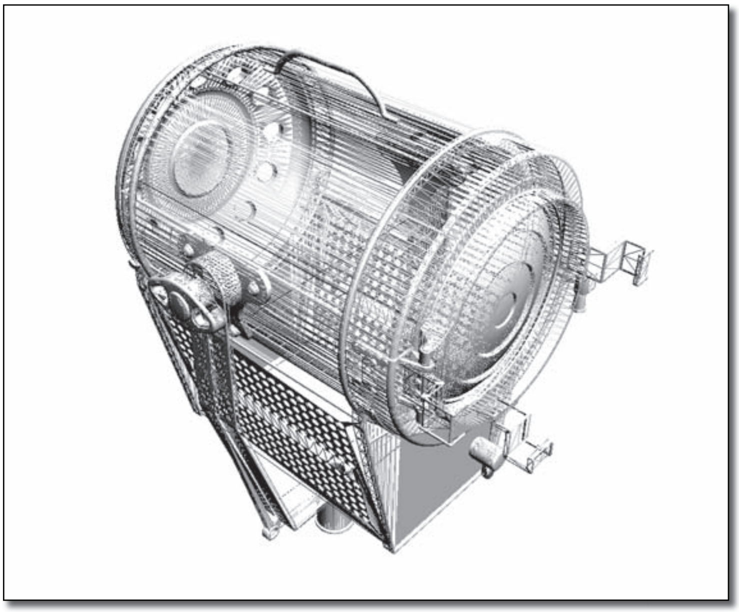

THE HISTORY OF LIGHTING

Lighting is to film what music is to opera.

- C.B. DeMille

Lighting creates the environment for storytelling and we must never forget that, at its heart, filmmaking is telling stories with pictures.

The first lighting for storytelling was fire. For some purposes, it is still nearly perfect. Firelight is warm and glowing, associated in the mind with safety, heat, and protection from nature. It draws people toward it; they automatically arrange themselves into a circle at a comfortable conversational distance. It flickers gently and provides a visual focus that prevents one's attention from wandering. It starts out bright and blazing, then gradually dims as the mood turns inward and eyes grow heavy; it fades away to darkness just about the time the audience is ready to go home. For the hunter returned from the hunt, the village shaman performing a ritual, or an elder recounting the story of the tribe, it was ideal.

As theater became more formalized, with written scripts and larger audiences, daylight performance became the norm: more light was necessary so that everyone could see

FIGURE 1.1 Motivated, dramatic lighting for *The Thread of Destiny* (1910).

clearly. Classical Greek plays were performed at festivals, which ordinarily began at dawn and continued through most of the day. With little emphasis on costumes (other than masks), staging, sets, or effects, the theater subsisted almost entirely on the power of the spoken word. (Some purists feel it's all been downhill from there.) Even up to the time of Shakespeare and the Globe, daylight performances were the standard for the mass market.

Increasingly, though, works were also performed in the houses of nobility and for smaller audiences. These indoor and evening performances were lit with candles and torches, which doubtless had a simple and powerful effect. Staging as we know it today came of age with the great spectacles of Inigo Jones, the seventeenth-century British architect who produced elaborate festival pieces with sumptuous costumes and sets.

Controllable Light

Controllable, directional lighting for the theater is not a new idea. In fact, it dates back to the French chemist Lavoisier, who in 1781 suggested that movable reflectors be added to oil lanterns. With such innovations French theater led the way in lighting during this period, but there was always a division of opinion in European drama between those who wanted simple illumination of the elaborate sets and drops and those who wanted to develop a more theatrical and expressive lighting art.

The first technological advance came with the introduction of gaslight, which was more reliable and less smoky, but only slightly less hazardous. The next advance was the introduction of limelight, which burned natural gas and oxygen in a filament of calcium oxide (limestone). This significant advance, which produced a beautiful warm light that complimented the actors' skin tone, is still commemorated in our everyday language with the phrase, "step into the limelight." At about the same time, this smaller, more concentrated source was combined with simple plano-convex lenses and spherical reflectors to provide the basis for one of the most important elements of modern lighting control: directional and focusable units.

