesting to the audience.
Objective: The teacher will be able to explain the artistic and functional roles of designed lighting on the stage.

Chapter 1 / Section 2: Controllable properties of light

This section explains the ways in which a lighting designer can adjust the light projected by stage luminaires to suit the needs of the performance and design.
Objective: The teacher will be able to describe how a beam of light can be used to help tell a story using colour, direction, shape, edge softness or hardness and movement in space.

Chapter 2 / Section 1: What equipment do we use to light the stage?

This section describes the luminaires used in the theatre, including their core features and their adjustable features. It includes descriptions of both conventional tungsten and LED luminaires.
Objective: The teacher will be able to make choices about which luminaire type is best for a certain application in a lighting design.

Chapter 2 / Section 2: Behind the scenes – what makes a lighting system work?

This section describes the equipment that drives the luminaires and allows the lighting designer to control the lighting in the performance from scene to scene.
Objective: The teacher will understand and be able to explain the roles of the power distribution equipment that feeds the luminaires and the lighting control desk that controls them throughout a performance.

Chapter 3: Achieving a lighting design

This section describes the process of creating a lighting design from the initial decision to become the lighting designer for a performance, to opening night.
Objective: The teacher will be able to explain the steps involved in producing a lighting design for a performance.

Supplementary materials

Appendix A: A brief history of stage lighting

This section explains a bit about how we transitioned from daytime performances outdoors to nighttime performances indoors lit by LEDs.

Appendix B: Technical details of the DMX512-A protocol and RDM (Remote Device Management)

This section provides an explanation of how the DMX512-A protocol and RDM (Remote Device Management) work in a lighting control system, including some troubleshooting steps that may help resolve basic issues with your lighting system.

Appendix C: Glossary

This section includes definitions of terms found in the guide.

Lighting Design Basics

Why do we light the stage?

Objective: The teacher will be able to explain the artistic and functional roles of designed lighting on the stage.

Theatres are not illuminated in the same way as other rooms – have you thought about why? Performance in general is about storytelling. Whether it is theatre, dance, opera, television, fiction, non-fiction, narrative or non-narrative, lighting is a key part of telling stories to large audiences. Light has been used throughout the history of theatre to focus the audience's attention on the story being told. The ancient Greeks used clever, open-air theatre design to maximise the dramatic nature of sunlight, and subsequent centuries produced innovations in artificial, flame-based light sources, from tallow candles and oil lamps to gaslight. The revolution of the electrical era has brought us to where we are now, with highly-specific lighting designs that often use hundreds of luminaires and thousands of LED pixels. The thread that ties all of this together is the idea that lighting is an integral part of the performance, designed to draw the audience into the piece and transport them along with the performers through to the end. The lighting design helps to tell the story by using the controllable properties of light to achieve a number of goals, as outlined below.

Visibility

The first job of a lighting design is to light the performance so that the audience can see what's going on. This can be achieved in a number of ways; for example, one big light or a number of general lighting fixtures (like in open plan office spaces). While visibility is the first goal of a design, there are other goals as well.

Focus and composition

This goal starts to explain why a generally lit room isn't suitable for theatre. Just as a narrator guides the reader through a story, the lighting of the stage can guide the audience through the action. Light can be used to take an expansive stage and focus the audience's attention precisely where the director wants them to look. From a technical perspective, this ability to get the audience looking at a specific area makes it possible for other apparent magic to occur unnoticed elsewhere on the stage. Using light to focus attention on the action stops the audience from losing connection with the story and becoming bored.

Revelation of form

Light can be used to create depth on stage, to push actors out of the background and to make scenes look more three-dimensional (or not, if the show requires it). This is especially important in dance lighting, where the shape and movement of the body is key. With the proper use of direction and colour – explained later in this guide – lighting can make spaces look flat and uninteresting, or larger than life.

Atmosphere or mood

Lighting can take a happy scene and make it feel sad or threatening. It can make the audience believe actors are standing in a bright day or wintry location or beautiful sunset. It can help the audience understand whether the scene is taking place at 10 o'clock in the morning or 10 o'clock at night. Think about how light can help or hinder the director's vision. If the actors' dialogue states that the room is cold, should the scene be lit with toasty orange light, or would pale blue be a better choice?

Movement in time or location

Theatres have so many lights because they are very rarely (if ever) all on at the same time. The lights are positioned and set up to create all the lighting scenes needed for a show – day scenes and night scenes, indoor and outdoor, realistic and overly dramatic, and so on. By changing which lights are on from scene to scene (known as cueing) the shifting of the light creates movement onstage.

Light can create the sense of time passing – by, for example, simulating the sun moving in the sky – which helps to keep a performance from feeling static or bland (unless this is the requirement of the show's script).

It may seem surprising that light does so much work in a performance, but light is a very malleable medium. The elements of a design are all manageable when you understand the controllable properties of light.

The Controllable Properties of Light

Objective: The teacher will be able to describe how a beam of light can be used to help tell a story using colour, direction, shape, edge softness or hardness and movement in space.

Intensity

A single candle doesn't emit as much light as a table lamp, and a table lamp doesn't emit as much light as an arena followspot. Every lamp type has an inherent brightness or intensity of light that it can create. Additionally, some lamps can be dimmed. Dimming an incandescent lamp (the type used in traditional theatrical luminaires) not only reduces the amount of light produced, but also creates an effect known as red shift – as the lamp burns at a lower temperature, the colour of the light produced becomes more red. You may have noticed this yourself if you have a dimmable lamp at home. At full intensity, the light in the room feels harsher as well as brighter; at lower levels, the light in the room feels warmer and more inviting.

Cool and warm colours

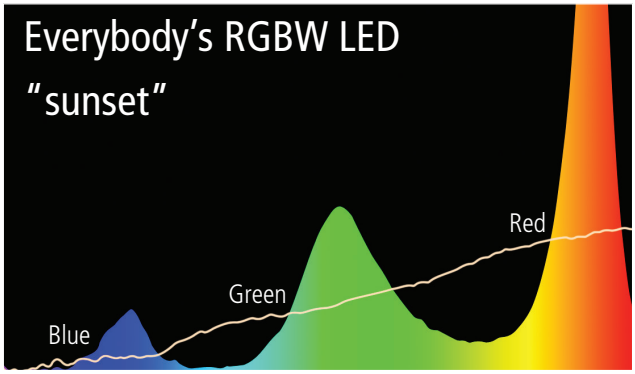
There's an interesting conflict in the way colours of light are described – by colour temperature and by colour of the beam. Light is measured by colour temperature on the Kelvin scale. We use a black-body radiator (an ideal measurement device) to give a Kelvin value to a perceived colour. Imagine a piece of metal being heated up – as it warms it becomes reddish in colour and gives off some light (think of your toaster). This red light is said to have a low colour temperature because the actual temperature of the metal is around 2700K. As the metal heats up, the light it gives off becomes bluer. So, blue light (like the sky during the day) is said to have a higher colour temperature because the metal must be heated to 6500K or more to make that colour light.

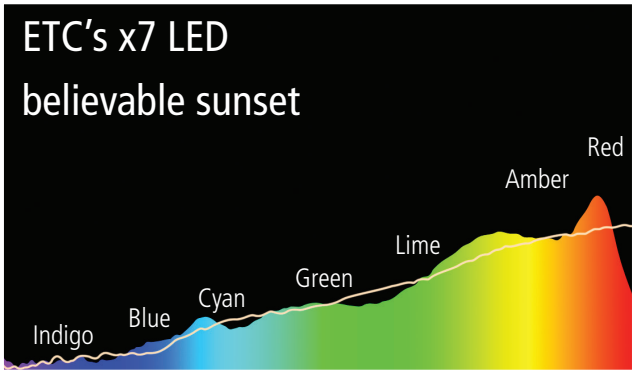
Humans relate red-orange colours (low colour temperature) to physical warmth, and icy blue colours (high colour temperature) to physical cold (imagine a clear winter day at noon – the light is generally harsh and not orange at all).

Colour

As mentioned above, dimming a lamp may affect the colour of the light being produced. There are other ways to change the colour of light as well. Some lamps create light of different colours due to the composition of the lamp (fluorescents and HID lamps, as an example), and there are colour filters that can be placed in front of a lamp. Why do we colour the light? We may not be consciously aware of it, but light in real life is very colourful. This is because light reflects off objects around us and colours our world. When we light a scene, we can paint the stage with colour to create moods and to replicate natural lighting effects. On stage, a forest scene may be lit with a lot of green lights, even though we know the sun is not green. Why? Because the light in a forest reflects off the leaves of the trees, giving it a green tint.

Graphs below represent R08 spectral distribution.





Related to colour is colour rendering. A theatrical lighting designer has the luxury of choosing light sources that render colour in certain ways. A conventional tungsten lamp, for example, renders the colour of skin and objects well, because – like the sun – it is a full-spectrum source that contains all colours of light. Fluorescent and high intensity discharge (HID) lamps do not produce light at all wavelengths of the visible spectrum. These sources are "peaky" in certain wavelengths and lacking in others, which means objects lit by them start to look unnatural – greyed out or unnaturally bright in some colours. LEDs in certain combinations can create light that is close to a full spectrum, but only when there are enough colours of LEDs in the mix. Simple Red-Green-Blue (RGB) luminaires should theoretically be able to create all colours of light, but because the RGB emitters are so narrow in bandwidth, their colour creation is actually quite limited.

