Combustion Based Light Sources and Devices

(Man Made Sources of Light)

Raymond Mccall

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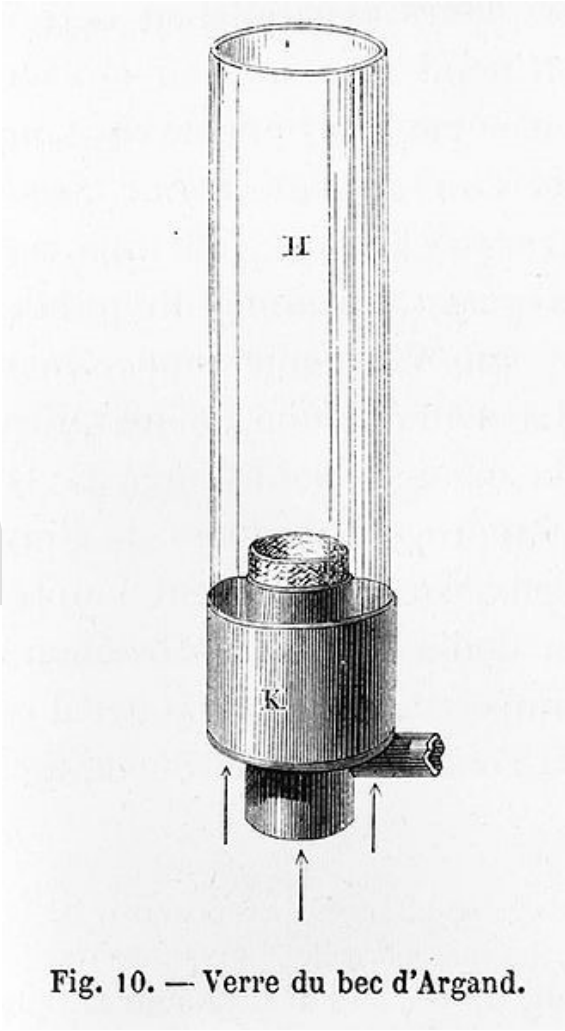


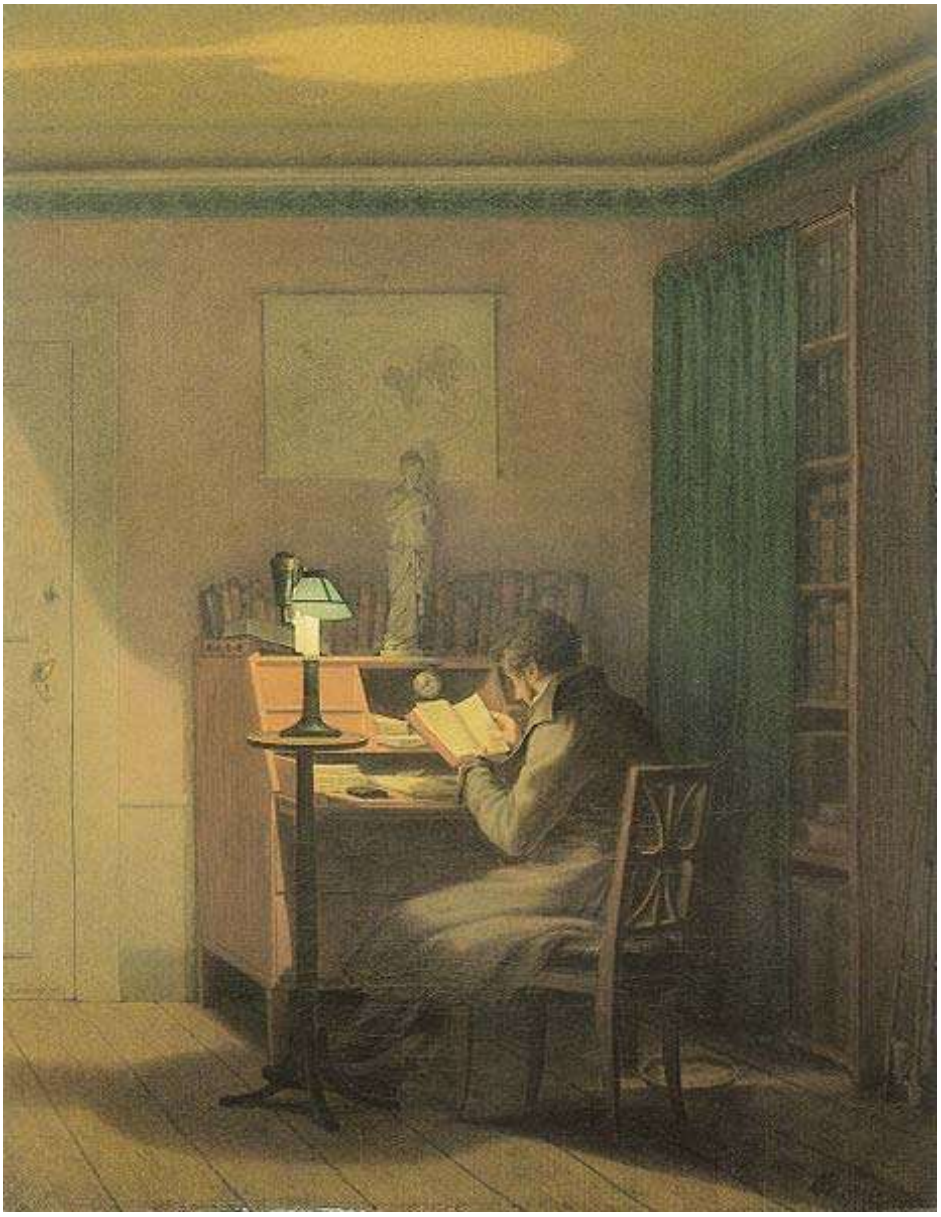
Fig. 10. — Verre du bec d'Argand.

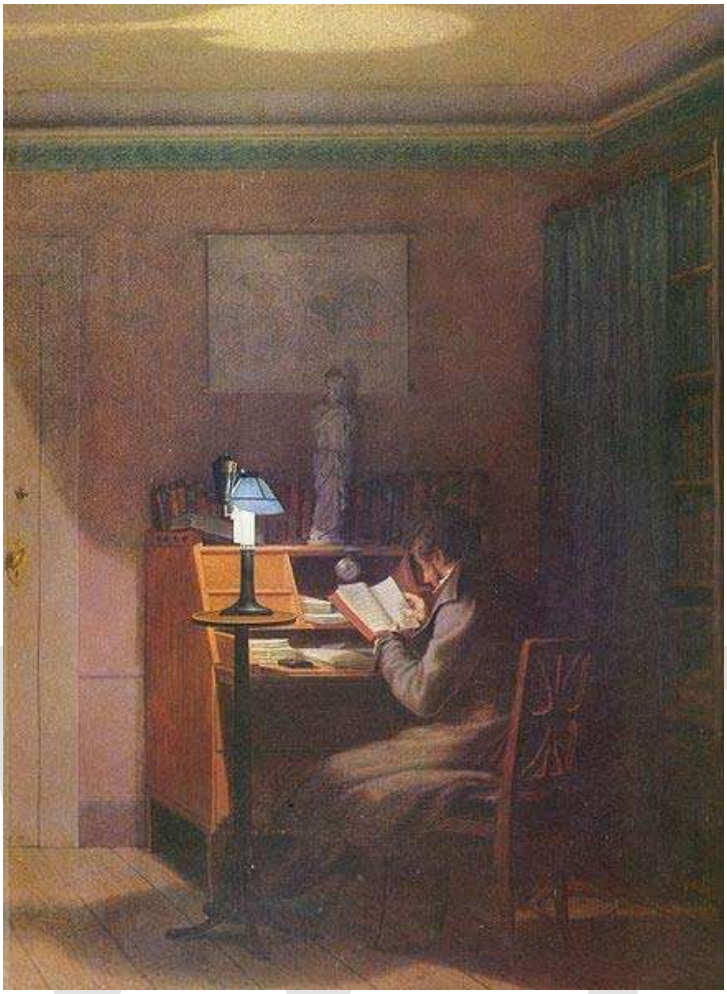
Argand lamp with circular wick and glass chimney

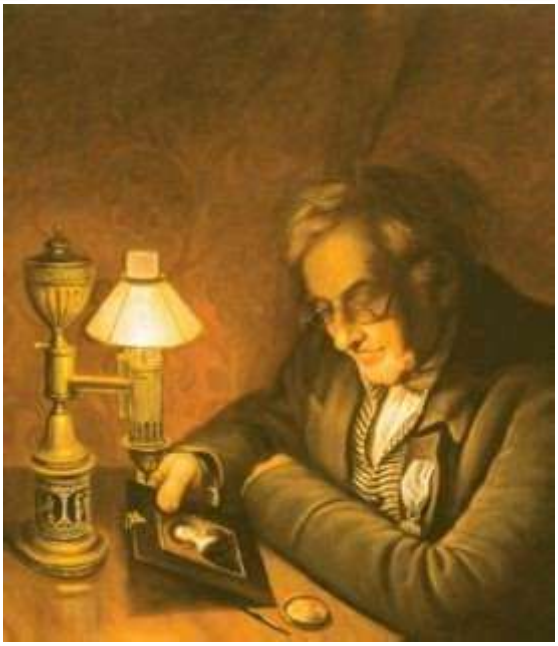
The **Argand lamp** was invented and patented in 1780 by Aimé Argand. It greatly improved on the home lighting oil lamp of the day by producing a light equivalent to about 6 to 10 candles.

Design

The Argand lamp had a tubular wick mounted between a pair of concentric cylindrical metal tubes so that air is channeled through the center of the wick, as well as outside it. A cylindrical chimney, in early models made of ground glass and sometimes tinted, surrounded the wick, steadying the flame and improving the flow of air. It used a supply of good liquid oil, usually colza or other vegetable oil as the fuel. This was supplied by gravity feed from a reservoir mounted above the burner. Aside from the improvement in brightness, the more complete combustion of the wick and oil required much less frequent snuffing (trimming) of the wick.

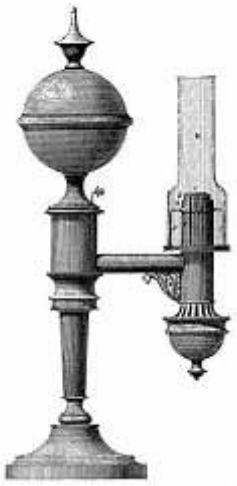






History

The Argand lamp quickly displaced all other varieties of oil lamps and was manufactured in a great variety of decorative forms. They were more costly than the primitive oil lamps of former times because of their increased complexity, so they were adopted first by the well-to-do, but soon spread to the middle class and eventually the less well-off as well. It was the lamp of choice until about 1850 when kerosene lamps were introduced. Kerosene was cheaper than vegetable oil, it produced a whiter flame, and as a liquid of low viscosity it could easily travel up a wick eliminating the need for complicated mechanisms to feed the fuel to the burner.



