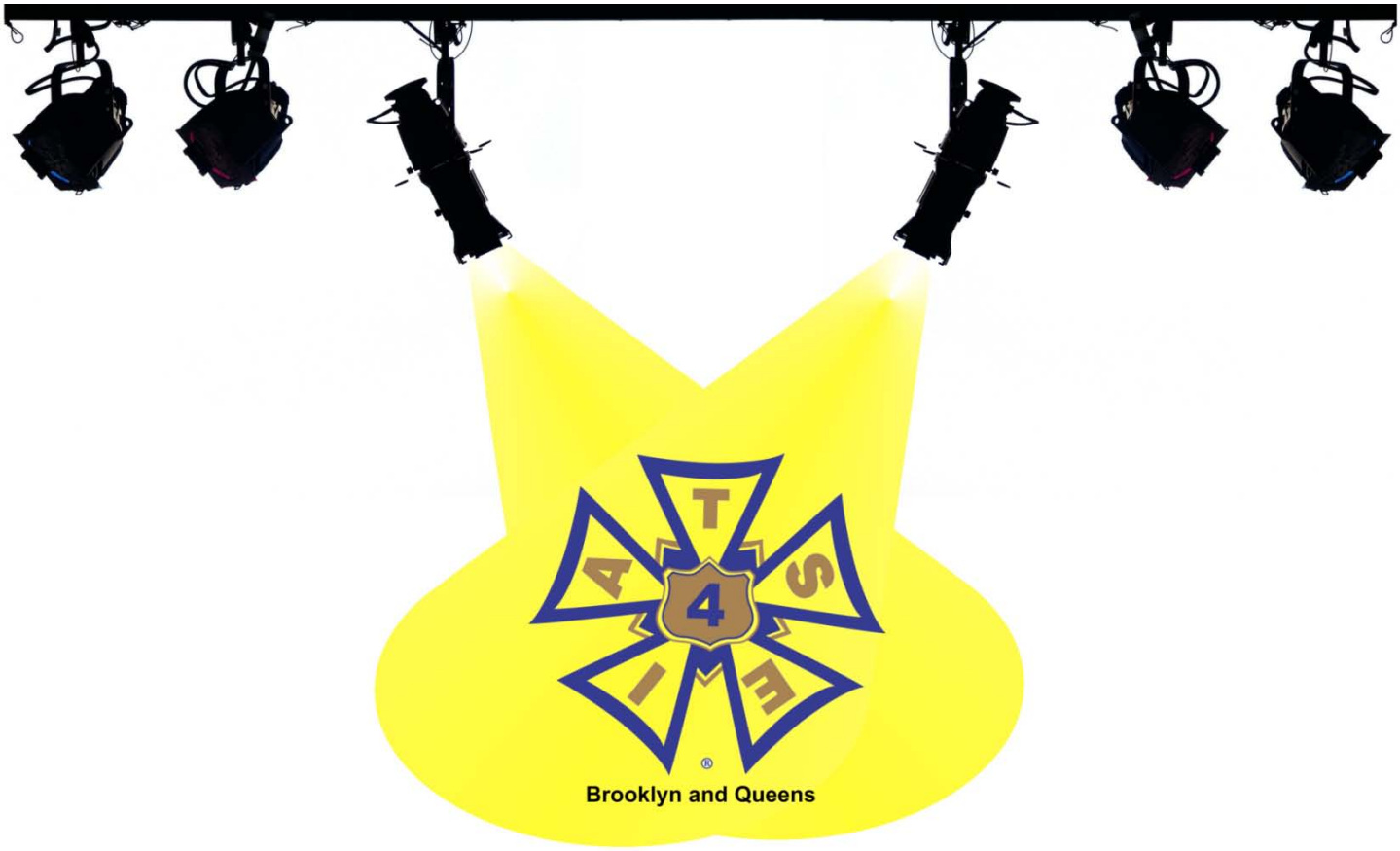

Theatrical Electrician Handbook

2011

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THEATER ELECTRICS OVERVIEW

In theater, the term electrician is generally applied to those that work with the various aspects of lighting. Some of the positions among Electricians include the Lighting Supervisor, Master Electrician, Deck Electrician, Light Board Operator, Moving Light Operator, Followspot Operator, as well as simply Electricians. This group is generally known as the “Electrics” Department or “LX Department”. These people are responsible from receiving the light plot from the Lighting Designer and translating the design as it is on paper, to the lighting that is seen by the audience in the final production. In small theaters many of these roles may be filled by a single person, while in large productions such as those on Broadway or a large tour, there may be several people filling these roles.

BASIC DUTIES OF A THEATRICAL ELECTRICIAN

Theater Electricians are responsible for all non-design aspects of the lighting in a theatrical production. They may be also responsible for special effects (such as fog) and powering other electrical items (such as motors) used in production.

Electricians install (hang), point and shape the beam (focus), and connect to power (circuit) lighting instruments. Additionally they may add gel to color the light, patterns (or gobos) to create texture or shape a light into a picture, and accessories that give the designer the ability to change some aspect of the light, such as scrollers (color changers) or pattern effects (gobo rotators).

