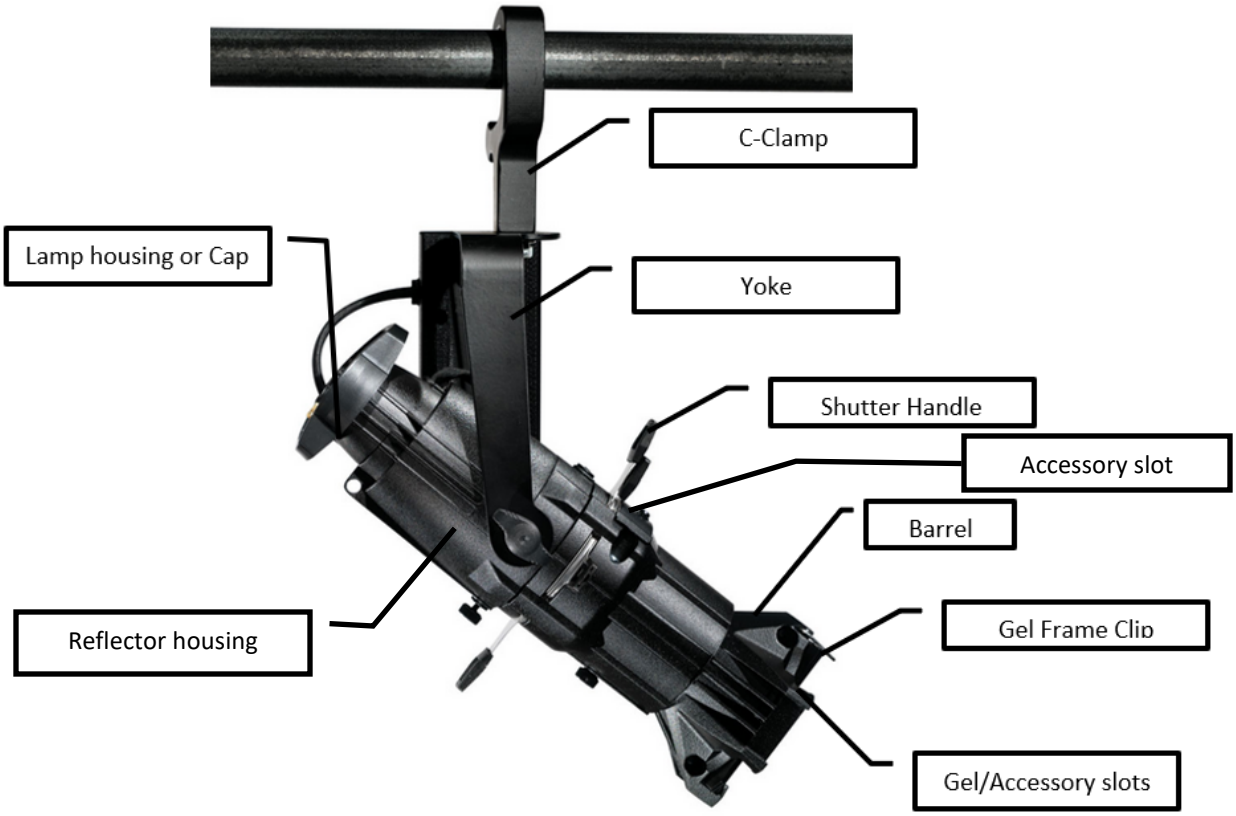



*Figure 3.3-1 - Typical ellipsoidal reflector spotlight (ERS) and its parts*

## Lighting instruments

The first important distinction to make about the terminology used by lighting technicians is that when we use the term "light" we are referring to the waves that come out of a **lighting instrument**, not the physical object itself. There are a couple of interchangeable terms – **lighting instrument**, **unit**, or **fixture** that all refer to the physical object that produces and focuses the light beam.

In this section we'll cover the various types of lighting instruments that you'll use in our spaces. We'll start with the **ellipsoidal reflector spotlight** or **ERS** (Figure 3.3-1). These are the most common type of instrument that you'll find in our spaces. The name comes from the fact that the reflector in the unit is elliptical in shape. This shape focuses all of the light waves coming from the **lamp** (the light source, and the proper name for what is commonly called a "light bulb") to a specific point in the instrument. This allows us to control the **sharpness** or clarity of the light beam by adjusting the position of the **lenses** (housed in the **barrel**). This is the reason that this type of unit is known as a spotlight. We are able to focus it into a sharp, well defined area.

Figure 3.3-1 calls out the various parts of an ERS, many of which will be in common with other instrument types. Starting at the top – Lighting units will typically be hung from a steel **pipe** sometimes referred to as a **batten**. Most conventional lighting units attach to the pipe through use of a **C-clamp** (Figure 3.3-2). We'll see C-clamps in other parts of our work as well, but these clamps are specifically

made to attach to circular pipes. The C-clamp bolts to the **yoke**, a U-shaped piece of steel which then bolts to either side of the lighting unit.