In France, they are known as "Quinquets" after Antoine-Arnoult Quinquet, a pharmacist in Paris, who stole the idea from Argand and popularized it in France. He is sometimes credited, in France, with the addition of the glass chimney to the lamp.

A disadvantage of the original Argand arrangement was that the oil reservoir needed to be above the level of the burner because the heavy, sticky vegetable oil would not rise far up the wick. This made the lamps top heavy and cast a shadow in one direction away from the lamp's flame. The Carcel lamp of 1800 and Franchot's moderator lamp of 1836 sought to overcome these problems.

Chapter- 2

Gas Lighting

Gas lighting is production of artificial light from combustion of a gaseous fuel, including hydrogen, methane, carbon monoxide, propane, butane, acetylene, ethylene, or natural gas. Before electricity became sufficiently widespread and economical to allow for general public use, gas was the most popular means of lighting in cities and suburbs. Early gas lights had to be lit manually, but later gas lights were self-lighting.

Gas lighting today is typically used for camping, where the high energy density of a hydrocarbon fuel, combined with the modular nature of canisters (a strong metal container) allows bright and long lasting light to be produced cheaply and without complex equipment.

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History

Gas lighting in the historical center of Wrocław, Poland

Background

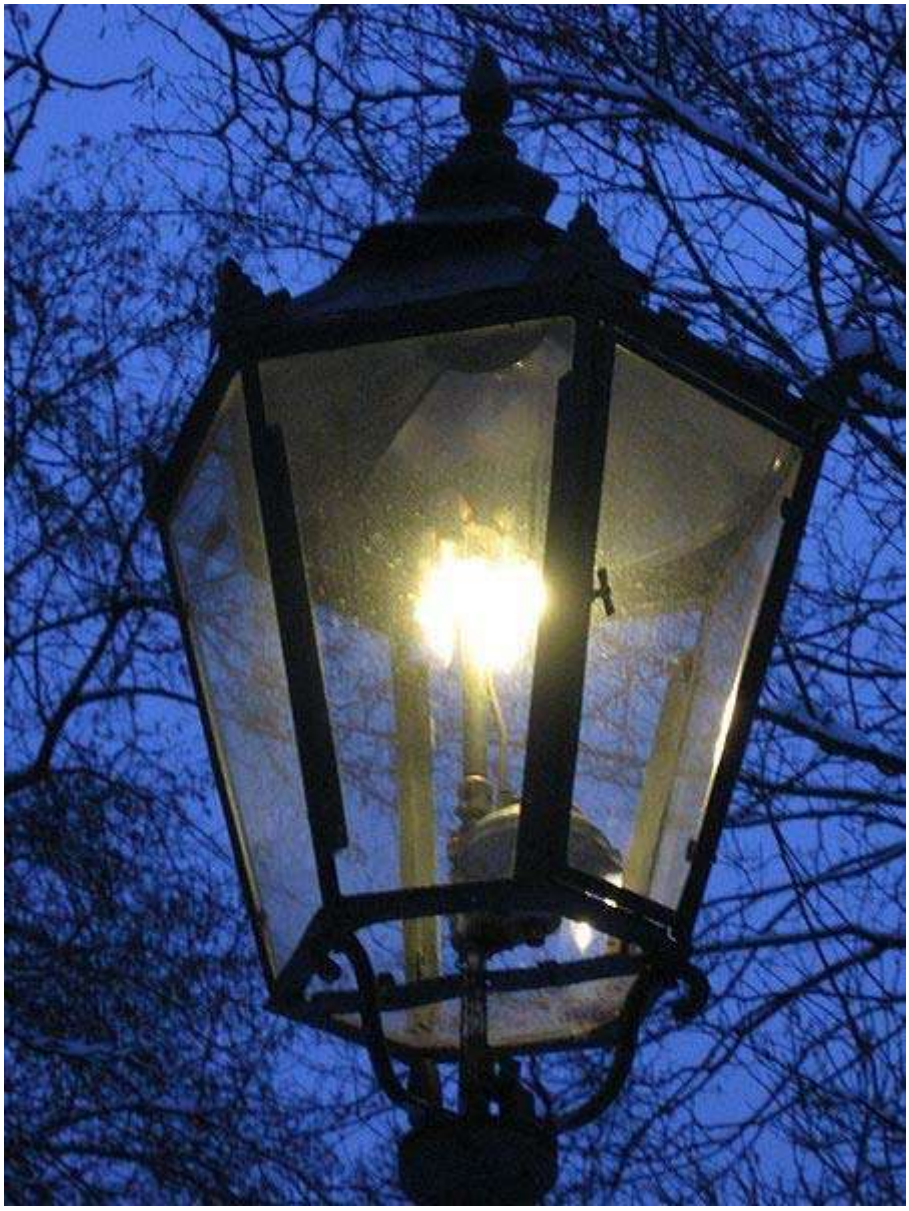
Early lighting fuels consisted of olive oil, beeswax, fish oil, whale oil, sesame oil, nut oil, and similar substances. These were the most commonly used fuels until the late 18th century. Chinese records dating back 1700 years note the use of natural gas in the home for light and heat via bamboo pipes to the dwellings.

Public illumination preceded the discovery and adoption of gaslight by centuries. In 1417, Sir Henry Barton, Mayor of London, ordained "lanterns with lights to be hanged out on the winter evenings between Hallowtide and Candlemasse." Paris was first lit by an order issued in 1524, and, in the beginning of the 16th century, the inhabitants were ordered to keep lights burning in the windows of all houses that faced the streets. In 1668, when some regulations were made for improving the streets of London, the residents were reminded to hang out their lanterns at the usual time, and, in 1690, an order was issued to hang out a light, or lamp, every night as soon as it was dark, from Michaelmas to Christmas. By an act of the common council in 1716, all housekeepers, whose houses faced any street, lane, or passage, were required to hang out, every dark night, one or more lights, to burn from six to eleven o'clock, under the penalty of one shilling as a fine for failing to do so.

In coal mining, accumulating and escaping gases were known originally for their adverse effects rather than their useful qualities. Coal miners described two types of gases, one called the *choke damp* and the other *fire damp*. In 1667, a paper detailing the effects of these gases was entitled, "A Description of a Well and Earth in Lancashire taking Fire, by a Candle approaching to it. Imparted by Thomas Shirley, Esq an eye-witness."

Dr. Stephen Hales was the first person who procured a flammable fluid from the actual distillation of coal. His experiments with this object are related in the first volume of his *Vegetable Statics*, published in 1726. From the distillation of "one hundred and fifty-eight grains [10.2 g] of Newcastle coal, he states that he obtained one hundred and eighty cubic inches [2.9 L] of air, which weighed fifty-one grains [3.3 g], being nearly one third of the whole." These results seemed to have passed without notice for several years.


HIETZINGER HEIMATMUSEUM
LETZTE
WIENER GASLATERNE



In the *Philosophical Transactions of the Royal Society* in 1733, some properties of coal-gas are detailed in a paper called, "An Account of the Damp Air in a Coal-pit of Sir James Lowther, sunk within Twenty Yards of the Sea." This paper, contained some striking facts relating to the flammability and other properties of coal-gas.

The principal properties of coal-gas were demonstrated to different members of the Royal Society, and showed that after keeping the gas some time, it still retained its flammability. The scientists of the time still saw no useful purpose for it.

Dr. John Clayton, in an extract from a letter in the *Philosophical Transactions* for 1735, calls gas the "spirit" of coal; and discovered its flammability by an accident. This "spirit" happened to catch fire, by coming in contact with a candle, as it escaped from a fracture in one of his distillatory vessels. By preserving the gas in bladders, he entertained his friends, by exhibiting its flammability.

The first gas lighting

William Murdoch (sometimes spelled "Murdock") was the first to utilize the flammability of gas for the practical application of lighting. He worked for Matthew Boulton and James Watt at their Soho Foundry steam engine works in Birmingham England. In the early 1790s, while overseeing the use of his company's steam engines in tin mining in Cornwall, Murdoch began experimenting with various types of gas, finally settling on coal-gas as the most effective. He first lit his own house in Redruth, Cornwall in 1792. In 1798, he used gas to light the main building of the Soho Foundry and in 1802 lit the outside in a public display of gas lighting, the lights astonishing the local population. One of the employees at the Soho Foundry, Samuel Clegg, saw the potential of this new form of lighting. Clegg left his job to set up his own gas lighting business, the Gas Lighting and Coke Company.

Close up of plaque on wall of Murdoch House

Murdoch House in Redruth

A "thermolampe" using gas distilled from wood was patented in 1799, whilst German inventor Friedrich Winzer (Frederick Albert Winsor) was the first person to patent coal-gas lighting in 1804.

In 1801, Phillipe Lebon of Paris had also used gas lights to illuminate his house and gardens, and was considering how to light all of Paris. In 1820, Paris adopted gas street lighting.

In 1804, Dr. Henry delivered a course of lectures on chemistry, at Manchester, in which he showed the mode of producing gas from coal, and the facility and advantage of its use. Dr. Henry analyzed the composition and investigated the properties of carburetted hydrogen gas. His experiments were numerous and accurate and made upon a variety of substances; having obtained the gas from wood, peat, different kinds of coal, oil, wax, &c. he quantified the intensity of the light from each source.

Josiah Pemberton, an inventor, had for some time been experimenting on the nature of gas. A resident of Birmingham, his attention may have been roused by the exhibition at Soho. About 1806, he exhibited gas-lights in a variety of forms and with great brilliance at the front of his manufactory in Birmingham. In 1808 he constructed an apparatus, applicable to several uses, for Benjamin Cooke, a manufacturer of brass tubes, gilt toys, and other articles.

In 1806, Murdoch presented to the Royal Society a paper entitled "Account of the Application of Gas from Coal to Economical Purposes" wherein he described his successful application of coal-gas to lighting the extensive establishment of Messrs. Phillips and Lea. For this paper he was awarded Count Rumford's gold medal. Murdoch's statements threw great light on the comparative advantage of gas and candles and contained much useful information on the expenses of production and management.

The first public street lighting with gas was demonstrated in Pall Mall, London on January 28, 1807 by Frederick Albert Winsor. In 1812, Parliament granted a charter to the London and Westminster Gas Light and Coke Company, and the first gas company in

the world came into being. Less than two years later, on December 31, 1813, the Westminster Bridge was lit by gas.