In the past (and even in some theaters today) the electrics department was in charge of all water and water effects used on or offstage (i.e. rain, waterfalls, pools, etc.) The following are some specific electrician positions.

LIGHTING SUPERVISORS:

The Lighting Supervisor is responsible for acting as the go-between for the designers, and the theatre's electrics staff. In the cases of shows done in repertory, they may have to adapt the designs of several designers to work together given the limits of the venue and the equipment, budget, and time available. In the case of a re-mount, they may adapt a design to newer equipment or a different venue than the design was originally created for. While Broadway and high end Off-Broadway productions have this position, the Master Electrician is often responsible for these duties in smaller productions.

DECK ELECTRICIAN:

The Deck Electrician, "Stage Electrician', "Deck Elec", or just "Stage LX" is a member of the running crew for a production and is responsible for all aspects of running the lighting for the show that happens on or backstage. This can include such things as changing color, focusing and readjusting lights that were moved, connecting and disconnecting practical units or set pieces which are electrified, and in some venues, assisting with motor control or effects. On touring or musical productions this individual is also referred to as the Dimmer Technician, as their responsibilities include supervising and maintaining portable dimmer racks.

LOAD IN ELECTRICIAN:

The Load in Electrician or "Production Electrician", often referred to simply as an electrician is a person usually hired on a per day or per project basis (freelance) to hang, circuit and focus the lights. Once the show goes into tech, the Load in Electrician will usually leave, although they may stay around to do "notes" with the lighting designer which may include adding or taking away lights, refocusing, or re-gelling lights. Even small productions usually have at least one or two Load in Electricians who are supervised by the Master Electrician.

BASIC DUTIES OF A THEATRICAL ELECTRICIAN

LIGHT BOARD OPERATOR:

The Light Board Operator, Lighting Operator, Board Op or just LX Op is the person who executes cues for a production. This can range from adjusting light levels of individual dimmers, such as on a two scene preset board, to simply pressing a "Go" button on a computer controlled console. They may need to be able to write cues for their lighting board, and to make adjustments quickly to account for equipment failure, or people being in the wrong location. For some live events, such as concerts, this person may also be creating cues and looks on the fly, and functioning both as an operator and a designer simultaneously.

MASTER ELECTRICIAN:

The Master Electrician, M.E. or "Chief Electrician", supervises all other Electricians working on a production or show. They are sometimes referred to as the Head Electrician or in a touring house, the House Electrician. Their other duties include:

- Planning and implementing of the cabling (circuiting) of lights and electric power distribution for any given show or production.
- Inventory and repair and maintenance of all stage lighting fixtures, cables, effects, power distribution, dimmers, networking and lighting control consoles.
- Organization and purchasing of all consumables including gels, gobos, and gaff tape.
- Documenting and tracking of all scenery circuiting addressing, and system configuration in cooperation with the Lighting Designer.
- If there are no light board ops, the Master Electrician may need to patch the board according to the L.D.'s designs.
- Solving any problems or issues with the electrical equipment that the Deck Electricians cannot resolve by themselves
- Occupational safety and health of workers and operational decisions as the Head of the Electrics department.

LIGHTING PROGRAMMER:

The Lighting Programmer is a person familiar with the lighting board being used who sits next to or in communication with the lighting designer during "tech". He or she is responsible for programming in the lighting cues as dictated to him or her by the lighting designer. This saves the designer the time and attention of using the light board and allows him or her to concentrate on building the cues. Often, especially in smaller theatres, this person is the Light Board Operator for the show's run.

BASIC DUTIES OF A THEATRICAL ELECTRICIAN

MOVING LIGHT PROGRAMMER:

The Moving Light Programmer is a person who specializes in the sometimes complex creation of cues for Moving Lights. For large productions with several moving lights, there may even be a separate control system for the moving lights from that of the "conventional" lighting. Some of these lights, in addition to being able to change focus from one location to another, can include many other features such as color and patterns. The coordinating of these fixtures can be complex enough to require a dedicated person to program.

FOLLOWSPOT OPERATOR:

The Followspot Operator is the person who operates the followspot, or spotlight on a production. This is a light which is physically moved by the operator during the production, to follow a performer as they move around the stage.

A follow spot may also have mechanisms to change color as well as an iris to change the size of the beam of light. The followspot operator may have to change several aspects of the beam from their unit simultaneously. This position is more common in musical theatre and concerts than for drama.

GAFFER:

A gaffer in the motion picture industry is the head of the electrical department, responsible for the execution of the lighting plan for a production. Gaffer within the motion picture industry originally related to the moving of overhead equipment to control lighting levels using a gaff. It has been used for the chief electrician in films since 1936. The gaffer's assistant is called the best boy. Sometimes the gaffer is credited as Chief Lighting Technician (CLT).

Experienced gaffers can coordinate the entire job of lighting, given knowledge of the time of day and conditions to be portrayed, managing resources as broad as electrical generators, lights, cables and manpower. Gaffers are responsible for knowing the appropriate color of gel to put on the lights or windows to achieve a variety of effects, such as transforming midday into a beautiful sunset. They can re-create the flicker of lights in a subway car, the motion of light inside a turning airplane, or the passage of night into day.

