

MAN-MADE LIGHTING

PALEOLITHIC AND ANCIENT

DEVELOPMENT OF OIL LAMPS

DEVELOPMENT OF THE CANDLE

GAS LIGHTING

KEROSENE LIGHTING

LIME LIGHT

ARC LIGHTING

INCANDESCENT LIGHTING

FLUORESCENT LIGHTING

SIGNIFICANT DEVELOPMENTS IN THE HISTORY OF LIGHTING

DAYLIGHTING

TEMPLE AT KARNAK

PANTHEON

HAGIA SOPHIA

ABBEY AT ST. DENIS

STE. CHAPELLE

CRYSTAL PALACE

UNITY TEMPLE

LA TOURETTE

KIMBALL ART MUSEUM

## Significant Developments In The History Of Lighting

Click on the timeline to view more information about each period

## The Paleolithic And Ancient Periods

The first and most basic artificial light source was of course fire. For tens of thousands of years it has provided man with the basic needs for light, heat, protection, and a means of cooking. But it has also served an equally important symbolic and religious role in every culture.

### SYMBOLISM / SOCIAL ISSUES

Fire has played an important role in almost every religious tradition. For instance, in the Judeo-Christian tradition God manifested himself to Moses as a burning bush in the Book of Exodus (3:1-21).



Moses and the Burning Bush, from St. Isaac's

Cathedral, St. Petersburg

It's also mentioned several other places in the Old Testament including the Pillar of Fire in Exodus 13:21-22. It was one of the manifestations of God that provided light to the Israelites so that they could travel by night during the Exodus from Egypt. "By day the Lord went ahead of them in a pillar of cloud to guide them on their way and by night in a pillar of fire to give them light, so that they could travel by day or night. Neither the pillar of cloud by day nor the pillar of fire by night left its place in front of the people".

In Greek mythology, the Titan Prometheus, defied Zeus and is said to have brought fire to mankind in the form of a giant flaming fennel stalk. For his betrayal, he was tied to a rock where a giant eagle ate his liver each day only to have it regenerate and have it eaten again.



Prometheus Carrying Fire by Jan Cossiers

The story conveys both the symbolic and functional importance of fire to mankind. As a province of the gods it was seen as sacred and when debased by giving it to mere mortals Prometheus deserved such a severe punishment. In Hinduism, the god of fire, Agni is one of the most important of the Vedic gods. As the god of fire he is the acceptor of sacrifices and acts as a messenger to the other gods.



Agni the Hindu god of fire, Wikimedia Commons, 18th C. Watercolor

As the god of fire he is manifest in every hearth and as such the making and use of fire becomes a religious act. Over time ritual practices developed to govern and guide users in the proper use fire. One ritual involves the correct

alignment of themselves, the fire, and the larger cosmos by facing the appropriate cardinal direction. For instance, when making sacrifices to the gods the fire must face east. When making sacrifices to the dead the fire must face south and when cooking food one must always face west.

Agni is also the primary witness in every Hindu wedding ceremony and no Hindu wedding is complete unless it is done so in the presence of the Sacred Fire.



Hindu Marriage Wedding Ceremony, Wikimedia

Commons

## TECHNOLOGY



Fire pit, Wikimedia Commons

## The Paleolithic and Ancient Periods

The first evidence of the controlled use of fire in a hearth dates to approximately 1,250,000 years ago in the South Africa's Swartkrans region. It most likely consisted of keeping a fire rather than starting it. Early man would have collected burning ashes or coals from naturally occurring fires and kept them smoldering in dry plant material for extended periods of time. When needed to rekindle the fire dry tinder would be added to the coals. If wrapped tightly in a waterproof container it could be easily transported and kept for several days.

The first evidence of man-made fire dates to about 500,000 B.C. These early fires were probably made either by friction or by sparks from flint and pyrite. To produce sparks, early man probably used a hard stone such as flint and then struck a second stone such as pyrite that contained iron. When the resultant sparks came in contact with dry tinder they would begin to smolder and ignite.



Otzi, the Caveman, Wikimedia Commons

In 1991, the frozen Neolithic man "Otzi" was discovered with a fire-making kit that included flints, pyrite, dry fungus and cedar embers wrapped in leaves.

The earliest friction tool was probably the hand drill. It consists of a thin, straight wooden shaft that is spun with the hands. One end of the shaft rests in a notch in a soft wooden base. The repetitive spinning generates heat that ignites dry tinder.



Fire making, Wikimedia Commons

## VISUAL EFFECTS

As people huddled around the fire for warmth and light it became a centralizing force for human activity. The high luminous contrast between the area immediately surrounding the fire and the outlying areas helped focus attention towards the fire. Storytelling and religious ceremonies were typically performed around the fire and focused everyone's attention and heightened their emotional impact. The modern desire for a fireplace in even in climates where it is not needed can be seen as a deep-seeded desire to maintain that emotional connection.



Dancing Around Fire, Wikimedia Commons

# Oil Lamps

## SYMBOLISM / SOCIAL ISSUES

Archeological evidence suggests that the earliest portable lighting device was not in fact the candle, but rather, the oil lamp. Filled with flammable oil it has provided illumination in almost every culture for thousands of years. Like fire, oil lamps have also played an important symbolic role. They have been integrated into almost every cultural and religious tradition. For instance, in Hinduism, Dewali, or the Festival of Lights, is celebrated between mid-October and mid-December. The celebration involves the lighting of oil lamps to signify the triumph of good over evil. These lamps are kept on during the night while one's house is cleaned, in order to make the goddess Lakshmi feel welcome.



Diwali Festival of Lights

Wikimedia Commons

In Jewish and Christian traditions a sanctuary or everlasting light is an oil lamp placed at the altar. Its light symbolizes God's eternal presence and should never be allowed to be extinguished.



Sanctuary Lamp

Wikimedia Commons

## TECHNOLOGY

### ancient lamps

The earliest use of stone lamps seems to have arisen approximately 15,000 to 20,000 years ago. Ancient stone lamps have been discovered in the ancient caves at Lascaux and seemed to have been used to illuminate the cave walls for the extensive cave paintings.



Cave Painting at Lascaux

Wikimedia Commons





These early lamps were carved out of indigenous stone and used animal fats for fuel. A small cavity held the oil and the lamp was initially wickless.

But by 8,000 B.C. plant-based oils started to appear particularly olive oil. Olives began to be cultivated in the Middle East where they later spread throughout the Mediterranean region. It proved to be a good flame source because it was easy and inexpensive to manufacture and produced a fair amount of light. In the northern climates where the olives couldn't grow animal-based fats remained popular.



The lamps were at first made of pottery and saucer-shaped, but soon evolved into the classic teapot-like shape. Initially oil lamps were wickless, but it was found that if a wick was used a more efficient and stable flame could be achieved. The first wicks were most likely a fibrous rush or a twisted piece of linen. But later developments included a woven and then a platted cotton wicks. The wick was an important development because it effectively draws the oil up to the flame by capillary action where it combusts and vaporizes. A stable flame that is less prone flickering and resistant to accidental blow out. To increase the luminous output multiple wicks can be used but the fuel will be consumed at a much greater rate.

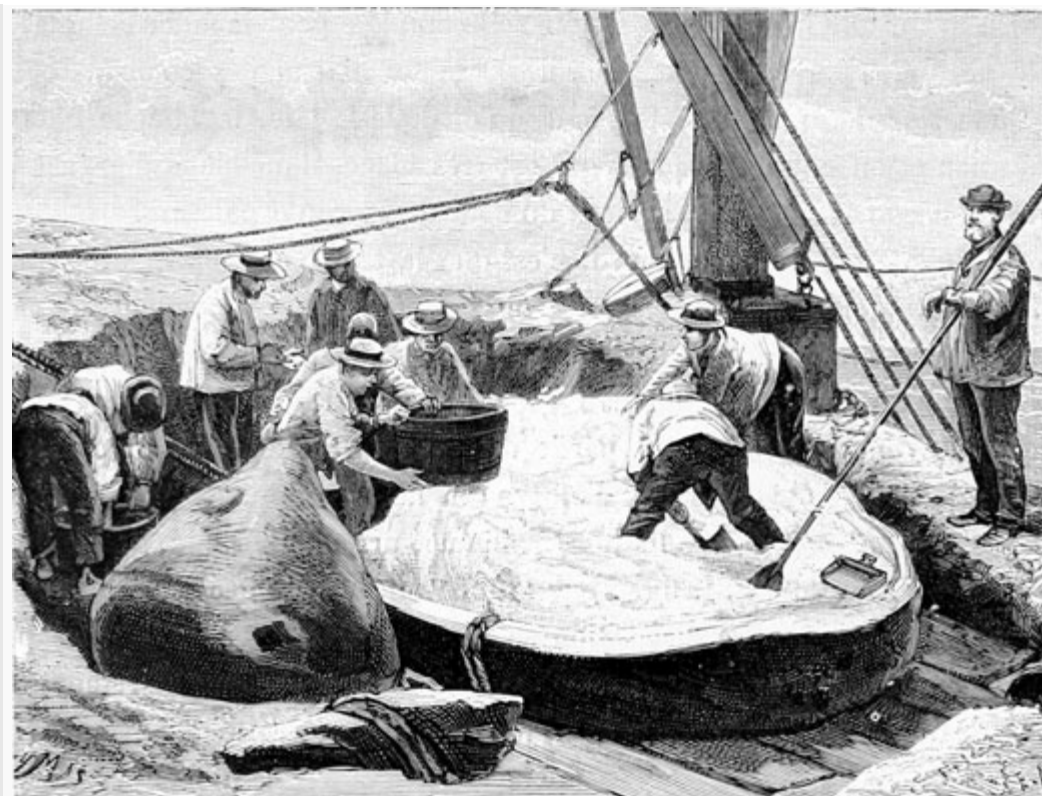


Ancient Oil Lamps

Library of Congress

### eighteenth century developments

This technology remained essentially unchanged until the seventeenth century when large-scale whaling was developed. It was found that whale blubber could produce a high-quality oil. The sperm whale was particularly valued because in addition to their blubber they produced a highly valued oil called spermaceti. Inside the flat head of the sperm whale between the skin and their skull is a cavity that contains up to three hundred gallons of spermaceti oil. Spermaceti oil was the most prized of all parts of the whale. It was not only a high-quality lubricant it was an outstanding illuminant. It produced more light and less odor than either solid fats or olive oils. So popular did spermaceti become that it was common for whalers to harvest over 100,000 gallons of sperm oil per year. Unfortunately it led to over harvesting of the whale population and contributed to their near extinction.



Processing Sperm Whale Blubber

Wikimedia Commons



Processing of Spermaceti

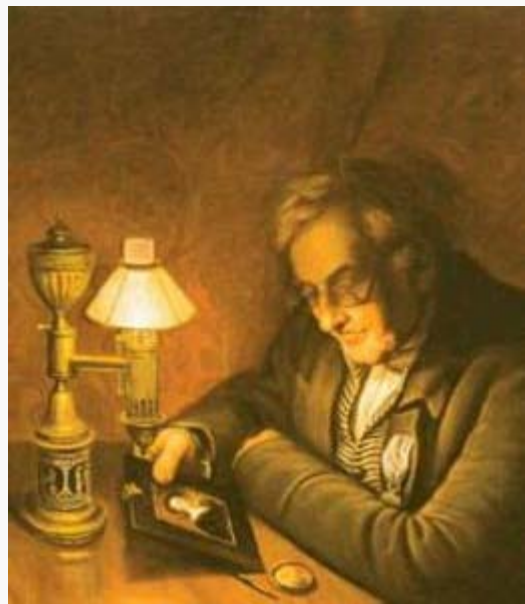
NOAA File



Processing of Spermaceti

NOAA File

One of the most common types of lamps for the burning of whale oil was the Argand Lamp named after Aime Argand who invented and patented it in 1780. It was an improvement over earlier lamps in two critical ways. First, it utilized a hollow cylindrical wick so that a draft of air was able to flow both through and around the wick. Second, a tall cylindrical glass chimney was added to steady the flame and improve air flow. The combined effect was an improvement in light output up to a total of 10 candlepower. The Argand lamp was the preferred lamp type until the development of the kerosene lamp in the middle of the nineteenth century.



Portrait of James Peale by James Wilson Peale

Wikimedia Commons



Argand Lamp

Wikimedia Commons

## VISUAL EFFECTS

The use of oil lamps transformed lighting. For the first time multiple light sources could be used in a space. No longer were they bound to only one source (i.e.) the central fire. Instead, light could be distributed throughout a space on as needed basis by using multiple lamps. Also, being portable they offered users the ability to take them

from room to room or place them where needed. Oil lamps of this type can be thought of as the first personal light source.

# Development Of The Candle

## SYMBOLISM / SOCIAL ISSUES

The symbolism of fire was extended to the use of candles after their introduction during the 1st century in Rome and continues to be important in many of today's religious traditions.

In Judaism, the Menorah, or seven branched candelabra was first used by Moses during the Exodus and later in the Temple in Jerusalem. It has been a symbol of Judaism since ancient times and is the emblem on the coat of arms of the modern state of Israel.

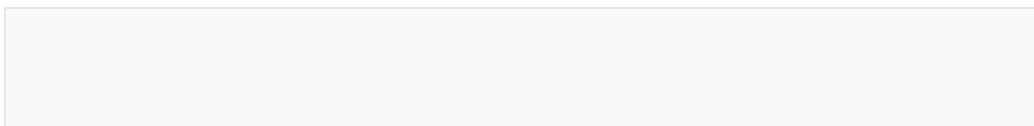


Seven Candle Menorah

Wikimedia Commons

The Menorah is also a symbol closely associated with the Jewish holiday of Hanukkah. According to the Talmud, after the desecration of the Jewish Temple in Jerusalem, there was only enough consecrated olive oil left to fuel the eternal flame in the Temple for one day. Miraculously, the oil burned for eight days which was enough time to make new pure oil. The Hanukkah menorah has become an eight-branched candelabra, plus a ninth branch with a candle that is used to light the other eight.

In the liturgies of many Christian denominations beeswax candles must be used in the majority of rites. Strict regulations have been developed to guide the number and placement of the candles for various services. In the Eastern Orthodox tradition the Paschal Candle is used during the Easter season. The composition of the Paschal candle is said to be representative of Christ. The beeswax is likened to the body of Jesus, the wick symbolizes his soul, and the flame his divinity.





