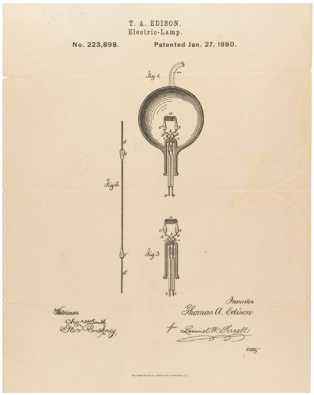
EVOLUTION OF LIGHTING

SECTION OBJECTIVES

1. Lighting Evolution
2. Introduction to LED Lighting
3. The Future of LEDs
4. LED Lifetime Systems
5. Systems Approach

1. Lighting Evolution

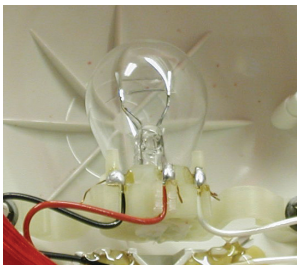
In 1879, Thomas Edison formally filed a patent request for his light bulb invention, a rudimentary bulb that utilized a carbonized bamboo filter that could last around 1200 hours. This invention paved the way for universal domestic use of electric light. Amazingly, for nearly 75 years after Edison's patent, there was very little technological change in incandescent lighting. There were minor improvements to the filament and support posts material, but the general design remained the same, which meant, for nearly 75 years bulbs were extremely susceptible to corrosion and vibration damage.


T. A. EDISON.
Electric-Lamp.
No. 223,898. Patented Jan. 27, 1880.
Fig. 1
Fig. 2
Fig. 3
Witnesses
Inventor
Thomas A. Edison
by Lemuel W. Serrell
atty

In 1955, two men, George Baldwin and Henry Grosser, provided a solution to the trucking industry with the very first sealed marker lamp. The idea of mounting a base-less bulb in a resilient compound and sealing it in the lamp allowed the light to have a longer lifespan — 10 to

15 times that of a conventional unsealed (bulb replaceable) light. And, just like that, Truck-Lite was born.

Not long after the first sealed marker lamp, lighting was taken in a vastly different direction when Nick Holonyak took lighting in a dynamic new direction. While working at General Electric in 1962, he developed the first practical visible spectrum (red) light-emitting diode (LED). It would take several years and numerous improvements before LEDs made their way into the commercial vehicle industry, but in 1991, Truck-Lite released the first LED stop lamp to the market, as an alternative light source to the traditional incandescent bulb replaceable and sealed lamps.



Truck-Lite currently offers three types of lighting: incandescent, sealed, and LED lighting.

Incandescent Lighting
An incandescent bulb is generally inexpensive. However, a bulb has many disadvantages.

The most significant disadvantages include:
-Limited life (less than 10,000 hrs.)
-Uses a fragile filament (susceptible to breakage during shock & vibration)

Some lighting manufacturers put bulbs in shock mounts to protect them from vibration, but even the best bulb will burn out or suffer a broken filament within three years. Incandescent lamps operate through the excitement of tungsten filaments that, when seeded in sealed glass housing, will provide light output. Truck-Lite has found that in the original 2-inch round and 4-inch round lighting applications, damage was most often found to have occurred due to bulb damage.

Sealed Lighting
While Truck-Lite manufactures lamps with shock-mounted systems (a method of attaching the bulb to the lamp in a suspended vibration-resistant device), not all lamp failure is a result of vibration. It was Truck-Lite's first development of the sealed lamp that began to tackle the problem of bulb failure.

Years ago, bulb replaceable lamps generally had poor lens gasketing, and often had drain holes. The drain holes allowed water into the lamp, which caused corrosion of the bulb socket and electrical contacts. Cold water could come in contact with the hot glass of the bulb, which would cause the bulb to crack. This led to a slow leak of air into the bulb, which caused failure. The filament would oxidize and produce a cloudy coating on the inside of the bulb. This dramatically reduced the bulb's light output and reduced the life to a few hours at most. If a crack was severe, failure could happen immediately.

Truck-Lite's work to prevent damage to the bulb resulted in the advent of the sealed lamp. Creating a lamp that allowed no way for chemicals or liquids to enter the lamp housing greatly decreased the possibility of damage.

2. Introduction to LED Lighting

Since they were first studied in 1988 for possible use in heavy-duty lighting applications, LEDs have become the new standard for long life, and low-current draw lighting.

LEDs are a monochromatic light source, meaning, each LED produces exactly one color. The core technology is a crystal growth onto a given medium—sometimes a silicone material, which is also used as the base for computer chips. When you expose this medium to a

combination of materials and run electricity through it, it lights up.

Even in the early days of LED use, their benefits were clear. LEDs appear brighter, with a more vibrant color. They also have a lower current draw.

In the late 1990s, Truck-Lite began to investigate the possibility of white LEDs. Because an LED diode is monochromatic, producing white—which is really a combination of the colors red, green, and blue—is very difficult. The problem was solved by creating a combination of RGB diodes that were packaged together. This final package emitted a white light.

Now, we know that there are many ways to produce white light with LEDs. The most efficient way is to use a blue LED chip and expose it to phosphor, which reacts and releases photons that fill up the rest of the color spectrum. Even now, significant improvements are being made in blue LED technology, which in turn improves white lighting technology.

In the mid-2000s, Truck-Lite was approached by the United States military, who asked for the development of white LED technology for headlights in the military market. Due to the extreme environments that military vehicles operate in, the filaments of traditional halogen bulbs easily break. With that in mind, it was important to provide a more reliable LED alternative as soon as possible. In 2007, Truck-Lite launched the world's first LED headlamp.