The great theater pioneers Adolphe Appia (1862–1928) and David Belasco (1853–1931) were revolutionary figures in the realm of expressionistic staging. Appia was perhaps the first to argue that shadows were as important as the light, and the first for whom the manipulation of light and shadow was a means of expressing ideas. In opposition to the "naturalism" of the time (which was, in fact, a very artificial broad, flat lighting), Appia created bold expressionist lighting full of *sturm und drang.*

Belasco emphasized realistic effects to underscore the drama. He foreshadowed the private thoughts of many a modern cinematographer when he stated, in 1901, that the actors were secondary to the lighting. His electrician Louis Hartmann is credited by some as inventing the first incandescent spotlight (Appia, Gordon Craig, and Max Reinhardt are also contenders), the forerunner of most of the lights we use today. To counteract the harsh theatrical hardness, Belasco and Hartmann also developed a row of overhead reflected soft lights, which were useful for naturalistic daylight scenes. (To this day there is no such thing as a true soft light in theater lighting.) Laudably, Belasco gave Hartmann credit on the billboards for the shows.

Carbon arcs, which use electrodes to produce an intense flame, were also employed in theatrical applications beginning in 1849. They were widely used, particularly in high-intensity follow spots.

Early Film Production

With the advent of motion pictures in 1888, the earliest emulsions were so slow that nothing but daylight was powerful enough to get a decent exposure. Filmmaking was largely an outdoor activity until Thomas Edison (1847–1931) unveiled his famous “Black Maria.” Built in 1893 by Edison’s associate William K.L. Dickson (co-creator of early motion picture technology), the Black Maria was not only open to the sky but could be rotated on a base to maintain orientation to the sun.

As the motion picture industry developed, early studios in New York City and Ft. Lee, New Jersey, were open to the sky as well, usually with huge skylights. Some control was possible, with muslins stretched under the skylights to provide diffusion of the light and control contrast. Because these were silent films and noise was not an issue, less space was needed in the studios since two or more production units could work within a few feet of each other.

The first artificial sources used in film production were Cooper–Hewitt mercury vapor tubes, which were suspended under the glass roof of the Biograph Studio on 14th Street in New York City around 1905. These were followed soon after by the introduction of arc lamps, which were adaptations of typical street lights of the time. The long-exposure requirements, the lack of adequate equipment, and the still slender economics of the business made anything but flat, overall lighting nearly impossible to attain.

As artificial sources were developed, the controlling factor was the spectral receptivity of the emulsions. Before 1927, black-and-white film was orthochromatic; it was not

FIGURE 1.2 Arc lights in use on an exterior set with rain effects. (Photo courtesy of Mole–Richardson Co.)

sensitive to red light. Tungsten lights were almost useless because of their large component of red.

Another adaptation of contemporary industrial equipment to motion picture use was the introduction in 1912 of white-flame carbon arcs, which had previously been used primarily in photoengraving. As with arcs today, these new units (called broadsides) were characterized by very high output and a spectral curve compatible with orthochromatic film. Carbon-arc spotlights were purchased from theater lighting companies such as Kliegl Brothers of New York (whose name still survives in the term *klieg* lights).

Another legacy of Belasco's illustrious career was carried on by a young man who worked as an actor for him, Cecil B. DeMille. DeMille rebelled against the flat illumination characteristic of the open-to-the-sky film stages. In the film *The Warrens of Virginia*, director DeMille and cameraman Alvin Wyckoff used a startlingly modern concept: they used sunlight reflected through windows as the sole source of light.

At the time, only a few American filmmakers, DeMille, Edwin Porter, and D.W. Griffith's cameraman Billy Bitzer, fought the stylistic preference for broad, flat lighting. Bitzer had used firelight effects in *The Drunkard's Reformation* in 1908, and the next year Pippa Passes evoked the changing time of day with directional lighting simulating the passage of the sun. *The Thread of Destiny* contained scenes lit solely by slanting rays of sunlight and may be the first truly effective use of chiaroscuro (dubbed "Rembrandt" lighting by Wyckoff).

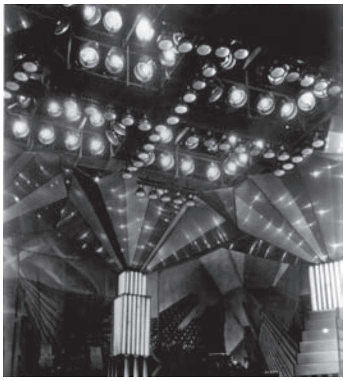

FIGURE 1.3 Early tungsten units in use on the set of *Broadway*. The dome-shaped units were called "rifles" for their ability to project light at a distance. The open-face units were called "Solar Spots". Films were "slow" back then (meaning they needed large amounts of light to get a good exposure). Lenses were also slow; the result was that sets had to be lit to a very high lighting level. (Photo courtesy of Mole–Richardson Co.)