Altar of Von St. Arsacius

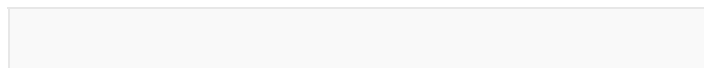
Wikimedia Commons



Paschal Candle

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Candles are also an important part of Buddhist religious traditions. Candles, incense, and flowers are commonly placed in front of Buddhist shrines as a sign of respect. The light of the candles represents the illumination of Buddha's teachings and the metaphor of light in various Buddhist scriptures.





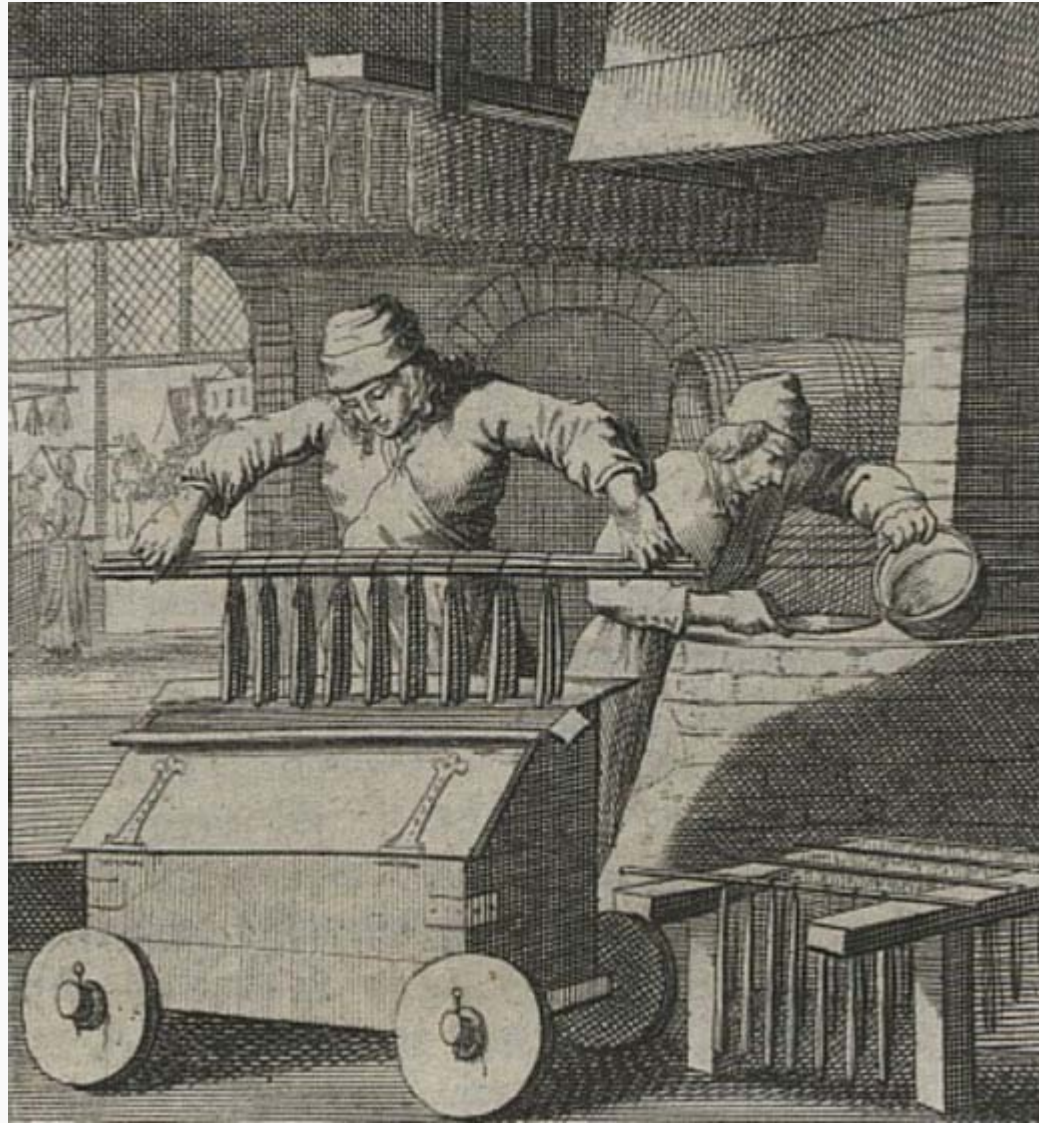
Buddhist Shrine

Wikimedia Commons

## TECHNOLOGY

The first definitive use of candles dates to the 1st C. of ancient Rome. Early candles were of two types. The first type was similar to a torch. It was made of a heavy wick of twisted fiber coated with pitch. The second, and the more common type, were made of tallow. Most tallow candles were made by repeatedly dipping the wick into molten tallow or by pouring melted tallow over a hanging wick and allowing it to cool.



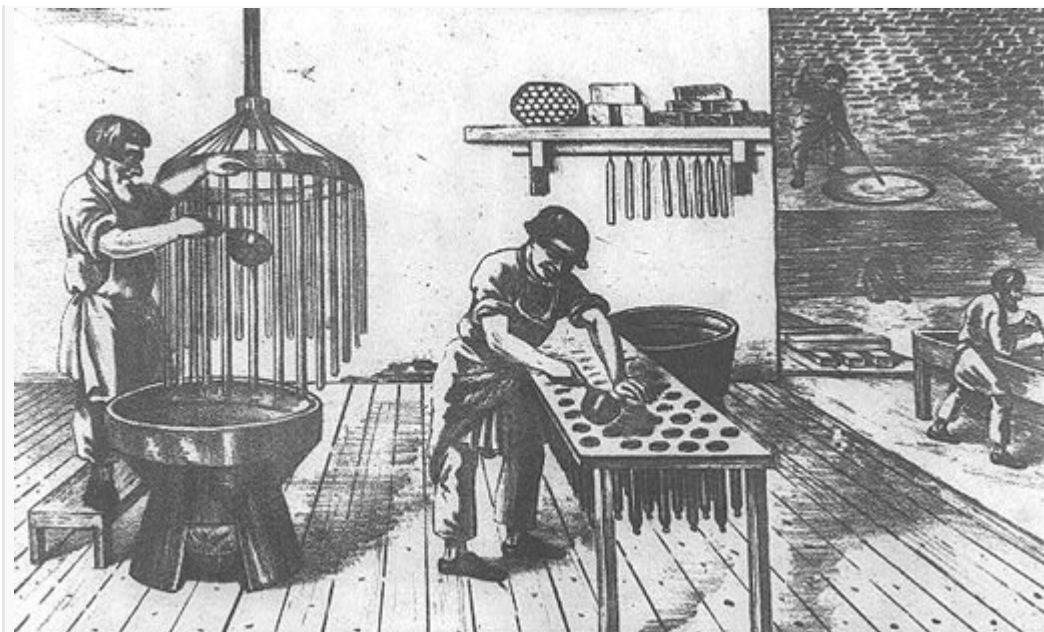


Medieval Candle-making

Wikimedia Commons

By the late Middle Ages candles started to be manufactured in metal molds. Copper, tin or pewter were the most popular and consisted of capped cylinders with small holes wick to pass through. With the wick in place, the mold was filled with melted tallow and allowed to cool.

## Development of the Candle



Medieval Candle-making

Library of Congress

In the middle of the 19th C. the English Physicist, Michael Faraday gave a series of lectures entitled the Christmas Lectures at the Royal Institution. One of the lectures was entitled, “The Chemical History of the Candle”. In it he described how the burning candle operates. The lighted wick melts and vaporizes the candle solids. The vapor rises into the middle of the flame with a moderately hot temperature of about 2100 degrees F (approx. 1420 degrees K). This temperature is not quite hot enough to entirely burn the carbon so it incandesces with warm yellow color. At the outer layer there is more oxygen available so the flame can reach a somewhat higher temperature of approximately 2600 degrees F (approx. 1800 degrees K). With this higher temperature the flame changes color and becomes a bit bluer but overall the light emitted remains a warm yellow color.

wood splinters and rushlight

A precursor to the candle was most likely the wood splinter and rushlight. The wood splinter was generally a long solid piece of straight-grained wood approximately  $\frac{1}{4}$ " thick. Rushlights were long freshly-cut rushes that were soaked in grease. Both could be made in quantity and stored for future use. When needed they would be held in a slanting upward position and then burned. A three foot long rush would burn for approximately one hour and give off the same quantity of light as a candle.

# Development of the Candle



Soft Rushes

Wikimedia Commons



Rush light

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## VISUAL EFFECTS



Medieval Candle-making

Library of Congress

## Development of the Candle

Because of the low lumen output of candles there is inevitably a large contrast created in the luminous environment. A candle is capable of only illuminating an area in close proximity to it. Therefore the areas remote from the candle are cast in shadow. This large contrast increases the perceived level of drama and can be creatively used to create a greater sense of intimacy. This visual effect can be clearly seen in this painting by Peter Paul Reubens, c. 1616.

# Gas Lighting

## Symbolism / Social Issues

As European cities grew and became denser, crime started to grow. The nighttime streets became crime-ridden and dangerous. In order to help deter the growing level of crime watchmen were hired to patrol the streets. London citizens were even required to hang out lanterns and place a burning candle in each window facing the street. For a farthing there were young boys called “Link boys” that would carry torches and accompany citizens through the streets to their destinations. These practices continued with limited success until gas street lighting was gradually introduced in the early years of the 19th C. Publications of the time reported that for the first time nighttime street crime was greatly diminished after the installation of gas street lighting.



## TECHNOLOGY

It had been known for much of the 18th C. that inflammable gases could be produced from most combustible materials, such as coal and wood through a process of distillation. But it wasn't until a German émigré named Frederick Winzor (later changed to Winsor) demonstrated a viable system by setting up and illuminating a number of street lights outside his home in Pall Mall in 1807 London. In 1812 he was granted permission to create England's first gas utility named the Gas Light and Coke Company. Gas soon proved itself to be less expensive and have better luminous characteristics than any of the traditional flame sources (candles, whale oil, etc.). As a result, by 1825 utilities had sprung up all over England so that almost every city with a population over 10,000 had a utility. Initial uses were for street lighting and for commercial users, but eventually spread to residential users as well.



A Peep of the Gaslights at Pall Mall by

Rowlandson

[Wikipedia Commons](#)

The technology soon spread across Western Europe and made its way to North America. Gas light was first introduced to the United States in 1816.

These early utilities operated as all-inclusive operations that provided everything a client would need to install gas lighting. They would create the gas from coal in large central plants, store it until needed, install the piping from the plant to the building, install the piping in the building itself, install a metering system to monitor gas flow, and finally work with the building owner to locate and install the gasoliers in the building.

The first gas burners, or gasoliers were little more than holes in the iron gas pipe, but they corroded rapidly. Early technical developments focused on the introduction of brass fittings, called jets, which would carefully shape the flame to maximize its luminosity.



Wall-Mounted Gasolier

Minnesota Historical Society



Gasolier Chandelier

Wikipedia Commons

The technology eventually reached its zenith with the development of the gas mantle. In 1882, the Austrian chemist Carl Auer von Welsbach developed the incandescent mantle. He had been experimenting with several rare-earth elements and noticed that many would incandesce when heated. Seeing its applicability to lighting he created a webbing of vegetable fiber and then soaked it in a solution of thorium and a variety of rare-earth chemicals. Once the webbing dried he incinerated away the webbing leaving a skeleton of the rare-earth chemicals. He then installed them in a lamp where the heat from the flame caused it to incandesce very brightly. Lamps with the gas mantles would produce a candlepower of 60 to 70, where a standard gas flame would only produce a candlepower of 6 to 10.

### VISUAL EFFECTS

The benefit of gas lighting over traditional oil lamps was dramatic. With a candlepower output of 6 to 7 times over standard oil lamps the overall level of illumination in a space was greatly enhanced. When multiple gasoliers were used in a single space the distribution of light became more even and the light level brighter. But it created a number of challenges as well. Unlike portable oil lamps, fixed gas lighting tended to make the arrangement of furniture much more static. Where previously furniture might be arranged around the perimeter of a room and then rearranged as needed, the permanent installation of the gasoliers required the arrangement of furniture to be anticipated. For the first time in history there had to be coordination between the lighting and the furniture arrangement. In many ways this can be seen as the infant stage of lighting design.

# Kerosene Lighting

## SYMBOLISM / SOCIAL ISSUES

In urban areas during the early years of the 19th C. the spread of gas lighting was rapid, but in rural areas it was very slow in developing. Instead, oil lights remained the most common type of lighting. The rural areas lacked the needed population density to make the production, distribution, and sale of gas cost effective. So it wasn't until the middle to the end of the 19th C. before it was replaced by another coal-based fuel – kerosene. Unlike the coal gas used in urban areas kerosene could be stored in containers and safely delivered to customers.

## TECHNOLOGY

As the price of whale oil started to rise during the early years of the 19th C. and gas lighting was not yet available in most areas, alternatives started to be sought out. The first fuel to be developed was a mixture of alcohol and turpentine. Known as Burning Fluid it was easily produced and was inexpensive to purchase. The lamps that burned it were simple to make and operate and it produced a white, smokeless flame. But it was also one of the most volatile and dangerous lighting fuels ever produced. Hundreds of people were injured or killed in accidental fires.



Therefore, a search for a better replacement was widely pursued. In 1846, a Nova Scotia physician named Abraham Gesner was experimenting with coal as a fuel source. Related to but different from illuminating gas, he produced a clear, thin fluid which he named kerosene. It was inexpensive to produce and much safer than the earlier burning fluids. It very quickly replaced oils as the main source of illuminate throughout the rural areas in America. By 1864 it unquestionably became the most popular lamp fuel in North America.





Kerosene Lamp

Wikimedia Commons, author: Okorok

A flat-wick lamp was the most common type of kerosene lamp. Simply constructed it consisted of a fuel tank with an attached lamp burner and a glass chimney. The chimney performed two important functions. The first is that it kept the flame from burning out, and second, its shape created a thermally induced draft which enhanced combustion. The bottom of the flat cotton wick extended into the kerosene and the top was held in place by a wick-adjustment mechanism. The quality of the flame was controlled by adjusting the height of the wick.