Usually, the gaffer works for and reports to the Director of Photography (the DP or DOP) or, in television the Lighting Director (LD). The DP/LD is responsible for the overall lighting design, but he or she may give a little or a lot of latitude to the gaffer on these matters, depending on their working relationship. The gaffer works with a key grip, who is in charge of some of the equipment related to lighting. The gaffer will usually have an assistant called a best boy and, depending on the size of the job, crew members who are called electricians. Colloquially they are known as "sparks" or "juicers".

BASIC DUTIES OF A THEATRICAL ELECTRICIAN

ELECTRICS LOAD IN:

Lighting technology has come a long way in recent years. One consequence is that the number of instruments has risen drastically. On large shows there is simply not enough time to hang all the lights used individually, so various strategies are used to speed the process.

Instruments used to be packed and trucked in crates. Each was hung one at a time on house battens. This is now very rare. Instruments now arrive pre-hung on light bars fitted with quick locking C-clamps. The bars are stored on "meat racks", rolling carts with pipes attached. The bars are hung for transport on these pipes.

An alternate approach is to attach instruments to aluminum truss, which is hung from house battens or more often from chain motors. This is especially common in arena shows, where there is no overhead house rigging, but it is a rare theater show that does not use a few lighting trusses for the heavier electrics

Cabling can be time consuming, and is expedited by permanently pre-wiring the instruments on the truss or bar with fan outs, then connecting the fan outs to the dimmers with multi-cables.

Moving lights are becoming quite common. Each "wiggle light" can replace several individual units, and can be quickly focused from a console and can be "re-focused" cue to cue.

The "Electrics" battens that hold lighting instruments, tend to be hung and flown before most of the carpentry goes in, as it is difficult to hang them afterwards. Electrics, like the battens, are numbered from the proscenium. The Electric furthest downstage is the first (1^{st}), the next upstage is the second (2^{nd}), etc. Similarly the front beam in the ceiling of the house closest to the proscenium is the first (1^{st}) beam, the next one is the second (2^{nd}) beam etc.

Many of the lights on the Electrics point straight down as "Top lights", but the lights at the offstage ends of the battens, the "Pipe Ends", are really "High Side Lights". These are all hung, circuited and tested before the scenery is placed.

As soon as on-stage electrics are hung and flown, the Carpenters take the stage and the electricians move on to the side lights and the FOH, which are usually hung while the carpenters are placing the deck and the scenery in position.

Booms are vertical hanging positions in the wings which hold the side lights offstage. Balcony Fronts are hung immediately off the front rail of the balcony rail. Beams are in the ceiling, and Coves are positions in the side walls. The Box Booms are the side positions immediately downstage of the proscenium, and provide side lighting to the Apron area. These will all be hung while the carpenters are setting the scenery.

BASIC DUTIES OF A THEATRICAL ELECTRICIAN

Once the scenery is in place and ready, the Electricians take the stage again and lights are focused. The Assistant LD usually directs the focus; the Lighting Designer is NOT typically out with the tour. On stage, an electrician goes up in a man-lift and focuses the lights one at a time, while other electricians move the lift along. (Legally, the genie should not be moved while elevated, as it is too easy to tip an elevated lift over.)

The ALD directs where to point and adjust the fixture. If the unit is a PAR can, the LD may tell the electrician to “spin the bottle”. That means the electrician should reach in the back of the PAR and rotate the lamp inside, which will rotate the oval shape of a PAR’s beam. On an ellipsoidal spot, the shutters will be adjusted and the lens “run” to sharpen or soften the beam by putting it in or out of focus. Fresnels will be “flooded” or “spotted” by moving the lamp further from or closer to the lens. The LD may ask the electrician to “flag it”, to wave his hand in front of the beam to make the light flicker and so stand out from the rest of the light. The LD then directs the electrician to “lock it”, or tighten all bolts so it won’t move.Focusing the “wiggle lights” is expedited by the fact that most moving light consoles now set position according to a “home” position. Instead of needing to reset every light in every cue, the operator can set the show in a new venue by re-setting the “home position”, and all cues for that unit are automatically updated so that the pre-recorded cues will work.

ELECTRICS ELECTRONICS

DIMMERS:

A number of types of dimmers have been used in theater, but today almost all dimmers are electronic dimmers. The vast majority is Silicon Control Rectifiers, or SCRs. Electronic dimmers work by chopping off a portion of the AC sine wave. If half of the wave is cut off, the light burns at half intensity. If ¾ of the wave is cut off, ¼ is left and the lamp burns at 25% intensity. Electronic dimmers are smaller and lighter than the old types, but their biggest advantage is that they are remote-controllable.

One effect of chopping the AC sine wave is to add electronic "noise" to the electronic circuits. This can show up as a hum or buzz in the sound system. This noise can be partially controlled by making sure that the lighting supply and the sound supply are completely separate and have separate grounding systems to limit cross-talk of this hum.