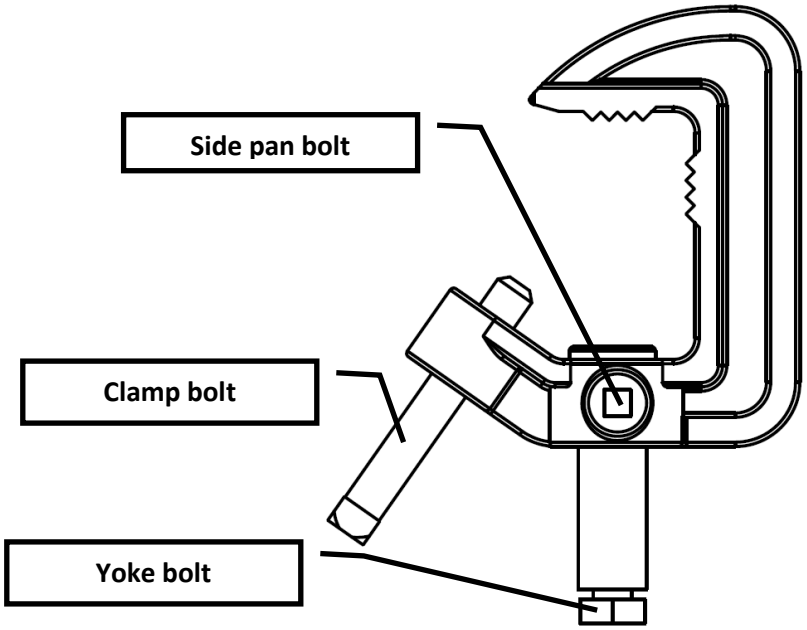



*Figure 3.3-2 - Lighting C-clamp*

The bolt connection between the C-clamp and the yoke (the **yoke bolt**) allows us to move the unit from side to side which is known as **panning** the unit for focus. The connections from the yoke to the unit itself allows us to move the unit up and down known as the unit's **tilt**.

The type of unit that we use most (as is the case in many theaters) is the ETC Source Four ERS (which is the unit pictured in Figure 3.3-1). At the back of these units you will find the **lamp housing** or **lamp cap**. This is the part of the instrument that makes the electrical connection between the power supply and the lamp itself. There are some fine adjustment knobs on the back of the cap which allow us to fine tune the focus of the beam. Adjusting the instrument using these knobs to achieve an optimal beam brightness and geometry is known as **bench focusing**. This is typically part of the maintenance schedule and is not usually something that a technician will deal with during focus.

As we move forward from the light source, we find the **reflector housing** where the ellipsoidal reflector resides. Next, we find the **shutter assembly**. The **shutters** are essentially thin, flat pieces of metal with straight edges that allow us to reshape the beam from its standard circular shape into a shape with one or more flat edges. Most often, the shutters are used to cut light off of elements we don't want to light.

Also in this area is the **accessory slot**. This is where we can insert various accessory items into the unit. This is also at, or very close to the focal point of the reflector which enables the unit to get a very sharp focus on the accessories used. One accessory used often is known as a **gobo** or **pattern**. Gobos are thin metal discs with specific shapes or text cut into them. There is also a larger slot for accessories like an **iris**, a series of metal fins that are controlled by a lever to reduce the diameter of the beam to a custom size. (See figure 3.3-3)

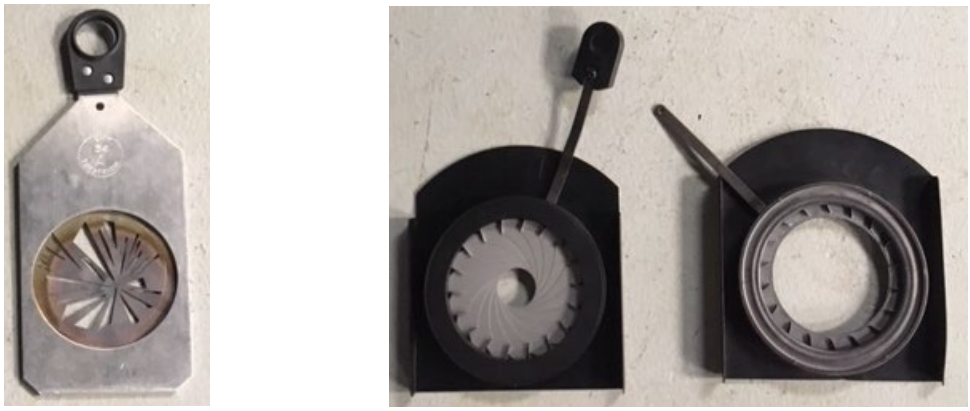


*Figure 3.3-3 - Gobo in its frame (left), Iris closed and open (right)*

The barrel is the part of the instrument that houses the lens tube. In Source Four ERS units, the lens tubes are interchangeable from unit to unit. Lens tubes come in a variety of beam angles. Beam angles are defined by the angle of the beam cone as it is projected from the instrument. For example, a 26° instrument will project a 26° cone of light (Figure 3.3-4). We have lens tubes in 5°, 10°, 19°, 26°, 36°, and 50° designations.