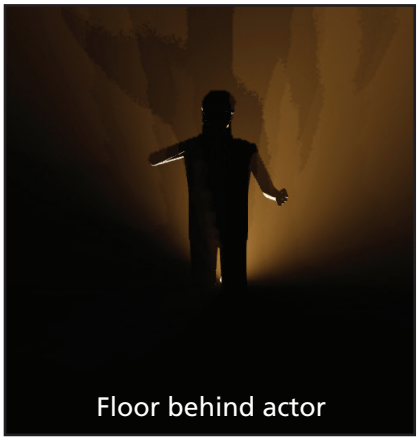
The colours used in a design are dependent on the show, the desires of the director and the vision of the designer. For very general stage lighting, it is typical to have a cool white (very light blue) and a warm white (very pale orange) set of lights focused onto the areas of the stage to illuminate faces. There may also be a light from above (downlight or toplight) in a tint of white, or lights from the back (backlight or diagonal back light) to help bring people on stage out of the background. If there is an orchestra on stage, it is best to use light from above in white – no colours – so that the musicians are able to read their music.

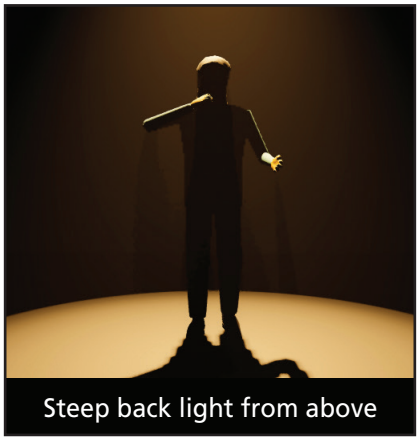
Colour filter booklets contain hundreds of colour options. The lighting designer selects their colours based on their vision of the show (which may be supported by visual research), discussions with the director and other designers, colours of the sets and costumes, and their experience. For broadcast, the designer also needs to consider the cameras and the colours they can produce on screen. All of these factors are considered when making the colour choices for a production.

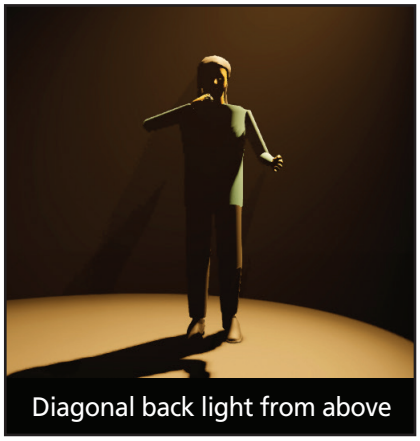
Direction

Humans are tuned to know the time of day by the angle of light hitting objects – long shadows at sunrise and sunset, short shadows at midday. We also use the shadows of objects illuminated by angled light to see in three dimensions. Theatres offer lighting positions from almost all directions so that designers can communicate and reveal form using directional light.

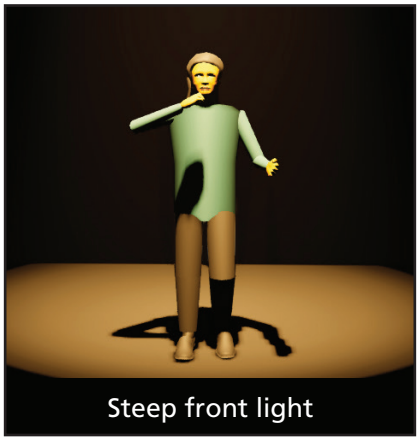
The human mind sees some directions of light as natural and others as odd. Light from the sides and above the actor are more natural than footlights, because the sun can only light you from the sides at certain times of day and otherwise from above. Other than reflection off another surface, there is no natural uplighting position, so we see this as a special direction of light. Now, it is much less common for footlights to be used in the theatre than it was in the past, therefore this direction of light has become very stylised – it is perceived as being very theatrical and presentational. In television, however, an uplight is often used to fill harsh shadows under the chin and nose so that the image on the screen appears more natural.

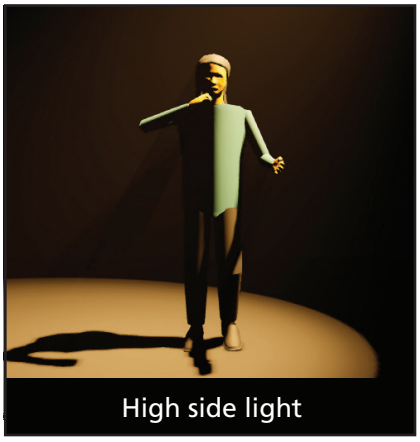

Floor behind actor


Steep back light from above

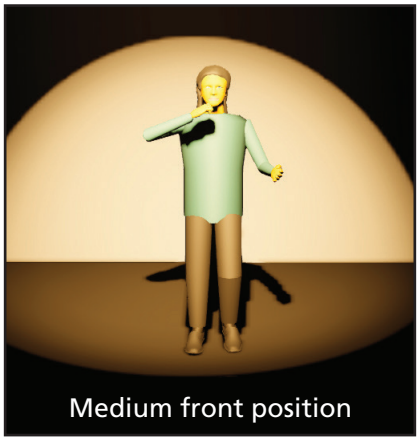

Diagonal back light from above


Diagonal front light from above


Steep front light


High side light


Mid-height side light


Medium front position


Floodlights/floats

Shape

In the natural world, light is shaped by shining through or around objects like trees, doors and windows. In the theatrical world, light can also be shaped by using luminaires with lensing for projection of patterns (leaves, blinds, etc) or shutters to cut a round beam into squares or other shapes. Fresnel luminaires have a softer beam not suited for crisp pattern projection, but they can be shaped by using a barn door at the front to cut light from the beam. Floodlights are typically difficult to shape with barn doors, but some have changeable lenses that create different oval or round beams.

Beam spread is another way of shaping the beam – in profile spotlights, Fresnels and some floodlights, the beam spread of the light can be adjusted by zooming (making it wider or narrower by adjusting the lenses or lamp position). It is important to note that a narrow beam spread is used for longer throws (when the spotlight is physically farther away from the object it is lighting) and a wide beam spread is used for shorter throws. It is typical to aim for a 3-metre (10ft) circle of light from a luminaire on the stage, to ensure that actors receive enough light to be seen by the audience.

Quality (hard or soft)

A spotlight typically creates a harder beam of light than a floodlight. Hardness relates to the crispness of the edge of the beam (profile spotlights can achieve a very crisp, hard edge of the circle of light) and the controllability of that beam – the ability to shape it with shutters. Fresnels exist somewhere in the middle; the soft but controllable beam of a Fresnel is said to be harder than the uncontrollable beam of a pure floodlight. Hard beams of light from a spotlight can be softened either by adjusting lenses or by adding a frost filter to the luminaire. Soft beamed luminaires, however, cannot easily be made harder or sharper.

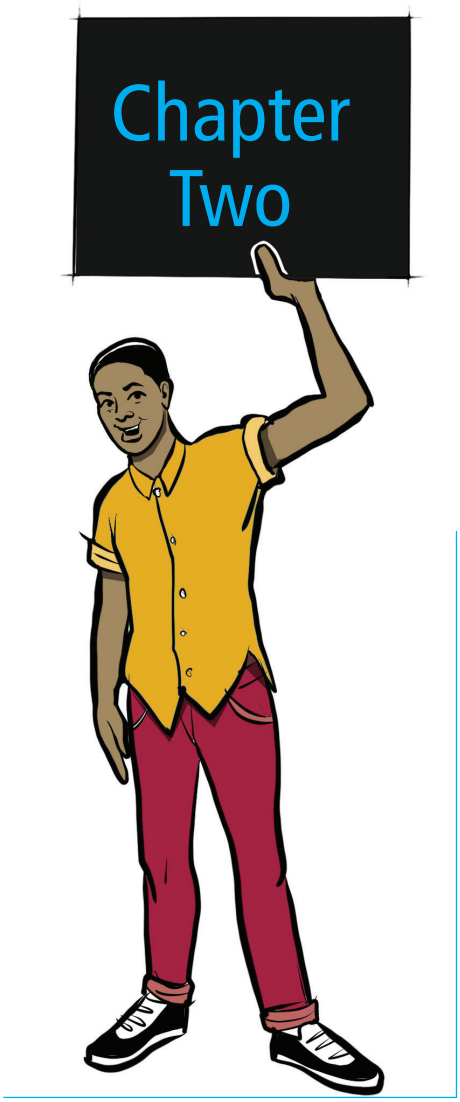
Movement in space

Luminaires used in the theatre can be grouped into two basic types – fixed position and moving lights. Most theatres have a lot of fixed position luminaires, as they are less expensive. Moving lights add a controllable property that is otherwise attainable only through followspots or practical effects: movement in space. Movement in space can be used to great effect in dance or concert lighting or as a special effect. For example, to simulate car headlights passing, a stagehand might manually move a pair of fixed luminaires.

LED Colour

ETC produces two families of LED luminaires – the x7 family and the ColorSource family. The x7 family for professional theatres produces the best range of colours and the best colour rendering on stage due to the use of up to seven different LED emitter colours in the array. With this configuration, designers can finely tune the colours they get on stage to precisely suit the moment.

The ColorSource family uses a mix of red, green, blue and lime LED emitters to get the best theatrical light at a more economical price point. The lime LED fills in the gaps in the spectrum and can be used with the more saturated RGB emitters to create subtle tints and full white light.



What equipment do we use to create designed lighting?

Objective:

The teacher will be able to make choices about which luminaire type is best for a certain application in a lighting design.