Dimmers come in various sizes according to the wattage they can handle. A 10 amp dimmer can handle 1200 watts (10 amps x 120 volts), a 20 amp dimmer handles 2400 watts and a 50 amp dimmer holds 6000 watts. To figure how many instruments of a given size will fit on a dimmer, simply divide the wattage of their lamps into the dimmer's watt capacity. Alternately, divide the total wattage by 120 volts to find the required circuit amperage.

One thing you cannot do is control a motor with a SCR dimmer. You will burn up the motor and may damage the dimmer.

PATCHING:

At one time, dimmers were quite expensive, and a large number of circuits were controlled by a relatively few large dimmers. "Hard-wired patch panels were used to connect circuits to dimmers. To control them, dimmers were controlled directly, or they were controlled using "preset boards". These had several parallel banks or "scenes" of controllers for the dimmers. The level for several cues could be set in advance, then activated one after another as the show progressed.

Today dimmers are fairly cheap, and one dimmer-per-circuit is now the norm. At the same time, computer control boards have replaced preset boards. Instead of a physical preset controller, there is now a virtual control channel.

The hard patch panel's connection between circuit and dimmer has been replaced by the assignment of dimmers to the virtual control channels. This is called a "soft patch", since it happens in the control board's software.

Soft patch has several advantages over hard patch. Soft patch can be done more quickly and accurately; it can be changed and corrected more easily right from the control board. Soft patch allows more flexibility. A patch panel limits the number of circuits in a dimmer to the capacity of the dimmer, while a soft patch allows everything from one channel-per-dimmer to every dimmer in the system to be assigned to a single channel. And a soft patch can be backed up to a computer disk and reloaded later in moments, even mid-show, while a hard patch must be redone manually.

Portable dimmer systems use a modern version of a somewhat older approach. Essentially you are creating a complete lighting system from one location and then removing it and reinstalling it in each subsequent venue. Instead of a patch panel or hard wired connections, road racks have plugs into which cable to the instruments is plugged in directly. To make this process easier, large road shows use multi-circuit cable or "mults" which allow 6 or 12 circuits to be connected at a time. At the batten end is a device called a breakout or fanout which connects to the multicable and separates the circuits out into individual circuit cables. The insulation on the fanout cords can be thinner than standard cable but are limited to a maximum of 10 ft. for each circuit cable before termination. The soft patch remains the same, but the wiring of circuit to dimmer is more flexible.

The biggest advantage for computer boards comes in running cues. Manual and preset boards limit the number of cues to how many can physically be set in the time allowed. With computer boards the cues are set and recorded in advance, and complex cues can be played back literally as fast as they can be triggered. Cues can even trigger other cues, and several can be run simultaneously.

CONTROL SIGNALS AND WIRING:

Remote control boards "talk" to the dimmers via low voltage signals through fine wires. In the analog system used in preset boards and early computer boards, each controller sent a control signal continuously through a unique wire to its dimmer. This meant that for 60 dimmers, there were 61 wires to the rack (one per dimmer plus a common neutral). The signal was a continuum from Off to Full. The need for so many wires made it difficult to set up adaptive arrangements of equipment. Each installation was almost unique, a custom installation, so changing a hookup was as much work as the building of it in the first place.

With the advent of computer boards control moved from analog (continuous) to digital (discrete values represented by a specific number). The computer divides the range of zero to 100% into steps, then records the exact step a dimmer is set at during rehearsals. In playback the recorded level is sent to the dimmer, where it is converted into the analog signal needed to set the SCRs. Initially this was done on the same multiple wires that the analog control had used. But then schemes to do so with only a few wires were developed, using "multiplexing". Under multiplexing, instead of sending signals to the dimmers down many wires continuously, the levels of each of the dimmers are sent one after another down the same two wires. The signal goes to all the dimmers, and circuitry keeps count of how many levels have gone by. When a dimmer gets to its own number, it notes the level and ignores all the other levels. It then "remembers" its level until the cycle repeats and it gets to its own number again. How often the cycle repeats per second is called the refresh rate.

POWER:

In electrics, one of the basic concepts to understand is the relationship between Watts, Voltage and Amperage. Voltage =the force behind the electrons as they move through the circuit. 120 volts is the most common in the United States. Amperage= the amount of electrical current flowing in a circuit Watt= the amount of power or work performed.

ELECTRICS ELECTRONICS

Away to remember the relationship of the three is the “West Virginia Formula”: W=V A So Watts=120V (x) Amps You would use this formula, when you know how many amps you have, but are not sure how many watts you can use. So let’s say for example you have a twenty amp circuit, and need to know how many watts you can use safely.

120 (times) 20= 2400 watts. Let’s say you have the watts but need to know the amperage. You would use this formula in reverse. Amps= Watts divided by 120.

Something else to consider is the resistance in a circuit which is measured in ohms. Ohms law is _ Direct current flowing in an electrical circuit is proportional to the voltage applied to the circuit. So, “the harder the push the faster the flow”.

A/C, or alternating current, means that the flow of electricity is reversed from time to time. The frequency of power in the United States is 60Hz. This means that the flow reverses sixty times per second. Electrical Capacity-the amount of current (amps) a conductor can carry without overheating.