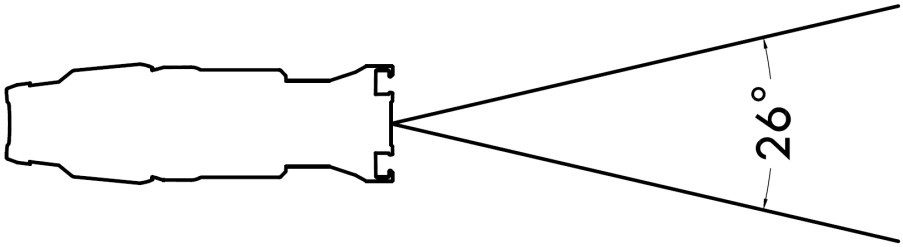



*Figure 3.3-4 - 26 degree beam angle*

Finally, at the front of the unit we find slots in the barrel into which we can insert **gel** (sometimes called **filters** or simply **color**) and other accessories like top hats and half hats. Lighting gels are sheets of heat-resistant plastic that allow us to change the color of the light beam. Gel is cut to specific size and then housed in thin metal **gel frames** that fit into the slots at the front of the lens tube. **Top hats** and **half hats** are accessories that reduce the flare of the beam on surrounding objects like curtains. (See figure 3.3-5)

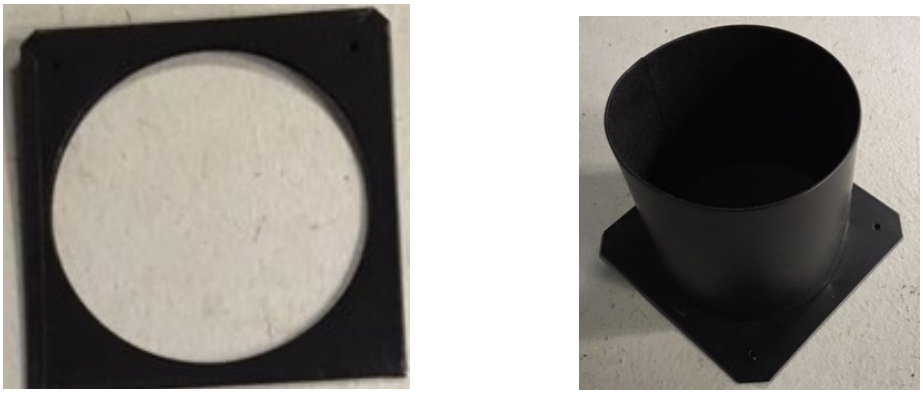


*Figure 3.3-5 - Gel frame (left), and top hat (right)*

Thus far we've been looking at spotlights which provide a localized beam of light with a discernable **hot-spot** – the brightest part of the beam. The other major family of lighting instruments that we use is known as **wash** or **flood** lights. These instruments provide a large even beam of light.

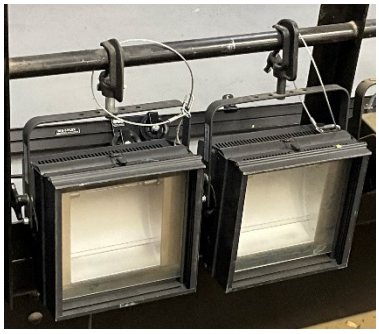
*Figure 3.3-6 - PAR 64 (left), ETC SourceFour PAR (right)*

The **PAR can** has been a mainstay of entertainment lighting for many years. PAR stands for **parabolic aluminized reflector**. The parabolic shape of the reflector results in all of the light waves exiting the unit in the same direction. When combined with a lens, the PAR units can achieve a small variety of beam types. The PAR can that has been present on the entertainment scene for decades utilizes a lamp that is combined with the lens of the unit in one physical element. This means that if we want to use a different lens (discussed below) or when a lamp blows, the whole assembly needs to be switched out. While we have some PARs of this older style, we typically use an updated kind of PAR made by ETC called the **Source Four PAR**. This unit has all of the traditional qualities of a PAR unit in a more flexible package. There are four lens types available for Source Four PARs – **wide flood**, **medium flood**, **narrow spot**, and **very narrow spot**. The flood versions of these lenses have a long, narrow hot spot which can be rotated to meet the directionality preference of the designer. This is known as rotating the **bottle** of the instrument.

Another type of flood unit that you will see in many theaters (though not very often in our theater) is a **Fresnel**. Fresnels utilize a spherical reflector and a cut glass lens to provide a general wash of light with a bit of control between full flood and a more focused spot field. Like the PAR, we have a Source Four version of this instrument, the **PARnel** that has many of the same characteristics but is a bit more elegant in its operation.

*Figure 3.3-7 – Fresnel (left), ETC SourceFour PARnel (right)*

One of the main benefits of the Source Four series of instruments it that they all use the same lamp. This means that instead of needing to stock a bunch of different lamps that are unique to each unit, we can stock one lamp that is usable in the vast majority of our instruments.



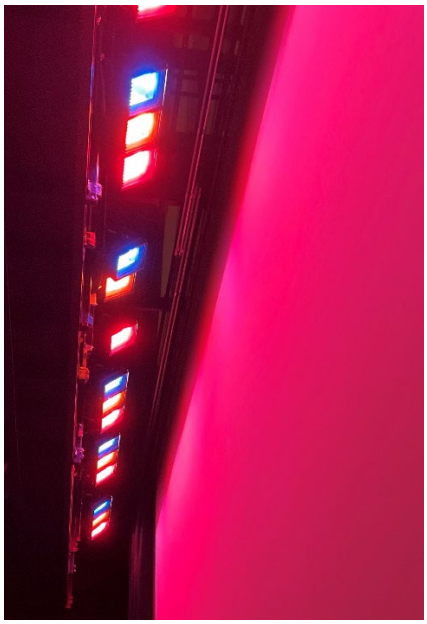


*Figure 3.3-8 - Single cell cyc units (above), three-color cyc system on a muslin drop (right)*

The last type of instrument that we'll cover here is our **cyclorama lighting units** or **cyc lights**. These instruments have a large, wide reflector that provides a wide wash beam that lights the cyc in a smooth, even gradient. These units are most often used in groups of three colors – frequently red, green, and blue – that allow lighting designers to mix a variety of colors to create a smooth color wash on the cyc.

