



Artificial Lighting Types and Applications

An Online Continuing Education Course for Engineers

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Artificial Lighting Types and Applications

Robert J. Scoff, PE

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1. Introduction

A study of artificial lighting must begin with fire, perhaps the most significant advance that the human race has ever developed. Before humans started using fire for heat and light, the livable world was a very dark world. Technology has progressed from simple fires for heat and light through torches, candles, whale oil, kerosene, and natural gas, to modern sources of light, including incandescent light to modern electronic sources of light, including LEDs. Most, if not all, of these sources, not only produced light but heat. The efficiency of our modern light sources has improved significantly over time, from fire to candles to ultra-bright LEDs. This course covers many of the light sources, and inevitably it is necessary to cover the heat generated by these light sources. The efficiency of converting heat to light will also be considered. Figure 4.2 covers the efficiency of many light sources. A good starting point is the practice of producing light from burning wood.

2. Light from Burning Wood and Other Organic Materials

It's hard to say when humans started burning wood as a source of heat and light. The heat was probably most important back then, before written language, as known today, was developed. Of course, pictures were drawn that are often found today decorating the walls of ancient caves. Figure 2.1 is one of the oldest paintings ever discovered. The oldest known figurative painting, a depiction of a bull, was discovered in the Lubang Jeriji Saléh cave dated as over 40,000 (perhaps as old as 52,000) years old. If it was painted in a cave, some source of light would have been necessary. Throughout history, and even up to the present time, primitive cultures painted the walls of caves with various depictions of animals and humans. One of the most common types of paintings are paintings of human hands. Or, the paintings might be pre-human hands. One of the possible explanations for the paintings of hands is a means of identifying various members of the tribe.



Figure 2.1 Oldest Known Art Found in a Cave

http://www.kalimanthrope.com/images_zoom/zoom_ilas-kenceng_bovides.html, Public Domain,
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By Unknown, but considering this painting is dated 40 000 YBP, and there are not any scriptures in the chamber, it is not likely that the author's name will be discovered.

Figure 2.2 shows some pictures of hands found in caves. The pictures imply that the people making the pictures had to see what was being painted. It looks as if a person put their hand on a cave wall, and then splashing some pigment on the hand to show the handprint. They may well have spit the color pigment on their hands as they held them against the wall. This would alleviate the need for brushes.



Cueva de las Manos located Perito Moreno, Argentina.
The art in the cave is dated between 13,000–9,000 BP



Caves in the district of Maros (Sulawesi, Indonesia). Hand
stencils estimated between 35,000–40,000 BP

Figure 2.2 Pictures of Hands Found in Caves

The lighting source used for the artwork can only be surmised. It could have been an open fire or a torch. The torch could have been a stick found in the woods, or made from natural materials that would burn. It is likely that the torches had a relatively short useful lifetime and a very low efficiency. Of course, the ingenuity of the human race might have found ways to make the lighting source burn brighter and longer. Animal fat or some other naturally occurring hydrocarbon could have been used. There are numerous examples of cave art found all around the world. Since caves offered protection from the elements of nature, caves were quite often used as places to live. And, if people lived there, they figured out how to be as comfortable as possible under the circumstances. So, we can say with a great deal of certainty that early humans used fire to heat and light their caves. It is said that the most common predictor of a long life is having a dry and warm place to sleep. The ancients probably knew this and found warm, dry places to live and sleep. Or, maybe they were just trying to be comfortable. Torches and open fires provided these luxuries. Primitive tribes were discovered as late as the 1920s that still painted on the walls of caves. The anthropologist Ivor Hugh Norman Evans visited Malaysia in the early 1920s and found that some of the tribes (especially Negritos) were still producing cave paintings and had added depictions of modern objects, including what are believed to be cars. There is also a story written by Marlo Morgan, about the aborigines of Australia. His book *Mutant Message from Down Under* focuses on a cave that was being used as late as 1990 to depict the history of the aborigine race in Australia. The number of stories and legends concerning caves being used as living places and canvases for paintings is too numerous and prevalent to be fabricated. Given this, fire must have been used to illuminate the caves, and this is especially true in caves with no openings to the lighted world. The ancients would have needed a source of artificial light to enter the caves where these paintings are located, and fire is the logical source. Fortunately, we have flashlights, but this period of history is far before modern lighting sources were developed. The efficiency of converting burning materials into light was probably very low. Figure 4.2 shows the efficiency of various light sources. Very little is known about finding the efficiency of burning hydrocarbons to generate light. Today, we have much better ways of generating light. The stated efficiencies are educated guesses or results of statistical analyses. In any case, early light sources probably had low efficiencies in turning burning material into light.

3. Light from Candles

A big improvement over open fires and/or torches was the invention and use of candles, which could be called the first dependable source of artificial lighting. Candles can burn for long periods of time at a dependable light output. Egyptians made candles from beeswax as early as 3000 BC. Other materials were used to make candles, including the oil from a gland in sperm whales. And, as strange as it seems, the basic definition of the light emitted from a source originally had to do with the light emitted by burning a certain type of candle. This would make determining the strength of a light source a very subjective matter. Not only do the various types of candles give off variable amounts of light, but one human observer could perceive the lighted candle differently from another observer. Figure 3.1 shows pictures of various types of candles burning. This potential variance makes the calibration of light sources somewhat difficult. The efficiency of burning candles to produce light is also very low. It seems that burning anything to produce light produces a lot more heat than light. Many modern sources of light also produce more heat than light.



Figure 3.1 Pictures of Various Burning Candles

The light emitted by any particular candle probably varies with the candle, the wick of the candle, the material of the candle, and the conditions near the burning candle. A slight breeze could make a big difference. The different outputs stemming from the varied elements of individual candles will be covered in the discussion of Lumens, the unit of light intensity used to determine how bright a light source is, and the resultant brightness of the surface that is being illuminated. A unit of light called a candela (Latin for Candle) is also used to determine the brightness of a light source. Studying the source of the brightness of a light source and the method used to measure light intensity are very subjective processes. Fortunately, our scientific method has determined ways to quantify light intensity.

Before the advent of solid state devices, a non-thermionic vacuum tube (or valve) device called a phototube was used to detect light. These vacuum tubes operated because light hitting the surface of an interior plate caused the plate to emit electrons that were collected by another element in the tube and caused a low current to flow. One of the original uses of these tubes was to pick up the sound level from movie tapes on a special track on the tape. This was state of the art before magnetic tapes, and solid state light detection devices were developed. The frequency response of these devices was somewhat different from the frequency response of the human eye.

Efficiency is also an important factor in burning organic material. Lumens. Because of the variability of a thing as a typical fire), is measured at a certain distance from a source to determine its light intensity.

lighting. The efficiency of a light source is measured in units of lumens per watt. The intensity of a typical fire (if there is such a thing) can always be measured, but it is not too close to a fire just to be possible but easy to do.

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4. What is a Lumen

A lumen is “a unit of luminous flux, the amount of light given out through a solid angle of one steradian in all directions.” Originally, a real candle was used to define a Lumen. The subjectivity of the candle as a light source and an approximation is the b

...equal to the amount of light given out equally in all directions from a point light source for defining a Lumen. The subjectivity of the candle as a light source to determine what a real Lumen is, is a problem. This definition also relies on another unit of