LIGHTING INSTRUMENTS AND HARDWARE

Light is controlled and directed on stage using various specialized fixtures. In the U.S. the theatrical name for a lighting fixture is an “instrument”, they are also called “luminaries” but this is a more European term.

LIGHT SOURCES:

The part of an instrument that actually makes light is called a lamp. This is often mis-named a “bulb” but the bulb is just the glass part. Most theatre lamps are “incandescent”;, a piece of tungsten wire is heated to white hot by running electricity through it. If this happens in air, the wire burns out immediately, so the filament is placed inside a glass bulb or envelope, and the bulb is filled with an inert gas, like argon, to prevent the filament from , failing immediately. If the gas used is a halogen gas like iodine or bromine a reaction occurs which greatly lengthens the life of the lamp and these so-called “tungsten halogen” lamps are almost universal in theatre.

Bulbs come in many shapes. Household lamps are often A- (Arbitrary) shaped. G- (Globe) and PS- (Pear Shaped) were once common but are now rare. T- (Tubular) is probably most common in theatre today, while R- (Reflector) and PAR- (Parabolic Aluminized Reflector) shapes are used for some flood lights.

Lamps must be physically supported in place and connected to the electric current. This is done through the Base, which has two electrical contacts insulated from each other except through the filament of the lamp,. There are many types of lamps used in theatre. The Screw Base, found in household lamps, is somewhat uncommon. Older units often used a prefocus base or a bi-post base, but these have been largely replaced in newer units by 2-pin bases, which look like a miniature bi-post base. There is also the RSC or Recessed Side Contact, found in striplights and many household security floodlights. The 2-prong base is used on large PAR lamps in PAR-cans.

Instruments like follow spots and most moving lights need a brighter source than incandescent lamps usually provide, so various tungsten short-arc lamps are used instead. These lamps use tungsten electrodes to create the electric arc inside a high pressure glass lamp filled with a special gas.

The gas slows electrode erosion so that the lamps last a long while. They are very bright and very white at a much lower wattage than the equivalent incandescent lamp, but they cannot be electrically dimmed.

Lamps are usually rated by color temperature of the light produced. Color temperature is a measure of how “white” a light is, measured in degrees Kelvin. Kelvin degrees are the same “size” as Celsius, but are measured from “absolute zero”. Typical incandescent lighting is very red, about 2500 K. Stage lights are whiter, about 3200 K, and Video lighting is whiter still, about 3600 K., and arc lamps are usually higher yet.

COLOR MEDIA:

Lighting instruments are colored using various types of color media. Most come in sheets which are cut to size, inserted in metal frames, and put in front of the lens to color the beam.

Most work by absorbing some colors in the light; the perceived color is what has NOT been absorbed or “subtracted” from the light. Comes in several forms:

LIGHTING INSTRUMENTS AND HARDWARE

Glass media: available as either custom glass sheets, usually cut into strips, or as Rondels, shallow glass "bowls" of colored glass. Permanent, but breakable, and only available in a few colors.

Colored sheets: a clear base is colored with dyes to make the color, short or long life depending on the base used. The sheets are numbered by color by the manufacturer. Since there are so many similar colors available, the FIRST thing to do upon receiving an order is to number each sheet with a china marker or wax pencil, even if the manufacturer has also printed the number on it. The sheets are then cut to fit the metal color frames, and each cut piece should also be marked with the color number.

- Gelatine- the original media, from which comes the generic name for all color media, "gels". Made of gelatin colored and dried in thin sheets. Very short life, but very cheap. Obsolete.
- Polyethylene- the first plastic color media used, is available in fewer colors but lasts longer than gel. Still has a relatively short life, especially in saturated colors.
- Polycarbonate, "Lexan"- a long life plastic media, available in a very wide number of colors from several manufacturers. The current standard color media. Will eventually fade, especially in saturated colors.

Dichroic filters: dichroics are a very thin layer of metal oxides is deposited onto glass, and then placed in the beam of the light. Dichroics change color by reflection rather than absorption. When the filter is tilted, some colors of light are reflected to the side and away from the opening. The rest pass through and to the stage. Which colors are reflected changes with the angle, which means that as you tilt the filter, you change the color that passes through. Used primarily in some moving lights. Permanent but very expensive.

INSTRUMENT TYPES:

Six (6) types of lights commonly found in the theater

- ERS (Ellipsoidal Reflector Spot)
- PAR (Parabolic Aluminized Reflector)
- Follow Spots
- Scoops
- Boarder Lights or Strip Lights
- Fresnel's

Instruments fall into several categories, but are all either floodlights or spotlights.

- Floodlights are any lighting instrument without a lens.
- Spotlights are any lighting instrument with a lens.

FLOODLIGHTS:

Floodlights are not quite as common as they used to be, but there are still many varieties in use, they are basically a reflector and a lamp, and a way to put color media in front of it. Floods are primarily designated according to the shape of the reflector used.

LIGHTING INSTRUMENTS AND HARDWARE

Ellipsoidal Reflector Floods (ERF or "Scoops"): uses an ellipsoid (a 3D ellipse) as a reflector. These lamps are efficient at covering a large surface area, like a drop or cyc, from a fairly close distance.