## Incandescent vs. LED sources

All of the units that we've been covering so far are known as "conventional" instruments, in this case meaning that they use an incandescent lamp. We're all familiar with such lamps: a glass bulb, inside of which is a filament that glows when an electric current is passed through it. But **LED (light emitting diode)** sources make up a consistently growing portion of the equipment being produced and used in the industry. There are several advantages to LED fixtures, though they have had detractors since their introduction a couple of decades ago. For one thing, LED sources can create a similar amount of light while using a fraction of the electricity required by incandescent sources. But another significant benefit is that LED fixtures don't just replace the incandescent lamp with a single LED, but with an array of many LEDs in multiple colors, which enables the instrument to produce a wide range of color options simply by programming the desired colors at the lighting control board, and without needing physical color filters/lighting gels.

*Figure 3.3-9 - RGBA LED PAR downlight system*

The most basic multi-color setup involves an arrangement of red, green, and blue LEDs (RGB), providing the primary colors of light that can be mixed to create a wide range of secondary and tertiary colors. This mirrors the basic colors that are often chosen for cyc lights, as mentioned above. Frequently, these units will also have a white or amber source to allow for a greater color range (RGBW/RGBA).

The main complaint about LED lighting in the past was the quality of the light as it dims. Very simply, we perceive a color shift in dimming incandescent sources that does not naturally occur with LED sources. But recent advances in LED lighting have allowed manufacturers to mimic the light quality of incandescent sources at lower levels. For this reason, many manufacturers now also include subsets of red, green, and blue LEDs, in order to provide a much wider range of color mixing capabilities. For example, the Source Four Lustr X8 uses eight colors: green, lime, blue, indigo, cyan, amber, red, and deep red. Manufacturers now make LED versions of most of the units described earlier in this section, so this color flexibility is available in, among others, ERS units, PARs, Fresnels, and cyc units.

# Lighting accessories

In addition to the instruments themselves, there are various accessories that add functionality or security to the unit. Some, like the gobo and iris, we've already discussed, we'll look at some other common items here.

*Figure 3.3-10 - Lighting safety cable*

The **safety cable** is a thin (1/8") piece of wire rope that wraps through the yoke of the lighting unit and around the batten to guard against structural failure or operator error.

*Figure 3.3-11 - Side arm*

**Side arms** allow us to hang a unit further away from the lighting batten. These are often used on **boom** positions – vertical hanging positions – which enables us to orient the unit in its usual way and makes the units a bit easier to focus.

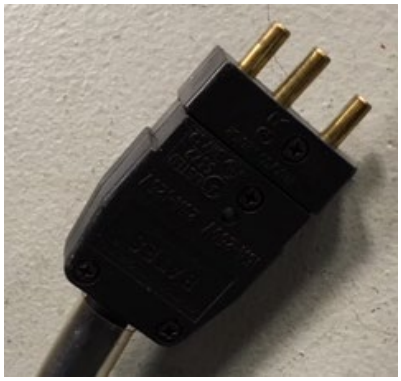


*Figure 3.3-12 - Stage pin connector*

The type of connector that a lighting unit has can vary form theater to theater. We use connectors known as **stage pin connectors** (occasionally called 2P&G for two pins and ground).

# Dimming and control

Controlling the brightness or **intensity** of the lighting instruments is one of the key tools the lighting designer uses to shape the look and feel of their design. **Dimmers** allow us to accurately control the intensity of a lighting instrument on a scale of 0-100% and to smoothly transition between those values. Each dimmer controls an instrument or group of instruments, and the lighting designer sets the intensity for each dimmer in each look or cue. A **lighting cue** is the look created by the lighting designer by adjusting the intensity and other attributes of the lighting instruments. This cue is then recorded, either in the lighting console's storage or, in the case of manual boards, on paper.

The **lighting board** or **lighting console** is the control center of a lighting design. Today, most light boards will be computerized, though you can still find **manual preset boards** here and in other small presentation spaces.

The controllers on a manual preset board are sliders, similar to those found on many home dimmer switches, that move vertically to set the intensity of a channel (more on that term soon) from 0-100%, usually represented on a scale of 0-10. One of the most popular configurations for preset boards is the **two scene preset**. This set up consists of two banks, or scenes, of sliders that the user can switch between using separate **crossfader** sliders that control each bank. This allows the user to have one scene controlling the cue that is actively onstage while they set up the next cue in the show on the other scene. When cued by the stage manager, the operator moves the crossfaders from one scene to the other, fading out of one cue and into the next. Then, the operator sets the next cue on the inactive scene and so on.