As artificial lighting became more common, desire grew for it to become readily available to the public. This was in part because towns became much safer places to travel around after gas lamps were installed in the streets, reducing crime rates. In 1809, accordingly, the first application was made to Parliament to incorporate a company in order to accelerate the process, but failed to pass. In 1810, however, the application was renewed by the same parties, and though some opposition was encountered and considerable expense incurred, the bill passed, but not without great alterations; and the London and Westminster Chartered Gas-Light and Coke Company was established. By 1816, Samuel Clegg obtained the patent for his horizontal rotative retort, his apparatus for purifying coal-gas with cream of lime, and for his rotative gas meter and self-acting governor.

The spread of gas lighting

Following this success, gas lighting spread to other countries. The use of gas lights in Rembrandt Peale's Museum in Baltimore in 1816 was a great success. Baltimore was the first American city with gas streetlights, provided by Peale's Gas Light Company of Baltimore.

The first private residence in the US illuminated by gas was that of William Henry, a coppersmith, at 200 Lombard Street, Philadelphia, Pennsylvania.

Among the economic impacts of gas lighting was much longer work hours in factories. This was particularly important in Great Britain during the winter months when nights are significantly longer. Factories could even work continuously over 24 hours, resulting in increased production.

In 1817, at the three stations of the Chartered Gas Company, 25 chaldrons (24 m^3) of coal were carbonized daily, producing 300,000 cubic feet (8,500 m^3) of gas. This supplied gas lamps equal to 75,000 Argand lamps each yielding the light of six candles. At the City Gas Works, in Dorset Street, Blackfriars, three chaldrons of coal were carbonized each day, providing the gas equivalent of 9,000 Argand lamps. So 28 chaldrons of coal were carbonized daily, and 84,000 lights supplied by those two companies only.

At this period the principal difficulty in gas manufacture was purification. Mr. D. Wilson, of Dublin, patented a method for purifying coal-gas by means of the chemical action of ammoniacal gas. Another plan was devised by Mr. Reuben Phillips, of Exeter, who patented the purification of coal-gas by the use of dry lime. Mr. G. Holworthy, in 1818, patented a method of purifying it by causing the gas, in a highly-condensed state, to pass through iron retorts heated to a dark red.

By 1823, numerous towns and cities throughout Britain were lit by gas. Gaslight cost up to 75% less than oil lamps or candles, which helped to accelerate its development and deployment. By 1859, gas lighting was to be found all over Britain and about a thousand gas works had sprung up to meet the demand for the new fuel. The brighter lighting which gas provided allowed people to read more easily and for longer. This helped to stimulate literacy and learning, speeding up the second Industrial Revolution.

Oil-gas appeared in the field as a rival of coal-gas. In 1815, John Taylor patented an apparatus for the decomposition of "oil" and other animal substances. Public attention was attracted to "oil-gas" by the display of the patent apparatus at Apothecary's Hall, by Messrs. Taylor and Martineau.

In 1891, the invention of the gas mantle by the Austrian chemist Carl Auer von Welsbach eliminated the need for special illuminating gas, a synthetic mixture of hydrogen and hydrocarbon gases produced by destructive distillation of bituminous coal or peat, to get bright shining flames.

Lamplighter lighting a gas streetlight in Sweden, 1953. By this time remaining gas lamps were rare curiosities.

Illuminating gas was used for gas lighting, as it produces a much brighter light than natural gas or water gas. Illuminating gas was much less toxic than other forms of coal-gas, but less could be produced from a given quantity of coal. The experiments with distilling coal were described by John Clayton in 1684. George Dixon's pilot plant exploded in 1760, setting back the production of illuminating gas a few years. The first commercial application was in a Manchester cotton mill in 1806. In 1901, studies of the defoliant effect of leaking gas pipes led to the discovery that ethylene is a plant hormone.

Throughout the nineteenth century and into the first decades of the twentieth, the gas was manufactured by the gasification of coal. In the latter years of the nineteenth century,

natural gas began to replace coal-gas, first in the US, and then in other parts of the world. In the United Kingdom, coal-gas was used until after the Second World War.

Gas street lighting today

In the early 20th century, most cities in the United States and Europe had gaslit streets. However, gas lighting for streets soon gave way to electric lighting. Small incandescent electric lamps began to replace gas lights in homes in the late 19th century, although the transition took decades to complete. *See*, for example, Rural electrification.

Gas lighting has not disappeared completely from cities. Cities that retain gas lighting now often find that it provides a pleasing nostalgic effect. Similarly, gas lighting is also seeing a resurgence in the luxury home market for those in search of historical accuracy.

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Gas lighting in the Honourable Society of Lincoln's Inn, London

The largest gas lighting network in Europe is probably that of Berlin with about 44,000 lamps. Quite a few streets in central London, the Royal Parks and the exterior of Buckingham Palace remain gaslit as well as almost the entire Covent Garden area. The Park Estate in Nottingham retains much of its original character, including the original gas lighting network.

In the United States, more than eleven hundred gas lights in Cincinnati, Ohio operate and have been named a historic district; gas lights also operate in parts of the famed French Quarter in New Orleans and of Boston's Beacon Hill neighborhood. A gas lamp is located at N. Holliday Street and E. Baltimore Street in Baltimore as a monument to the first gas lamp in America erected at that location.

South Orange, New Jersey has adopted the gaslight as the symbol of the town, and uses them on nearly all streets. Several other towns in New Jersey also retain gas lighting: Glen Ridge, Palmyra, Riverton, and some parts of Orange, Cape May and Cherry Hill. The Village of Riverside, Illinois, still uses its original gas street lights that are an original feature of the Frederick Law Olmsted planned community.

Many gas utility companies will still quote a fixed periodic rate for a customer-maintained gas lamp and homeowners still utilize such devices. However, the high cost of natural gas lighting at least partly explains why a large number of older gas lamps have been converted to electricity. Solar-rechargeable battery-powered gas light controllers can be easily retrofitted into existing gas lamps to keep the lights off during daylight hours and cut energy consumption and green-house gas carbon emissions by 50%.

The most popular gas lighting fixtures today are made from copper, a sustainable and durable metal that ages and patinas to protect itself from the elements. Gas Lights today are also used with electronic ignition systems that allow the lights to be controlled from an ordinary light switch. With energy conservation a pressing issue today, these systems can also allow gas lights to be placed on a timer or photocell so that they are not running continuously, only when needed. Today gas lights are widely used for creating ambiance and to accentuate a property's design.

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The use of natural gas (methane) for indoor lighting is nearly extinct. Besides producing a lot of heat, the combustion of methane tends to release significant amounts of carbon monoxide, a colorless and odorless gas which is more readily absorbed by the blood than oxygen, and can be deadly. Historically, the use of lamps of all types was of shorter duration than we are accustomed to with electric lights, and in the far more draughty buildings, it was of less concern and danger. There are no suppliers of new mantle gas lamps set up for use with natural gas; however, some old homes still have fixtures installed, and some period restorations have salvaged fixtures installed, more for decoration than use. New fixtures are still made and available for propane (sometimes called *bottle(d) gas*), a product of oil refining, which under most circumstances burns more completely to carbon dioxide and water vapor.

In some locations where public utility electricity or kerosene are not readily accessible or desirable, propane gas mantle lamps are still used, although the increased availability of alternative energy sources, such as solar panels and small scale wind generators, combined with increasing efficiency of lighting products, such as compact fluorescent lamps and LED's are diminishing their use. For occasional use in remote cabins and cottages, propane mantle lamps are still far more economical and less labor intensive than the investment in and ongoing maintenance of an alternative energy system.

Other uses

Perforated tubes bent into the shape of letters were used to form gas lit advertising signs, prior to the introduction of neon lights, as early as 1857 in Grand Rapids, Michigan. Gas lighting is still in common use for camping lights. Small portable gas lamps, connected to a portable gas cylinder, are a common item on camping trips. Mantle lamps powered by vaporized petrol are also available.

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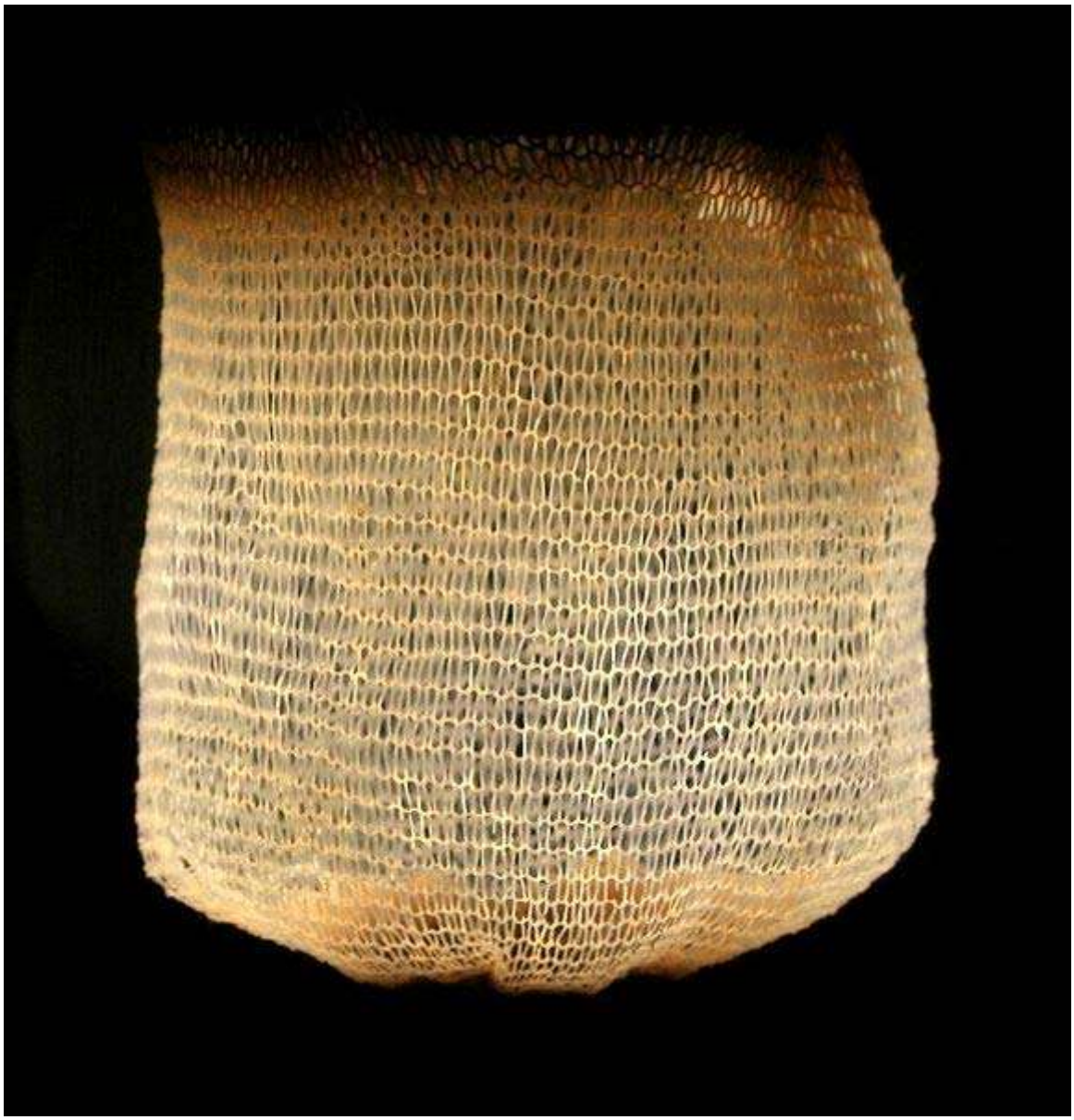
Chapter- 3

Gas Mantle

An **incandescent gas mantle**, **gas mantle**, or **Welsbach mantle** is a device for generating bright white light when heated by a flame. The name refers to its original heat source, existing gas lights, which filled the streets of Europe and North America in the late 19th century, mantle referring to the way it was hung above the flame. Today they are still used for portable camping lanterns and pressure lamps.