Striplights are basically a row of small floods arranged in either three (3) or four (4) circuits so that every third or fourth lamp is on the same circuit.

All lights on the same circuit are given the same color, usually red, green, and blue, the primary colors of light, for additive color mixing of light. Amber is also often used, since it is a difficult secondary color to mix.

Older Striplights use spherical reflectors, or R-lamps and newer ones use a lineal reflector parabolic in one plane and flat in the other. Often colored using roundels, curved bowls of colored glass placed over the lamps and reflectors. There are also Striplights that use MR-16 high intensity lamps to make a bright but compact strip. Striplights are also used to light large flat surfaces from close range, like drops and cycs.

Far-Cycs and Cyc floods are four floodlights arranged in a rectangular array. Each individual bay is one separate circuit. These lamps are used in groups to light drops and cycs. Similar to strips in that four (4) colors are additively mixed to make other colors, but since they use sheets of color media, they can be easily other than the primary colors usually found in Striplights.

Beam Projectors are floods using a parabolic reflector, which project a very compact parallel beam similar to a narrow spotlight. still very popular in Europe but has been replaced by Par-cans in the United States.

Par units (Par-cans) are basically a self-contained Parabolic Aluminized Reflector and lamp combination with some rudimentary lensing built into the front to shape the beam, and placed in a tin-can to contain some of the spill. In many ways just an updated beam projector is quite efficient and very popular for concert work. Recently have been updated again by making the lamp replaceable, as in a Source 4 Par and the Altman Star Par. in some ways they sort of recreate the Beam Projector but with PAR,s lensing added. Pars are often used as wash lights because they produce a beam with a soft edge.

LENS IDENTIFICATION:

VNSP: very narrow spot (clear glass) 15degree round beam shape

NSP: narrow spot (stipple glass) 19degree round beam shape

MFL: medium flood (fewer facets) 21x34degree oblong beam shape

WFL: wide flood (many facets) 30x51degree oblong beam shape

SPOTLIGHTS:

Lenses in spotlight are used to gather and control the light produced by the lamp. Like floods, the different types are defined by their reflector as well as their lenses.

PC Spots: an obsolete type, but worth examining as the prototype theater spotlight. a lamp with a spherical reflector in back and a Plano-convex lens on the front.

A PC lens is a flat plane (the Plano part) on one side and
Convex (curved out) on the other. A very important theater lens type and the basis of most lenses. Adjustable from flood to spot like a Fresnel.

Fresnel: a modified PC spot, has a spherical reflector like a PC, but uses a Fresnel lens instead. A Fresnel lens is planar on the back, but is cut away on the curved side in concentric rings. The result has the same curve as a PC lens, but removes most of the glass between the surfaces, making the lens thinner and lighter, and less prone to breaking from the heat. A 1/2" thick Fresnel lens is about the equivalent of a 2" thick PC lens. However to keep the rings from showing up in the projected image, Fresnel lenses usually have a dappling added to the planar side as built-in diffusion.

The lamp and reflector are fixed on a moveable carriage. When the lamp is moved forward near the lens, the projected pool of light gets larger ("Flood" position). When the lamp is moved away from the lens, the pool of light gets smaller ("Spot" position).

Ellipsoidal Reflector Spotlight (ERS, Ellipsoidal, Leko, Source4)- uses an ellipsoidal reflector with a PC lens or lenses in front. Most efficient spotlight type, can illuminate well from a distance, so is the best instrument for FOH (Front of House) lighting, from the Beams, Coves, and Balcony Fronts positions.

Ellipsoidal Reflectors are unique in that they have TWO focal points. When the lamp is placed at one focal point, the light beam can be shaped at the other focal point with shutters, irises, and patterns called "gobos" or "cookies". This second focal point position is called the "gate".

The lens is usually one or two PC lenses. Using two lenses makes a combined focal length shorter than either lens separately.

Effectively, Ellipsoidals with a long focal length will project the same size beam on stage from a long distance (called "throw") as a short focal length will at a short distance.

A label such as "36-degree" means that the angle of the beam spread is 36 degrees. Logically, a Source 4 19-degree will produce a smaller beam than a Source 4 36-degree.

A label such as "6 by 9" indicates that the ERS has a lens that is 6 inches in diameter and a focal length of roughly 9 inches. A 6 x 12 has the same size lens, but a longer focal length.

Tips:

The beam of light from a 6x9 is similar in size to a 36-degree.
The beam of light from a 6x12 is similar in size to a 26-degree.
The beam of light from a 6x16 is similar in size to a 19-degree.

LIGHTING INSTRUMENTS AND HARDWARE

AUTOMATED LIGHTS:

Moving light are becoming quite common. They are expensive compared to "conventionals" , but one "wiggle light" can replace several individual units. They are much quicker to focus from a console & can be "re-focused" cue to cue. They require a power connection like any other light AND a data line for the remote control signal. The control data may be in a proprietary language, but most moving lights can also be run using DMX-512 as the protocol (see Dimmers).

