An Introduction to TECHNICAL THEATRE

by Tal Sanders
An Introduction to Technical Theatre
Here is a list of the most common fixtures, or luminaires, in use today.

**Hard-edged or profile fixtures**: These fixtures produce a sharply defined beam of light.

**Ellipsoidal reflector spotlights** (Also referred to as ERS or Leko): These hard-edged fixtures are the traditional workhorses of theatrical lighting. They produce a narrow beam of light that can be effectively transmitted over long distances. The older units use a two-lens system and an elliptically shaped reflector to collect and concentrate the light. The reflector captures all the light emitted by the lamp and reflects it toward the two lenses. The first of these two plano-convex lenses (flat-planed on one side and convex on the other) gathers the light from its flat surface and concentrates (refracts) it toward its center as the beam passes through the convex shape of the lens. The second lens takes the now concentrated light and spreads it out over the flat surface as it leaves the fixture. Between the two lenses where the light has been concentrated, a set of shutters, a series of flat metal flags, can be used to block or limit a beam of light. This allows the light to be shaped and prevents objects that should not be seen from being illuminated. The slot between lenses also allows us to insert a template image. A template is a cut-out image through which the light passes to project that image over an area or surface. Templates, also known as gobo, come in an infinite variety of shapes, and modern gobos can either be a laser cut metal plate or a full-color image printed on glass. A template can be used to create texture in light or to project a graphic image. As the light passing through two lenses, the image turns both upside down and backwards, so the shutters operate on the opposite side of the instrument from the projected light. Also, the template pattern needs to be inserted both upside down and backwards in order to project correctly.
Ellipsoidal reflector spotlights have been around for many years, and theatres may have an inventory of older units. They may be mounted axially, when the lamp enters directly through the rear of the reflector, and radially, when the lamp enters the reflector at a downward angle. Recent advances in these fixtures have made them more efficient and given them greater clarity. Better design, improved materials for the reflectors and lenses, more efficient lamps, and improvements in the user interface (the ability to move or "zoom" the lens or lenses), have vastly improved the latest fixtures. Most ellipsoidal reflector spotlights are still incandescent lamps of high wattage, though LED fixtures are improving in this market and will eventually become common.
When using an ERS, it is important for designers to consider both the instrument’s **beam angle** and its **field angle**. The beam angle refers to the area within the cone of light where the strength of the beam is no less than 50% of the brightest area it produces. The field angle is the outer ring of the cone wherein the brightness dips below 50%. Designers often plot equipment so field angles overlap between instruments to make up for the brightness lost at the edges of the beams.
**Soft-edged or wash fixtures:** These fixtures produce a diffused light.

**Fresnel:** A Fresnel can be recognized by the concentric circular pattern on its lens. This “step lens” is similar to the plano-convex lens, but rather than a thick convex face, the shape has been cut-away to create steps that maintain the curve without the thickness. The back of the lens is textured to further diffuse the source. This lens was originally invented for use in lighthouses. They produce a relatively even field of soft light. A Fresnel is equipped with an adjustable track that allows the lamp source and reflector to be moved closer to and away from the lens, thereby changing the size of the projected cone of light from **spot to flood.** Though these fixtures do not have the ability to use shutters to shape their light output, adding a **barn door** to the instrument allows the flaps of the barn door to block the light as it leaves the fixture.

*A cut-away view of a Fresnel*
Parabolic aluminized reflector (PAR): A PAR light uses a parabolic shaped reflector to capture the source light and redirect it toward the stage. The instrument itself is merely a housing for the lamp and reflector, which come as one solid unit much like a headlight from a car. PAR cans, as they are commonly known, produce a light shape that is elliptical rather than round. Lamps are available with varying widths of spread from very narrow to narrow to medium and wide spreads. A workhorse of rock tours, these lights are durable and very quick to focus as only the angle of the fixture and the position of the lamp inside it must be adjusted. PAR lamps are sized by measuring in $1/8''$ segments across the glass face. Sizes range from a PAR16, which is 2” across to PAR64, which is 8” across.
Striplight or borderlight: These units are long multi-lamp fixtures made to create a smooth wash of light for backdrops and cycloramas. Most often manufactured in three- or four-circuit styles, they allow for a pre-spaced series of cells to work together to create an even field of colored light projected onto a backdrop or stage area. These incandescent fixtures are now being replaced by LED versions that are more economical, heat-free, and capable of mixing an infinite variety of colors.
Cyc. light (Cyclorama light): These soft-edged fixtures are meant to light a very large area. They are calibrated to cast their light evenly across a field and hung close to the top of the projection plane. Their asymmetrical reflectors are engineered to cast more of their light toward the bottom of that vertical plane to keep the field more even. These units can be single-cell or multi-cell lights. Like strip lights, cyc. lights are also moving to LED technology for advanced color control.