Composed lighting uses the controllable properties of light to fulfil the goals of lighting design as described in the previous chapter. Different types of luminaires with different types of reflector and lens arrangements are used by lighting designers to paint the stage with light. One big differentiating factor when choosing a luminaire is how controllable the actual beam of light is – can it project images and can it be cut-off of surfaces where the designer doesn't want it to go? When lighting for theatre, the designer typically wants as much control over where light goes as possible. This is partly due to wanting to keep stray light off scenery and partly due to the audience being in the room with the lighting. If there is a proscenium arch, the designer can use that wall to hide a lot of spill light from the audience. If the venue is a more open space or a thrust stage, being able to cut light off walls and audience members is very important to the look of the show. Although most lighting rigs contain a vast number of luminaires, there are only a small number of different types of lighting fixtures. The different types can be categorised in a variety of ways – this guide focuses on spotlights, Fresnels and PAR cans. In addition, there are some special purpose luminaires that don't fit into these categories. All types may have either a tungsten-halogen lamp or LEDs as their light source. This section describes these types of luminaires using the ETC ColorSource family of products as examples.

Spotlights

The profile spotlight is so-called because the internal shutters can shape or "profile" the light beam. It can also project an image cut into a metal disc (gobo) which is inserted into the light path through a special slot in the body of the luminaire. Profile spotlights are also called ellipsoidal reflector spotlights (ERS) because the design of the luminaire uses a reflector that is half of an ellipse in cross section. This type of reflector has two focal points. At one focal point (inside the reflector) is the lamp, and at the other (in front of the reflector) all the light from the lamp converges. This point is called the gate. Gobos placed at this focal point are projected through lenses at the front of the fixture, and shutters at this position can create sharp cuts of the beam.

Profile spotlights are available with two types of lens system – fixed angle and zoom optics.

Fixed angle optics (5-90 degrees)

Fixed angle optics, as the name implies, use a set of lenses in a lens tube to produce a beam of a fixed spread. The lenses can be moved in relation to the focal point of the luminaire so that the sharpness of the edge of the

beam can be adjusted. This allows for the softening of hard edges or the projection of sharp gobos. Fixtures such as the ColorSource Spot support the swapping of lens tubes, meaning that a single fixture body can produce a beam with any of the available beam spreads, as long as one has the appropriate lens tubes to swap out.

Zoom optics at 15-30 and 25-50 degrees

The zoom profile has two lenses with individual control knobs. By adjusting these lenses it is possible to change the beam spread within the range of the specific zoom lens tube, as well as soften the edges. These functions are particularly useful when focusing gobos into a particular space or position. Zoom fixtures are longer than those with fixed angle optics, but they provide instant flexibility as the lens tube need not be swapped to change the beam size.

Fresnels

The Fresnel lens found in theatrical spotlights is a variation of the one originally designed for and used in lighthouses. It produces a very soft-edged yet controllable beam and is quick and easy to use. It has become one of the main on stage luminaires in use all over the world. A locking knob on the ColorSource Spot with Fresnel adapter is used to move the lens back and forth relative to the LED light source, allowing a beam angle of 15°-50° to be selected. In a traditional tungsten Fresnel, the lamp is moved in relation to the spherical reflector to change the beam from spot to flood. The addition of a barn door accessory at the front can be used to shape the beam.

PAR Cans

The PAR Can has been in common use for about 40 years. The original model was based on a PAR 64 lamp – essentially a very old automotive headlight lamp. The Parabolic Anodised Reflector (PAR) lamp is a sealed beam unit that contains the reflector, filament and lens in a single unit; each type of PAR lamp will deliver a different beam angle. Using PAR Cans requires keeping a good selection of lamp sizes available in storage. Many of the PAR lamps produce an oval beam shape, allowing the adjustment of the axis of that oval by turning the lamp within the housing. All PAR Cans in the UK should be fitted with an insulated cover which surrounds the ceramic lamp connection. Students in the UK are not encouraged to adjust PAR Cans (rotating the lamp) with or without a protective insulating device fitted.

The PAR Can idea has been improved over time and made safer. The ETC Source Four PAR was designed to use the HPL lamp (the same as the Source Four ERS spotlight) with a fixed reflector and interchangeable front lenses. Different beam angles can be achieved by fitting one of the interchangeable lenses, and rotating the beam can be achieved by rotating only the front lens without touching the electrical connections or lamp itself.

The spirit of the PAR Can is retained in the basic shape of many LED floodlights. The ETC ColorSource PAR provides the traditional PAR beam


ColorSource Spot


ColorSource Zoom


ColorSource Fresnel


ColorSource PAR

– but with an LED light engine that delivers a wide spectrum of different colours. Diffusers can be fitted to achieve different beam angles and round or oval shapes.

PAR Cans in any form are not generally suitable for beam shaping with barn doors. A barn door may, however, be used on a PAR Can type fixture to help prevent or reduce glare from the front face of the fixture.

Additional Types of Luminaires

Linear or Batten

ColorSource Linear

The ColorSource Linear batten-style fixture has a low-profile and compact construction designed to distribute light in a long, narrow shape. The basic unit performs much like a floodlight, as light is distributed evenly and is suitable for a general wash across the stage. Like the ColorSource PAR, each unit can be fitted with beam shaping diffusers, which, when inserted into a slot covering the light optics, provide different beam angles.

Batten fixtures are often used to illuminate cycloramas, due to their low-profile design; however, there are other more efficient luminaires for producing smooth cyc lighting.

Cyc Lights

ColorSource CYC

The ColorSource CYC luminaire is an asymmetrical floodlight that is designed for lighting large, flat surfaces, (such as cycloramas, backdrops and walls) as evenly as possible. The lens at the front of the fixture body produces an asymmetrically distributed beam of light that is smooth and bright - both near the lens and far up the backdrop - and blends smoothly with fixtures to the right and left of it.

Soft Lights

Soft lights

In a television studio, the designer lights for the camera, not for the human eye. This means that the designer must take into consideration the colour rendition of the camera (the white balance), and the contrast ratio the camera can produce. The human eye has a much higher ability to see varying levels of contrast in colour and brightness than a camera. This means that lighting designed for the camera typically needs to be very smooth and even, otherwise the viewer will see hotspots on screen. Soft lights are used in television and film lighting because they create very soft, wide beams of light. These types of lights are typically not used in theatre due to their short, wide throw, their sometimes bulky nature, and their uncontrollability; however, small soft lights might be useful as set mounts if you need to get light into a tricky corner.

Moving Lights

Moving lights are available in spot, profile and wash varieties. An automated spot fixture can project gobos, harden and soften the beam edge, and may be able to zoom for adjustable beam spreads. Spots may

include a colour mixing system or may be fitted with a colour wheel – or sometimes both. Profile luminaires will do what spots do and include framing shutters within the fixture design. Automated framing shutters are challenging to design in a reliable way, which means they add significant expense to the cost of a luminaire. Automated wash lights typically use a colour mixing system and may offer some beam shaping capabilities to make a round beam oval. Moving lights range from disco lighting (inexpensive effect lights) to professional-quality automated profile spots. The more expensive the luminaire, the more likely it is to be suitable for use in the theatre – with acceptable noise levels, repeatability, refined control, and usable colours.

Behind the Scenes
What makes a lighting system work?

Objective:

The teacher will understand and be able to explain the roles of the power distribution equipment that feeds the luminaires and the lighting control desk that controls them throughout a performance.

In addition to the luminaires, a lighting system contains power control equipment and a lighting control desk.

Power Control Infrastructure

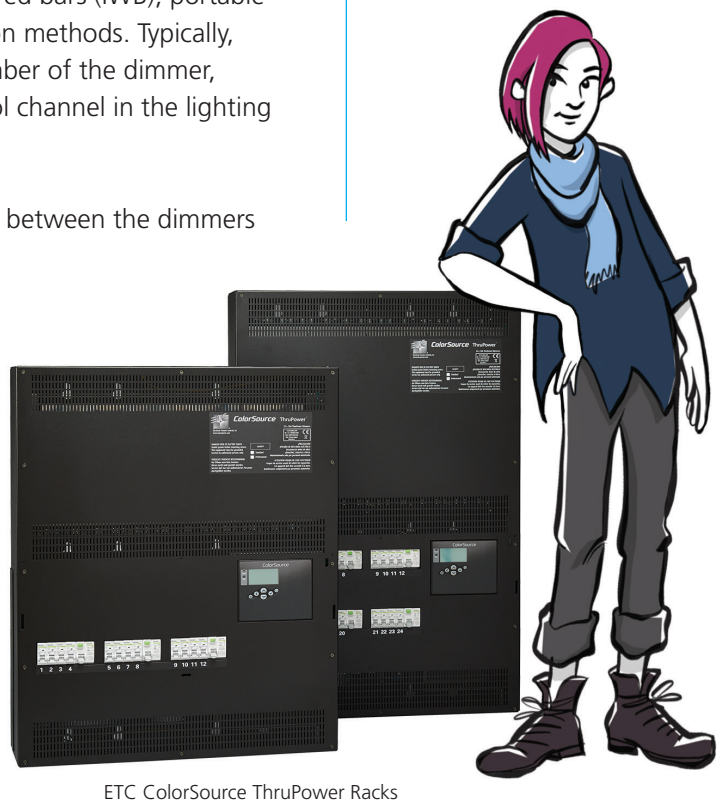
A lighting system requires power. In a conventional tungsten lighting system, mains power connects to a dimmer rack, which connects to distribution hardware. This hardware may include distribution channels with outlets with numbered circuits, internally wired bars (IWB), portable circuit boxes with long cables, or other distribution methods. Typically, the number of the outlet corresponds to the number of the dimmer, which makes connecting that dimmer to a control channel in the lighting control desk quite simple.

Older systems may have a physical patch panel in between the dimmers and the circuit outlets, in which case the circuit number gets physically connected to a separate dimmer number. It is the dimmer number that is important for the control desk.

The proliferation of LED technology has changed the requirements for power control in lighting systems. Instead of large dimmer racks, LED fixtures just need basic, constant input power (in fact, LED fixtures should not be connected to dimmed circuits) and a way to shut that power off easily. Most theatres still use conventional, dimmed fixtures, so a combination of dimmers and constant power via relays is the best solution for mixed

What do lighthouses have to do with theatre?