Kerosene Lamp with Welsbach Mantle

Wikipedia Commons



Modern Kerosene Lamp with mantle

[Wikipedia Commons](#)

The last and most significant advancement in lamp design was when the Welsbach mantle technology that was commonly used with coal gas lighting was applied to kerosene lighting (refer to the Gas Lighting section). This technology proved so successful that it has remained essentially unchanged and continues to be used in modern camping lanterns.

Kerosene lamps continued to be used in many parts of the U.S. well into the 20th C. until the rural areas were fully electrified and incandescent lighting was introduced.

### VISUAL EFFECTS

The visual effects of kerosene lighting remained similar to that of animal and plant oil lighting except it was much brighter – approximately twice as many lumens per Btu.

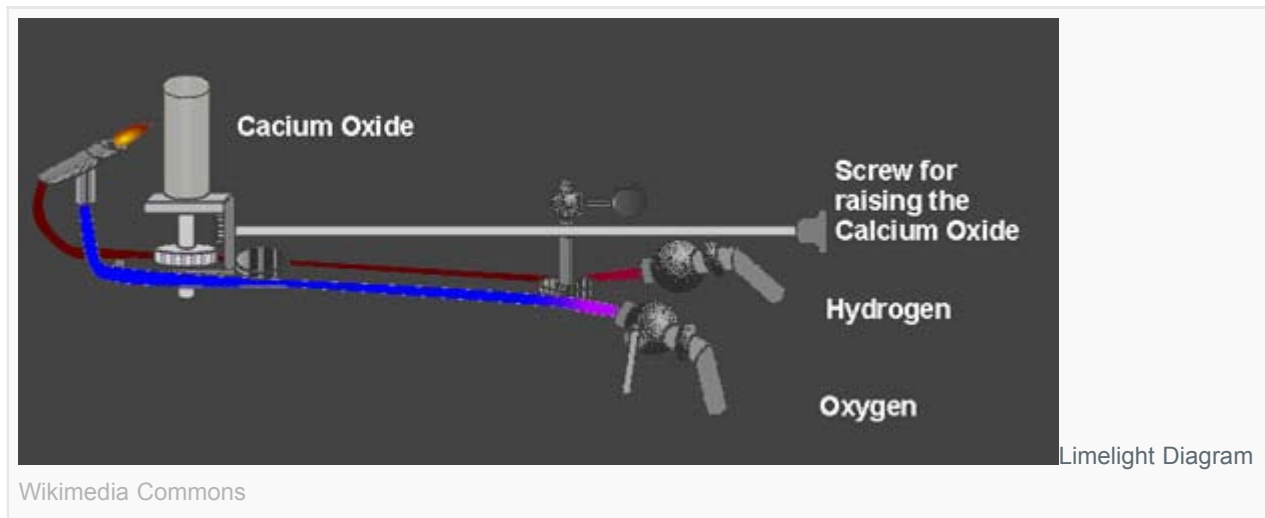
# Lime Light

## SYMBOLISM / SOCIAL ISSUES

The expression “in the limelight” originally referred to the most desirable acting area on a stage, the front and center, which was brilliantly illuminated by a special type of theatrical lighting called limelight. Today, the term has entered the common vernacular and its meaning refers to someone in the public spotlight. But limelighting was a significant advancement and transformed theatrical lighting

## TECHNOLOGY

In the 1820's the English chemist Sir Goldsworthy Gurney discovered that when calcium oxide, or quicklime, was heated with a flame to a temperature of approximately 4,660 degrees F it started to incandesce or glow brightly -- much more brightly than by just the flame alone. He achieved this high temperature through the development of the oxy-hydrogen blowpipe. Oxygen and hydrogen are passed through separate pipes under pressure and mixed just before being ignited.



The English surveyor Thomas Drummond utilized this technology in the development of his Drummond Lamp that was used for surveying. It was often necessary to locate a prominent geographical point from a long distance through a telescope. The Drummond Light created a bright enough light that could be seen even in bright daylight.



Candle footlights

Wikimedia Commons

But during the 1830's the technology started to be applied to theater lighting. No longer did performances have to be illuminated by inefficient candles, oil lamps, or gas lighting.



Ballet Dancer painting by Degas

Wikimedia Commons



Ballet Rehearsal on Stage by Degas

[Wikipedia Commons](#)

The most common lime-light luminaire was a rectangular wooden box lined with metal. The back wall of the box was omitted to allow free access by the operator to easily control the oxy-hydrogen blowpipe. In the front there was a large circular hole in the front wall that determined the desired beam spread. Later developments saw the introduction of the focused lime-light that utilized a focusing lens. By manipulating the lens greater flexibility in beam spread could be achieved. A hand-held luminaire was introduced (1877) that gave the operator considerable freedom of movement.

### VISUAL EFFECTS

The first use of limelight for a performance was at the Convent Garden Theater in London in 1837. Its use quickly spread across Europe and across the Atlantic to North America. It offered several advantages over earlier flame technologies. First, its light output was approximately 35 times brighter than a conventional gas flame. Second, because of the increased light output special effects became possible. For the first time, a tight spotlight could be developed and focused on individual actors. Realistic special effects such as sunlight or moonlight could also be easily developed. Third, several limelights mounted on the front of the stage balcony could be used for general illumination much more effectively and naturally than footlights.

# Arc Lighting

## SYMBOLISM / SOCIAL ISSUES

The properties of electricity have fascinated scientists and lay people for hundreds of years. For early scientists its mysterious, quasi-magical properties were not well understood but its manifestations as static electricity or lightning was experienced by everyone. Early medical experiments discovered that the limbs of dead animals could be made to twitch when an electrical charge was sent through them. There were reports of apparently dead or drowned individuals being revived with a jolt of electrical current. Perhaps the most famous use of electricity was in the novel Frankenstein (1819) by Mary Shelley on just this premise of revitalizing the dead. Needless to say electricity held the public's fascination more so than almost any other technology. So when electricity started to become a viable alternative to gas lighting it was received with both a sense of trepidation and wonder.

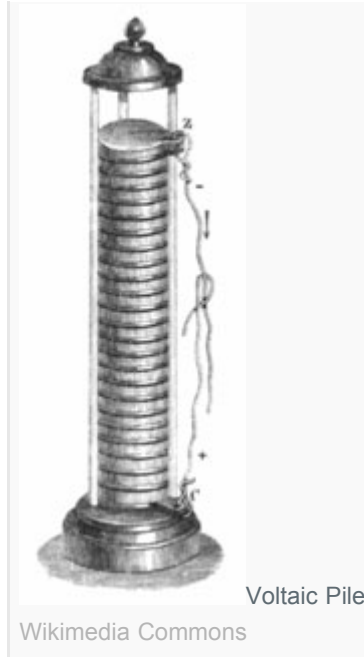


Boris Karloff as Frankenstein

Wikimedia Commons

## TECHNOLOGY

The study of electricity had been taking place since the 17th C. but it wasn't until the beginning of the 19th C. that scientists started to really understand its basic properties. In 1800 Alessandro Volta developed his voltaic pile, the first battery made from alternating layers of zinc and copper. With this device he created the first sustained, continuous flow of electricity.



Interest in electric lighting started to parallel the development of electricity almost immediately. In 1809, Sir Humphry Davy with the aid of a large voltaic pile produced the first lasting electric arc – the voltaic arc. He passed a current through a charcoal stick, touched another charcoal stick where a spark passed from the first to the second stick. He then separated the sticks enough so that a brilliant continuous spark leapt between the charcoal sticks. The charcoal sticks also heated up causing them to incandesce creating additional light. Unfortunately the charcoal sticks deteriorated rather quickly and the dc power that the batteries produced was unsustainable. Unfortunately, significant advancements in the generation, storage, and transmission of electricity had to be made before any real progress could be made. It wasn't until after 1821 and 1831 when Michael Faraday made his important discoveries in electromagnetism and induction that led to the development of electric motors and dynamos.

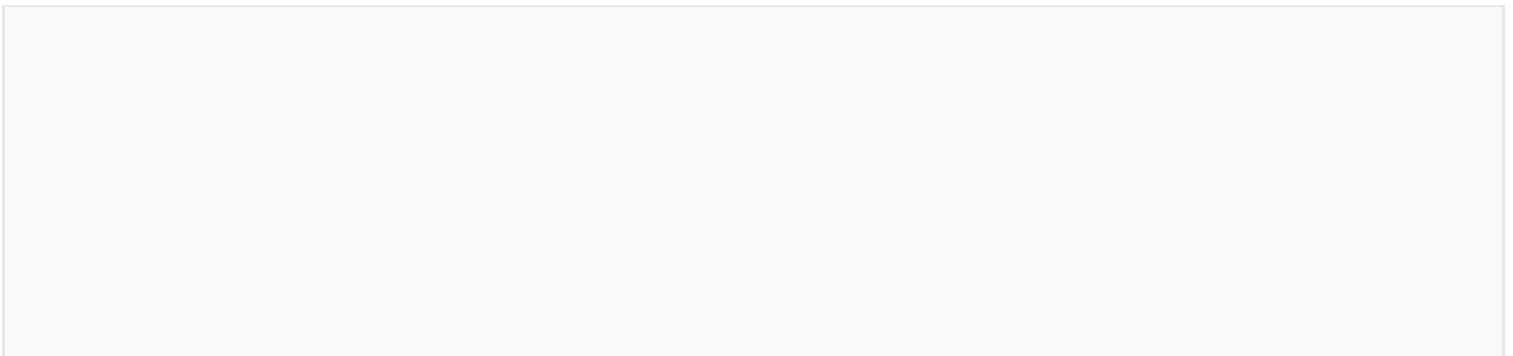


Electric Dynamo by Zeobe Gramme

Wikipedia Commons

One of the other most important advancements was made by the Belgian Zeobe Gramme who developed a variety of electrical dynamos that ranged from small hand-crank dynamos all the way up to a large steam driven dynamo that was capable of producing large quantities of ac power.

Another important development was made by the Russian Paul Jablochhoff who improved the arc lamp by placing the charcoal conductors inside a glass globe and regulated how the carbons would burn. When he married his arc lamp technology with Gramme's large dynamos he was able for the first time to develop the first integrated system of electrical production and illumination. He got the opportunity to demonstrate his ideas at the Paris Exposition of 1878. He was able to install 64 arc streetlights along a half-mile stretch around the Place de l'Opera. Since the arc lamps were much brighter than the existing gas street lights they were able to be placed approximately 150 feet apart. Each one replaced up to six gas streetlamps.

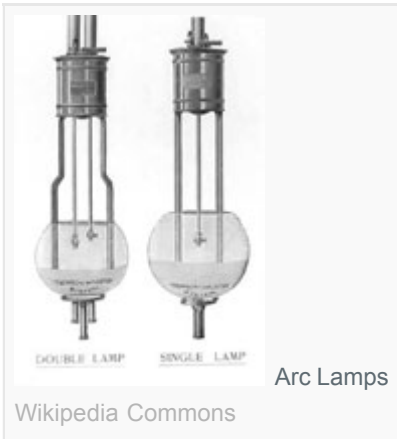






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Paul Jablochkoff's Arc Lighting Candles Illuminating the Avenue de l'Opera, 1878



Arc Lamps

Wikipedia Commons

## VISUAL EFFECTS

Arc streetlights were not without their detractors. The output ranged from 500 to 3,000 candlepower which was significantly greater than gas lighting. Without proper shielding the lamps produced copious amounts of glare and the quality of light was more objectionable than gas lighting. As a result the street lamps had to be installed at much higher than above normal sightlines than gas lamps. This spread the light out over much larger area and profoundly changed the scale to which people related to the distribution of light. No longer was there the intimacy of pools of light close to street level where people would walk. Instead, the light was distributed over large areas and spread widely over the street and high up onto the sides of buildings where it was unwanted.



Arc Street Lights

Wikipedia Commons

# Incandescent Lighting

## SYMBOLISM / SOCIAL EFFECTS

The electrification of homes and businesses revolutionized American life in an unprecedented manner. The electric lamp gave people complete control over lighting inside their homes and workplaces. The natural biological rhythms of day and night/light and dark were overturned. No longer were we bound to the natural cycles that ruled mankind since our beginning. Both home life and the workplace experienced unprecedented change. The workplace could now effectively be done on a 24 hour schedule. If desired, more than one shift of workers could run the factory each and every day. The incandescent light was almost as effective at illuminating tasks as was daylight. As a result the design of buildings also started to fundamentally change. No longer were building foot prints determined by the need for daylighting. In fact, daylighting soon became seen as a supplemental source of lighting rather than its primary means.

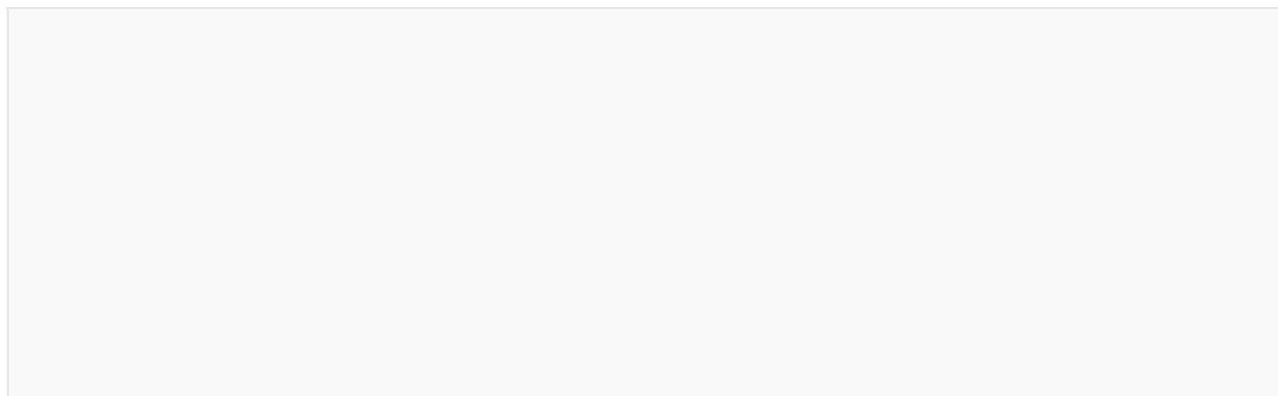
Electricity for elevators (along with the development of the curtainwall) helped usher in the development of the high-rise building. No longer were buildings limited in height because of the user's unwillingness to walk up a building more than about six stories.