Introduction of Tungsten Lighting

For years, cameramen looked longingly at the compact, versatile tungsten lamps that were then available (called Mazda lamps at the time), but attempts to use them were foiled by the spectral sensitivity of the film stocks in use at the time; they were almost completely blind to red light—even slightly red objects would photograph as black. The tungsten incandescent bulbs were (as they are today) heavily weighted in the red end of the spectrum.

In 1927, the introduction of a film stock sensitive to all visible wavelengths (hence its name, *panchromatic*) altered lighting capabilities radically. The new stock was compatible with tungsten incandescent sources, which offered many advantages, including reduced cost. *Broadway*, produced in 1929 by Universal and shot by Hal Mohr, was the first film lit entirely with tungsten.

Studio management saw in the new technology an economical means by which set lighting could be accomplished by the push of a button. The "bean counters" in the head office (they had them even then) responded enthusiastically to the economics of incandescent lighting, so much so that in some studios the use of arc lighting was banned except by special permission. With sound technology confining the cameras to immobile sound-proof "ice boxes" and the resulting lack of the powerful arcs to create strong effects, together with very static camera work, the outcome was many a visually dull picture and one of the low points of studio cinematography.

(a)

(b)

FIGURE 1.4 (**a**) Before the invention of halogen bulbs, a typical large tungsten lamp (in this case a 5K bulb in a Mole Skypan) was enormous. (Photo courtesy of Mole–Richardson Co.)
(**b**) Tungsten halogen bulbs allowed the invention of "baby" units—much more compact than the normal units. Shown here is a Mole "Baby-Baby"—a "baby" size 1000-watt light, which is commonly called a baby light.

The makers of carbon arcs responded to this challenge by developing carbons that were compatible with panchromatic film. Even with the new carbons, arcs remained (as they do to this day) more labor-intensive and bulky. The death blow was dealt by the advent of HMIs, which are more efficient in their use of power and don't require a dedicated operator.

The drawback of incandescent lights was (and still is) that they are inherently far less powerful than carbon arcs. The need to achieve maximum output from the incandescent lamps resulted in the introduction of an improved reflector made of highly polished, mirrored glass. Lights based on this technology were sometimes called rifles, for their capacity to project sharp beams long distances. They were efficient but hard to control; they were hardly more than a raw source of light. What cinematographers yearned for was a light of even greater intensity, but with controllable beam spread and distribution. In 1934, the introduction of the fresnel lens led to the development of lighting units that are almost indistinguishable from those we use today.

Following the introduction of three-strip Technicolor with the film *Becky Sharp* in 1935, arcs came back into favor. Technicolor required a spectral distribution close to that of natural daylight, which made tungsten lighting difficult. In the intervening years, manufacturers had managed to make arcs quieter and so white-flame carbons, which produce daylight blue with very high output, were just the ticket for the new process. The addition of the fresnel lens also made them more controllable.

This was the heyday of the carbon arc. Not only did they have the correct color balance, but the fact that Technicolor is a process where the image formed by the lens is split by prisms into three different film strips meant that enormous quantities of light were needed. Some early Technicolor films were lit to such intensity that piano lids warped and child performers (most notably Shirley Temple) were barely able to withstand the heat on the set.

To use tungsten lights with color, it was necessary to lose almost half of the light to filtration, so their use on color sets was very limited; they still found wide use in black-and-white filmmaking and later in television.

The Technicolor Era

As with the advent of sound, Technicolor imposed severe restrictions on cinematographers. Until color came along, the use of light meters was almost unknown: cameramen used film tests, experience, and guesswork to establish exposure. The precise engineering needs of the three-strip process made it necessary to impose rigid standards. In the early days, cameramen were not trusted to handle the job alone. The licensing of the Technicolor process carried with it the obligation to employ one of Technicolor's advisory cameramen to oversee color balance and exposure. Films of this period are distinguished by having two cameramen listed in the credits.

The constant supervision of the Technicolor cameramen, along with the employment of color advisors, gave rise to the still current myth of the "Technicolor look." Contrary to popular belief, the Technicolor process and the film stock then available did not necessarily lead to bright, intense color completely lacking in subtlety. What we think of as the Technicolor look is in fact a reflection of the desire to show off the new technology, coupled with the somewhat primitive artistic tastes of the studio chiefs of the period. Since the process gave engineers and advisors as much input into the look of the film as the cameramen and directors, the dictates of the head office could be implemented in an orderly, bureaucratic way, thereby bypassing the age-old film tradition according to which directors and cameramen would agree to ridiculous demands in the conference room, then follow the dictates of conscience and art while on the set.