A Fresnel spotlight is identified by the Fresnel-type lens fitted at the front of the lens tube. The basis for the construction of this type of lens was first created by Georges-Louis Leclerc (Comte de Buffon). But, it was Augustin-Jean Fresnel, a French physicist and engineer, who developed and perfected this lens for use in lighthouses in 1823. Since then, a Fresnel lens has been used to project the rotating beam of light associated with lighthouses.



ETC ColorSource ThruPower Racks

ColorSource Relay

systems. The ETC ColorSource ThruPower rack provides 24 circuits that can either be dimmed or controlled by a relay, giving theatres the most flexibility in placement of conventional and LED luminaires.

If LED fixtures are added to an existing lighting system, it may not be possible to change the dimmer rack to a ThruPower rack. In that case, the ColorSource system offers the ColorSource Relay products. These small devices can be placed in the theatre where LED fixtures are used. They need only be connected to constant mains power and a control signal from the lighting desk (known as DMX – see Appendix B for more technical information about DMX). When the ColorSource Relay sees DMX signal from the desk, the internal relay switches on, powering the luminaires connected to the device. After a short period of no DMX present, the internal relay switches off again. This turns the LED fixtures completely off when they are not being used, keeping them from consuming small amounts of power in standby mode. Each ColorSource Relay can power up to 16 amps worth of fixtures and is available in wireless or wired DMX versions.

ColorSource 20 and ColorSource 40

ColorSource 20 AV and ColorSource 40 AV

Lighting Control Desk

At the front end of the lighting system is a computer (the ETC ColorSource or ColorSource AV console) that sets the levels for the luminaires' intensity and other parameters, such as the colour mix of LEDs or the settings for moving lights. This computer can store those settings and levels into memory and then play back entire looks either by manually raising a fader or by pressing a "go" button. The desk sends the commands to the lighting system using the DMX protocol, which can be sent over a cable or wirelessly using the ColorSource Wireless DMX Transmitter. Looks may be flashed onto stage using a bump button (usually found under a fader) or may be executed with a recorded fade time using the "go" button.

These looks are known respectively as playback memories or cues, depending on whether they are stored as a single look on a fader (playback memory) or within a list of looks in a sequential order with recorded fade times (cues).

Lighting desks can control up to a certain number of individual controllable devices – this may be a dimmer, a grouping of dimmers, an LED luminaire, a moving light, or other DMX-controllable equipment. These devices are called control channels in the desk. A channel is mapped to a DMX address (or a number of them, depending on what

the "thing" is) in the patch. Patching is important because the raw DMX addresses are not always assigned in a logical way for the design, they are assigned due to the physical location of the device in the theatre. Two lights that hang right next to each other may serve unrelated purposes in the design (one does daylight, the other does nighttime, for example), and the lighting designer may want to place lights of similar purpose next to each other in the channel listing. The patch function allows the lighting designer to arrange their lights in logical ways that serve their design.

Once patched, each dimmer, group of dimmers, LED or moving light is associated with a channel fader on the ColorSource console. Moving the fader up turns the light on and selects the channel. A selected channel can be controlled with the virtual level wheel on the console touchscreen and can have other parameters, like colour mix or position, adjusted with those specific controls. The operator can also select lights by touching their cells on the touch screen. Other desks may use a keypad entry system for selecting channels and setting levels. Selected lights are available for manual control. Once the operator has set the intensity, colour and other settings the lighting designer needs for that look, they record the look either onto a fader so that it can be turned on and off at will, or to a cue so that it can be played back using the "go" button.

Should looks be stored to faders or to cues?

The answer depends on how the designer likes to work and how complex the show is. If only a couple of looks are needed, storing them to faders makes more sense. If the show has lots of looks and transitions, it might be better to store cues and let the desk do most of the playback work. Using cues means the lighting designer can stack up as many looks as needed and easily play them back with specific timing.

Computer lighting desks offer methods of backing up the show data – it is highly recommended that a copy of the show be saved to an external medium like an SD card or USB stick, depending on the type of desk in the theatre.

Achieving a lighting design

Objective:

The teacher will be able to explain the steps of producing a lighting design for a performance.

Designed lighting is created to suit a specific purpose – in our case the illumination and support of a specific production in a specific venue for a specific audience type. General purpose lighting is the kind of lighting you find in open offices or classrooms – lighting fixtures that are placed at regular intervals to produce the required amount of light in a space at a certain distance above the floor (desk height, for example). Theatre pieces should be lit specifically for the content of the production, and in this chapter we will explain the process of getting from "let's put on a play!" to opening night.

Why are we making a lighting design?

Unless the production is occurring outdoors during daylight, it is likely it will need some kind of lighting design. To determine what kind of design is needed, the designer needs to consider all aspects of the production.

Production type	Environment	Audience type
Play (scripted)	Proscenium theatre	Present in the room/auditorium
Musical or opera	Thrust theatre	Television audience
Dance	Arena theatre	Mixed live/broadcast audience
Improvisational	Found space	
Chat show	TV studio	
News broadcast	Outdoors	

Understanding these basic facts about the show will help the lighting designer (LD) to form some basic assumptions about the equipment and crew needs. Followspots, for example, require a specific position in the rig and a crew member to run them. Footlights, if the LD chooses to use them, will take up space at the front of the stage. When the production has special needs, the LD needs to ensure that the whole design team and director understand those needs. How does the lighting designer determine what is needed to light the show?

Read the script/understand the content of the show

For plays and scripted shows, it is important for the lighting designer to read the script carefully. It is suggested that it is read it once for enjoyment, read a second time for understanding, then read again with an eye towards lighting requirements. It is common to make notes about where scene changes happen and when the setting changes in a way that affects the lighting (from indoors to outdoors, from day to night, etc), at the same time getting an idea of the number of cues or different stage looks needed. For unscripted performances like concerts or dance recitals, the LD will collate information in advance about the piece to be presented. It is crucial to get to know the material well – by, for example, listening to recordings of the music, talking to the choreographer and seeing rehearsals of the dance pieces.

Talk to the director and other designers

This is a collaborative art form and the work of the lighting designer is not done in a vacuum. Directors usually have a grand vision for their shows – they have an image in their mind of how the show should look. The lighting design should support the director's vision for the show. The LD can only place lights where there is no scenery, so it is important to discuss the design needs with the scene designer. The scene designer's choices of textures and colours can also help or hinder the lighting design's ability to focus the audience's attention or bring the actors out of the backgrounds. Costume designers can make it easy or difficult to make the stars of the show shine – their choices in colours for the costumes and makeup can clash with the lighting design, causing the actors to appear bland or dull on stage. It is important that all members of the creative staff of a production are really working together on the "same" show – designs that clash with each other do not lead to good reviews.

Do some research

The lighting designer often does research to find visual images (artworks or photography, for example) that display aspects of their intended design. Visual research helps to create a visual vocabulary that the lighting designer and director can use to discuss the lighting design. What the LD sees in their mind's eye may not be at all like what the director or other designers are seeing in theirs. A picture or a sketch can help to smooth this communication and ensure the whole team is working to the same expectations. Lighting designers can take the pencil sketch elevations of the set from the scenic designer, make copies and create simple sketches of the intended lighting for each scene using pastel chalks, watercolours or other media. These sketches can be used as a storyboard to show how the lighting will look throughout the show.

Analyse the scenic design

When the lighting designer receives the ground plan for the scenic design, they look to break the set up into acting areas that make sense – for example, a living room set with some seating areas and doorways will likely see action at those doorways and in those seating areas. A lighting design that fails to put light on someone sitting on the sofa or standing at the door will not be as successful as one that specifically lights those areas. This is the difference between using general lighting that covers five basic areas evenly distributed across the stage and a specific lighting design that puts light mainly where the actors will be in a show.

Watch rehearsals

This is very important so that the LD can see that the director is sticking to his or her vision, and so that they can understand the blocking (positioning of actors) and the timing of the show.

During rehearsals, the LD should take notes in the script to refine the positioning of the cueing and to get a good idea of the timings of the transitions before the final hectic days of technical rehearsals. The more information that can be gathered in the rehearsal room, the better prepared the LD will be when time gets short at the end of the production process.

Prepare the lighting paperwork

At some point, the lighting designer will need to write down all the information required to get the lighting design installed in the theatre. The venue may have an existing lighting system, in which case the LD must use the lights in the theatre as rigged. It may be possible to able to add some specials to do very specific work in the show. Or, the production may be moving into an empty space where all the lighting is rigged specifically for that production. Either way, the crew will need a lighting plan, sometimes known as a light plot, showing where to hang the specials within the existing rig or where to hang everything. It is helpful to make tables or lists showing detailed information about each light, including the kind of luminaire, the DMX address or dimmer number, the channel number, the colour filter number if working with conventional tungsten lights, and notes about where the light should point and its purpose in the design. These lists can be created either in special software just for this purpose, or in a spreadsheet program, which allows the LD to collect and sort this data as needed. Typical list reports used in the theatre include:

The **Patch sheet** – a listing by control channel used by the lighting designer and lighting desk operator.

The **instrument schedule** or equipment list – a listing by hanging position used by the electricians during the get-in.

The **lighting plan or light plot** – a scaled drawing showing the positions of each luminaire in the rig, its channel and DMX address or dimmer number, the colour filter number (if used), and the purpose or focus position of the light. Some designers draw the luminaire symbols only at 90 degree angles from one another, pointing generally in the direction they will be focused. Others draw their symbols aligned with their focus position. In all cases, it is a good idea to always draw and keep a minimum of about 50cm (or 18 inches) between lights, as this provides space for the light to be focused in the correct position without interference from other luminaires. Spotlights with zoom optics and moving lights may require more space between fixtures – it is important to keep this in mind while making such a drawing, especially if it's not possible to use proper drafting symbols on the plan.