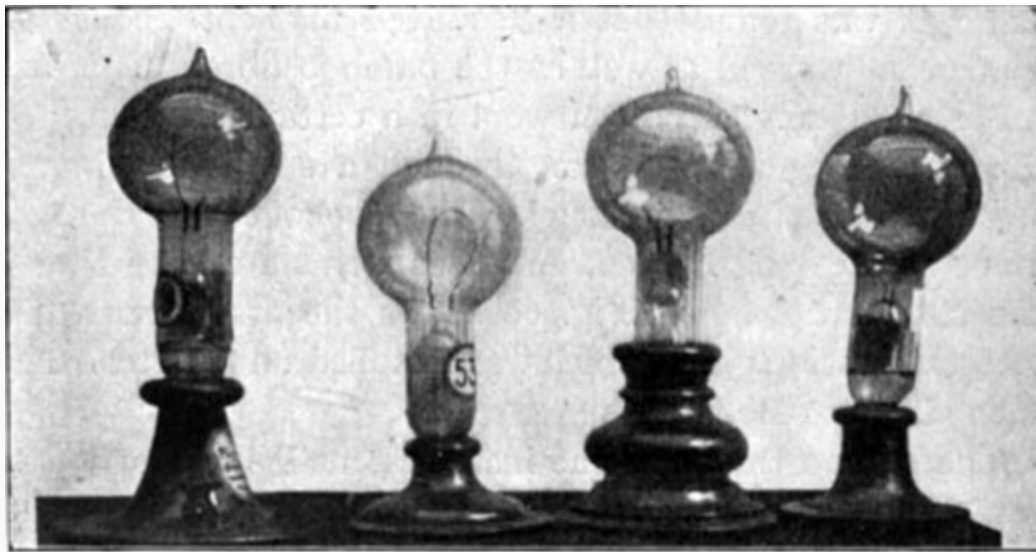
In the home electrification helped reduce the drudgery of the middle-class housewife. Small electrical appliances were developed for ironing, vacuuming, clothes washing, and refrigeration. Tasks that used to take all day could now be done in a manner of hours. Electricity also created a new hearth – the radio. The family now gathered around the radio and connected to the outside world in an unprecedented manner. Music, news, weather reports, and entertainment were all immediately accessible. With the advent of electricity the world became a much smaller place.

## TECHNOLOGY

In popular culture Thomas Edison has been given credit for inventing the incandescent lamp. In fact there were over twenty documented scientists/inventors from all over the world who contributed to its development over an eighty year span. In 1802, Humphry Davy was experimenting with incandescent lighting at the same time he was experimenting with arc lighting. He created the first incandescent lamp by passing current through a thin strip of platinum. He chose platinum because of its high melting point but it quickly burned out and was too expensive to be practical. In 1840, the English scientist Warren de la Rue also passed an electric current through a coiled platinum filament enclosed in vacuum bulb. The vacuum increased the life of the filament but not enough to justify its high cost. For the next forty years a large variety of materials were experimented with including chromium, iridium, molybdenum, carbon, carbonized paper and wood.

In 1879, Edison successfully tested a lamp that utilized a carbon filament that lasted for 13 ½ hours. He continued experimenting and he discovered that a lamp with a carbonized bamboo filament would last over 1200 hours.





Early Edison Lamps

Wikimedia Commons

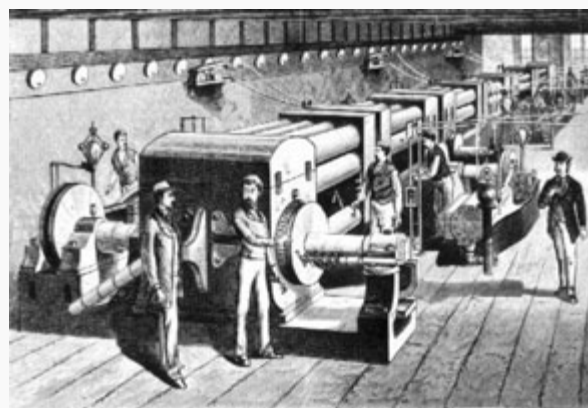
But developing the lamp technology was only one of the challenges that Edison faced. He had to create a workable delivery system, methods to wire buildings, develop workable switches, luminaires, and most importantly an efficient dynamo to generate the electricity. He found a workable direct current dynamo that was designed by an engineer named William Wallace and that had an output of 6.0 kW.

By 1880 Edison had made enough advancements to create the Edison Illuminating Company. The company created the first investor-owned electric utility in 1882 at the Pearl Street Station in New York City. It eventually served one square mile with six large dc dynamos with each producing 10 kW.



Pearl Street Station Exterior

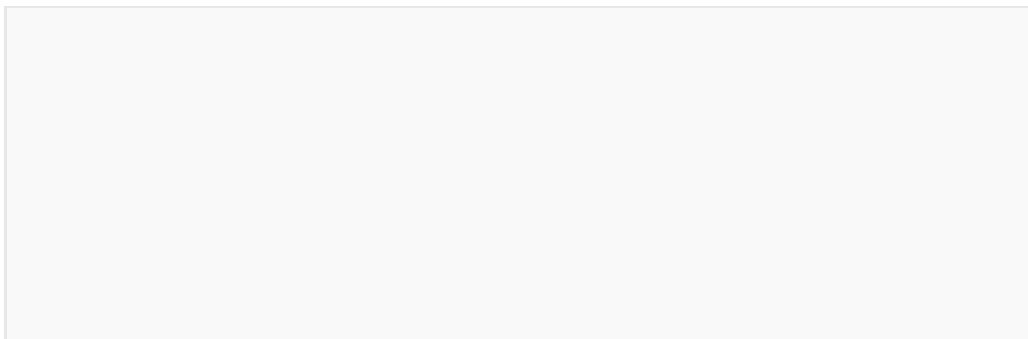
New York Public Library



Pearl Street Station Interior

New York Public Library

The system cost \$300,000 to build with the installation of 100,000 feet of underground conduits.





Pearl Street Station Laying Wiring

New York Public Library

But direct current systems had their limitations. First, after approximately one-half mile the current quickly diminished and couldn't easily be bolstered. Second, direct current lines could deliver 110 volts, but more powerful currents to run motors couldn't travel over the same lines.

When George Westinghouse became interested in electricity he came to realize these shortcomings and understood that alternating current (ac) systems avoided these problems. It could be efficiently transmitted over long distances and the voltages could be easily stepped down. In 1886, he contracted with Nicola Tesla to help develop alternating current systems for Westinghouse. After immigrating to the U.S. in his twenties, Tesla briefly worked for Edison who never really acknowledged his talents and when there was a dispute over a promised pay bonus he quit. In anger he went to work for Westinghouse.

Edison publically condemned alternating current and led a self-serving crusade against its use. He charged that because of its higher transmission voltage it would never be free of danger and frequently referred to it as the "executioners current". To prove his point he even promoted several high profile electrocutions of animals to prove his point. In response, Westinghouse went to great lengths to assure the public of its safety. The competition between Edison and Westinghouse became very public and quite bitter and became known as the "War of the Currents". Over time as the advantages of alternating current started to be recognized and concerns for its safety minimized its use started to rapidly expand. By 1891 there were almost five times as many alternating current stations in the U.S. as direct current stations.

The competition between Edison and Westinghouse came to a head when they both competed to supply the illumination for Chicago's Columbian World Exposition in 1893. Westinghouse along with Tesla's polyphase ac

generators outmaneuvered Edison and his dc power in getting the lucrative and highly visible contract. Once fully installed the electric lighting of the exposition consumed three times the electrical power of all of nearby Chicago. Every night 200,000 incandescent lamps outlined the edges of the buildings and lined the boardwalk and even more illuminated the dozens of building interiors.

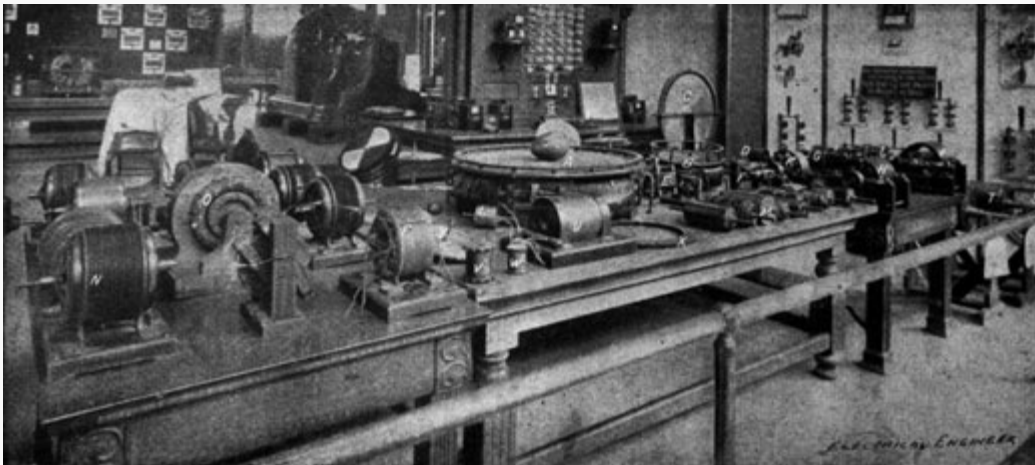


Administration Building at the Columbian

Exposition

Brooklyn Museum Open Collection

In the Electricity Building the public saw exhibits of the latest motors, engines, welding machines, and a myriad of electric devices and tools.

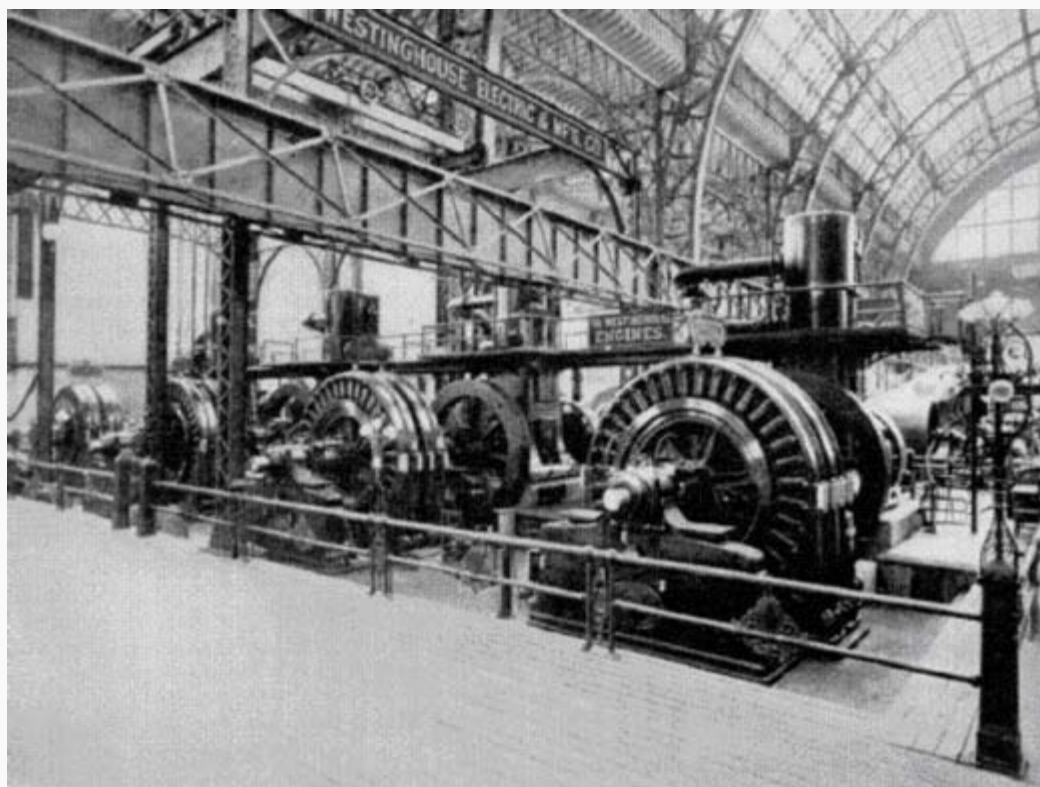


Tesla's AC Display at Columbian Exposition

Wikimedia Commons

In the Machinery Hall the public saw Tesla's twelve giant, 75 ton dynamos generating the electricity for the entire

exposition. Never before had there been such an astounding display of the future of electrical power.



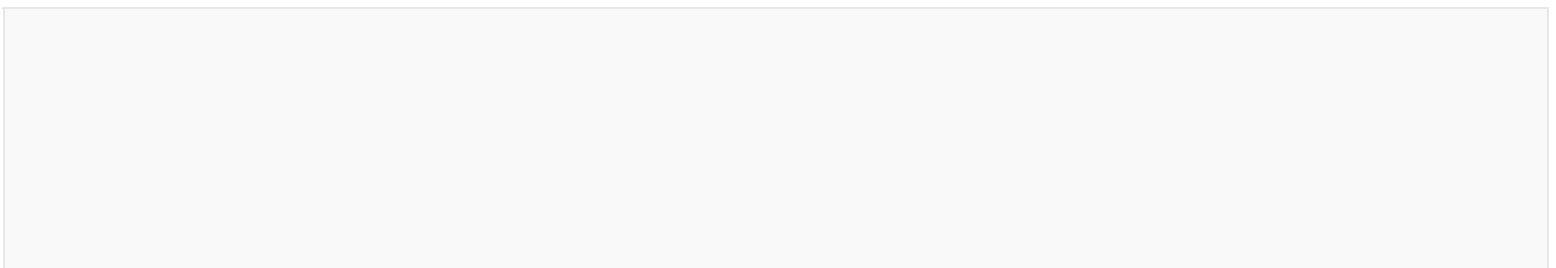
Tesla's Dynamos in Machinery Hall at

Columbian Exposition  
[Wikimedia Commons](#)

Eventually alternating current systems came to be the standard for electrical generation in this country and Edison's dc systems were relegated to the past. Improvements continued, especially in lamp development, and in 1906 the General Electric Company patented a design for a lamp that used ductile tungsten for the filament that was truly commercially viable. Its design has remained essentially unchanged from today's incandescent lamps.