Modern units can change intensity, focus, color, gobo, size, and sharpness and other characteristics. these are referred t a "attributes", and each takes one or more channels of control from the control board to operate.

As far as the board is concerned, the state of each attribute is treated as a "dimmer" and the dimmer level is translated into an attribute state or position.

There may be as few as 5 or 6 attributes or as many as 32 attributes per unit, depending on the complexity of the moving light.

There are two broad categories of Moving lights:*Moving body types* have a body held by a motorized yoke. Stepper motors in the base are used to pivot the yoke to control "Pan", the horizontal motion, and stepper motors in the arms of the yoke control "Tilt", the vertical movement of the beam. Inside the unit are many small motors which can rotate controls to iris the beam, spin one or even two disks full of gobos into place, perhaps rotate the gobos, change colors, and diffusion effects, focus the beam for sharp or soft, and even zoom in and out to change the image size. Examples include units from Verilight, some Martins, Icons, Clay-Pakys, and some High-End units.

Some units that are basically motorized Fresnel's (Robo-colors), PARS (VL-5), and zoom ellipsoidal (VL-6 and VL-7).

Moving mirror units use a body which is fixed in position, but which directs the light beam onto a mirror attached to a stepper motor. The light is directed by changing the angle of the mirror to redirect the angle the light is reflected from it. All the other controls, the motorized iris, the gobo and color wheels, the focus and zoom motors are inside the non-moving body, and alter the beam before it gets to the mirror. Examples of this system are the High-end Intellibeam, Cyberlights, and Trackspots, and some Martins and Clay-pakys.

There are advantages to each method. Both types are heavy because of all the stepper motors.

Moving body units: the light beam can literally be directed in any direction at all. Most lamp heads can roll completely over inside their yoke, and so can even point straight up. However, to move the light beam, the motors in the base and the yoke must throw around the weight of the entire head, including all the motors and gearing. To keep the head small enough to be moved, everything inside must be miniaturized compact, but this tends to make the mechanism delicate.

Rapid movement places most stress on the mechanism, but is very dramatic and "fun". Moving body units are therefore much more prone to breakdown, and repair resembles that of a clock.

Moving mirror units: move only the mirror, so there is less stress placed on the mechanism. The heavy stuff doesn't get thrown around. The body can be much larger because it is fixed, and so there is also more room for the motors and gears.

Moving mirror types tend to be more durable; less stress and more room means less frequent repair and easier repairs then needed. However, the movement of the beam is limited by the position of the body itself. Instead of a full sphere, the beam can reach only about a third of the sphere around the unit. Also, movement is just not as "flashy" to watch, and in some shows, that flash can be as important as what the beam itself is doing.

Automated color change is handled in various ways:

Color Scrollers: used to add automated color change to conventional fixtures. These consist of a strip of different colored "gels" taped together and placed on a motorized scroll. A motor scrolls the strip back and forth to the color desired, then scrolls to a different color on the scroll to change the color of the beam.

Color Wheel: used by many of the "ellipsoidal" types of moving lights. Fixed colors rotated into position by rotating the wheel in the light beam. Colors are changed by "subtraction" just like traditional color media. It is a simple straight forward and most important, a compact method, so it gets used where size and cost are major considerations.

FOLLOW SPOTS:

Follow Spots are specialized instruments meant for manually following a performer around the space to keep them lit. They often have a parabolic reflector to project the light through the lenses, and a gate with irises, shutters to shape the beam. The lenses may also be adjustable to increase and decrease the size of the projected spot field.

Follow Spots use a variety of light sources. Small spots may use incandescent bulbs. Bigger, brighter spots use HMI, HTI, or Xenon arc lamps. These are short-arc lamps using tungsten electrodes to create the arch inside a high pressure glass lamp filled with a special gas. They will last many hours before they must be replaced. However if they are not cooled properly before being re-lit, the life will be drastically shortened. Therefore, once an HMI,HTI, or Xenon lamp is "struck" or turned on, leave it run until the performance is over, and let it cool at least ten (10) minutes before re-lighting.

Strong Followspots is a popular brand of spotlight. There are a number of models depending on the "throw" distance involved.

Strong spots typically have two (2) or three (3) control levers on top. The front lever is the Iris, which mechanically reduces the size of the round beam. The middle lever is the Chopper, a shutter that cuts of the top and bottom of the beam. The rear lever is the Douser, which mechanically fades the beam. Followspots are usually an arc light of some sort, which cannot be electrically faded, but must be mechanically faded. There is also a lever on the side, the Trombone, which adjusts the size of the beam field optically, varying it from normal to very large.

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- ***A Trouperette*** is a small, short range incandescent spotlight, with an effective throw of about seventy five (75') feet.
- ***A Super Trouperette*** and a Trouperette 575 are similar to Trouperettes, but have HMI arc lamps.
- ***Trouper*** was the original Strong arc spotlight. It was a AC carbon arc spot: the carbon rods are both identical and interchangeable about 1/4" x 7". It has no douser, and it has an effective throw of about one hundred twenty five (125') feet.
- ***Xenon Trouper*** is a similar updated model using a Xenon arc light source instead of carbon arc. it is much brighter than a carbon arc.
- ***Super Trouper*** is a DC carbon arc spot with a built in rectifier to change AC voltage to DC for the arc. Front carbon is 9mm x about 13", and rear is about 7mm x 9". has a throw of about two hundred (200') feet.
- ***Xenon Super Trouper***, is similar but with a Xenon arc light source.
- Gladiator is basically a movie projector head with a Super Trouper barrel. Both older carbon arcs and newer Xenon arcs. It is a long range spot two hundred (200) yards.