Mantles in their unused flat-packed form

Mechanism



A Coleman white gas lantern mantle burning at full brightness

The mantle is made from oxides that, when heated, glow brightly in the visible spectrum while emitting little infrared radiation. The rare earth oxides (cerium) and actinide (thorium) in the mantle have a low emissivity in the infrared (in comparison with an ideal black body), but have high emissivity in the visible spectrum. This is because of candoluminescence. Hence, when heated by a kerosene or liquified petroleum gas flame, the mantle emits radiation that is weighted less heavily in the infrared and more heavily in the visible spectrum, leading to an enhanced output of useful light.

Modern mantles are made by saturating a ramie-based artificial silk or rayon fabric with rare earths. When the mantle, which resembles a small net bag, is placed in the flame for the first time, the fabric burns away, leaving a residue of metal oxide, which glows brightly.

The mantle shrinks and becomes very fragile after this first use.

The mantle also aids the combustion process, keeping the flame small at higher flow rates than in a simple lamp. This concentration of combustion near the mantle, in turn, improves the transfer of heat from the flame to the mantle.

History

For centuries, artificial light had been generated using open flames. Limelight had been invented in the 1820s, but the temperature required was too high to be practical for small lights. In the late 19th century several inventors tried to develop an effective alternative based on heating a material to a lower temperature but using spectral lines to simulate white light.

Many early attempts used platinum-iridium gauze soaked in metal nitrates, but were not successful because of high cost materials and poor reliability.

The first effective mantle was the *Clamond basket* in 1881, named after its inventor. It was exhibited in the Crystal Palace exhibition of 1883. This device was made from a mixture of magnesium hydrate, magnesium acetate and water which was squeezed through holes in a plate to form threads, which were then moulded into a basket shape and ignited. The acetate burnt, the combustion products forming a matrix to support the magnesium oxide formed as the hydrate decomposed. The fragile structure was supported by a platinum wire cage and heated by a coal gas flame.

The modern gas mantle was one of the many inventions of Carl Auer von Welsbach, a chemist who studied rare earth elements in the 1880s and who had been Robert Bunsen's student. Ignaz Kreidl worked with him on his early experiments to create the Welsbach mantle. His first process used a mixture of 60% magnesium oxide, 20% lanthanum oxide and 20% yttrium oxide, which he called *Actinophor*, and patented in 1885.

The original mantles gave off a green-tinted light and were not very successful, and his first company, which established a factory in Atzgersdorf in 1887, failed in 1889. In 1890 he discovered that thorium was superior to magnesium, and in 1891 perfected a new mixture of 99% thorium dioxide and 1% cerium dioxide that gave off a much whiter light and produced a stronger mantle. After introducing it commercially in 1892 it quickly spread throughout Europe. The gas mantle remained an important part of street lighting until the widespread introduction of electric lighting in the early 1900s.

To produce a mantle, cotton is woven into a net bag and impregnated with the soluble nitrates of these metals and then heated; the cotton burns away and the nitrates are

converted to nitrites, which fuse together to form the solid mesh. As the heating continues, the nitrites decompose into the final solid, (but fragile) very high melting point oxides.

Early mantles were sold in the unheated cotton mesh condition, since the oxide structure was too fragile to transport easily, and the purchaser carried out the conversion when it was first used. The cotton quickly rotted because of the corrosive nature of the acidic metal nitrates (although was later reduced by soaking the mantle in ammonia solution to neutralise the excess acid).

Later mantles were made from guncotton (nitrocellulose) or collodion rather than ordinary cotton, since extremely fine threads of it could be produced; it was converted back to cellulose before heating (since these materials are highly flammable or explosive) by dipping in ammonium sulfide.

It was discovered that the finished mantle could be strengthened sufficiently by dipping in a solution of collodion, which would coat it with a thin layer of the material to be burnt off when the mantle was first used, although modern mantles are now usually sold in their original fabric condition.

Early mantles often had a binding thread of asbestos for tying onto the lamp fitting, but because of its carcinogenic properties it has been replaced with wire or ceramic fiber thread in modern mantles.

Safety of thorium

Since thorium is radioactive and produces a radioactive gas, radon-220, as one of its decay products, there are concerns about the safety of thorium mantles. Some nuclear safety agencies make recommendations about their use . A study in 1981 estimated that the dose from using a thorium mantle every weekend for a year would be 0.3-0.6 millirems, tiny in comparison to the normal annual dose of a few hundred millirems, although a person ingesting an entire mantle would receive a comparable dose of 200 mrem (2 mSv; ,). However, the radioactivity is a major concern for those people involved with the manufacture of mantles and with contamination of soil around some former factory sites . All of these issues have meant that alternatives, usually yttrium or sometimes zirconium, are used in some countries although they are either more expensive or less efficient.

One potential cause for concern is that particles from thorium gas mantles "fall out" over time and get into the air, where they may be ingested in food or drink. These particles can also be inhaled and remain in the lungs or liver. Also of concern is the release of thorium bearing dust if the mantle shatters due to mechanical impact.

Secondary decay products of thorium include radium, actinium, and radon gas.

Chapter- 4

Kerosene Lamp

Swiss kerosene lamp. The knob protruding to the right adjusts the wick, and hence the flame size.

The **kerosene lamp** (widely known in Britain as a **paraffin lamp**) is any type of lighting device that uses kerosene (British "paraffin," as distinct from paraffin wax) as a fuel. There are two main types of kerosene lamp, which work in different ways, the "wick lamp" and the "pressure lamp."

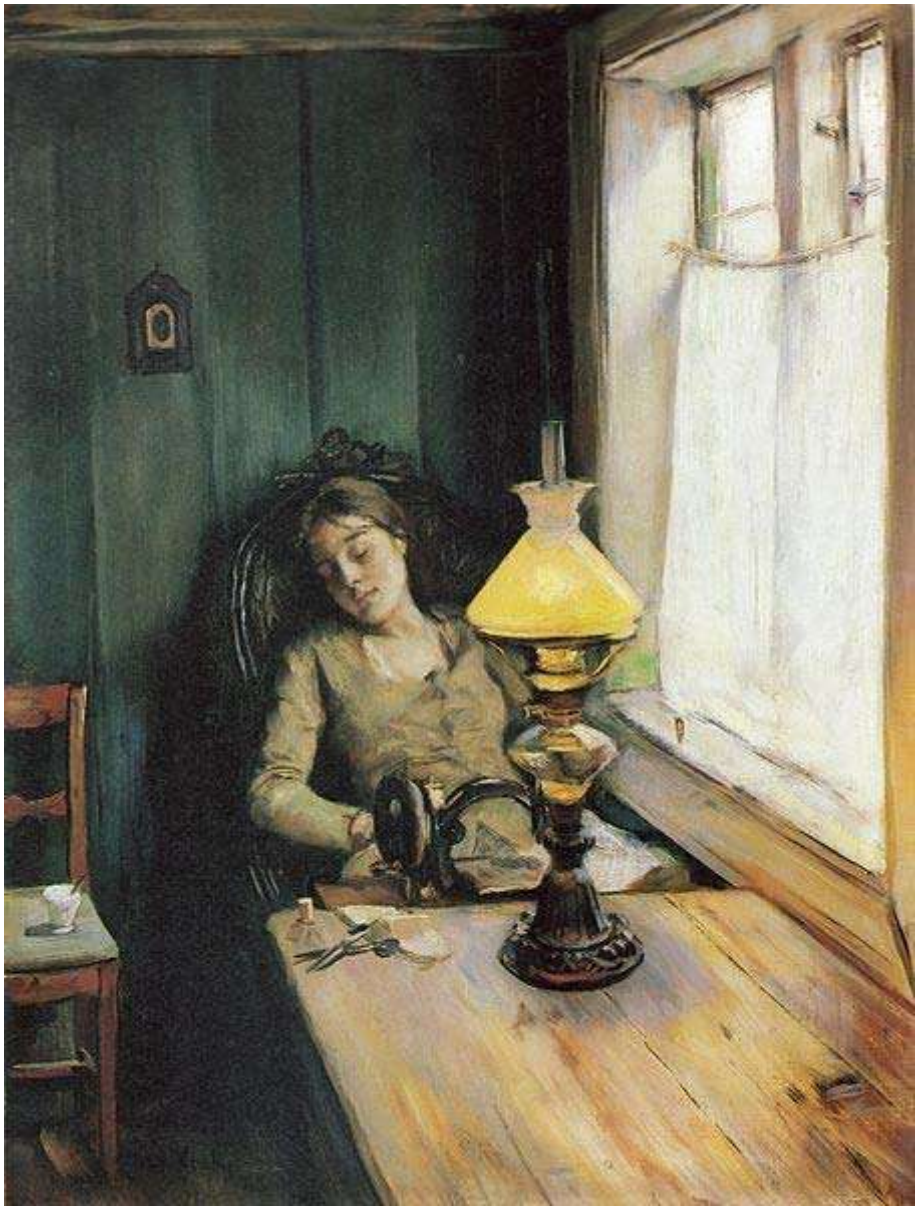
The first description of a simple lamp using crude mineral oil was provided by al-Razi (Rhazes) in 9th century Baghdad, who referred to it as the "naffatah" in his *Kitab al-Asrar* (*Book of Secrets*). Modern versions of the kerosene lamp were later constructed by Polish inventor Ignacy Łukasiewicz in 1853 (in Lviv, Austrian Empire), and by Robert Edwin Dietz of the United States at about the same time; the question regarding the primacy of these two inventors' versions of the lamp remains unresolved.