### VISUAL EFFECTS

The chemistry of gas combustion in gas lighting was quite unhealthy. It produced water vapor and smelly fumes. Small gas lit rooms became unhealthy rather quickly and most rooms had to have a window cracked open to let in fresh air and ventilate disagreeable fumes. The fumes frequently damaged fabrics, tarnished metals, and left unsightly stains and deposits on walls and ceilings. Incandescent lighting changed all that. It provided a clean, safe, and immediate light source. But the early lighting systems were not without problems. The bare clear non-directional lamps were significantly brighter than gas lamps and created an even and overly flat light with harsh shadows. The lamps were not always well-screened and users were commonly subjected to direct glare. But nevertheless it was a significant improvement over gas lighting and laid the groundwork for improved lighting in the 20th C.





Social Evening in the Banqueting Hall of the

Carlsberg Glyptotek  
by Eder Severin Kroyer



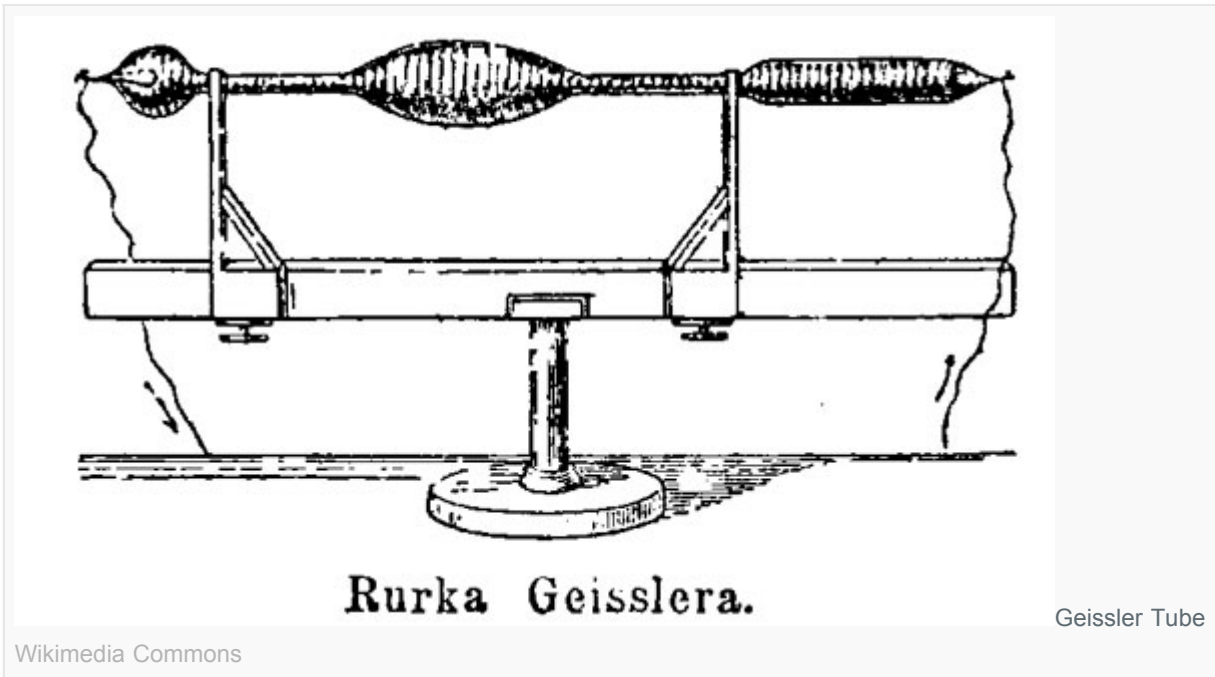
# Fluorescent Lighting

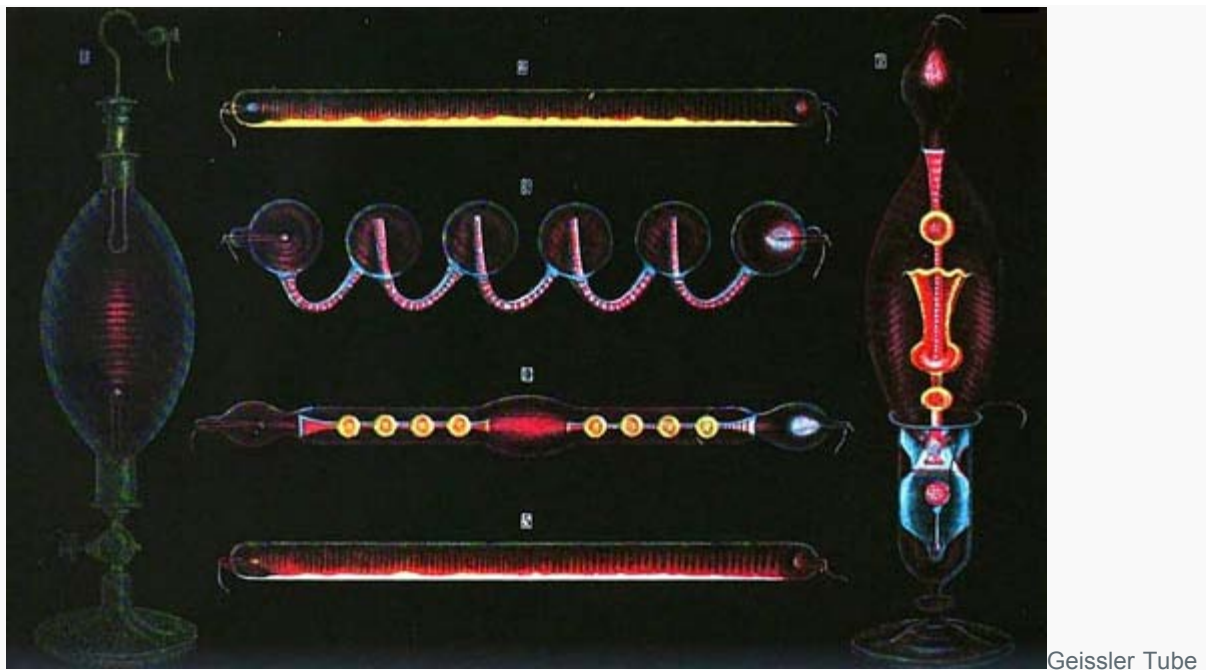
## SYMBOLISM / SOCIAL EFFECTS

Of all of the modern sources of light none are as controversial as fluorescent lighting. It has become ubiquitous in many building types including office spaces, retail spaces, and factories, yet it inspires intense hatred. Concerns range from a dislike for its color temperature and color rendering capabilities, disposal issues, to more serious (but unfounded) health concerns. These concerns have recently intensified because of the federal government's gradual banning of certain types of incandescent lamps thereby limiting consumer choice. Even with the rapid development of LED technology fluorescent lighting is likely to remain popular for at least the near future.

## TECHNOLOGY

In 1856 a German glassblower named Heinrich Geissler created a sealed, evacuated glass tube with a metal electrode at each end. He then filled the tube with gases such as neon and argon. When an electrical current was passed through the tube to the other electrode the gas would emit light. Known as a Geissler tube it was not really seen as a possible light source, but rather only as a parlor trick. But nevertheless, it was a significant development and ultimately led to the development of fluorescent lighting.





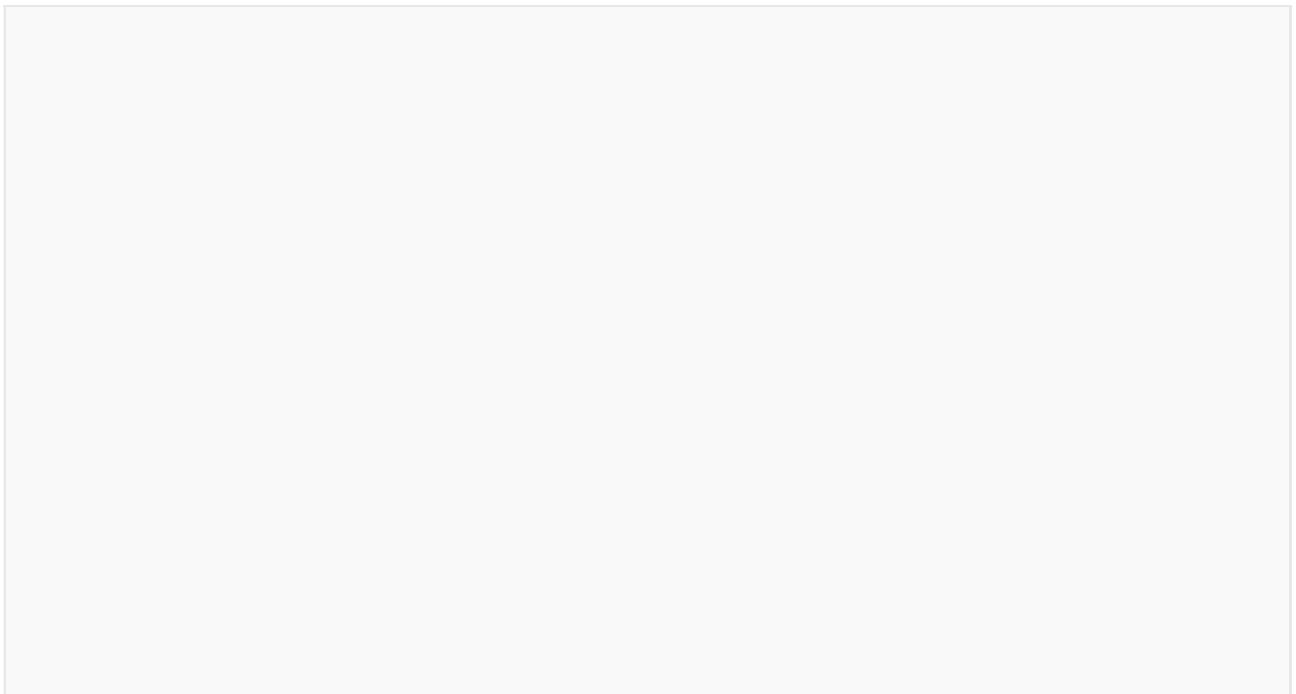
Wikimedia Commons

Geissler Tube

The next major development was made by the French scientist A.E. Becquerel who experimented with phosphorescence and applied various luminescent materials as coatings to the inside of Geissler tubes. Fluorescence successfully occurred but unfortunately they were inefficient and had a short operating life.

Inspired by the Geissler tube the Frenchman Georges Claude successfully patented his electrode for neon tubing (1915) and then went on to build a world-wide neon signage empire that lasted through the 1930's.

A parallel development was made by the American electrical engineer and inventor Peter Cooper Hewitt. He developed a lamp that was the precursor to the modern fluorescent lamp. He coated the inside of a glass tube with a luminescent compound and filled the tube with mercury vapor. An electrical current was then passed between the electrodes producing a bluish-green light. It was much more energy efficient than incandescent lighting but because of its color it found limited use.



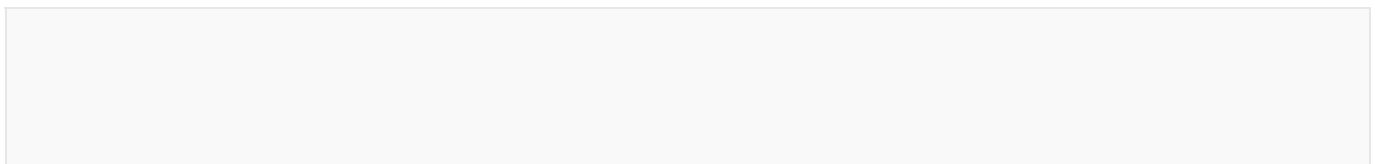


Peter Cooper Hewitt Portrait

Library of Congress

The modern fluorescent lamp was developed between 1934 and 1938 at the General Electric laboratories in New York. The glass tube was filled with mercury vapor and argon and coated with phosphors on the inside. As a current passes through the mercury vapor the electrons from the electric current collide with the mercury gas and ultra-violet light is produced. The ultra-violet light then reacts with the fluorescent coating and causes it to glow brightly. Different phosphor coatings produce different shades of white.

General Electric introduced fluorescent lighting to the public at the 1939 New York World's Fair. The quality of the phosphors was still rather primitive so the color was rather poor. Still, fluorescent light offered an economical and efficient alternative to incandescent lighting and became the standard light source for office interiors, factories, and retail stores. Research has continued for the past seventy years concentrating on the improvement of the phosphors. The current generation of rare earth tri-phosphors produces an outstanding quality of light.





Library of Congress

1939 New York World's Fair

## VISUAL EFFECTS

Unlike incandescent light sources fluorescent lighting is not considered a point source. Since its light output per unit area is much smaller it needs a substantial amount of surface area to generate its light. Historically this meant 4 foot and 8 foot long lamps that were excellent at creating an even distribution of high levels of ambient light. This type of lighting was desirable for building types such as office interiors, large retail spaces (big box stores), and factory interiors. It wouldn't be until the late 1980's that compact fluorescent lamps were developed and could be used as point sources.

# Temple At Karnak

## SYMBOLISM / SOCIAL ISSUES

The Temple of Khonsu at Karnak (c.1100 B.C.) is an excellent example of a small but complete New Kingdom Temple. It was dedicated to the moon god Khonsu who was the son of Amun and Mut. Its layout, spatial sequencing and lighting effects are all a testament to the powerful religious ideals of the ancient Egyptians.

## TECHNOLOGY

By designing the architecture around strong axial alignments, bi-lateral symmetry and simple masses the architecture becomes a visual expression of the hierarchal and unchanging nature of the social and religious customs. Though the use of the arch was known as early as the fourth dynasty post and lintel construction was preferred for all monumental construction. But because of the poor tensile strength of stone the lintels had to be supported by closely spaced massive columns and covered with simple flat roofs. When this type of construction was illuminated by the strong desert sun strong contrasts in light and shade were created. Strong shadows were cast across the cylindrical columns, walls and ground plane creating a wonderful, animated play of light that contrasted with the bright shadowless areas.