The lighting paperwork is important preparatory work. It communicates to the technicians the intentions of the designer and facilitates communication between the designer and the technicians. It allows the lighting crew to prepare equipment ahead of time for a smooth get-in, and it becomes the guide for maintaining a show after the opening.

The Get-In and Focus

A lighting designer first sees the results of all their preparation once the set and lighting equipment are installed in the theatre. Often, the lighting rig must be hung before all the scenery gets in the way. This means the LD has committed to the placements of the lighting fixtures based on drawings – ground plans and sections – provided by the scenic designer or technical director. Until the set is installed, the LD won't know if everything is in the right place and should be prepared to make adjustments on site.

At the get-in, the lighting (LX) crew hang and cable all the luminaires and check that all are getting power and are functioning correctly. Profile spotlights should have their shutters opened at this time so that light will come out when the luminaire is powered on. LEDs and moving lights without RDM capability can be addressed as desired (it is helpful to figure out an addressing scheme before the get-in). At this point, the lighting desk patch can be completed as the paperwork is updated with dimmer numbers. Once the luminaires have been rigged and plugged in, the lighting positions are tidied up so that cables are safely tied to the lighting bars. Cables should not be so tightly attached to the lighting bars that the luminaires can no longer move; a bit of cable should be loose so that the fixtures can be pointed in the right directions during the focus call. Cables should also be attached to the bars with, for example, electrical tape so that it is easy for a person in a lift or on a ladder to adjust cables as needed. Where lighting equipment and people come into close proximity, cables should be covered to avoid snag and trip hazards.

After the get-in, the scenery is brought into the theatre and set up. Depending on the complexity of the show, the stage crew may need to make adjustments to the scenery for the lighting crew to focus the lights. Good communication with the technical director will help make the focus call run smoothly. During the focus call, the lighting designer works with the LX crew to point the lights in the right directions, lock them into position so that they do not slip out of focus, adjust shutter blades to cut unwanted lights off walls and scenery, adjust the lens positions in the luminaires to get the correct softness or hardness of the edge of the beam, and adjust the placement of gobos in their frames so that projected textures look right for the show.

The lighting designer stands on the stage in the position the light should hit (unless the position is on a vertical surface, like scenery illumination). It is best practice not to look into the light, so the designer often stands with their back to the technician. The hotspot or centre of the beam should be focused on the designer's head (or hand-held-up, if the designer is shorter than the actors). When the designer is happy with the position of the light beam, they will tell the technician to "lock off there," meaning the technician should tighten the lock off knobs and other adjustments they may have loosened to move the light. The luminaire should stay pointing at the desired point on stage when nobody is holding the luminaire. The lock off knobs and other adjustments should be tightened only about ¼ turn past snug so that they do not fall or loosen, but are not tightened to the breaking point. Fixture focusing usually follows this order:

- Colour filter is removed, if it is hard to see the beam on stage
- Pan/Tilt knobs and other adjustments are loosened (but not too much) and the light is pointed in the correct direction
- Pan/Tilt position is locked in place
- Lenses are adjusted for sharpness/zoom; gobos are adjusted
- Shutters on profile spotlights are moved into position
- Colour filter, if removed for focusing, is replaced

During the focus, the designer and the technicians should be in communication at all times. The LD may choose to use hand signals instead of shouting to the technicians, or the team may use radios to communicate. The order of the focus is often set by the technicians as they need to get to and work at each of the lighting positions. This likely means jumping around in the patch list, and justifies the creation of instrument schedules or equipment lists for the team. If the LX crew is large enough, the designer may be able to focus more than one position at a time.

Once the focus is complete, it is a good idea to perform a channel check – stepping through each channel in the patch until all have been tested. This is to ensure that all lights are still working and that they have not slipped out of focus during the rigging process. Sometimes lights get unplugged or moved during the process of working among the luminaires, so it's always a good idea to check at the end of the focus session.

Patching The Lighting Desk

The lighting desk should be completely patched by the end of the get-in. In an ideal world, all your devices use RDM and can be configured, addressed and patched directly from the lighting desk. More often, there is a mix of devices. Here are some hints:

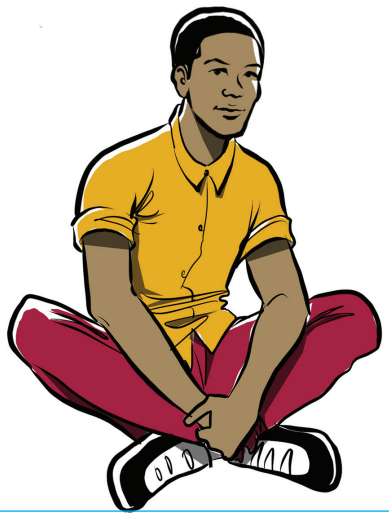
Addressing for moving lights and LEDs can be figured out ahead of the get-in by using the features of the lighting desk to determine next-available start addresses (by patching a block of luminaires at one time – the desk figures out the addressing on its own). This can be copied into the paperwork and lighting plan so that the addresses can be set or verified during the get-in. Once connected to the patched desk, they should "just work."

Dimmer assignments are usually figured out as the lights are hung, so the dimmer patch may be completed as part of the get-in.

What are cues?

Cues are a combination of the lighting look on the stage and the transitions that lead into and out of them. Cues contain the intensity levels and parameter settings of the lights used in the stage look, as well as up and down fade timing. The uptime is the time it takes lights moving from a lower intensity level to a higher level to complete that move. The downtime is the time it takes lights moving from a higher intensity level to a lower one to complete their move.

Uptime and downtime may be the same or they may be different values, based on the needs of the show. Getting the timing right is a big part of lighting design. Fades that are too fast may jar the audience out of the mood set by the actors (which may or may not be the intention). Fades that are too slow can cause the action to drag. Most of the cue editing in rehearsals relates to getting the timings right.



Plotting the show

Between the focus and the first technical rehearsal, the LD should try to get some time to create looks and record them into the lighting desk. This creates a rough version of the show and means that there is some lighting already in place for the actors. The plotting time provides an opportunity to get the basics of as many cues as possible into the desk. An unoccupied crew member is often asked to stand in as a reference for the LD when writing cues; this helps the LD to see what the light will look like on the actors and not just on the stage.

Tasks to complete during the cueing session:

- Create a basic look for every cue in the show – this is a starting point for future editing.
- Create the timed transitions as much as possible. Know that these will be refined as the rehearsals happen.
- Work on any time-consuming effects while the stage belongs to the lighting crew.

The lighting designer should use this time to develop a good communication style with the desk operator, since intercom lines will soon be complicated with stage management and sound crews. Having a good working relationship with the operator will make editing the show on the fly much easier. It is important to be consistent when communicating. The LD should state when they are working on a new look versus editing the current one, state clearly what they want the lights to do, and state clearly when and to where the look should be recorded.

Before actors join rehearsals, it is a good idea for the LD to discuss the show with the deputy stage manager (DSM), if there is one. The lighting designer and stage manager (or desk operator, if they must work alone) should go through the script of the show and place every lighting cue into the "book" – a script constructed so that each page has a blank page facing it for notes and cues. It is a good idea to plot standby locations into the book as well so that the stage manager can keep the crew apprised of when they must pay close attention, especially during complex transitions. The stage manager typically marks the location to the word or musical note where a cue must be called. The calling of the cue should anticipate the beat it takes from the DSM saying "go" to the operator reacting, especially when it is critical that the lights match the action on stage tightly. To facilitate this, the DSM should call cues using this kind of language: "LX 3 GO," and not the other way around (Go lights 3). This is because the lighting operator should only press the button on the word "GO," and they need to know that that particular "go" is meant for them and not for sound or scenic cues.

During rehearsals

It is usually possible for a lighting designer to make edits during rehearsals while actors are on stage. This should be done quickly and

with respect for the other members of the production. It is best to avoid stalling the rehearsal to make lighting changes. If the LD attempts to make changes on the fly, they should be aware of how much time there is to the next cue, and try to get everything done in that time so that the stage manager can call the cue with the action on stage. If there is not enough time, the LD can record where they are and make a note so that the rehearsal can continue. Lighting notes can typically be entered into the desk at the end of the rehearsal before and after the director starts giving notes to the team. If additional work needs to be done, the crew should plan to do that in a work call outside of the rehearsal time. The LD should take clear notes so that the electricians know what they can do on their own before the lighting designer returns to the theatre.

When is the lighting design done?

Some designers would say their design is never done, but the opening night traditionally marks the conclusion of the design and editing process. Unless there are special circumstances – new cast members joining a long-running commercial theatre production, for example – it is rare for a design team to make adjustments to a show that has opened. Generally speaking, the version that gets shown on opening night is "it." After the opening night, the crew should enjoy the after party and look back on a job well done (or, as is the case for many professional lighting designers, miss the opening night party because they're on to their next production already).

Looking for help?

ETC has a set of online forums where users can ask about our products and their use. Feel free to join the forums at community.etcconnect.com to ask questions and get help! We also have a blog where teachers and students can gain inspiration at blog.etcconnect.com. Please check out our online course offering at the LearningStage, ETC's online training portal at courses.etcconnect.com.

Appendix A:

A Brief History of Stage Lighting

Theatre is about storytelling. We track the idea of theatre with stage and audience back to the 6th century BCE and the Greeks, who presented dramatised stories using masks, wigs and costumes. The Greeks performed in open air theatres for thousands of spectators. Over the centuries, plays were lit by torches and candles, moving from outdoor to indoor theatre spaces. Many theatres burned down.

In the 18th century, open flame oil lamps with floating wicks replaced candles as the main source of light. The new lamps, which produced less smoke and did not drip wax on the patrons and actors, were seen as a great improvement over tallow candles. Because of these lamps, the footlight position in English theatres is still known as the "floats."