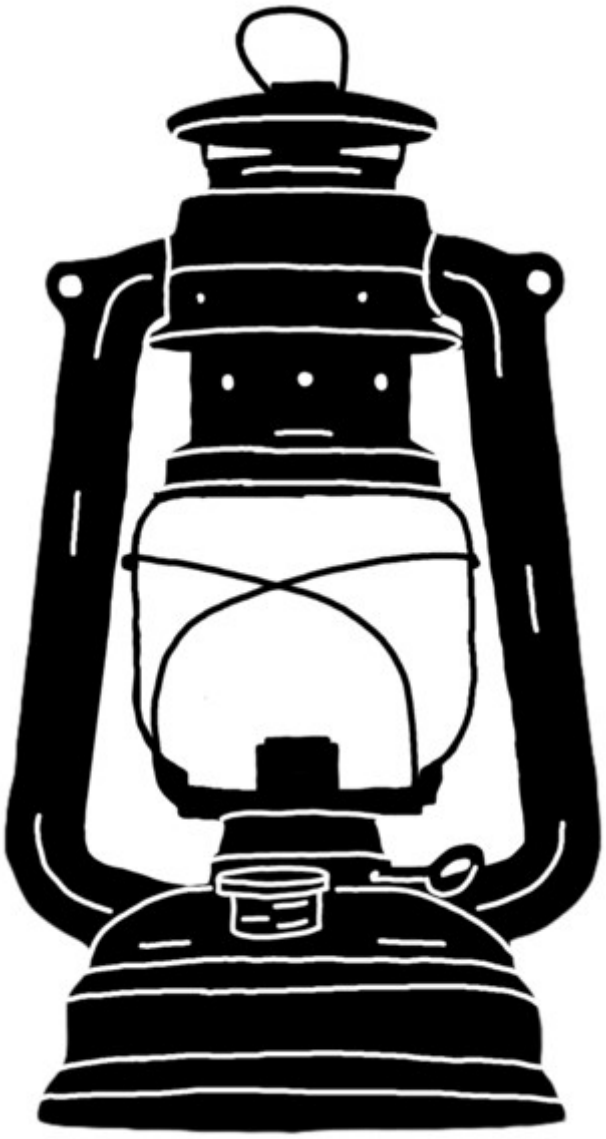
Wick lamp

A wick lamp is a simple type of kerosene lamp that works in a similar way to a candle. This type of lamp is also known as an "oil lamp" or, in the United Kingdom and Ireland, a "paraffin lamp." A wick lamp has a small fuel tank and a lamp burner attached to the top of it. There is also a wick, usually made of cotton. The lower part of the wick dips into the fuel tank and absorbs the kerosene. The top part of the wick extends out of the wick tube of the lamp burner, which typically includes a wick-adjustment mechanism. There are many variations in wick-lamp burner designs. The most common lamp burner is the hooded type, with four prongs to hold the glass chimney. The next most common are round-wick lamps, such as the Rayo-type, which have a flame spreader in the center of a round wick.

When the lamp is lit, the kerosene that the wick has absorbed burns and produces a clear, bright, yellow flame. As the kerosene burns, capillary action in the wick draws more kerosene up from the fuel tank.


Bundesarchiv, Bild 183-2005-0803-511
Foto: o.Ang. | 1949

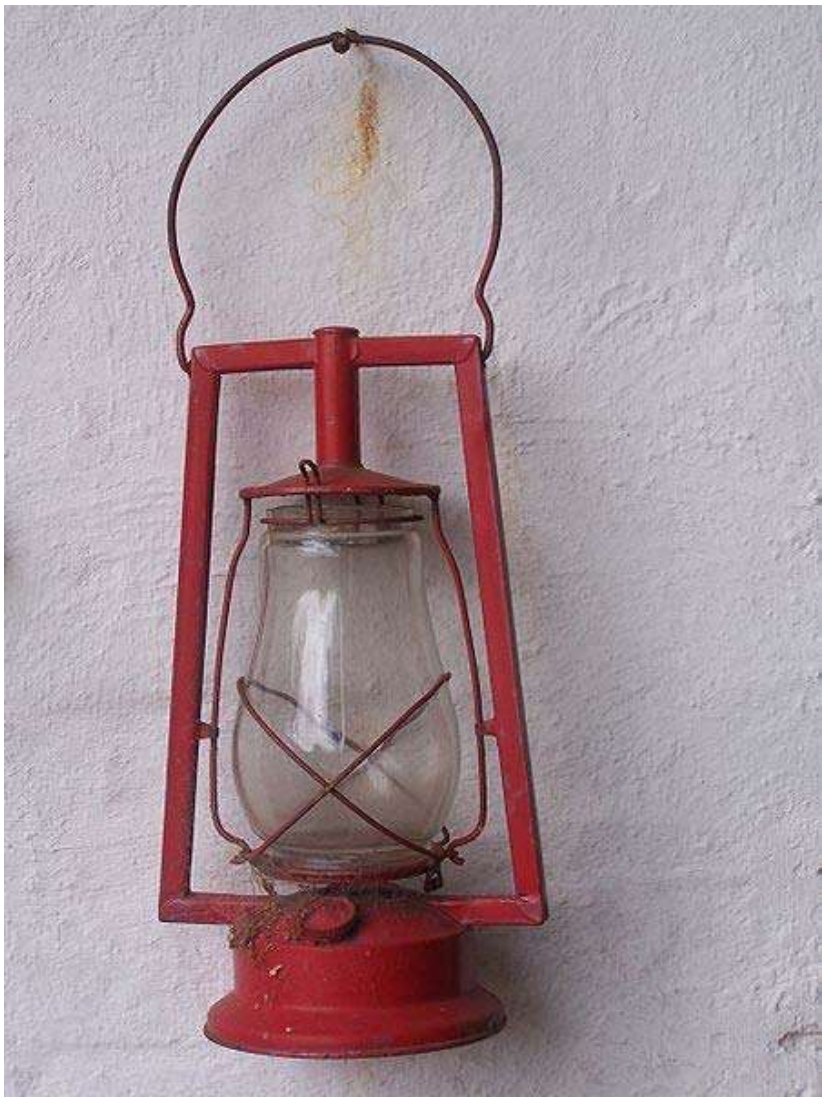




Adjusting how much of the wick extends above the wick tube controls the flame. The wick tube surrounds the wick, and ensures that the correct amount of air reaches the lamp burner. Adjustment is usually done by means of a small knob operating a cric, which is a toothed, metal sprocket bearing against the wick. If the wick is too high and extends beyond the burner hood at the top of the wick tube, the lamp will produce smoke and soot (unburned carbon).

A glass chimney usually protects the flame. The glass chimney acts to prevent the flame from being blown out and enhances the thermally induced draft. It needs a "throat" or slight constriction to create the proper draft for complete combustion of the fuel; the draft carries more air (oxygen) past the flame, helping to produce a brighter, smokeless light than an open flame would produce. Wick lamps can also be quite odorous if the kerosene is old or if the wicks and burners are not thoroughly clean. A smoking, odorous lamp and

blackened glass chimney are most often caused by improper adjustment of the burner or poor fuel.



Hot-blast kerosene lantern

Barn lamps (or lanterns) have several design variations. The earliest lanterns used the dead-flame design, where the flame was fed fresh air from beneath and warm air was expelled above. Because this design does not feed air directly, this type of lamp produces only a dim yellow light and is not much brighter than a candle. Most Aladdin-style lamps are dead-flame, but some use mantles to increase the light output. The following section contains details of these mantle lamps.

Tubular lamps were invented in the latter part of the 19th century when, in the late 1860s, Dietz Lantern designed the "hot blast" lantern, which recirculated a mix of fresh and warm air back to the flame through side tubes, thus improving oil-burning efficiency. By 1880, the "cold blast" lantern was designed, using a similar circulation system, but with

only fresh air, to increase the brightness of the flame. Cold-blast lanterns are the brightest and most efficient of all wick-lamp designs.

Except for decorative purposes, emergency lighting, or in remote areas without electricity, kerosene lamps are rarely used today in countries with a developed national grid for electricity and natural gas, but were popular before electrical lighting became widespread. In other countries, kerosene is popular for space heating, lighting, and cooking stove fuel due to the relatively cheap cost of the fuel, appliances, and infrastructure.

Abraham Gesner's **Kerosene Gaslight Company** were the first to produce wick lamps in 1850, and they replaced the Argand lamp, which had been in widespread use for seventy years.

Mantle lamp

A variation on the wick lamp is the mantle lamp, which has a circular wick that burns below a conical mantle containing thorium or other actinide or rare-earth salts that incandesce (glow brightly) when heated in a flame. Though it has a mantle, like pressure lamps and lanterns, it is not a pressure lamp.

As mantle lamps are considerably brighter than wick lamps, and produce a whiter light, a lamp shade is often desirable. They also consume fuel at a greater rate than simple wick lamps and produce commensurately large amounts of heat. A few operating mantle lamps can serve to heat a small building in cold weather.

Mantle lamps, because of the higher temperature at which they operate, do not produce much of an odor except when they are first ignited or extinguished. Like wick lamps, they can be adjusted for brightness, and can also be adjusted too high, which will cause the lamp chimney and the mantle to soot up.

If a too-high adjusted lamp is caught promptly, it can simply be adjusted down and the small amount of soot on the mantle will soon be burned off. If it is not caught soon enough, a "runaway-lamp" condition can result.

A runaway-lamp condition, with flames coming out of the top of the chimney, can be dangerous and difficult to extinguish. It can also crack the relatively expensive (and fragile) glass chimney, irreversibly soot up the mantle, and release large amounts of soot into the room. The best way to extinguish a runaway lamp is by covering the top with a non-flammable object, such as an empty steel can.

Once the runaway lamp has been extinguished and allowed to cool, the chimney can be cleaned with soap and water. A badly sooted up chimney may require the use of lye or oven cleaner. The mantle, if still intact, can often be salvaged by removing it from the burner and heating it in the flame of a blow torch, propane torch, or a gas stove burner.

This can be a difficult procedure and may result in breaking the mantle. As mantles are expensive, it is worth the effort to try, however.

Mantle lamps are still made by the Aladdin Mantle Lamp Company in the United States.

Pressure lamp

Tilley Lamp TL10 from 1922 to 1946

Pressure lamps are far more sophisticated than wick lamps and produce a much brighter light, although they can be quite complicated and fiddly to use. This type of lamp is commonly known in the UK as a "Tilley lamp", after a manufacturer of the same name, and in North America as a "Coleman lantern" for similar reasons.

A kerosene blowtorch displaying the various aspects of the kerosene burner

A pressure lamp has a fuel tank at the bottom with a small pump to pressurise the kerosene. There is a narrow gap up to the top of the lamp, called a flue, and at the top of the lamp there is a burner (gas outlet). Directly underneath the burner is the mantle, a fabric bag coated with chemicals that incandesce when heated by the gas flame.