Lycian Spotlights are another common brand of follow spot. Lycians have similar controls but they are located in different places on the spot. The Iris is typically a lever located on the side rear of the lamp head. The douser is a small lever located at the front of the barrel and at the rear, and the chopper is a twist lever at the back or the controls may be located on top like those of Strong lights. The design seem to vary more model to model and depending on when it was produced.

- Lycian Midget is comparable to the Trouperette line. Available in short throw incandescent and HTI lamp. Short throws of about ninety (90) to one hundred fifty (150) feet.
- Lycian Super Arc 400's are medium throw spots with HTI lamps, similar to Xenon Troupers. Throws approximately two hundred and fifty (250) to four hundred (400) feet.
- Lycian Superstars are longer throw spots with HMI and Xenon lamps, similar to Xenon Super Troupers. Throws four hundred (400) to six hundred (600) feet.

CABLE:

On most types of cables you will see numbers sometimes written on them. These numbers are very important to know the amount of current that the cord can carry safely.

For example: **14/3**. These numbers represent the gauge of the cable and the amount of conductors. So in the term **14/3SJ**, the cable is a **14 gauge** cable with **3 conductors**. (Hot, Neutral, Ground). The SJ refers to the cable assembly, annotations include:

- S= Service Cord (600 volt standard if no J is present)
- J= Junior Service (300 volt)
- T= Thermoplastic
- E= Elastomer (Thermoplastic that looks and feels like rubber)
- O= Oil Resistant Outer Jacket
- OO= Oil Resistant Outer Jacket and Oil Resistant Conductor Insulation
- W= CSA Weather and Water Resistant (approved for indoor and outdoor use).

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According to the American Wire Gauge(***AWG***), each size of multi-cable can only safely carry a certain amount of current(*amps*)

- 18/3= 5 amps
- 16/3= 10amps
- 14/3= 15 amps
- 12/3= 20 amps
- 10/3= 30 amps

As you can see, **the larger the *gauge*** number, the **less amperage** a wire can carry, and the **smaller the *gauge*** number, the **more amperage** a wire can carry.

When the ***gauge*** number becomes smaller than zero(0) *–zero being pronounced as* ***aught-*** instead of using negative(-) numbers, the standard is to append another zero(0) to the ***gauge*** number, *i.e.* a gauge of '0' or 1/0 is referred to as; "*one aught*", 00 or 2/0 as "*two aught"*, 000 or 3/0 as "*three aught*", etc.

- 1/0 or 0 (*one aught*) = 150 amps.
- 2/0 or 00 (*two aught*) = 190 amps
- 4/0 or 0000 (*four aught*) = 302 amps

CONNECTORS:

Some of the most common connectors used in the theaters are listed below:

20amp Stage Pin:

These plugs are found on most conventional lighting fixtures. The center pin is connected to the ground wire. The pin closest is the neutral, and the remaining pin is the hot. Note: on a 60 amp connector the ground and the neutral are reversed.

Twist Lock:

These plugs are used in different capacities. You may find twist lock connectors on moving light fixtures, motor power and motor control. Pin configurations and sizes vary by number of conductors and amperage. Check the top of the plug for ratings. Usually the L-shaped pin is the ground and the silver pin is the neutral.

Edison Cable, Parallel Blade, A/C:

These plugs are the most recognizable, as most common household appliance's have these plugs. You may often see them without the rounded ground.

Camlock:

Camlock, or feeder, is used heavily in power distribution. They are large, single conductor rubber insulated cables. When connecting camlock cables, always start with the Green cable. This cable is the ground. After connecting the green cable, move on to connecting the White cable (this is the neutral). After that the three hot legs, (red, black, and blue) can be connected in any order. It is important to remember when removing the cables, do the process in reverse. Disconnect the 3 hot legs, then the white and the ground last.

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Metering Power:

When metering power between different legs on a 3 phase Camlock system, here are the results:

The measurement between 2 hot legs should be 208 volts

The measurement between ground and neutral should 0 volts

The measurement between the ground and a hot leg, or a neutral leg and a hot leg should be 120 volts.

SOME TERMS AND PHRASES TO REMEMBER

ACL- Aircraft landing light

NEC- National Electrical Code

Electrical Circuit- a wire or bar used to transmit electricity

Drop Box- an electrical plug in or junction box dropped from overhead via a spotted line

AWG- American Wire Gauge- a standard measurement for wire conductor

Twofer- a cable with one male end and two female ends for the purpose of powering two (2) lamps from a single circuit.

Primary colors in light- red, green, blue

Secondary colors in light-cyan, yellow, magenta

3 basic things needed for a focus- gloves, c-wrench, and circuit tester.

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