## VISUAL EFFECTS

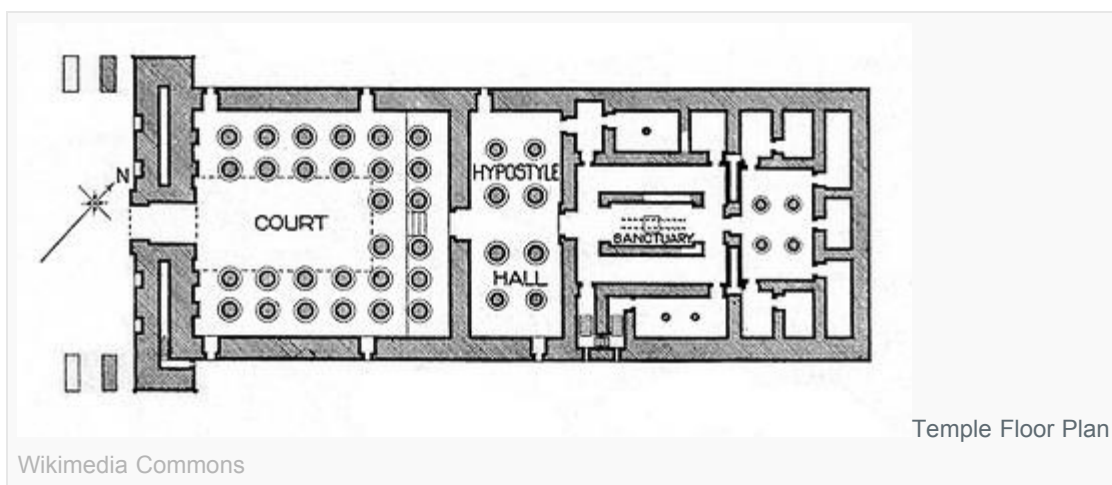
The temple is organized around a strong central axis that moves through a series of ever-increasing sacred and intimate spaces. The type and quantity of light was also correspondingly manipulated. The power of these spaces and lighting effects can be best understood in the context of a description of how the architecture was used during festivals and religious ceremonies. During most festivals a large procession of commoners and priests headed by the pharaoh would approach the temple.



Entry Pylon

Wikipedia Commons, author: HoremWeb

They would be first greeted by a row of small stone sphinxes on either side of the path. The sphinxes in turn would introduce the procession to the entry pylon or “entry gate.”



Temple Floor Plan

Wikipedia Commons

The walls of the pylon were edged with torus moldings, crowned by a cavetto cornice, and decorated with masts for royal banners. It was meant to portray the power of the gods and of the pharaoh. In the center of the pylon is a modest opening through which only the pharaoh, the priests, and high-ranking officials could pass. The opening created a strong sense of threshold that signifies that one is entering a sacred precinct. Once the procession

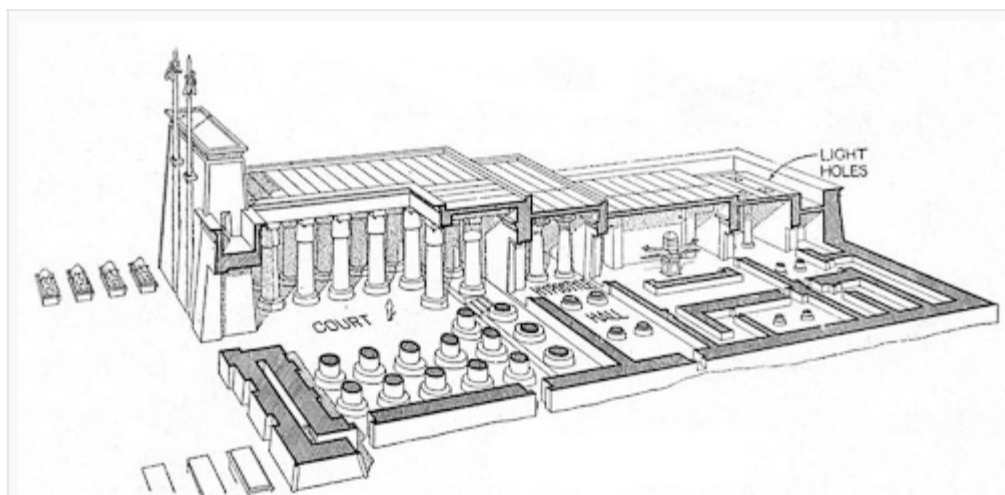
passed through the gateway they found themselves in a high-walled enclosure with two rows of massive colonnades on either side of the center pathway.



Temple Peristyle

Wikimedia Commons

Open to above the strong Egyptian sunlight poured in to the center of the space while the roofed perimeter was immersed in shadow. The change in light prepared the procession for the coming darkness of the inner spaces. Next in the progression of spaces is the hypostyle hall with its filtered light from its screened clerestory windows. Enclosed by full-height walls, the roof was supported by eight free-standing columns. The lower light level and filtered quality is a profound change from the previous courtyard space. The spaces became progressively smaller, shorter, darker, and holier.



Temple Section

Penn State Libraries Pictures Collection

Correspondingly, the entourage gets progressively smaller with only the highest ranking officials proceeding

forward.

The next space was the Hall of the Barque that displayed the barque that was used to transport an effigy of Khonsu from the Amun Complex of Karnak to the temple at Luxor. The final space behind the Hall of the Hall of the Barque was the Pronaos. It was the smallest and holiest space as it housed the effigy of Khonsu.



# Pantheon

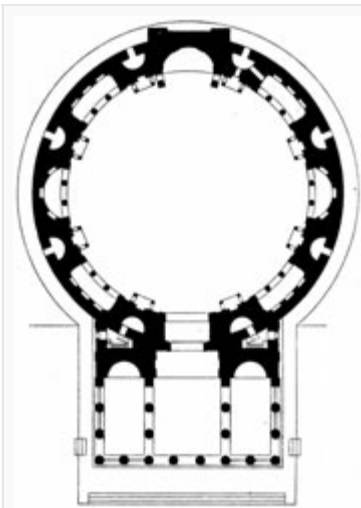
## SYMBOLISM / SOCIAL ISSUES



Entry Facade

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Located in Rome, Italy, the Pantheon was originally commissioned by the Roman statesman Marcus Agrippa and then later rebuilt by Emperor Hadrian around 126 A.D. The building was first used as a temple to the major gods of Ancient Rome. The design features a circular structure (rotunda) with a portico of granite columns supporting the pediment. The rotunda sits under a coffered, concrete dome with an oculus (central opening) at its top.



Floor Plan

Wikimedia Commons



Section

Wikimedia Commons

As the building was originally dedicated to the twelve most powerful gods of the Roman pantheon, the dome was intended to represent the sky dome and the heavens above. The centralized point of natural light provided by the oculus was symbolic of the sun being the source of all light on earth.

### TECHNOLOGY

The Pantheon features the largest unreinforced concrete dome in the world. The thickness of the dome gradually reduces as the dome approaches the oculus. By doing so the overall mass of the dome, its internal stresses, and outward thrust could be minimized. The coffering further reduces the mass of the dome while articulating its overall appearance.

The oculus with its natural light served as the primary source of illumination. On sunny days a circular beam of light tracks across the temple animating its interior. In addition to illumination, the oculus also serves as a method for cooling and ventilating the interior. Any hot air that builds up will be naturally drawn up and out the top of the building. Because the oculus is unglazed and open to the air, any rain water that falls into the building is carried away through an elaborate drainage system in the floor.

### VISUAL EFFECTS

The Pantheon creates a unique spatial experience resulting from a combination of engineering, symbolism, and emotional design. The spatial experience of a visitor actually begins well before they reach the building. As they walk through the nearby neighborhoods they are spatially compressed by the narrow streets and tall buildings. But once they emerge from the streets and enter the open piazza in front the building the space decompresses and opens up to the sky. At this point the visitor can then clearly see the temple before them, but much of its form is obscured by its large entry portico. As a result they do not get any of the typical visual cues that suggest overall building form and interior volume. But as they move forward and enter the space under the portico they are immediately enveloped in shadow and drawn to the open, bronze doors. Finally, as they enter the rotunda they are met with the soaring overhead dome and bright central oculus. The open-air oculus is the only light source and allows the natural light to spill freely into the interior. And as the sun crosses the bright Italian sky, it casts a strong pattern of light across the colorful floors and walls creating an ever-changing luminous and spatial experience. The building itself is massive, but the interior experience is one of visual lightness and where the visitor cannot help but be emotionally connected to the divine.



Interior Perspective

Wikimedia Commons



Oculus

Wikimedia Commons

# Hagia Sophia

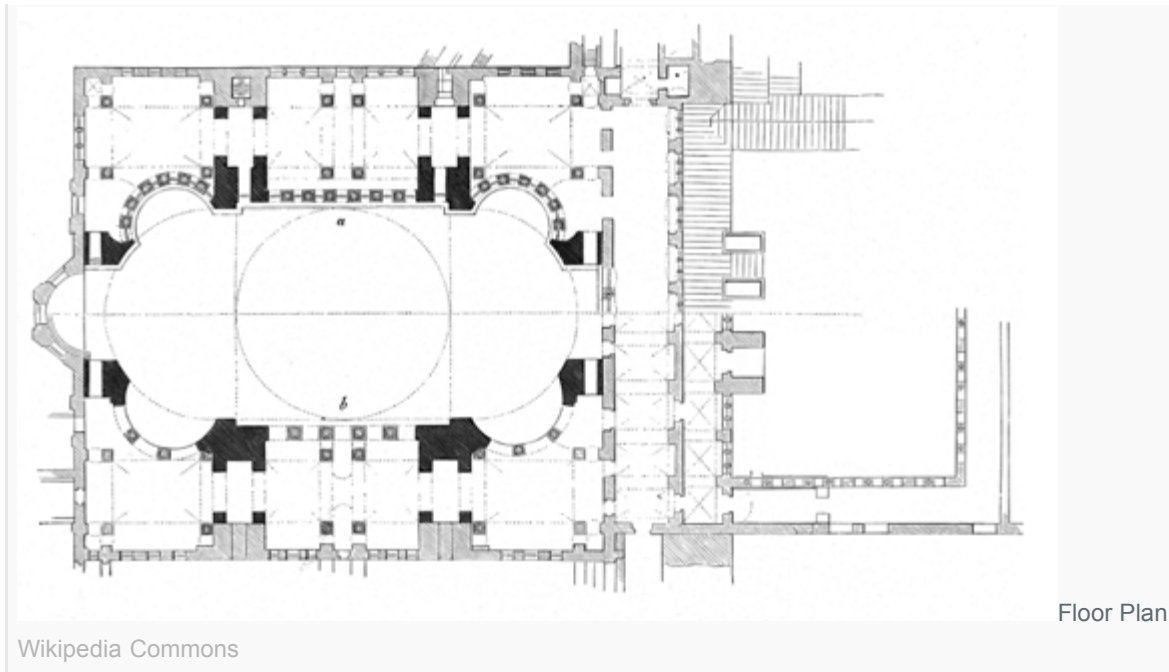
SYMBOLISM / SOCIAL ISSUES



Exterior

Wikipedia Commons

Christianity, unlike the pagan religions that preceded it believes in the presence of a transcendent and incarnate God. For early Christian architects the challenge was how to express in material form the ideals and presence of an immaterial God. The western Roman Catholic Church adopted and evolved a model based on the horizontal axis of the Roman basilica. In the east, the Byzantines and the Eastern Orthodox Church developed a layout based on a centralized plan and domed architecture.



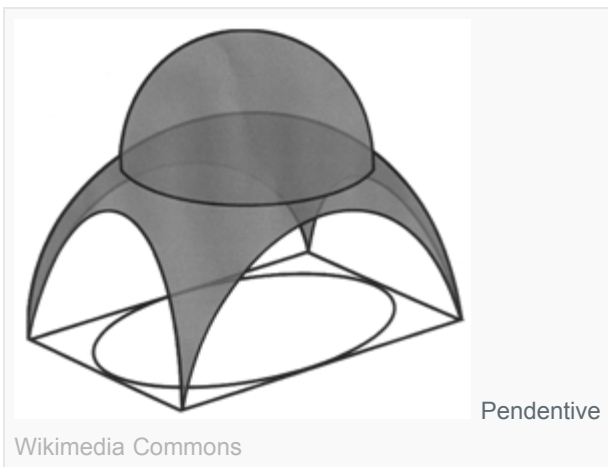
Floor Plan

Wikipedia Commons

The Hagia Sophia is considered the finest example of Byzantine ecclesiastical architecture. It was built as the Cathedral of Constantinople (Istanbul, Turkey) by Emperor Justinian between c. 532 – 537.

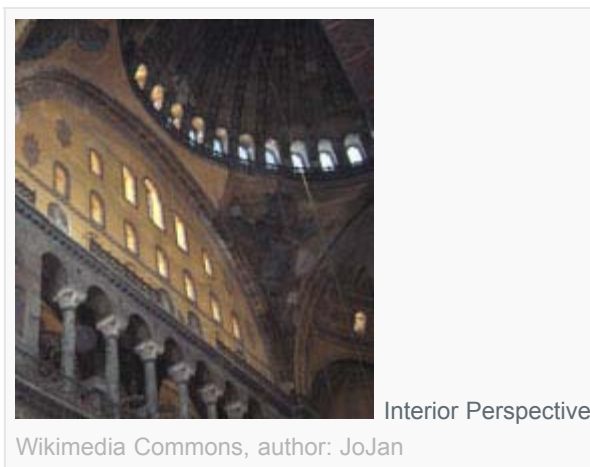
### TECHNOLOGY

The central dome of the church was made possible by use of pendentives. Invented by the Romans it was adopted and further developed by the Byzantines. A pendentive is a type of construction that allows a circular dome to be placed over a square space. The pendentives are the concave triangular segments that are created when four large arches rise upward from the four edges of the square space and transition to the circular base of a hemispherical dome. The pendentives receive the weight of the dome and then concentrate it downward along the tapering mass of the pendentives to the four corners of the square base. Since the spaces beneath the large arches are essentially non-load bearing large windows can be used to fill the interior with light.