The burner lamp is known for its brightness. It is so bright because of the amount of pressure that is placed onto the wick. This pressure allows a steady flow of fuel and a constant light.

If the mantle is damaged, heat may become focused and damage the glass surround (windscreen). After the first burning of a new mantle, the size of the mantle will reduce significantly, and the mantle will become more fragile.

This type of lamp is popular amongst campers and others who engage in outdoor activities. Gasoline-burning lamps have also been produced; these do not require any primer liquid. However, both have lost popularity in recent years to portable lamps that burn butane or propane gas, as well as electrical fluorescent lamps, as these are easier to use, though more expensive to run.

There are also portable kerosene stoves, which work in much the same way as pressure lamps.

Operation and Maintenance

Strong odors can be caused by the design of the lamp burner and chimney. Generally, larger lamp burners emit less odor than very small burners. Stale fuel, gummy burners, and clogged, dirty wicks are the main causes of strong odors. If a kerosene lamp is not used regularly, it should be emptied of kerosene, and the font (fuel tank), wick, and burner should be cleaned before storage.

The wick of a wick lamp may need to be trimmed periodically. The shape in which a flat wick is cut affects the shape of the flame it produces.

Fuels

Pure paraffin (wax) oil (aka Ultra-Pure, Nowell's, etc.,) is marketed as "smokeless and odorless" lamp oil, but is improperly labeled in the United States for use in wick lamps and lanterns. In fact, it will not burn properly in lamps or lanterns with 5/8" (1.59cm) or larger wick, and will create smoke and odor. Paraffin oil has a flash point in excess of 200°F(93.33°C), and will only burn half as bright as standard lamp oil or kerosene, and will sputter in lamps with deep founts, or that have 7/8"(2.22cm) or larger wicks. It is suitable for use in candle lamps, similar to those used in restaurants. Paraffin oil is not recommended for use in antique lamps or lanterns as the higher ignition temperature may result in damage to the lamp. Pure paraffin oil can solidify in environments below room temperature, greatly limiting its suitability for outdoor or emergency use. Drug-store

mineral oil is paraffin oil. (Note: "Paraffin" in the UK is "kerosene" in the United States, and should not be confused with solid paraffin wax or the Pure paraffin (wax) oil discussed above, both of which are sold in the US.)

Generic lamp oil is widely available in supermarkets and hardware stores. It is usually less expensive than pure paraffin oil, but costs considerably more than kerosene. Lamp oil burns cleaner and with less odor than kerosene.

K-1 kerosene(clear as water, or slightly yellow) is, in most countries, more readily available in bulk than lamp oil and is typically much less expensive. However, kerosene contains more impurities, such as sulfur and aromatic hydrocarbons, than lamp oil. Kerosene obtained from filling stations is more likely to be dyed red or contaminated with water than kerosene obtained in prepackaged containers.

The odors produced by burning kerosene in wick lamps can be quite objectionable indoors, unless the kerosene is fresh, the lamp, wick, and burner are kept scrupulously clean, and the lamp burner is adjusted properly. Kerosene should be stored away from sunlight in a cool, dark place, not longer than a year or so, as it will eventually deteriorate. Stale kerosene smells like furniture polish, and takes on a deep yellow color, or darker.

Red kerosene is slightly less expensive than K-1 kerosene, as no motor-fuel taxes are collected on it. It is generally available in bulk at filling stations in agricultural areas, for use in farm tractors or diesel generators.

Klean-Heat is a cleaner burning, nicer smelling kerosene substitute, sold at many hardware stores during winter.

Biodiesel is a clean-burning "green" alternative to kerosene. Biodiesel packaged for lamp burning is best purchased, to avoid biodiesel / diesel mixtures available at the majority of filling stations' biodiesel pumps.

Citronella oil is used for its insect-repellant properties, and can be burned in wick lamps or torches outdoors. This is meant for outdoor use only and generally has a yellow color. To improve wick life and make citronella oil burn cleaner, it can be mixed 50:50 with kerosene.

Motor Kerosene or Tractor Vaporizing Oil, is very hard to find nowadays, although it can be found at some feed stores or near farming communities. This can be used, but may be expensive.

Sometimes dyes and fragrances are added to fuels, which can increase soot deposits on glass globes/chimneys, and reduce wick life. Some manufactures have even created special novelty formulations that will cause the flame to burn in different colors.

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Emergency Substitutes

Kerosene lamps should only be operated with kerosene or lamp oil, but alternative fuels may be used in an emergency.

Whale oil burns incredibly bright, and was once the standard for use in illumination, but is rarely found, today, due to whaling regulations in most of the world.

Diesel fuel and **home heating oil** has a flash point greater than 200°F, and will not burn properly in conventional wick lamps/lanterns. Most diesel fuels have a fairly high sulfur content and contain fuel additives that produce toxic by-products if burned in a lamp. They also produce more soot than kerosene.

Jet A is safe to use, as it is essentially kerosene with a few harmless additives. It burns well in wick lamps.

One can even use **lubricating oil**, though not the sort found in aerosol cans. Because of the additives, use outdoors or in well ventilated areas.

Olive oil, **canola oil**, and other vegetable oils can be used in lamps designed for their use, but will not burn in conventional wick lamps or lanterns.

Charcoal lighter fluid is usually suitable for wick lamps/lanterns; most brands are kerosene. Be certain, however, to use only the type intended for starting charcoal briquettes. The lighter fluid intended for cigarette lighters is naphtha, which is highly volatile and has a low flash point, making it dangerous to use in a wick lamp.

Hazardous Fuels

- **Gasoline** gives off harmful vapors and aromatics, and makes for serious risk of fire and explosion.
- **Naphtha** is a very corrosive and toxic substance, is highly flammable and gives off a tantalizingly beautiful, but deadly odor when burned.
- **Rubbing alcohol** can give off an obnoxious odor when burned, due to denaturants, and can cause respiratory distress. Also, it burns with a dim, blue flame. Isopropyl rubbing alcohol is unsuitable for use in lamps due to its high vapor pressure, as well as its typically high water content, which will vaporize to steam creating excessive pressure.
- **Mineral oil** gives off toxic vapor.
- **Castor oil** burns at a very high temperature.
- **Mineral spirits** or paint thinner has a flash point of 110°F, making it highly flammable and possibly explosive. It should not be used in any wick lamps or lanterns.

Chapter- 5

Lantern

A railroad brakeman's signal lantern.

A **lantern** is a portable lighting device used to illuminate broad areas. Lanterns may also be used for signaling, to guide your path somewhere or as general light sources for camping. In the older days it would have been used like a torch. Dim varieties are often used for decoration. The term "lantern" is also used more generically to mean a 'light source' or the enclosure for a light source, i.e., the housing for the lamp and lens — that is the top section — of a lighthouse.

Traditional and decorative lanterns

The simplest technology used is the *candle lantern* which can be lit with fire. Candles give only a weak light, and must be protected from wind to prevent flickering or complete extinguishment. Thus the lantern was invented. A typical candle lantern is a metal box or cylinder with glass or mica side panels and an opening or ventilated cover on the top.

Decorative lanterns exist in a wide range of designs. Some hang from buildings, while others are placed on or just above the ground. Paper lanterns occur in societies around the world. Modern varieties often place an electric light in a decorative glass case.

The ancient Chinese sometimes captured fireflies in transparent or semi-transparent containers and used them as (short-term) lanterns. *Raise the Red Lantern*, a Chinese film, prominently features lanterns as a motif.

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A wooden lantern found on board the 16th century ship *Mary Rose*

Lantern at the head of a Russian Orthodox procession with processional cross and banners

A chōchin in an okonomiyaki restaurant in Japan

Use of fireflies in transparent containers was also a widespread practice in ancient India. But since these were short term solutions, the use of fire torches was more prevalent.

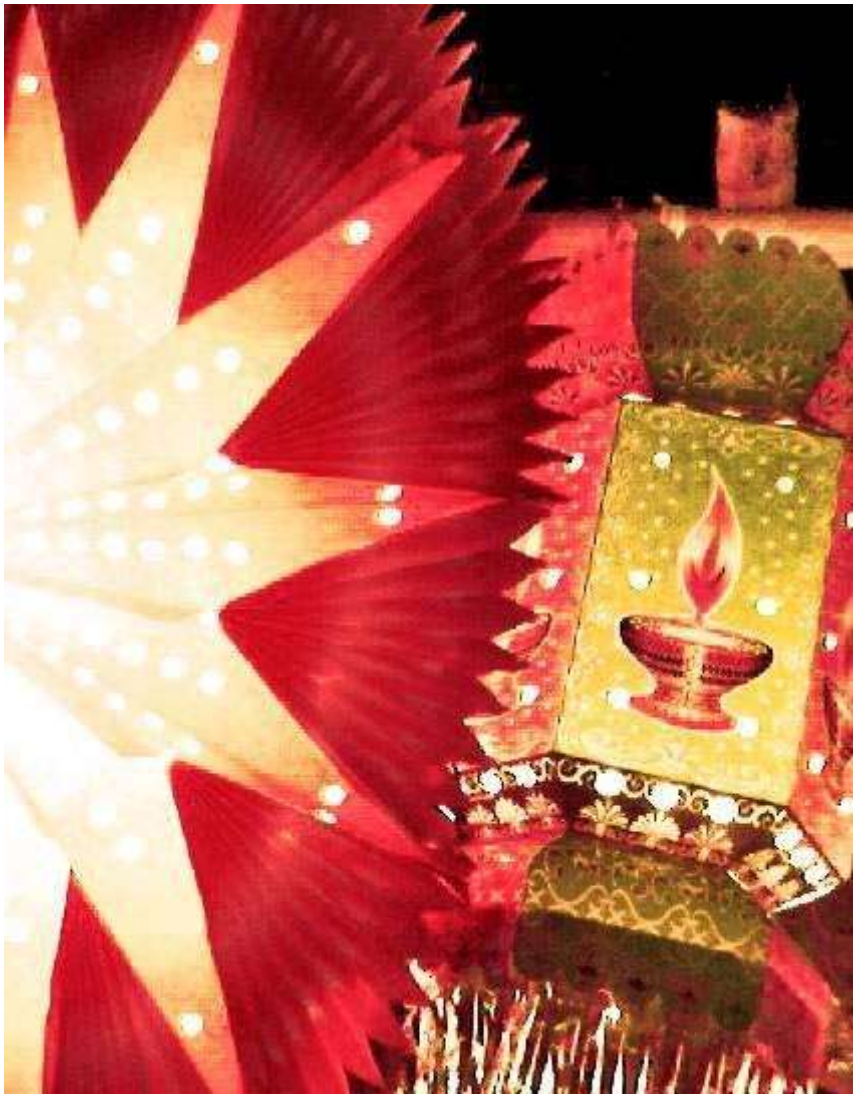
In the Eastern Orthodox Church lanterns are used in religious processions and liturgical entrances, usually coming before the processional cross.