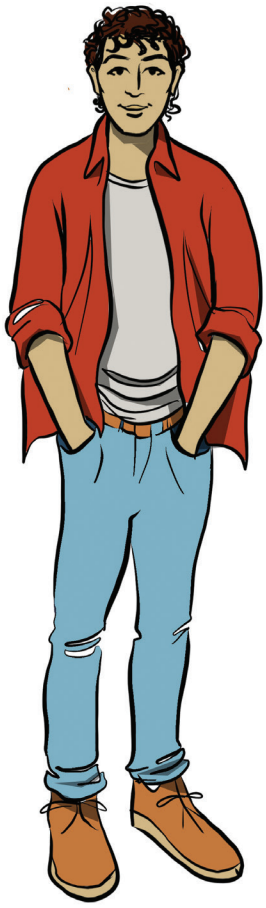
In the late 18th century, Swiss chemist Aimé Argand improved upon the older, floating-wick design with an oil lamp that contained a cylindrical wick in a glass chimney. This light was whiter and brighter, leading London's Haymarket Theatre to design chimneys of coloured glass in an attempt to bring more coloured light onto the stage.

In the early 19th century, the Chestnut Street Theatre in Philadelphia and the Covent Garden and Drury Lane Theatres in London installed the first gas lighting systems. Pipes were installed for gas jets all around the theatres. This system offered the first centralised lighting control system. There was a gas controller with a main tap and several smaller taps for controlling sections of the theatre independently. This system was still dangerous, due to open flame light sources and toxic and explosive fuel. Many theatres were damaged by gas lighting systems, and many people died. After 186 people lost their lives in a fire at the Exeter Theatre in Devon, it became law in England that every theatre must be fitted with a safety curtain (the "Iron"). This flame-resistant curtain separates the stage house from the auditorium in case of fire, and it must be shown to the audience at every performance. This rule applies today in theatres where a safety curtain is fitted.

Candles in the theatre

Candles used in theatre lighting in the 16th century were expensive and made of tallow – a smoky, drippy wax – and required frequent trimming of the wick. Candles were placed in chandeliers in the auditorium and over the stage, as well as along the front edge of the stage and vertically on the edges of the scenery. During the performance, "snuff boys" would make constant adjustments to the twisted wicks.

Candles were also a dangerous lighting source and led to many theatre fires throughout history.



Later in the 19th century, theatres began using a new spotlight to follow actors on the stage. This luminaire used an oxygen/hydrogen gas mixture to heat a piece of quicklime in the lamp house until it became incandescent. The light was focused through a simple lens to make a round spot of light on the stage. This innovation led to the term "being in the limelight" and, in some theatres, followspots and their cues are still referred to as limes or lime cues.

The Age of Electricity

In 1881, Richard D'Oyley Carte opened the new Savoy Theatre in London with an advertisement proclaiming it "the first public building in the world to be lit 'entirely' by electricity." In fact, 1158 incandescent filament light bulbs invented by Joseph W. Swan were used to light the auditorium, dressing rooms, corridors and stage.

This innovation was a major milestone in the development of stage lighting and its control, although it took a further 20 years before electricity became the established source of lighting in theatres. The main cause for the delay was the invention of the gas mantle, which greatly increased the efficiency of gas lighting. Theatres were reluctant to invest in the costly changeover from gas pipes and mantles to electric cables and filament lamps. Eventually, the changes were made, and the filament lamp was further improved; tungsten filaments were introduced, and a rare gas replaced the vacuum in the glass envelope. By the early 1900s, the tungsten filament light bulb was developed still further – and so began the manufacture of theatrical spotlights.

In 1914, two London theatre electricians formed a company called Strand Electric and began designing and manufacturing their range of theatrical spotlights. In America in 1929, Joseph Levy and Edward Kook founded Century Lighting. In 1933 they introduced the Leko Lite ellipsoidal reflector spotlight (ERS), named after the first two letter of their surnames. In 1969, Leko Lite became a Strand Lighting brand. This style of spotlight was refined by a number of manufacturers throughout the 20th century. In 1993, ETC introduced what became the state of the art of this luminaire design: the Source Four ERS.

Electrical lighting can be dimmed by increasing or decreasing the resistance on the circuit. The first dimming systems included a small number of large dimmers. Like the early gas systems, these allowed selective dimming of some parts of the theatre. As electrical lighting systems evolved over time, smaller and smaller dimmable circuits were developed so that designers could gain finer and finer control over the light on stage. These days, it is common practice to see a single dimmer connected to one or two outlets on stage, giving dimmer per circuit control of the lighting rig. In this kind of setup, almost every lamp lighting the stage can be individually controlled.
From the 1930s until the end of the 20th century, theatres throughout the world used the same basic lighting system: a lamp of some type contained in a metal lamp house located behind a lens system, electrically dimmed.
In the 21st century, all that changed.

The Age of the LED

Electric light created a much safer environment within the theatre, and we continue to use electricity to power lighting systems today. The current concern is not one of safety as much as it is one of energy efficiency. Incandescent light is a beautiful light that renders the colours of skin, makeup, costumes and scenery very well. It is also a reasonably inefficient light source; a lot of the energy put into the lamp actually comes out as heat instead of light. New light sources have been developed over time to be more efficient, but bad colour rendering and bad dimming performance have made them unsuitable for use as the key lighting source in theatre (we don't light theatre pieces with fluorescent light sources, for example, unless it's a specific artistic choice). In the early 21st century, development of the light emitting diode (LED) as a light source has brought new tools to the lighting designer in a flexible and energy efficient package.

Spotlight history wall at ETC.

Conventional theatrical spotlights that use up to 800 watts can be replaced by LED profiles that use around 120 watts. Conventional spotlights use lamps with a life of about 300 hours, whereas LEDs can have a life of 20,000 hours or more, depending on how they are used. Conventional spotlights produce coloured light using colour filters, which throw away light energy to in a process called subtractive colour mixing. LEDs, on the other hand, can use additive mixing to create coloured light, blending the output of LEDs of different base colour to create secondary colours or tints. In this way, LEDs only use power for the components required to create the desired colour and intensity – nothing is thrown away. The maintenance and upkeep of LED luminaires is lessened due to their energy savings, their lamp life and their ability to mix colour inherently.

Control

The gas table and the manually controlled resistance dimmer were early methods of controlling the intensity of light on stage. The development of SCR dimming and the ability to control those dimmers from a remote location immensely improved the designer's ability to control the lighting system. LED luminaires and moving lights don't require external dimmers at all and are controlled via DMX512 protocol generated by a lighting control desk. All modern lighting systems include a lighting desk – a computer-based system that enables the control of intensity (and other) information for a given production. Some of these desks are still manually

About dimmers

Dimmer technology has evolved from large capacity individual resistance dimmers (manually controlled with individual handles) to the smaller, remote controlled (but troublesome) thyratron tube dimmers of the mid-1900s, to the SCR (silicon controlled rectifier) dimmers we use today. SCR dimmers are small devices and are able to be remote controlled. The SCR chops the AC sine wave into pieces, rapidly switching the lamp on and off at different levels to create dimming. It is not recommended to run inductive loads (motors, fans, electronics, etc) on dimmed circuits.

Sine Wave Dimming, which came into play in the early 2000s, sought to dim by adjusting the amplitude of the AC sine wave rather than chopping. This technology was expensive and was ultimately superseded by the emergence of LED.

Three-pin or five-pin connectors for DMX?

DMX controlled equipment can be found with 3-pin and 5-pin connectors – which is correct? The DMX standard calls for 5-pin XLR connectors. Most equipment only uses the first three pins, because a single run of DMX only requires three conductors. The remaining 2 pins can optionally carry other data associated with the devices in use. However, sound equipment also uses 3-pin XLR connectors. Microphone cable should not be used for DMX as it has the wrong conductive properties and may affect the quality of signal. To avoid future problems and ensure the path for a second data stream is available, always use 5-pin connections when XLR connectors are used.

DMX may also use Cat-5 (network) cable with RJ-45 connectors. This connector type is less robust than XLR connectors and should be used mainly when devices are installed permanently or for long-term use.

controlled, with short faders taking the place of the old dimmer handles. Others are memory systems where the lighting changes are all pre-programmed during the rehearsal period, reducing the operator's involvement with the lighting during the actual show to pressing a "go" button. The control system is the medium through which a designer crafts their lighting design.

Appendix B:

Technical details of the DMX512-A protocol and RDM (Remote Device Management)

Dimming systems were once operated directly – with large handles on the actual dimmers themselves. Over time, as technology improved, remote control became possible with the use of lighting control signals. Originally, this was done with a 0-10v wire connected between the channel fader on the lighting desk and the dimmer itself (known as analogue control). This type of control required large bundles of wiring to control a relatively small number of dimmers. As dimming systems became larger and more complex, digital signals became the norm, with each manufacturer developing their own protocol.

In 1986 the Engineering Commission of the United States Institute for Theatre Technology (USITT) developed a standard Digital Multiplex system called DMX512. Revised in 1990, DMX512 was universally adopted as standard protocol for the theatrical lighting industry. A further revision began in 1998 in order to develop an American National Standards Association (ANSI) standard, and in 2008, the current standard was agreed upon under its title E1.11-2008 USITT DMX512-A. This is now generally referred to as simply DMX512-A, and it includes a definition for a new feature called Remote Device Management or RDM. RDM adds bi-directionality to the protocol, allowing devices and controllers to communicate with each other for configuration and reporting of error states.

DMX is an 8-bit protocol that can send brightness instructions or "levels" to up to 512 addresses on a set of three thin wires. This is known as a DMX universe. Desks that can control more than 512 addresses are said to support multiple DMX universes. Each of the 512 addresses corresponds to a single controllable parameter of a device.