The next phase was to introduce military-grade LED technology to the commercial vehicle market, which was done with the 7-inch round and 5x7-inch headlights. Fleets who were already beginning the transition into custom halogen headlamps realized that there was an opportunity for life of the vehicle head lighting that offered longer life, lower current draw, better illumination, and the accompanying safety benefits.

THE BENEFITS OF LED LIGHTING

SAFETY

- Increases vehicle conspicuity with intense displays of light output
- Instantaneous response time, 200 milliseconds faster than that of incandescent lamps, creating 18 feet of additional stopping distance for trailing vehicles at highway speeds
- Low power consumption increases the length of time disabled vehicles can operate their 4-way flashers

ENERGY EFFICIENCY

- 85% reduction of load on electrical systems allows more power for other vehicle applications
- Minimizes voltage drop and reduces load on alternators, flashers and switches

RELIABILITY

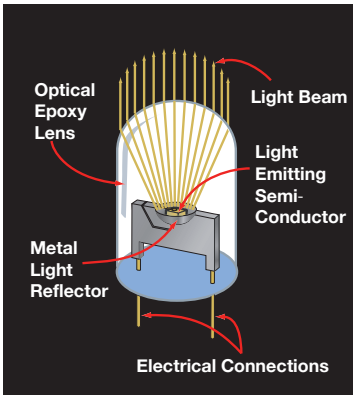
- Related at 100,000 hours of operation, covering 4 million miles, and Warranted for life when equipped with Fit ‘N Forget® connectors and Series 88 harnesses
- Extended period of operation translates to less vehicle downtime and zero maintainence

DURABILITY

- Solid-state construction, with extra measures taken to assure longevity of circuitry and components
- Virtually impervious to shock and vibration

Unlike their incandescent counterparts, LED lamps produce light without relying on a heated filament. This solid state method of producing current eliminates filament failure, and ultimately translates into a much longer life. LED lamps continue to gain popularity as more and more industry professionals recognize the benefits that LED lamps provide.

Truck-Lite's LED lamps are extremely reliable and efficient, because they are internally sealed with epoxy to encapsulate the electronic elements. The solid state design makes for an extremely impact resistant light source that is impervious to shock and vibration, even in the most damaging applications.



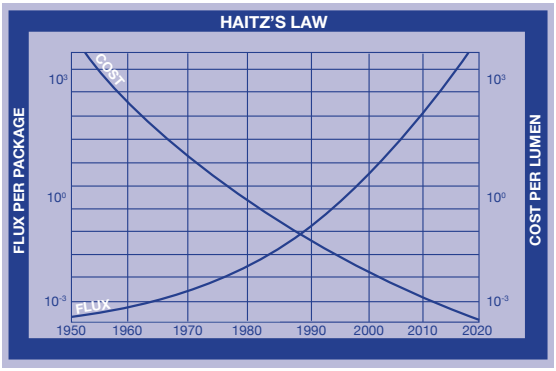
Because filament failure is not a concern for LED lights, they have an extremely fast turn-on time, and can last up to 100,000 hours. Combine this with their durability, and it's clear that they are ideal for the heavy duty industry.

LEDs come in different types:
- "T1-3/4's"
- "HPA's"
- "SnapLED®"

Colors Of Light
The colors of light produced by filament lamps in vehicle applications are the result of colored lens placement in front of an incandescent white filament. The red and amber color produced by LED lamps in vehicle applications are the result of colored light emitted from the diodes.

3. The Future of LEDs

Even in the earliest days of LED lighting, the benefits were clear, and as technology progresses, the benefits are continually improved. According to Haitz's Law, the cost per lumen of LEDs will fall by a factor of 10, and the amount of light generated per LED package will increase by a factor of 20 every decade. This continued refinement of the technology has continually led to reductions in cost and improvements in technology, which will continue to open doors to new LED lighting applications.



In the future, OEMs that do not currently have LED technology will look to implement it right away. There will also be the emergence of new forward lighting methodologies. Many of these developments will be focused on reducing headlight glare, which, according to NHTSA, is one of the most frequent complaints that they receive. One of the most promising new developments being tested is that of adaptive drive beam headlights.

The core principal of adaptive drive beam headlights is that vehicles will only have a high beam headlight in their vehicle. The headlight is paired with a forward facing camera, which senses oncoming traffic, and, by either mechanical or electronic beam blockers, blocks the specific area where the camera senses oncoming traffic or tail lamps.

4. LED Lifetime Systems

Customer Experience
The best warranty is one that you never have to use! Lighting has the highest frequency of failure of any device on a truck and trailer and is third in total cost. All vehicles equipped with Truck-Lite LED Lamps, Fit 'N Forget® Connectors and 88 Series "Plug Together" Harness Systems will be under warranty for the life of the vehicle!

88 Series "Plug-Together" Harness System
-Sealed, plug-together system
-Ensures solid, weather-tight contacts
-Eliminates the need for junction boxes, distribution outlets, and troublesome splices
-Internal ground guarantees reliability
-Color coded connections and wires
-Rear, 7-way adapter offers versatility

Lifetime Systems Warranty
A Lifetime Systems Warranty is a major step in making vehicles safer, by ensuring products last longer. Truck-Lite's Lifetime Systems Warranty offers significant reduction in maintenance costs and provides the peace of mind that your lighting system will keep you on the road.

5. Complete Systems Approach

The common downtime and repair of incandescent lighting extends past the price alone of replacement lamps.

Part Cost + Labor + Downtime

Downtime is costly, and when you add in the hidden costs of halogen lamps—repairs and replacements—the initial savings from a halogen bulb quickly disappear. While the initial cost of LED lighting products may be higher, the advantages of not having to replace or repair the lamps will result in significant savings over the life of your vehicle.