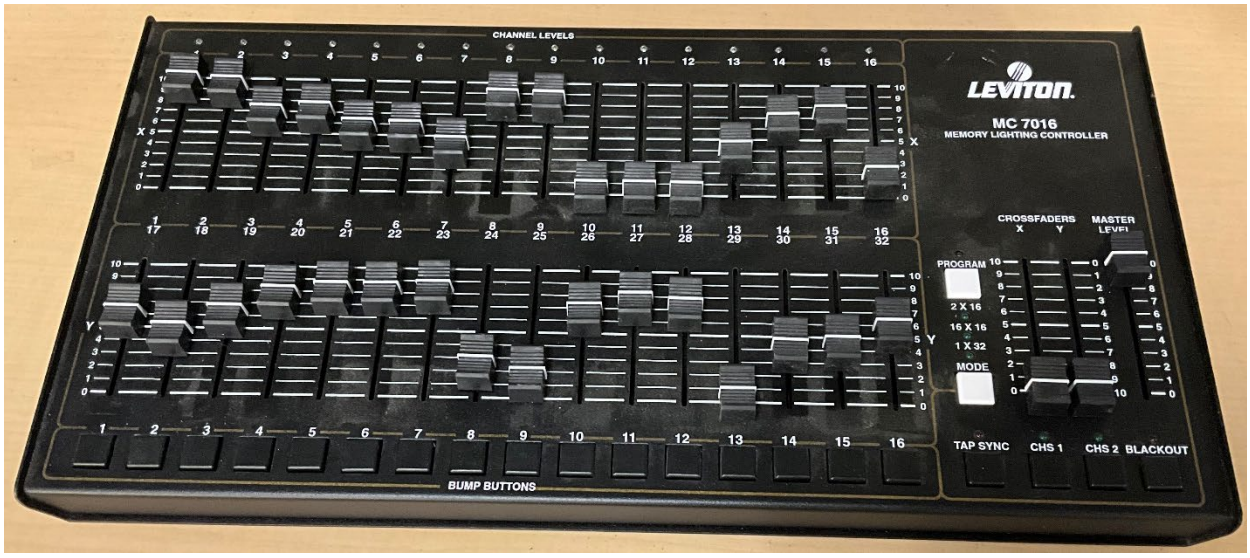



*Figure 3.3-13 - Manual two-scene preset light board*

As stated earlier, most consoles are computerized. These are basically personal computers with specialized connections and control (although there are really advanced, really specialized versions). Modern consoles allow designers to record the values for all the channels and addresses (more on these terms below) into cues which are then stored in a list. During a show, the stage manager cues the light board operator to press the “GO” button for each lighting cue, and then the console executes the cues, controlling the timing and intensity of each instrument’s action according to the cue’s programming. Obviously, the computerized system gives the lighting designer much more capability in the number of channels that can be controlled in each cue and the consistency with which cues can be executed.

*Figure 3.3-14 - ETC Ion Xe lighting console with fader wing*

**Address**, **channel**, and **circuit** are terms that are used quite a bit in lighting programming and people will sometimes confuse them, ***but they are not interchangeable***. It's important to understand the distinctions among them, as well as how they relate to one another and the instances in which they overlap.

The **channel** is the first concept to come into play, right from the initial stages of the lighting design. The **channels** are, effectively, the names given by the designer to each lighting instrument or group of lighting instruments. Channels are the way that the designer and everyone else will refer to the lighting units when they work with them in the theater space. Each designer tends to have their own process for channeling lights—for instance, one designer's front lights may always be numbered 1-20, or their side light systems may always be given numbers in the 200s. While the exact numbers may be different from design to design, having a more or less consistent system helps a designer to focus lights and cue a show efficiently, because they know their own channeling system so well that the numbers come easily to their mind when they need certain groups of lighting instruments.

**Addresses,** on the other hand, tell the lighting board/computer where to find the various "attributes" of the lighting units. You can think of addresses as being where the attributes "live." On a simple incandescent fixture, there is really only one attribute to control—the intensity of the light we see—so a simple, incandescent instrument will have only one address. Intelligent lighting instruments—such as LED units or units that can be made to move around/focus under the control of the light board—require more addresses to control all of their possible attributes, such as color, programmable movements, and more.

But this brings us to a concept of more complexity: Addresses can either be tied to a physical source of power in the room, or they can exist purely digitally, within the control system built into the lighting board. (Hold onto that thought—we'll explore it in more depth shortly.)

There's a relationship between **addresses** and **circuits.** Circuits, in this usage, basically refer to wires in the wall. In our spaces, there are groups of circuits spread throughout the space. These are usually in electrical boxes containing either three or six stage-pin receptacles. When you consider any lighting instrument—whether a simple, incandescent unit or an intelligent unit—it's obvious that it will need real-world electrical power to operate. It must, at some point, be plugged into a circuit from which it can receive power. In our spaces, there is a **one-to-one** relationship between the physical circuits and addresses. This means that the number on the receptacle, which is the circuit number, is *also* the address. This is not always the case, but we'll explain that a little more when we cover patching.