Lanterns are also used to transport the Holy Fire from the Church of the Holy Sepulchre on Great Saturday during Holy Week.

Modern fueled lanterns

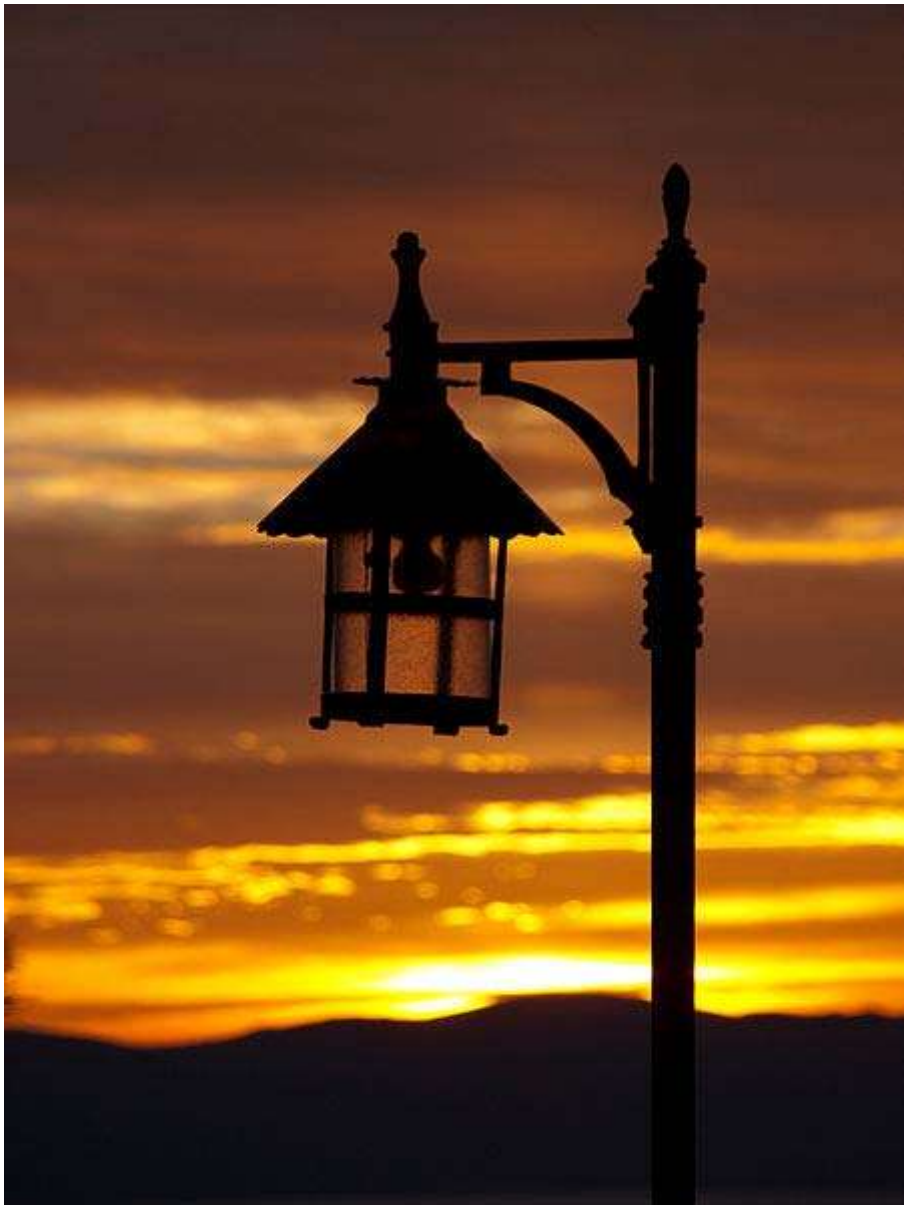
All fueled lanterns are somewhat hazardous due to the danger of handling flammable and toxic fuel, danger of fire or burns from the high temperatures involved, and potential dangers from carbon monoxide poisoning if used in an enclosed environment.

Simple wick lanterns remain available. They are cheap and durable, but provide little light and are unsuitable for reading. They require periodic trimming of the wick and regular cleaning of soot from the inside of the glass chimney.



Indian lanterns

People across India celebrate Diwali Festival via symbolic lanterns as a part of Diwali decorations.



Park lantern

Paper lanterns as part of the Chinese moon festival, Ottawa, Canada, 2010

Mantle lanterns use a woven ceramic impregnated gas mantle to accept and re-radiate heat as visible light from a flame. The mantle does not burn (but the cloth matrix carrying the ceramic must be "burned out" with a match prior to its first use). When heated by the operating flame the mantle glows incandescently. Such lanterns are very bright, and can easily be used as reading lights. The heat may be provided by a gas, by kerosene, or by a pressurized liquid such as "white gas," which is essentially naphtha. For protection from the high temperatures produced and to stabilize the airflow, a cylindrical glass shield called the *globe* or *chimney* is placed around the mantle.

Manually pressurized lanterns using white gas (also marketed as "Coleman Fuel" or "Camp Fuel") are manufactured by the Coleman Company in one and two mantle models. Some models are "dual fuel," which can also use gasoline. These are being supplanted by a battery-powered fluorescent lamp models by many manufacturers including Coleman. Liquid fuel lanterns remain popular where the fuel is easily obtained and is in common use.

Many portable mantle-type fuel lanterns now use fuel gases that become liquid when compressed, such as propane, either alone or combined with butane. Such lamps usually use a small disposable steel container to provide the fuel. The ability to refuel without liquid fuel handling increases safety and additional fuel supplies for such lamps have an indefinite shelf life if the containers are protected from moisture (which can cause corrosion of the container) and excess heat.

The leading manufacture of kerosene mantle lamps in the United States is the Aladdin Mantle Lamp Company, which has long produced an extensive line of utilitarian and decorative mantle lamps. A specialized cylindrical wick with a central airflow tube satisfies the high and uniform heating demands of the mantle.

Modern electric lanterns

Some lanterns are battery-powered and have a simple lightbulb, but power supply to operate a Fluorescent lamp. They are easy to use and comparatively durable, but less bright than propane or liquid fuel lanterns, require battery replacement, or if rechargeable and not constantly plugged in must be brought to full charge every few months.

Some rechargeable fluorescent lanterns may be plugged in at all times and may be set up to illuminate upon a power failure, a useful feature in some applications. During extensive power failures (or for remote use), supplemental recharging may be provided from an automobile's twelve volt electrical system or from a modest solar powered charger. Solar-powered lanterns have become popular in developing countries where they provide a safer and cheaper alternative to kerosene lamps.

Battery-powered lanterns utilizing LEDs are becoming increasingly popular due to improvements in LED technology and reduced production costs. LEDs have become brighter and more rugged, and typically run longer (due to low current draw from the batteries) than incandescent bulbs or fluorescent tubes of comparable brightness.

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Chapter- 6

Candle

A close-up image of a burning candle showing the wick and the various parts of the flame

A **candle** is a solid block of fuel (commonly wax) and an embedded wick, which is lit to provide light, and sometimes heat.

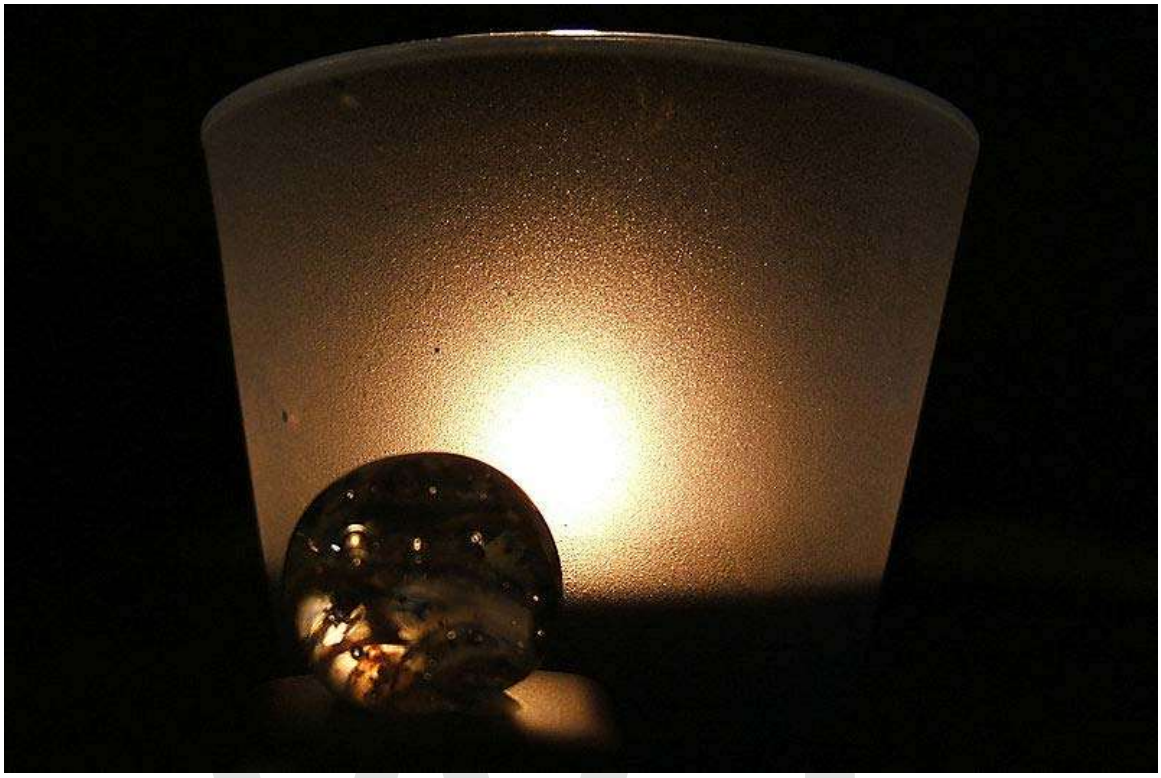
Today, most candles are made from paraffin. Candles can also be made from beeswax, soy, other plant waxes, and tallow (a by-product of beef-fat rendering). Gel candles are made from a mixture of paraffin and plastic.

A candle manufacturer is traditionally known as a chandler. Various devices have been invented to hold candles, from simple tabletop candle holders, to elaborate chandeliers.

The heat of the match used to light the candle melts and vaporizes a small amount of fuel. Once vaporized, the fuel combines with oxygen in the atmosphere to form a flame. This flame provides sufficient heat to keep the candle burning via a self-sustaining chain of events: the heat of the flame melts the top of the mass of solid fuel, the liquefied fuel then moves upward through the wick via capillary action, and the liquefied fuel is then vaporized to burn within the candle's flame.