A multi-cell cyc. light
Incandescent cyc. lights are connected through electrical cables to a **dimmer** unit that allows the electrical flow to their lamps to be reduced so the lights can be dimmed much like the dimmers on your household lights. Theatrical dimmers carry larger loads of current. Most of today’s theatrical dimmers are SCR (silicon control rectifier) units and, on average, control about 2,400 watts per dimmer (often abbreviated as 2.4K), although wattage varies, and each unit should be checked for its capacity. Each dimmer has an address much like a street address, that the control console uses to control the voltage the dimmer sends to each fixture. In some theatres, the dimmers are located backstage or in the basement, and miles of cables run out from there to all of the lighting positions of the theatre. In this type of configuration, the cables from the dimmers that appear on the electrics and through raceways to other positions end in numbered **circuits** to which the instruments are connected. These theatres usually also employ a **patch panel**. The patch panel allows for an interface wherein the dimmers and circuits can be connected in any configuration necessary so long as the dimmer’s capacity is not exceeded. Some modern theatres are wired as **dimmer per circuit**, meaning no patch panel is necessary as each circuit is permanently connected to its own dimmer. Still another dimmer system hangs small dimmer units directly on the electrics and connects them to their power feed cables at those locations. The advantage to a central bank of dimmers is that the dimmers can be noisy while operating and the central bank can be located away from the stage area where the noise will not disrupt the production.

A number of styles and sizes of electrical connectors are common to the theatre. If your show is loading in to a theatre and your equipment is meant to connect with that owned by the theatre, you need to know what style of connectors they use. If the two styles do not match, adapter cables are required to mate the equipment. These adaptors are generally available to rent when needed. Common connectors include **twist-lock**, **stage-pin**, and **standard grounded Edison** (PBG) connectors.

![Edison connector, Twist-lock connector, and Stage pin connector](image)

The dimmers are controlled by an electronic signal sent to each individual dimmer address from the lighting control console. A low-voltage electronic protocol language is used to achieve this communication. The **DMX512** (digital multiplexing for 512 channels) signal can simultaneously control 512 separate addresses.
Lighting system path

The lighting control board uses control channels to interface with the operator. These channels can be arbitrarily connected to the dimmer addresses (soft-patching), so the interface at the board remains flexible. This is important because it allows the designer to organize the hundreds of control channels into a logical system, making it easier to find the channels for the individual instruments or attributes they are trying to control.
LED fixtures

LED fixtures do not need to be connected to a dimmer because their diodes can be dimmed internally. Therefore, less equipment is needed when they are used. However, modern fixtures, including LED fixtures, do have a variety of functions or attributes that can be controlled remotely by the lighting control console. Each function typically requires a separate DMX address from the board, so a single fixture could consume as many as 20 control channels. If you run above the 512 allowed channels in your DMX communication, you need to add a second DMX universe, which adds an additional 512 control channels. It is not unusual for large shows to run two or three DMX universes, though the lighting control console must be capable of controlling multiple universes.
There’s More to Know

Modern lighting control consoles are designed to allow a programmer working with smart lighting equipment, such as moving lights or LED color controlled equipment, to interface with the attributes of that equipment, like panning, tilting, or color changing graphically rather than by entering the information as % in individual DMX control addresses. This allows for more intuitive programming of these multiple addressed fixtures. Many consoles recognize these smart fixtures once they are connected via DMX or may offer lists of fixture choices to assign to the console’s attribute controls. Once assigned, all multiple functions of the devices can be programmed from a single graphic interface. This makes the use of multiple LED fixtures and moving light units far simpler for the programmer who otherwise would have to track each change of range for every control channel the fixtures employ.