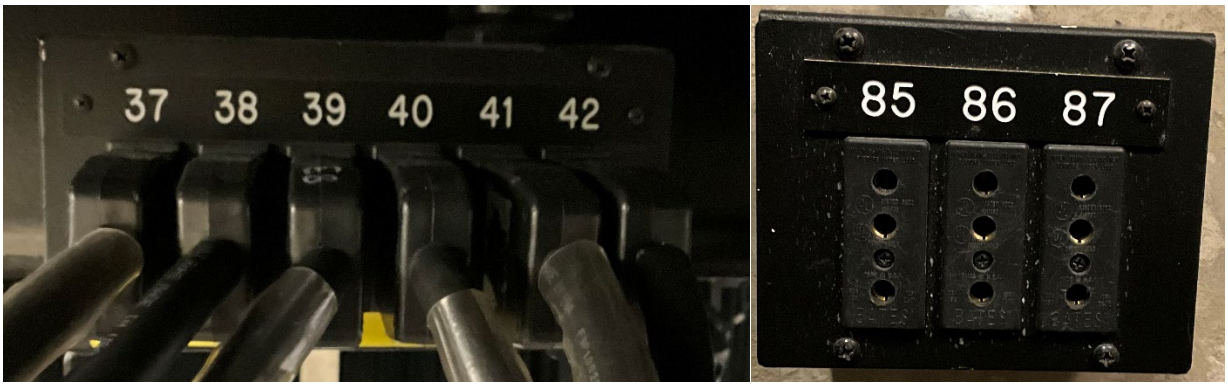



*Figure 3.3-15 – Stage pin receptacles*

As mentioned above, the **channel** is the number we use to talk about specific lighting units (or groups of lighting units that need to work together). Having control of the right instruments with the right channels is crucial for the lighting designer to write cues efficiently. If they want one of the units in their front light system to be at 50% intensity, they might say to the board operator, “Give me channel 3 at fifty.”

But when electricians are hanging the designer’s plot, for a number of reasons, they need to have the freedom to plug the lighting units into the circuit that makes the most sense given the layout of both the circuits in the room and the lighting design. So, if the lighting unit that the designer has designated “channel 3” is closest to the circuit numbered “9,” we need to be able to connect those two numbers via the lighting board, so that the light plugged into circuit 9 can be controlled by telling the light board to bring channel 3 up to fifty percent intensity. And remember that circuit number 9 has a one-to-one relationship with address number 9 in our space.

To bridge the gap between the channel number the designer has chosen, and the circuit/physical address number the electrician needs to use, the solution is **patching**. Patching allows us to relate an address and a channel to each other as fits our need. Continuing our example, let’s say that the front light we need to control on channel 3 is plugged into circuit 9 in our space (which in our system is hardwired to physical address 9). In the patching setup on the board, we’d tell the system that *address 9* is controlled by *channel 3*. This allows us to use the circuits that are most convenient to the physical location of the instruments and still give the lighting designer control of the channels using their personal, preferred channel numbering system.

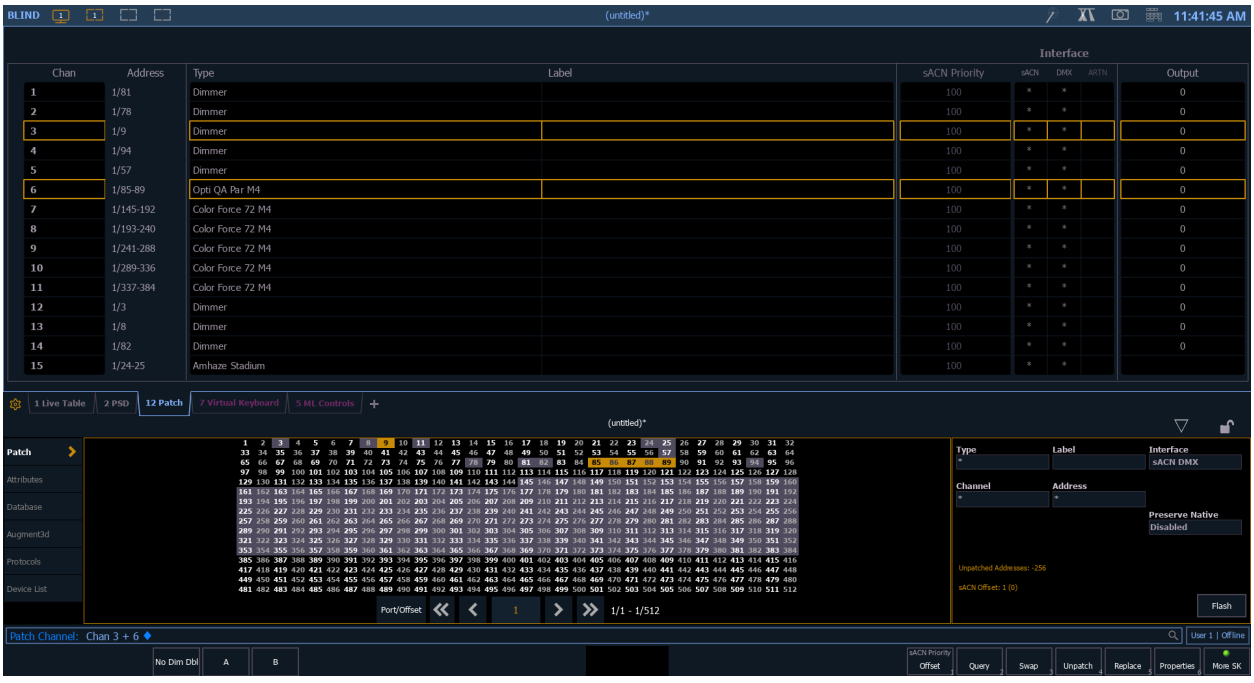



*Figure 3.3-16 - ETC Eos software patching screen*

We use patching to connect the physical circuit/address to the preferred channel number, but we also use it to ensure that all of our intelligent lighting units’ other attributes map to a designer’s preferred channel numbers. Intelligent units require not only physical circuits/addresses to power them, they also require a number of digital addresses to control each of their attributes. For instance, the RGBW LED unit

mentioned earlier would require five digital addresses, one to control each of its four colors and one to control intensity (see channel 6 in Figure 3.3-16). Patching such a unit just requires giving the board a little more information in order to assign those additional digital addresses to the unit correctly and ensure that the board has control of everything, but the concept is essentially the same, whether you're patching a physical address or a digital address to a channel.