For example, the dimmer pack in the school connects to the lighting desk via DMX and the first dimmer in that pack responds to fader 1 (when DMX address 1 is patched to channel 1.) As the fader moves from the 0 position to the full position, the desk sends increasing levels out on DMX address #1. The dimmer pack reads this information in and it increases the power output on dimmer #1, and the luminaire gets brighter. Addresses can also correspond to non-intensity parameters like colour mixing or pan/tilt of non-dimmer devices as well.

The DMX is distributed over multiple connectors in the theatre or by using Ethernet network protocols and converter boxes. The standard DMX connector is a 5-pin XLR type connector. Some equipment uses 3-pin XLR connectors. You can connect up to 32 devices in a DMX daisy chain. In cases where more than 32 devices need

to be connected to a single DMX universe, a converter box known as an opto-splitter is used to duplicate the DMX signal and distribute it over more than one cable. Do not build, buy or use DMX "two-fers" where a single XLR socket is connected to two (or more) XLR plugs – this will make your system flicker.

Each address in a DMX universe can be sent a level from 0-255. For simplicity's sake, most lighting desks show you intensity levels in percentages (0-100%) rather than in the raw, 256-step levels of the DMX protocol. Non-intensity values may be indicated as percentages, as 0-255 or as text, depending on the desk.

How DMX works

This guide will not go into deep technical detail about DMX512-A. More information is available from the references listed at the back of this guide. This guide will cover some troubleshooting information because DMX with RDM can sometimes generate flickering of lights and devices, and these issues are generally simple to clear up with an understanding of the basics of how DMX works.

DMX packets contain levels for up to 512 addresses. These packets are sent repeatedly to the lighting system. Each packet has a "start code" that identifies the protocol to the receivers so that they can properly interpret what's being sent. Start codes can tell a device whether the DMX signal also includes RDM information, for example. DMX packets also need to be sent to devices at an acceptable "refresh rate" so that dimming/movement/colour changes appear smooth. This rate, per the standard, should be 44Hz (or 44 packets a second); however, there are many controllers on the market that send slower DMX, and many devices on the market that can't handle full speed DMX. Quality lighting desks allow you to change the speed of the DMX output so that you can accommodate devices that are built with lower-quality DMX receivers

RDM communications are fitted into the gaps between the DMX packets. These bursts of communication use a different start code so that devices that are RDM-compatible understand which packets include levels and which include the RDM messages. Some non-compatible devices don't understand this different start code and may interpret the RDM messages as new DMX levels. When this happens, those lights or devices misbehave – flickering or twitching their motors.

The lights are flickering – what do I do?

There are a couple of things to look for in a lighting system that's misbehaving by flickering.

Is RDM enabled?

As described above, lighting equipment that is not RDM compatible often doesn't like having RDM messages in the DMX line. Turn off RDM in the lighting desk to see if this solves the flickering problem.

Light bulbs or lamps?

It should be noted here that, in theatre terms, the light bulb is known as a lamp. Lamps fit into a lamp holder in front of a reflector inside the lamp house located behind the lens – bulbs are planted in the ground and grow into tulips and daffodils and other types of flowers. Technicians in the UK who work with theatrical spotlights are affectionately known as lampies.

In the new world of LEDs, the light producing LEDs themselves are known as emitters and the collection of LEDs within a luminaire is called the array.

DMX Controversies

Three-pin and 5-pin, terminated or not – these subjects are heatedly discussed by lighting technicians. The reason is that DMX is generally a quite forgiving protocol, so problems with flickering don't always arise – even when not following the best practices in a lighting system. Someone will always say "I used a DMX two-fer!" or "I never terminate," or "I always use mic cable – it's fine," but the problem is that it's fine until it suddenly isn't. And that moment is usually five minutes before the curtain goes up.

For more information about DMX cable, please see: www.learnstagelighting.com/can-i-use-microphone-cables-for-dmx-lighting/

Is the DMX line terminated?

DMX – especially DMX with RDM – doesn't like an open-ended cable run. It is permissible to connect from the desk to devices in a daisy chain – into one device and out of that device to another – for up to 32 devices. At the end of that run, a DMX terminator should be installed (check if the devices are self-terminating, in which case the extra external terminator is not needed). Terminators are made of a connector with a resistor soldered between two of the pins and should be purchased already built. The terminator provides a dampening of the signal at the end of the line, which prevents reflections of the signal back up the line. Devices interpret reflections as real DMX, which is why they flicker.

Am I using proper DMX cable?

Even if there are 3-pin devices in the lighting system, proper DMX cable should be used rather than microphone cable. Microphone cable has a lower impedance than DMX cable which makes it a very bad conductor of the protocol. On short runs it might all just work, but it is best practice to use the right cable type for DMX at all times.

Are my cables and connectors in good condition?

If the items above have been checked and the system is still misbehaving, it's time to start checking the cables and connections. Often a mechanical failure is found in a cable – the cable has been damaged or the connections within the connector have loosened or broken. If this is the case, swap the cable for a known working one. Sometimes the bad connection may be inside a luminaire or dimmer rack. If this is the case, contact your equipment supplier for assistance.

Appendix C:
Glossary Of Terms

Ampere: Amps define the rate of electrical current on a circuit. Electrical circuits are defined by their amperage, which in combination with the supply voltage determines how much wattage can be safely connected to that circuit.

Apron: A part of the stage that extends in front of the *proscenium arch*.

Array: The term used to describe a collection of *LED* emitters in a luminaire. The recipe of *LED* colours in an array defines the type of light that luminaire can produce (the colour *gamut*).

Backlight: Light shone on a subject from behind, used to push the subject out of the background and define form.

Backing: A light that illuminates the area behind a door or window.

Backstage: Stage area behind the *proscenium* and scenery.

Bar: A plain bar or internally wired lighting bar (IWB) suspended above the stage or auditorium onto which spotlights are attached.

Barn doors: Hinged metal flaps that can be attached to the front of Fresnels to adjust the beam shape. These can also be used with other types of lights to reduce glare.

Beam spread: Light from theatrical luminaires typically forms a conical beam – narrow at the fixture and wider as the light gets farther from the

fixture. The angle of the cone is called beam spread. This value is important in calculating how much light will hit the stage from a luminaire rigged at a certain distance from the stage.
Blind: Changes made to the programmed lighting states that do not affect the current lighting state on stage.
Board: Another term for a lighting control desk or console.
Boom: A vertical lighting *bar*.
Boom arm: A metal support that attaches a spotlight to a boom.
Build: Slow increase in light intensity.
Check (back): Reduce light intensity.
Circuit breaker: a device that automatically interrupts an electrical circuit when an overloading fault is detected. This is usually caused by a short circuit or too much connected load.
Colour call: List of coloured filters required for tungsten lighting when rigging a show.
Colour filter booklet: a small booklet of sample pieces of colour filter materials including their name, number and spectral distribution characteristics. These booklets serve as a reference for the lighting designer when choosing the colours for a production. Colour filters are generally designed to work on conventional tungsten luminaires, but there are some manufacturers making colour filters for white-light LED luminaires as well. Colour filter booklets are available from a theatrical equipment dealer.
Control channel: The control channel is the numerical name the designer uses for a luminaire or set of luminaires that are controlled together. Control channels are used to group sets of luminaires or devices together in a logical way relating to how the designer thinks about the design, rather than to their physical location in the venue.
Crossfade: Gradual change from one lighting state to another where the incoming state replaces the previous state.
Cue: The starting point for a lighting change. A word or action or signal from performer or stage manager that initiates a lighting change or some other change onstage .
Cyclorama (cyc): A white backcloth or painted surface at the rear of the stage.
Dimmer: A device that increases or reduces the power reaching the luminaires in a tungsten lighting system, usually in response to signals from a control desk.
Dimmer rack: A wall mounted or floor standing cabinet which contains a number of dimmers, controlled by a lighting desk. Dimmers in a rack can sometimes be replaced by relays, which turn the power for a circuit on or off, like a switch. *The ETC ColorSource ThruPower rack combines dimmers and relays on each lighting circuit – the user can change the setting of each circuit at the rack. The circuit can then be used either with a traditional tungsten load (with a dimmer) or with LEDs, moving lights or other devices that require constant power (with a relay).*
DMX512-A: A Digital Multiplex protocol used for controlling dimmers and devices from a lighting control desk.
DMX terminator: A device used to dampen the end of a run of DMX512-A signal. This consists of an XLR-M connector with a 100 ohm resistor soldered between pins 1 and 2. These can be hand-made or purchased from an equipment dealer.
Deputy Stage Manager (DSM): The DSM is the person who is in charge of running the show on a daily basis. It is their job to call all the lighting cues, scene changes etc, ensuring the performance runs as rehearsed and agreed. All the information, cues, scripts and important notes are kept in a book which never leaves the stage or theatre. The DSM usually sits at the SM desk, sometimes called the prompt desk, on stage left (Prompt side).
Dips: Low level electrical sockets or sockets below the surface of the stage.
Fixed lens: A lens fitted to a profile luminaire that will produce beam of light at a known or "fixed" angle.
Floodlight: Stage luminaires that produce a wide beam of light. Floods are not normally fitted with lenses.
Focus: To adjust a beam of light to deliver the required beam shape or sharpness.
Followspot: A long throw profile spotlight mounted on a swivel base, used to follow a person as they move around the stage.
Fresnel: A stage luminaire fitted with a Fresnel lens that produces a soft edged, controllable beam of light.
Front of House (FoH): The area in front of the stage or proscenium containing the audience.
Frontlight: Light that hits a subject from the same direction as the audience is looking. Frontlight is used for visibility of actors' faces.