Pendentive

Wikipedia Commons



Interior Perspective

Wikipedia Commons, author: JoJan

The official court historian Procopius wrote the following concerning the dome:

“And since the arches where they are joined together are so constructed as to form a four-cornered plan, the stone-work between the arches produces four triangles. And while each supporting end of a triangle, having been contracted to a point by the coming together of each pair of arches, makes the lower point an acute angle, yet as the triangle rises and its width is extended by the intermediate

surface, it ends in the segment of a circle which it supports, and forms the remaining angles at that level. Upon this circle rests the huge spherical dome which makes the structure exceptionally beautiful. Yet it seems not to rest upon solid masonry, but to cover the space with its golden dome suspended from Heaven.”

## VISUAL EFFECTS

In addition to the windows in the clerestories beneath the pendentives there are forty windows under the base of the central dome that flood the interior with light. As a result the dome appears to float above its base on a cushion of light. The visual effect is further enhanced by magnificent golden mosaics and marble surfaces that line the interior surfaces of the church. Or as Procopius wrote: “... it abounds exceedingly in sunlight and in the sun’s rays from the marble. Indeed one might say that its interior is not illuminated from without by the sun, but that the radiance comes into being within it, such an abundance of light bathes the shrine.”

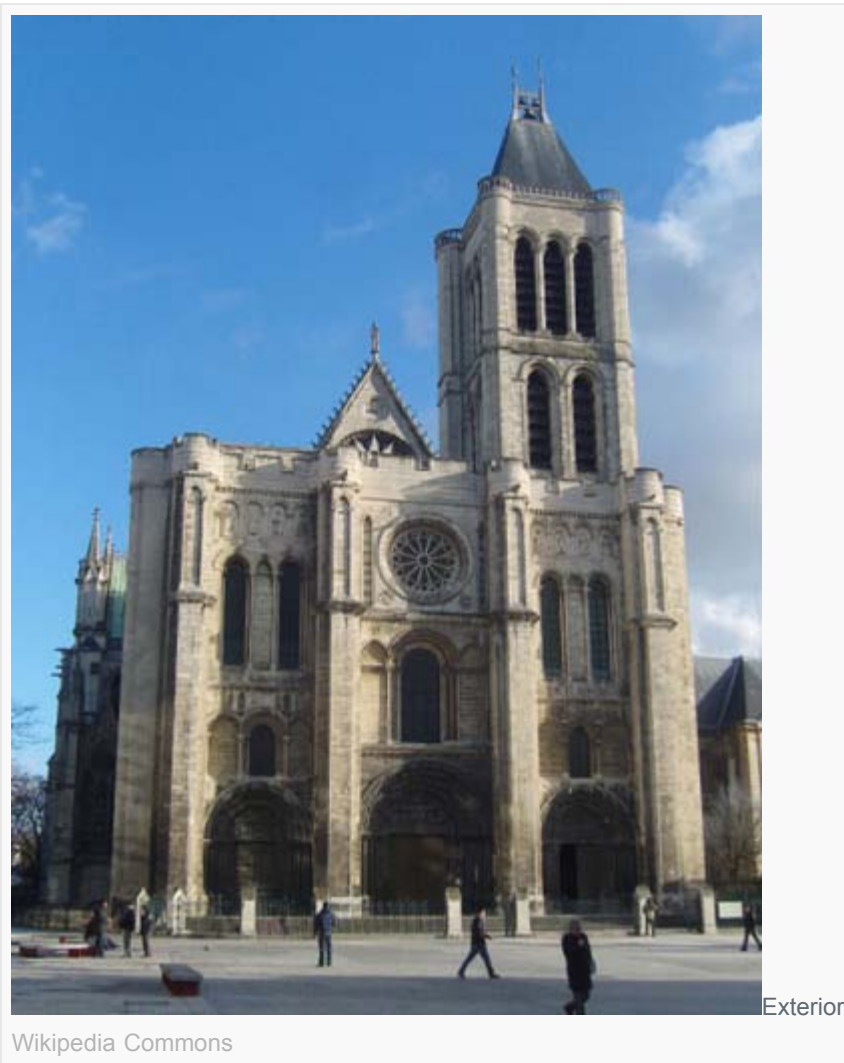


Interior Perspective

Wikipedia Commons

# Abbey At St. Denis

## SYMBOLISM / SOCIAL ISSUES



Wikipedia Commons

Perhaps no other period of architecture is more recognizable to the layman than is the Gothic. With its soaring interiors, flying buttresses, and stained glass windows. It has come to embody the epitome of religious architecture. The Gothic began in the Ile-de-France region of northern France in the twelfth century and the rest of Western Europe anywhere from a generation to a century later. It transformed Romanesque architecture and reigned supreme in Western Europe until the start of the Renaissance in the fifteenth and sixteenth centuries. The two driving forces that propelled the movement forward were a reverence for the mysticism of light as a manifestation of God and the structural development of the pointed arch and ribbed vault.

The actual start of the Gothic is attributed to the rebuilding of the ambulatory and the radiating chapels at the Abbey Church at St.-Denis located outside of Paris between 1140 and 1144. Suger, the Abbot of St.-Denis oversaw the rebuilding and from his accounts of the time was enthralled with the notion of a light-filled interior. He wrote concerning the stained glass:

“Thus, when out of my delight in the beauty of the house of God – the loneliness of the many-colored gems has called me away from external cares, and worthy meditation has induced me to reflect, transferring that which is immaterial, on the diversity of the sacred virtues: then it seems to me that I

see myself dwelling, as it were, in some strange region of the universe which neither exists entirely in the purity of heaven; and that, by the grace of God, I can be transported from this inferior to that higher world in an analogous manner”.

The desire for a lighter-scaled architecture filled with light suddenly replaced the desire for the existing heavy, massive, and cloistered Romanesque architecture.

## TECHNOLOGY

Corresponding with this desire for a more light-filled interior there were a number of structural innovations that made it possible. There is evidence that Norman masons had been experimenting with the development of the ribbed vault in a number of smaller churches. The master mason for St. Denis is unknown, but it is likely that he was familiar with the innovations and chose to use them for the first time in a large scale at the Abbey. With the ribbed vault roof loads no longer have to be supported by heavy continuous exterior walls. The structural loads are collected and then concentrated onto columns, collonettes, or compound piers. This frees the exterior walls from carrying additional loads. Four thousand years of post-and-lintel construction and at least a thousand years of massive vault design had suddenly become obsolete. All because of the desire to admit as much light as possible into the interior. The necessary use of buttresses and spires to brace the ribbed vaults were moved to the exterior in order to minimize their visual impact on the interiors and detract from the visual presence of the windows.



System of Ribbed Vaulting

## VISUAL EFFECTS

The visual effects of the newly renovated St.-Denis were profound and eventually fueled a competition between cities, church officials, architects, sculptors, and painters to create the tallest, grandest and most light-filled church interiors well into the sixteenth century.



Ambulatory

Wikipedia Commons



Nave

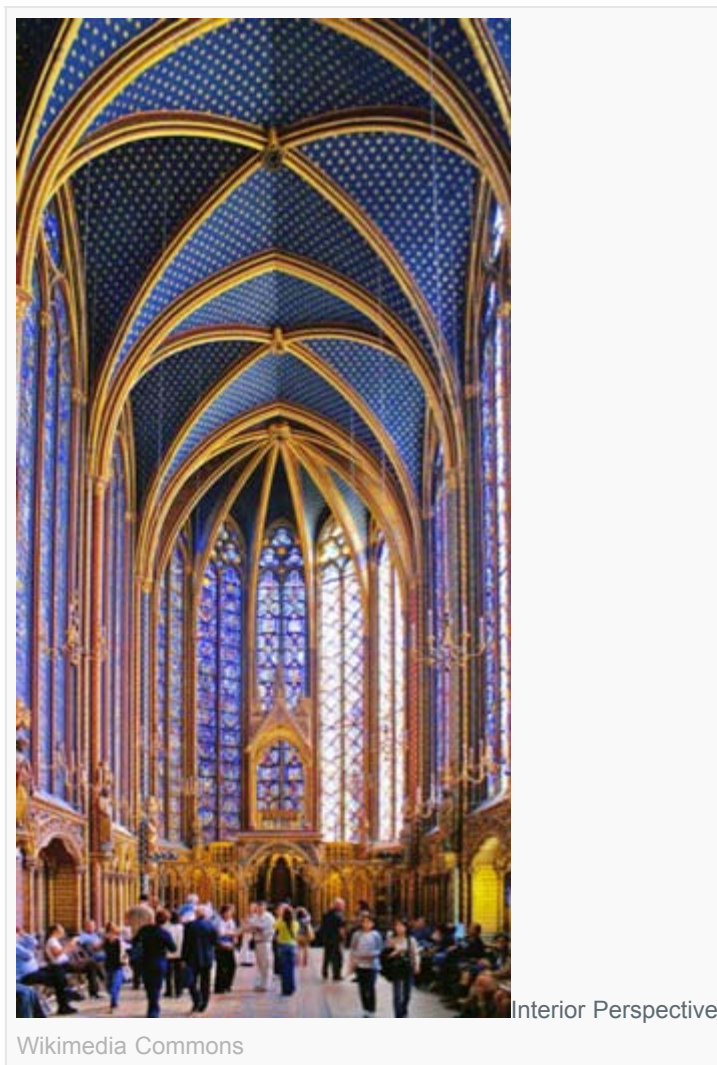
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# Sainte-Chapelle

## SYMBOLISM / SOCIAL ISSUES

Sainte-Chapelle was built in Paris from 1241-1248 by the greatest of the French medieval kings, Louis IX. It served as the royal chapel and a repository for a number of purported Holy Relics including fragments of the Crown of Thorns and Christ's Cross. It is two-stories high with a parish church used by the public on the ground floor while the king and his court worshipped in the main chapel on the upper floor. In the upper chapel, except for the dado zone the exterior walls of the church are reduced to a minimal skeletal form. The stone skeleton extends upward to support the delicate groin vaults that form the ceiling structure and the walls are in-filled with a stunning expanse of brilliant stained glass.



## TECHNOLOGY

Sainte-Chapelle is perhaps the greatest example of Rayonnant style of the French Gothic. The style is characterized by a greater concern for two dimensional surfaces and the appearance of structural lightness. More of the wall surface than ever before was pierced by windows with the desire to maximize the quantity of light admitted into the church. Sainte-Chapelle achieved this through the use of two innovative constructional techniques. First, was the use of a sophisticated external buttressing system, and second, the use of encircling iron chains hidden in the window tracery. Both were used to resist the substantial outward thrust of the roof in a visually

minimal manner.

## VISUAL EFFECTS

The visual effects of the chapel are astounding. The interior is completely saturated in light from the large and colorful windows. The slender and elongated collonettes soar dramatically upward drawing one's eye to the ribbed vaulting and ceiling above. The color of the blue ceiling and the blue glass closely match and appear to blend into one and fully envelope the viewer in a heavenly cloak.

# Crystal Palace

## CULTURAL / SOCIAL ISSUES



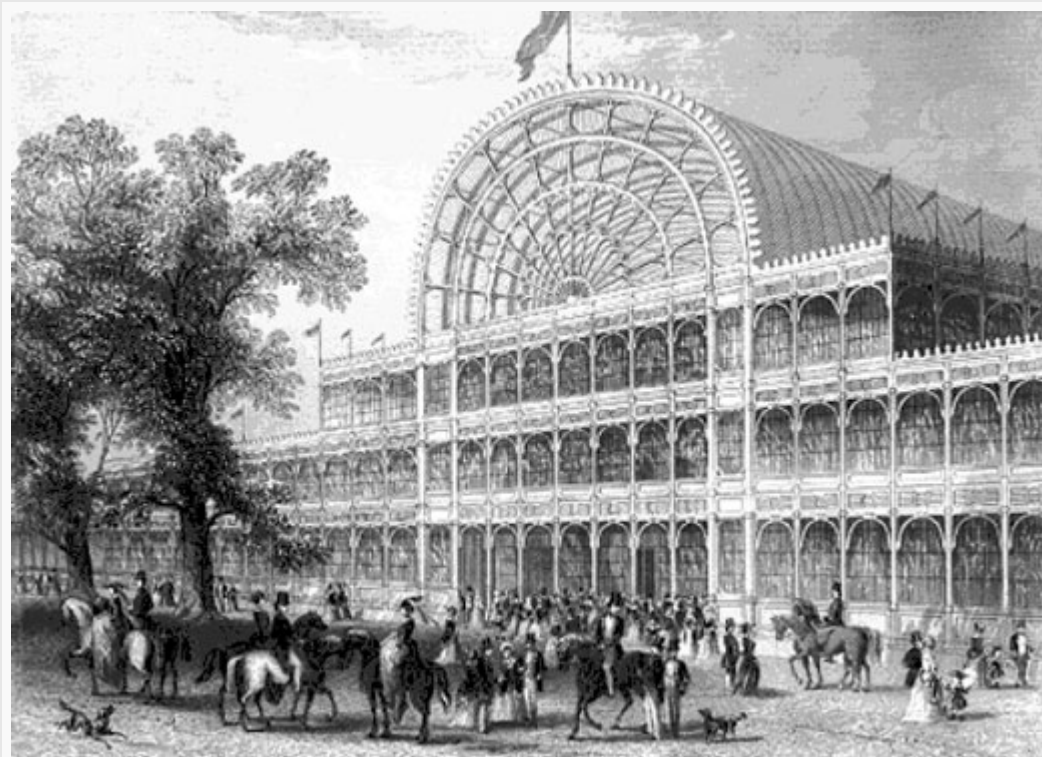
Exterior Perspective

Wikipedia Commons

The Great Exhibition of the Works of Industry of all Nations was an international exhibition that took place from May 1st to October 15, 1851 outside London, England. It was the first of a series of World Fairs of culture, technology, and industry that became popular during the nineteenth century. It laid the groundwork for all subsequent World Fairs that included the famous Paris Exposition Universelle of 1889 and the 1893 World's Columbian Exposition in Chicago. Organized by Prince Albert and the Members of Royal Society for the Encouragement of Arts, Manufactures and Commerce, the Great Exposition was meant to show the world England's leadership in industrialization. The exhibition, which ran for six months, was wildly popular and attracted over six million visitors. In 1850, the Royal Commission announced an international invitation for architects to submit design proposals for the construction of a great building to house the exposition. In response, approximately 250 architects submitted design proposals. For better or for worse all of the designs were rejected primarily because of cost or too lengthy of construction times. But late in 1850 the gardener and greenhouse designer Joseph Paxton submitted a design for essentially a gigantic greenhouse. Immediately accepted with substantial modification it was constructed in less than nine months' time. It was immediately maligned by the larger architectural community for not embracing the traditional values of mass, void, and spatial articulation, but the public became enamored with it. Its futuristic visual effects, the dematerialization of the exterior walls, its enormous size yet lightness, as well as, its saturation in natural light all created a dramatic visual effect.