There are several different languages or protocols that can be used to control lighting equipment, but the most common protocol is called **DMX-512** (digital multiplex 512). Most people will refer to this simply as DMX control, and it can also be used to control equipment other than lighting equipment. The ins and outs of exactly how DMX-512 works are beyond the scope of this class and text but essentially, DMX is the language by which we're able to give each controllable attribute an address, and then, using the light board, we can send a numerical value to that address that affects that attribute (whether it's intensity, color, movement, etc.).

## Lighting Paperwork

The first and most recognizable piece of paperwork generated for a lighting design in the **light plot**. The light plot is basically a map of where each lighting instrument or element is placed in the space. The largest portion of this drawing is usually presented in a groundplan view, but sections and elevations are also commonly necessary views in the light plot.

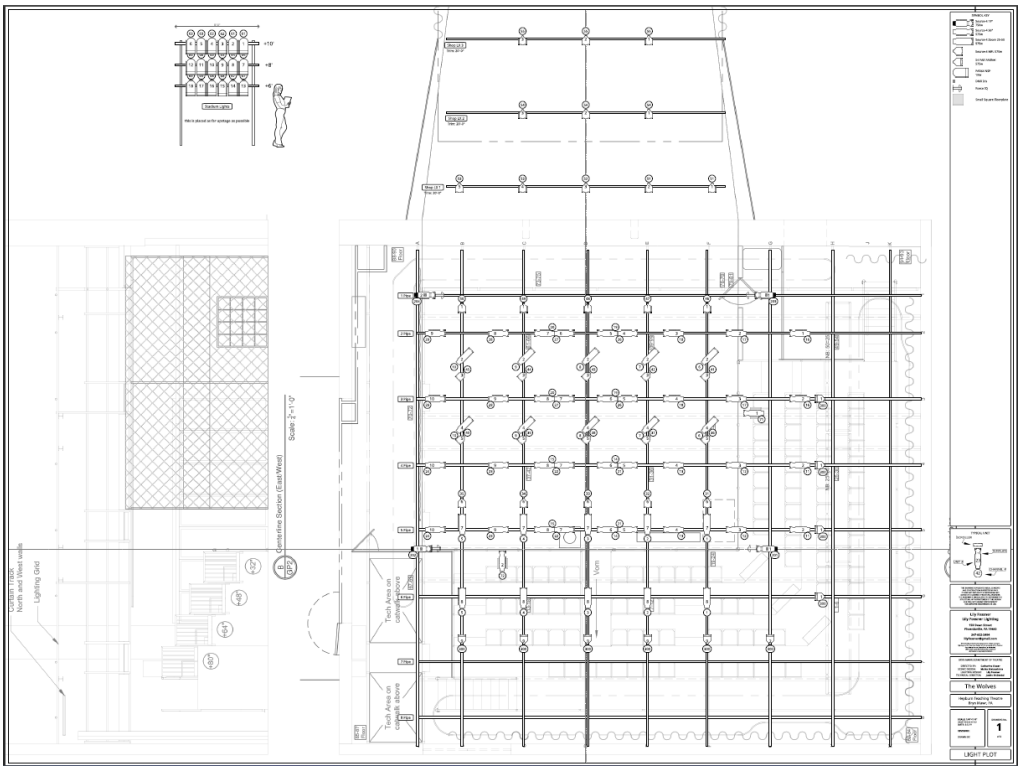



*Figure 3.3-17 - Light plot for* The Wolves *at Bryn Mawr College, courtesy of Lily Fossner*

On the plot, each type of instrument will have a different symbol, allowing the user to quickly identify which instruments should be hung in a given area. In addition to the symbols representing the instruments, information like unit number, channel number, gel color, and other accessory details is typically indicated on the plot. Each lighting plot is different and each designer has their own way of structuring the information. The **symbol key** and an example of how a typical unit is represented on the plot is usually found in the title block of the drawing.