Moving light units and moving mirror units

Some fixtures are automated and have the ability to rotate, pan/tilt, change color, change size, utilize multiple templates, and strobe. Most moving lights achieve these functions by utilizing a series of motors that move the elements of the fixture. Moving mirror lights motorize only a single mirror onto which the instrument’s beam is focused, allowing the light to be reflected around the stage.

A moving light
Safety for a stage electrician

Keeping safe in this environment of temporary installations requires knowledge of the equipment and its limitations and a significant amount of personal focus and discipline. Safety involves using the correct electrical connections, but there are also lifts and ladders that are used to access the equipment.

Ladders must be in good repair and must only be used where all of the ladder’s feet can be placed solidly on a sturdy surface. Freestanding, portable ladders are equipped with a “step” at the top, however that step is not intended for standing. The center of gravity of the individual working on the ladder should not be placed above the ladder’s recommended working height (typically listed on the ladder itself). A good rule of thumb is that your waist should not be above the top step of the ladder.

Powered lifts must be used in accordance with their safety guidelines, and outrigger supports should always be employed where possible. Electricians should empty their pockets of anything that might fall on workers below, and wrenches or other tools should be secured to the user with a fall arrest.

Keeping all electrical cables in good working order is also key to electrical safety as
exposed wires can be a danger. Do not pull on electrical cables or allow the plug to carry the cable’s weight. Connection points should be supported with tie line where appropriate. Never touch exposed wires while they are connected to a power source. Power services, dimmers, and cables all have power limitations that must be considered. If you have ever touched a power cable at home and found that it feels hot, that is a sign you are pulling more power through the cord than it is rated for and have a potentially dangerous situation. When more power is pulled through a cable than it is rated to carry, the cable overheats and may melt through its jacket causing an electrical short and possible fire. A cable rated to carry a larger electrical load may be all that is required to correct the problem.

There’s More to Know

In order to calculate the electrical load carried by an instrument we need to understand some basics of electricity.

In the United States the electricity in our homes and businesses comes to us as alternating current and is typically sent to us at 115 volts. Our cell phones and other devices that run on batteries are fed by direct current and may be of any number of voltages. In either case, a set of formulas allows us to calculate the factors that govern safe use of the electricity. Volts represent a scale of the relative strength of the flow of electricity (from the supplier). Watts represent the amount of electricity needed to do the work (consumed). Amperage (amps) represents the speed and amount of electricity that can be safely transported.

If we know two of these three figures, we can calculate the third using these formulas:

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\text{Wattage} = \text{voltage} \times \text{amperage.} \quad \text{Amperage} = \frac{\text{wattage}}{\text{by volts.}}
\]

Using the first of these formulas we can tell that if we have a circuit rated at 15 amps (perhaps this is the rating of the breaker for this electrical service), we can calculate the wattage by multiplying the standard 115 volts by the allowable 15 amps to get 1,725 watts. This means we can safely connect lamps that add up to that voltage. This load could be three instruments with 575-watt lamps, two instruments with 750-watt lamps, or 17 instruments with 100-watt lamps.

If we want to power three lighting instruments each equipped with a 575-watt lamp (3 x 575=1,725 watts), we can use the second formula to divide the wattage by the standard 115 volts (1,725/115) to tell us we need a cable rated to carry at least 15 amps to safely transport the electricity. This calculation also tells us that any electrical breakers in the system must be rated for at least 15 amps. Cable is rated by gauge, or thickness of the wire, which is usually printed along the cable’s jacket. The gauge of the wire is directly related to the amount of electrical current it can carry safely. Electric current is measured in amps. A cable of made of 14-gauge wire can safely carry 15 amps of electric current.

Calculating electrical loads will keep you and the lighting equipment operating within safe limits.
For Further Exploration