The pendulum swung back to tungsten with the introduction of high-speed Technicolor film balanced for incandescent light in 1951. Other companies such as Kodak and Ansco also made tungsten-balance films available. This established the standard that now prevails: color films balanced for tungsten light but usable in daylight with filtration. Only recently have Kodak and Fuji introduced excellent lines of daylight balance negative films. In 1955, yellow-flame carbons (tungsten balance) were invented, which made arcs usable with the new tungsten-balanced films without the use of color correction.

One major obstacle remained for incandescent lamps: the vaporized tungsten metal that burned off the filament tended to condense on the relatively cooler glass envelope of the bulb. As a result, the output of the lamp steadily decreased as the lamp burned; in addition, the color balance shifted as the bulb blackened.

A far more practical solution was the invention of the tungsten–halogen bulb in the early 1960s. Employing a gas cycle to return the boiled-off metal to the filament, the design resulted in lamps with longer life spans and more efficient output. Another advantage of the smaller quartz lamps is their capacity to fit into smaller housings than could a conventional tungsten incandescent. The result has been more compact lights (baby babies, baby deuces) and smaller lights, such as the popular Tweenie 650-watt size.

(a)

(b)

(c)

FIGURE 1.5 (**a**) Kino Flo color-correct fluorescent lamps on a set. (Photo courtesy of Kino Flo, Inc.) (**b**) Mole–Richardson 12K fresnel HMI. (**c**) LED panel lights mounted on a camera. (Photos courtesy of Lite Panels, Inc.)

HMI, Xenon, Fluorescent, and LED Sources

A revolution in lighting came in the late 1960s when enclosed metal arcs (HMIs) were developed for German television. Their main features are the tremendous advantage in lumens-per-watt output over conventional sources and the fact that they are daylight–color-balanced without the need for filtration.

HMIs have changed the lighting business by allowing more powerful sources with less electrical input, which translates into smaller generators and smaller cables. The largest sources (12K and 18K) have output that equals and exceeds the output of the power-hungry carbon arcs, but don't require direct current (DC) or a full-time operator.

Although these stable, efficient sources were originally developed for television, filmmakers were quick to recognize their advantages. When the first film was shot using the new lights, everyone was horrified when the exposure varied constantly. Research quickly revealed the cause of the notorious flicker effect: HMIs are arc sources just like the old Brutes, but while Brutes were DC, HMIs are alternating current (AC). The light output varies as the AC cycle goes up and down; as a result, the output of the light varies as well.

With a few exceptions (such as using PAL equipment in a NTSC country or running the lights off of a noncrystal sync generator), in video this is no problem, since both are synchronized to the same AC cycle. In film, however, there are many conditions in which the two are not synchronized. We now know the conditions that must be met for HMIs to be used successfully, but the problem has added new considerations to filming and imposed limitations on many types of filming, particularly high-speed photography and working with live monitors.

Meanwhile, 1982's *Blade Runner*, with its stunning cinematography by Jordan Cronenweth, popularized a new player—xenons. A gas-discharge arc, the xenon is a cousin to the HMI and big brother to the xenon gas projector lamps used in theaters. A highly efficient source coupled with a polished parabolic reflector gives xenon the capability of extraordinary output in an extremely narrow, focused beam. Although very specific in application, xenon has proved a useful and powerful tool for the image maker.

The development of flicker-free HMIs that feature electronic rather than magnetic ballasts eliminated most of the technical problems involved in using HMIs in off-speed filming. One drawback is that in flicker-free mode, some units emit a loud hum, which may be objectionable to the sound department.

Kino Flo and LED

Other developments include the creation of fluorescent tubes with color rendition good enough for color filming applications. Pioneered by Kino Flo, color-corrected, high-frequency fluorescent sources (to eliminate flicker problems) have been extremely popular in all types of applications.

A more recent development is LED panel lights, which are extremely compact and can be made very small; they have become very popular for applications such as car interiors and when it is important to hide lighting units throughout the set.

Today's image maker has a wide variety of powerful and flexible tools available for lighting in film and video. The history of lighting is the story of adapting new technology and new techniques to the demands of art and visual storytelling. The same concerns still face us every day on the set, and we can draw on the rich experience of those who have gone before us.