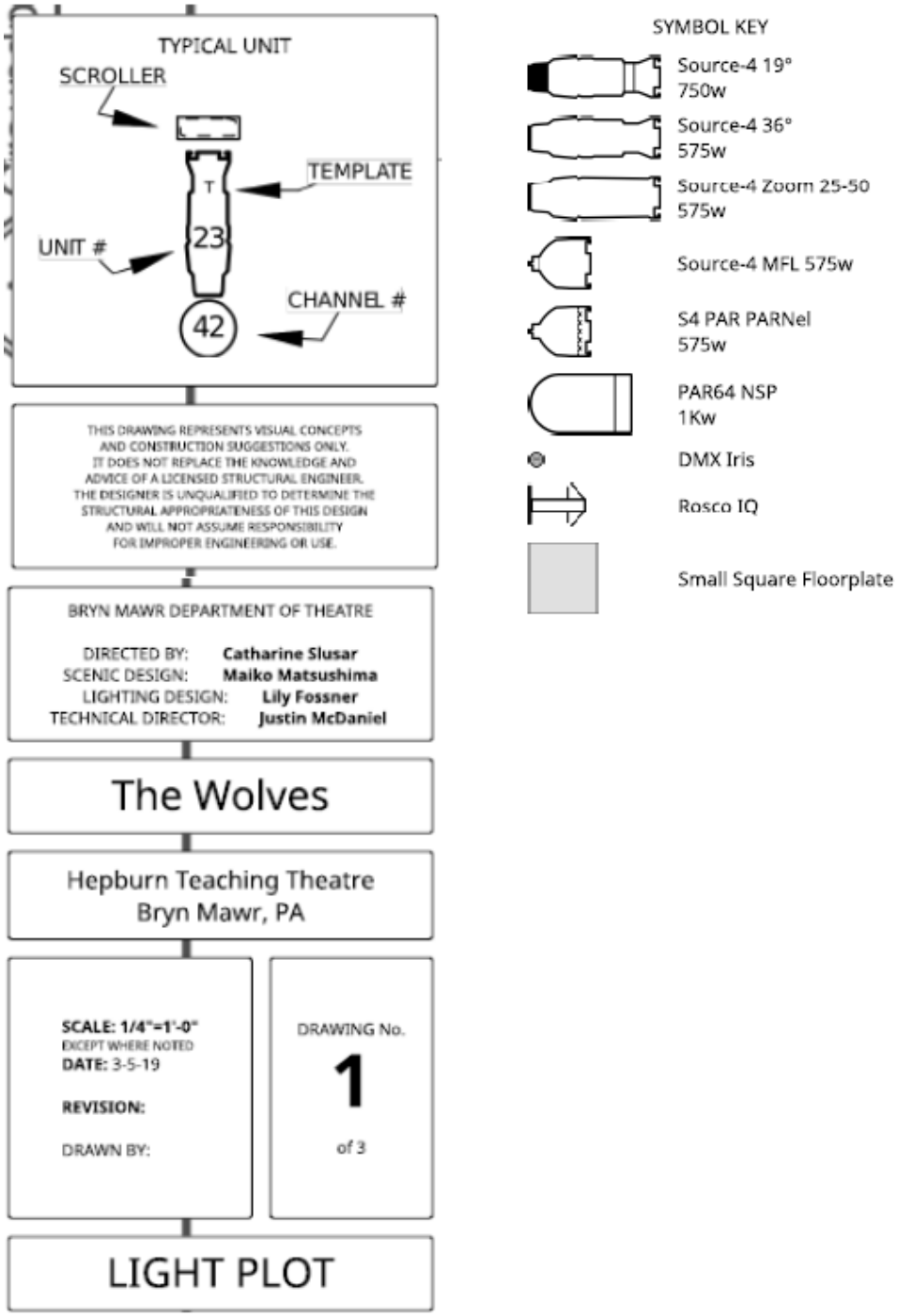



*Figure 3.3-18 - Lighting symbol key and title block, from* The Wolves *at Bryn Mawr College, courtesy of Lily Fossner*

In addition to the plot, there are some other documents that are typically generated as part of the lighting package. There are various lists of the instruments and other elements of the plot that are commonly referred to as **schedules** and are designated for the main element by which they are sorted. For example, a **color schedule** lists all the instruments in the show sorted by what color gel they need. This is a useful document when estimating and pulling gel. Other common schedules are the instrument schedule and pipe schedule, and the **channel hookup**, which is another list, this time sorted by channel and including all sorts of useful information about the instruments, including where they are circuited, making patching an easier task.

## Tools

The single most ubiquitous lighting tool is the **adjustable wrench**. Also, commonly known as a Crescent wrench or simply a C-wrench, which comes from the popularization of the tool by the Crescent Tool Company.

*Figure 3.3-19 - Adjustable wrenches in 10", 8", and Amy--I mean--6" sizes. 6" with a safety lanyard for working at height*

Adjustable wrenches come in a wide variety of sizes, but for lighting the most common size is 8" although 6" wrenches are more pocket-friendly for many and the newer models have larger jaws that now enable these smaller wrenches to expand to fit the larger ½" bolts on the instruments.

There is a smattering of other lighting specific wrenches that have come to the market over the years, but few have found wide-spread usage, and none have unseated the tried-and-true adjustable wrench as the primary lighting tool. The one lighting specific wrench that has found a bit of a foothold in the industry is what's known as a lightspeed wrench. This tool is a speed wrench (a fixed size ratcheting wrench) that has the sizes necessary to hang and focus most lighting instruments. This eliminates the need to adjust your wrench and adds the convenience of a ratcheting tool.

*Figure 3.3-20 - Lighting specific wrenches. Counter-clockwise from top, Mega Handle, Lighting wrench--manufacturer unknown, Altman wrench, LightSpeed Wrench*

In terms of unit maintenance and troubleshooting there are a few lighting specific tools that you're likely to run into in addition to the typical screwdrivers, wire strippers, and meters that are used for general electrical work. A couple of the most common are the **pin splitter** and the **GAM check**. The pin splitter is a tool that cleans and spreads the pins of a stage pin connector, making it fit more securely into the outlet or mating plug. The GAM check is an electrical tester made by GAM Products, Inc. that enables one to test cables and incandescent lamps for continuity, and live stage pin circuits for faults.

*Figure 1 - GAM Check (left), Pin Splitter II (right) from ToolsforStagecraft.com https://www.toolsforstagecraft.com/product154.html*

There are also a variety of other testing tools for lamps, cables, DMX circuits, and radio frequencies that one may come across in the lighting industry, but the pin splitter and GAM check are the tools you're most likely to come across here.