Fuse: A safety device fitted to older dimmer circuits and some plug tops (13A) to detect overload. Modern dimmers use circuit breakers .
Gamut: The colour gamut is the complete range of colours that an LED luminaire can produce. The fewer the colours in the LED array, the smaller the colour gamut.
Gate: Part of a profile spotlight, located at the internal focal point where gobos and other beam shaping devices can be placed.
Gels: Sheets of coloured, transparent material which are fitted at the front of stage luminaires in order to colour the beam of light (from Gelatine, the original colour filter material).
Gobo: A patterned metal or glass disc which, when fitted into the gate of a profile spotlight, will project the pattern onto the stage, cyc or scenery.
Groundrow: A row of floodlights, used to illuminate a cyc or backcloth from below.
Hook clamp: A hook-shaped clamp used to attach luminaires on to a bar.
Inrush current: A surge of current on an electrical circuit, produced when a device is first turned on. The inrush current of a set of devices may exceed the current rating of a circuit and cause a circuit breaker to trip, even if the normal operating current is under the limit of that circuit.
Iris diaphragm: A device with an adjustable hole, which can be inserted into the gate of a profile to change the diameter of the projected beam.
Kilowatt (kW): 1000 watts.
Lamp: A glass envelope containing a tungsten filament or other lighting source. Not required in LED luminaires.
Lantern: The original term for a stage luminaire.
LED – Light Emitting Diode: An LED is a small electronic device that emits light of a specific colour. LEDs may produce very narrow frequencies of light or may produce a wider range of frequencies when manufactured with phosphors. LEDs are combined into arrays to produce the light in entertainment luminaires – the more colours available in an *array*, the greater the range of coloured light a luminaire can produce.
Lighting control desk: The computer used to control connected *dimmers* and devices and to store programmed *cue* information for a production. Also known as a light board or console.
Lighting Plan or Light Plot: a schematic drawing of the lighting rig, used to communicate to technicians where to hang luminaires and how luminaires will be patched in thelighting control desk .
Limes: The old name for followspots , derived from the use of lime – the original light source.
Master: A fader that can over ride all other fades and function on a lighting desk
Ohm: A unit of electrical resistance. Conductors (wires) are rated in ohms.
O.P. (Opposite Prompt): A stage direction meaning stage right.
Offstage: Any area of a stage which cannot be seen by the audience.
Onstage: Any area of a stage which can be seen by the audience.
P.S. (Prompt Side): A stage direction meaning stage left.
Pan: To move a spotlight or moving light in a generally left-right or horizontal motion.
PAR Can: A luminaire based on a sealed beam lamp contained in a simple can-shaped housing.
PAR lamp: Sealed beam lamp to fit into a PAR Can.
Patch panel: A physical connection point between numbered circuits in the theatre and the dimmers in the dimmer rack . Patch panels have been replaced by dimmer-per-circuit systems where each circuit is directly wired to a dimmer position in adimmer rack .
Patching: The linking of dimmer circuits or DMX addresses to control channels in the lighting control desk.
Perch: A stage lighting position located on either side of the proscenium.
Plan: The drawing indicating where all luminaires should be placed and how they should be connected to the lighting system. This drawing is usually drawn to scale.
Plot: The list of cues and other instructions necessary to produce the necessary lighting changes for the entire performance.
Practical: A prop or other electrical device (table lamp, TV, etc) which is operated, or apparently operated, by a member of the cast. Depending upon function, the practical may not be connected to the dimming system.

Preset (1): A term originally applied to a simple manual lighting desk where two groups of faders *(A and B)* were raised to the levels needed in two different scenes. A cross-fader provided a means to fade between "*Preset A*" and "*Preset B*." Not widely used now.
Preset (2): A term used in some modern control desks to denote a single fader to which a number of channels at different intensities has assigned and recorded. These may also be known as submasters.
Preset (3): A lighting state on stage before the performance begins.
Profile spot: A stage luminaire fitted with either one (fixed angle) or two lenses (zoom). The profile can project images or patterns (gobos) and can be accurately focused and shaped using internal shutters.
Prompt: Lines fed to an actor who has forgotten his/her place. The "prompter" is the person who would normally give these lines, but this is no longer used in the professional theatre. If lines are missed, theDeputy Stage Manager(DSM) on the "book" will call the missing dialogue. Also see P.S.
Proscenium (arch): An arch or opening in the front wall of the stage, which frames the audience's view of the show. Some performance spaces have no proscenium; others install a temporary "false proscenium" made from drapes or curtain or scenery flattage.
RCD (Residual Current Device): A safety device connected to an electrical supply to detect whether the current between the energised and return conductors of a circuit is balanced. A difference in current on these two lines can indicate a short circuit or leakage to the earth conductor (a live shock in progress). Imbalance causes the RCD to trip, breaking the circuit.
Record: The process of saving information to a computerised, or memory desk. All the information relating to the show is recorded and will include cues, times, softpatching and other set up procedures. The combined show data is stored in a show file, which can be stored on the console hard disk itself, and to an external memory stick for backup.
Rig: The lighting installation and placement of luminaires for a particular show. The rig may be changed from show to show.
Safety bond: A safety device made of rated clips and wire rope, intended to prevent a stage luminaire falling if the main suspension point fails. Safety bonds have replaced safety chains. Unlike chains, safety bonds can be tested and made to a common safe weight standard. Safety bonds should be weight stamped so the correct bond can be used with the selected luminaire.
Safety chain: A strong welded link chain used to prevent a stage luminaire falling if the main suspension point fails. Replaced by safety bonds.
Shutter: Metal plates that are fitted into thegate position of a profile spotlight, used to control the shape and size of the projected beam.
Sidelight: Light that hits its subject from the left or right (from the point of view of the audience). Sidelight is used to reveal the form of three-dimensional objects or performers.
Special: A light that is intended to perform very specific task, like spotlighting an actor during a big downstage monologue or lighting a presenter at a podium. Specials may be added to help an existing rig better suit the needs of a show.
Spigot: A short metal rod which connects a luminaire to a lighting stand.
Spill: Unwanted light from a luminaire.
Spotlight: The generic name for any luminaire which has a controllable beam.
Stage Manager's desk *(SM desk)*: Located on stage left (PS or prompt side) this is where the *DSM* on the "book" will call all the cues for the show. In some theatres, the SM desk is located on stage right (O.P. or opposite prompt) this is known as a bastard prompt.
Stirrup: The U-shaped metal supporting hoop attached to a luminaire (also known as a trunnion arm).
Tabs: A set of curtains that can be closed across the front of the stage (behind the proscenium, if there is one).
Throw: The distance from a luminaire to the stage or area on the stage. Throw affects the size of the beam of light and will help to determine which size lens to use.
Thrust stage: a stage that extends into the auditorium and is surrounded on three sides by audience seating.

Tungsten-halogen: The correct description of a tungsten lamp. A thin tungsten filament is supported in quartz-glass envelope filled with a halogen gas.
UV: Ultraviolet light, used for special effects.
Upstage: The area of a stage closest to the back wall or cyclorama .
Volt: A unit of power that quantifies the difference of potential that carries one *ampere* of current against one *ohm* of resistance. Electrical supplies are rated in voltage.
Watt: A unit of power that quantifies the rate of energy transfer. Used to describe the power consumption of lamps and devices. Wattage equals a circuit's *voltage* multiplied by its *amperage* (W=VA).
Wings: The side areas of a stage not seen by the audience.
Working lights (1): An independent lighting system, not connected to the stage dimming systems, which can be switched on and off as required by the stage crew.
Working light (2): Lighting is sometimes required on stage for the crew to set a new scene. In some circumstances normal working lights would be too bright, so a cue is incorporated into the lighting plot allowing the crew to work quickly and safely.
Zoom: A system comprising two lenses that can be adjusted to vary the size and focus of a beam of light from a profile luminaire.

Further reading and resources

Stage Lighting Design: The Art, The Craft, The Life
Richard Pilbrow (2008) – Nick Hern Books

Stage Lighting Handbook
Francis Reid (2002) – Routledge

A collection of pages with information about technical theatre
www.theatrecrafts.com

Information about the technology, practices and education in the world of stage, theatre and event lighting
www.onstagelighting.co.uk

Royal Opera House – behind the scenes content
www.roh.org.uk/news/tags/behind-the-scenes

A multi-angled view of the intricate theatrical process behind the scenes during a performance
www.roh.org.uk/interactives/opera-machine

Practical technology for the classical singer – courses and podcasts
https://techfortheclassicalsinger.wordpress.com/2013/09/03/itunes-u-courses-and-podcasts-on-acting-stagecraft-and-theatre-via-nationaltheatre-and-others/

Lighting: the basics – a series of audio podcasts by BBC Academy
https://itunes.apple.com/gb/itunes-u/lighting-the-basics/id1023662835?mt=10

Entertainment technology books
www.etbooks.co.uk

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Corporate Headquarters ▪ 3031 Pleasant View Rd, PO Box 620979, Middleton WI 53562 0979 USA ▪ +1 608 831 4116
London, UK ▪ Unit 26-28 Victoria Industrial Estate, Victoria Road, London W3 6UU, UK ▪ +44 (0) 20 8896 1000
Rome, IT ▪ Via Pieve Torina, 48, 00156 Rome, Italy ▪ +39 (06) 32 111 683
Holzkirchen, DE ▪ Ohmstrasse 3, 83607 Holzkirchen, Germany ▪ +49 (80 24) 47 00-0
Hong Kong ▪ Room 1801, 18/F, Tower 1 Phase 1, Enterprise Square, 9 Sheung Yuet Road, Kowloon Bay, Kowloon, Hong Kong ▪ +852 2799 1220
Web ▪ etcconnect.com ▪ 7412L1003-GB Rev A 1/18