## TECHNOLOGY

The reduced construction time and cost were due primarily to the mass produced and prefabricated components that made up the structure. Techniques that had been recently developed in English factories were applied for the first time on a building scale. To streamline the process a limited number of parts were manufactured in vast quantities and repetitively assembled by thousands of workers. There were 3,230 columns, 2,141 girders, and over 1,000,000 linear feet of sash bars.



Exterior Perspective

Wikipedia Commons

Also important were recent developments in the inexpensive production of glass. Just a few years earlier the production of rolled plate glass was invented by the Englishman James Hartley. He developed the process where molten glass was first deposited on the smooth cast-iron bed of a rolling table. A large roller was then passed over the surface of the soft glass that formed the glass to a constant and uniform thickness. The glass was then cut and trimmed to the desired size and finally passed through an annealing tunnel where it gained its final strength. Over 900,000 square feet of glass were produced for the building – more than any other building in the world at that time.

### VISUAL EFFECTS

The visual effects for the Victorian visitor must have been astonishing. With its tremendous scale -- 1,851 feet in length (a play on the fact that the exhibition was held in 1851) by 456 feet in width and 128 feet in height the light-filled vistas must have been awe-inspiring. The vistas must have seemed to have faded into the horizon.



Interior Perspective

Wikipedia Commons

And so great was the light during the day that no supplemental lighting was needed to illuminate the interior. The light was even so bright and the building so tall that one of the great elm trees that was living on the original site was spared and the building built around it.



Interior Perspective

Wikipedia Commons



Interior Perspective

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Even today we rarely see such a building so transparent and visually dematerialized. But all this unfiltered glass was not without problems. The building had a strong tendency to overheat even in the mild English weather. To counter this a canvas screen was installed on the outside of the glass to filter the harsh sun. The cooling effects of the screens were also enhanced by spraying them with water. On the interior the light was softened and given a light egg-shell hue. To help animate the interior much of it was colorfully painted. The structure, the vertical surfaces, struts, and columns were all painted a light blue. The undersides of the galleries were painted a dark red and the column capitals were painted a dark yellow.

# Unity Temple

## SYMBOLISM / CULTURAL ISSUES

Located in Oak Park, Illinois and finished in 1908, the Unity Temple was commissioned by the Unitarian Universalist Church to replace their place of worship that had burned down a few years earlier. Designed by Frank Lloyd Wright it is considered one of his most significant buildings from his Prairie School period.



Exterior Facade

Wikimedia Commons, author: IvoShandor

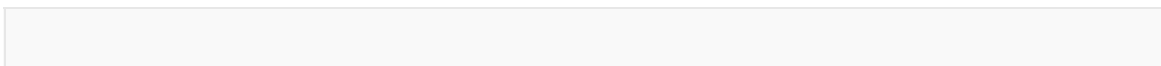
Made out of exposed, cast concrete, Unity Temple has a similar monolithic appearance to ancient Greek and Egyptian temples. Egyptian temples in particular made use of clerestories, as Unity Temple does, to bring in natural lighting. Wright once said that “the sun is the great luminary of all life.” This philosophy of Wright’s is evident in the extensive use of natural lighting in the Unity Temple. Throughout history, natural light has represented the divine and eternal. Light is a provider for many essentials in life such as food, sight, and warmth. Through the use of natural lighting, the building allows man a space for worship and self-reflection to better understand the divine and eternal nature God.

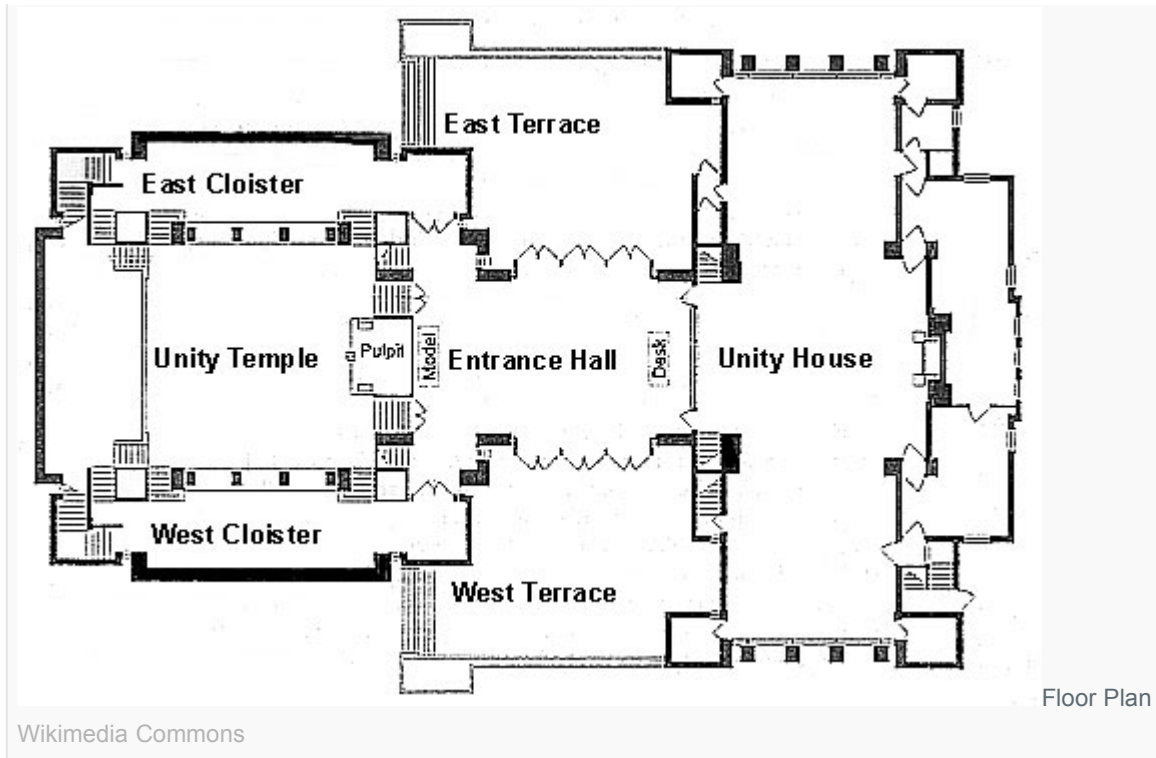
## TECHNOLOGY

Unity Temple was one of the first buildings constructed entirely of poured-in-place, exposed concrete. Concrete was the perfect material for several reasons. First, the budget was relatively small and the concrete was a very cost-effective. Second, it gave the temple a timeless, dignified and monolithic appearance. Third, the concrete helped to acoustically isolate the sanctuary from the noisy adjacent street.

## VISUAL EFFECTS

The overall building massing is rather simple. It consists of two large masses that enclose the sanctuary space (Unity Temple) on one end and the common space (Unity House) on the other. The two masses are in turn linked together by the Entrance Hall.





The masses that form the Temple and the Unity House spaces are rather plain with solid massive walls. Visual interest comes from the projection of strong horizontal roofs supported by muscular columns that in turn screen deeply recessed windows.

Once a visitor approaches and enters the Entrance Hall Wright carefully manipulates their spatial experience on their way to the sanctuary. The Entrance Hall is linked to the outside with the extensive use of stained glass windows and doors that Wright referred to as “light screens.” The visitor then turns to the left and enters one of two rather small, dark passageways that Wright referred to as the “Cloisters”. These spaces lead to the sanctuary and help to enhance the visual explosion of light and space as one enters the sanctuary.





Interior Perspective

Wikimedia Commons

The sanctuary is filled with natural light, streaming through the clerestories and skylights above. Wright often used this spatial journey of compression and expansion to enhance the overall spatial experience of his buildings. To further complement his spatial decisions he typically developed a number of lighting strategies to enhance the emotional impact of his spaces. For instance, he used large eaves on the exterior to protect the interior from glare and to help diffuse the light from the clerestory windows. The clerestory windows then create a perimeter ring of light making the roof visually float above the lower walls. Equal attention was paid to the roof and skylights. The exterior features an outer glass roof that captures and directs the light to the interior stained glass ceiling. The stained glass in turn diffuses the light even more. Wright then chose warm, earthy tones for the stained glass to evoke feelings of nature and the outdoors. Although it may have been done partially for practical purposes, the lack of eye level glazing, coupled with natural light streaming in from above, offers the visitor the opportunity to be emotionally transported to the heavens and God above.

# Sainte Marie De La Tourette

## SYMBOLISM / SOCIAL ISSUES

Designed by Le Corbusier and constructed between 1956 and 1960, it is Dominican monastery near Lyon, France. Built for approximately 100 monks it consists of two levels and houses a church, library, study halls, work areas, refectory, and sleeping rooms. Its layout is based on a traditional cloister with perimeter circulation. But since the building is built on a steep slope the traditional layout is creatively abstracted with the circulation areas elevated well above the courtyard.

## TECHNOLOGY

The monastery is constructed of poured-in-place concrete creating a massive and at times a severe appearance. But Le Corbusier expertly manipulated the exterior massing, detailing, and textures to enhance the play of sunlight on the surfaces of the building over the course of the day. Le Corbusier also utilized a number of innovative daylighting strategies to illuminate the interior. Light shafts, or what Le Corbusier referred to as “light cannons, guns”, were cast into the concrete to capture and deftly aim the light to specific locations in the interior. To control the daylight entering the monks sleeping cells he utilized a brise-soleil, or “sun breaker”, system of louvers that were cast into the exterior concrete. For the walls of the corridors facing the courtyard he developed a system of concrete frames and glass panes whose spacing was based on musical theory. Le Corbusier even referred to them as “musical glass panes.” The dappled pattern of light and shadow that they cast across the floor was visually dynamic and constantly animated the spaces.

## VISUAL EFFECTS

The play of light is creatively integrated in almost every interior space of the monastery. But perhaps the grandest use was in the church portion of the monastery. It is a large box-shaped space laid out on an east-west axis. The space is divided transversely by five steps. The western, lower half has rows of benches arranged parallel to the long walls. The benches are illuminated by daylight that enters the space through long brightly colored slots located above and behind the monks. The visual effect is one of a soft shower of light cascading over the monks when praying at the benches. To the south of the altar is an opening in the wall. There, behind a screen, is the sacristy lit by a number of daylight admitting light cannons. To the north of the altar the wall opens onto a side chapel. It extends into the upper area of the lower church and is illuminated by colored light emanating from light cannon. In this chapel stands the sacramental altar. Behind and to the north of the sacramental altar is lowered chamber that houses a number of small altars. The walls of this chamber are painted red and yellow and the ceiling painted blue. The light cannons bring in light from above and shower each altar with light.

# Kimball Art Museum

## SYMBOLISM / SOCIAL ISSUES

Located in Ft. Worth it was designed by the architect Louis I. Kahn to house the art collection of Kay and Velma Kimball it is considered to be one of the most significant museum buildings in the United States. Richard Brown, the museum's curator, desired a modestly-scaled building where natural light would play an important part. This meshed with Kahn's almost mystical belief in the importance of daylighting in architecture.



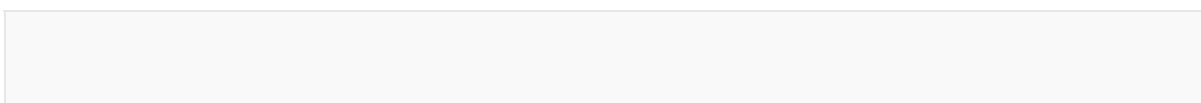
Exterior

Wikimedia Commons

## TECHNOLOGY

In response to Richard Brown's call for a museum that utilized daylight, Kahn designed the building that consists of a series of sixteen parallel concrete cycloid vaults. Each vault is 100 feet long by 20 feet high by 20 feet wide by 5 inches thick. The cycloid vaults are not technically vaults, but rather, beams taking the form of concrete shells. To achieve this dynamic structural form the concrete is post-tensioned and supported by a concrete column at each corner. Kahn wrote concerning the vaults: "My mind is full of Roman greatness and the vault so etched itself in my mind that, though I cannot employ it, it's there always ready. And the vault seems to be the best"...and, "The vault, rising not high, not in an august manner, but somehow appropriate to the size of the individual. And its feeling of being home and safe came to mind."

To admit daylight a thin linear skylight was installed along the top of each of the vaults and runs their entire length. To screen the artwork from harmful UV radiation and reflect the light up onto the underside of the vaults a specially designed reflector with perforated aluminum screens was installed. Louis Kahn referred to it as a "natural lighting fixture" that is a "modifier of the light, sufficiently so that the injurious effects of the light are controlled to whatever degree of control is now possible. And when I look at it, I really feel it is a tremendous thing".





Exterior Vault

Wikimedia Commons

## VISUAL EFFECTS

The luminous quality of the museum is greatly admired. The ambient light is soft and even and creates a comfortable and relaxed environment. Yet the character of natural light subtly changes during the day and is affected by changing weather conditions. Kahn wrote concerning this... “And as the cloud that passes over gives the room a feeling of association with the person that is in it, knowing that there is life outside of the room, and it reflects the life-giving that a painting does because I think a work of art is a giver of life. So light, this great maker of presences can never be... brought forth by the single moment in light which the electric bulb has. And natural light has all the moods of the time of the day, the seasons of the year, which year for year and day for day are different from the day preceding.” For many, the luminous quality of the Kimball Art Museum is the benchmark against which all other spaces are compared.



Interior Perspective

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