The burning of the fuel takes place in several distinct regions (as evidenced by the various colors that can be seen within the candle's flame). Within the bluer regions, hydrogen is being separated from the fuel and burned to form water vapor. The brighter, yellower part of the flame is the remaining carbon being oxidized to form carbon dioxide.

As the mass of solid fuel is melted and consumed, the candle grows shorter. Portions of the wick that are not emitting vaporized fuel are consumed in the flame. The incineration of the wick limits the exposed length of the wick, thus maintaining a constant burning temperature and rate of fuel consumption. Some wicks require regular trimming with scissors (or a specialized wick trimmer), usually to about one-quarter inch (~0.7 cm), to promote slower, steady burning, and also to prevent smoking. In early times, the wick needed to be trimmed quite frequently, and special candle-scissors, referred to as "snuffers" until the 20th century, were produced for this purpose, often combined with an extinguisher. In modern candles, the wick is constructed so that it curves over as it burns, so that the end of the wick protrudes into the hot zone of the flame and is then consumed by fire—a self-trimming wick.



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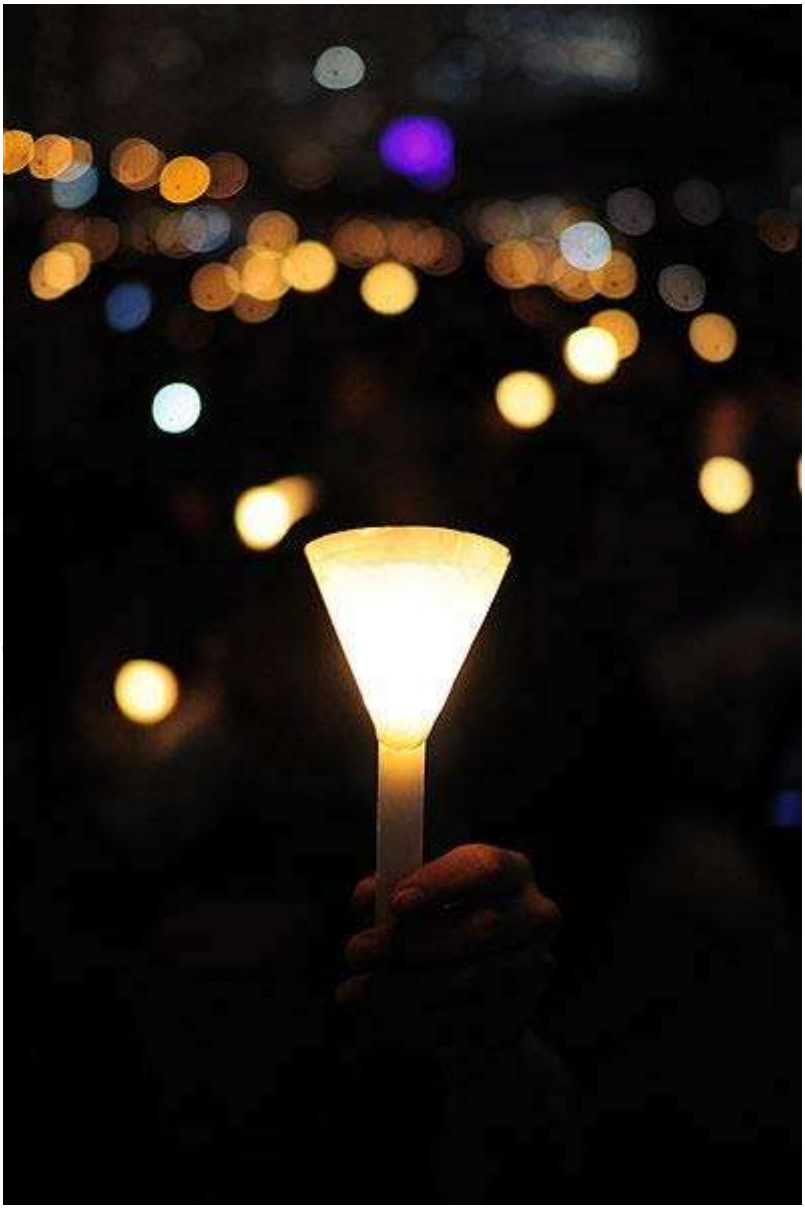

Components

Wax

The candle can be made of paraffin (a byproduct of petroleum refining), stearin (now produced almost exclusively from palm waxes), beeswax (a byproduct of honey collection), gel (a mixture of resin and mineral oil), some plant waxes (generally palm, carnauba, bayberry, or soybean wax), tallow (rarely used since the introduction of affordable and cheap wax alternatives) or spermaceti (extracted from the head of a Sperm

Whale). The size of the flame and corresponding rate of burning is controlled largely by the candle wick.

The most basic production method of candles generally entails melting the solid fuel by the controlled application of heat. The liquid is then poured into a mold or a wick is repeatedly immersed in the liquid to create a dipped tapered candle. Often fragrance oils, essential oils or aniline-based dye is added.

Candles made of beeswax burn more cleanly and release fewer chemicals than petroleum-based paraffin waxes. Highly refined paraffin wax, however, can burn as cleanly as natural waxes, creating fewer particulates during combustion than synthetic candles. The type of wick and inclusion of any scents and/or dyes have a much greater impact on the release of compounds, particulates, and smoke, regardless of the base material. The cleanest burning candle will be well-constructed, unscented, undyed, and burn in a draft-free area. Candles will burn well when formulated waxes are blended together (soy, paraffin and other waxes), and fragrance oils and wick selections are balanced properly.

This holder uses a spike to stabilize the candle.

A collection of lit candles on ornate candlesticks

A smoke film can be a concern to those who frequently burn a candle indoors and is also referred to as ghosting, carbon tracking, or carbon tracing. Smoke can be produced when a candle does not burn the wax fuel completely. A scented candle can be a source of candle smoke deposits. Trimming candle wicks to about 6 millimeters (¼ in) or shorter will keep smoking to a minimum. A flickering flame will produce more smoke, therefore a candle should be burned in an area free from drafts.

There are differing opinions about which kind of wax in a candle is natural. Proponents of the soy wax candle note that the material is biodegradable. Also, most soy beans used in the manufacture of soy wax are genetically modified. Paraffin wax, as used in candle making, is also biodegradable. It also often meets the United States Food and Drug Administration criteria for use in foods and food contact. Natural waxes have a neutral carbon footprint as carbon dioxide was removed the air to produce the natural wax, which upon burning would not result in a net increase in carbon dioxide.

Wick

A candle wick is a piece of string or cord that holds the flame of a **candle**. A candle wick works by capillary action, drawing ("wicking") the melted wax or fuel up to the flame. When the liquid fuel reaches the flame, it vaporizes and combusts. The candle wick

influences how the candle burns. Important characteristics of the wick include diameter, stiffness, fire-resistance, and tethering.

Characteristics

Light

Based on measurements of a taper-type, paraffin wax candle, a modern candle typically burns at a steady rate of about 0.1 g/min, releasing heat at roughly 80 W. The light produced is about 13 lumens, for a luminous efficacy of about 0.17 lumens per watt (luminous efficacy of a source), a hundred times lower than an incandescent light bulb.

The luminous intensity of a typical candle is thus approximately one candela. The SI unit, the candela, was in fact based on an older unit called the *candlepower*, which represented the luminous intensity emitted by a candle made to particular specifications (a "standard candle"). The modern unit is defined in a more precise and repeatable way, but was chosen such that a candle's luminous intensity is still about one candela.

Temperature

The hottest part of the flame is just above the very dull blue part to one side of the flame, at the base. At this point, the flame is about 1,400 °C. However note that that part of the flame is very small and releases little heat energy. The blue color is due to chemiluminescence, while the visible yellow color is due to radiative emission from hot soot particles. The soot is formed through a series of complex chemical reactions, leading from the fuel molecule through molecular growth, until multi-carbon ring compounds are formed. The thermal structure of a flame is complex, hundreds of degrees over very short distances leading to extremely steep temperature gradients. On average, the flame temperature is about 1,000 °C. A typical candle creates 50 BTUs per hour of heat. The color temperature is approximately 1,000 K.

History of study

One of Michael Faraday's significant works was The Chemical History of a Candle, where he gives a in depth analysis of the workings and science of a candle.

Hazards

According to the U.S. National Fire Protection Association, candles are one of the leading sources of residential fires in the U.S. with almost 10% of civilian injuries and 6% of civilian fatalities from fire attributed to candles.

A candle flame that is longer than its laminar smoke point will emit soot. Soot inhalation has known health hazards. Proper wick trimming will prevent soot emissions from most candles.

The liquid wax is hot and can cause skin burns, but the amount and temperature are generally rather limited and the burns are seldom serious. The best way to avoid getting burned from splashed wax is to use a candle snuffer instead of blowing on the flame. A candle snuffer is usually a small metal cup on the end of a long handle. When placed over the flame the oxygen supply is cut off. They were used daily when the candle was the main source of lighting a home, before electric lights were available.

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Glass candle holders are sometimes cracked by thermal shock from the candle flame, particularly when the candle burns down to the end. When burning candles in glass holders or jars, users should avoid lighting candles with chipped or cracked containers, and stop use once 1/2 inch or less of wax remains.

A former worry regarding the safety of candles was that a lead core was used in the wicks to keep them upright in container candles. Without a stiff core, the wicks of a container candle could sag and drown in the deep wax pool. Concerns rose that the lead in these wicks would vaporize during the burning process, releasing lead vapors — a known health and developmental hazard. Lead core wicks have not been common since the 1970s. Today, most metal-cored wicks use zinc or a zinc alloy, which has become the industry standard. Wicks made from specially treated paper and cotton are also available.

Candle holders

Decorative candle holders, especially those shaped as a pedestal, are called candlesticks; if multiple candle tapers are held, the term *candelabrum* is also used. The root form of *chandelier* is from the word for candle, but now usually refers to an electric fixture. The word *chandelier* is sometimes now used to describe a hanging fixture designed to hold multiple tapers.

Many candle holders use a friction-tight socket to keep the candle upright. In this case, a candle that is slightly too wide will not fit in the holder, and a candle that is slightly too narrow will wobble. Any candle that is too large can be trimmed to fit with a knife; a candle that is too small can be fitted with aluminium foil. Traditionally, the candle and candle holders were made in the same place, so they were appropriately sized, but international trade has combined the modern candle with existing holders, which makes the ill-fitting candle more common. This friction tight socket is only needed for the federals and the tapers. For tea light candles, there are a variety of candle holders, including small glass holders and elaborate multi candle stands. The same is true for votives. Wall sconces are available for tea light and votive candles. For pillar type candles, the assortment of candle holders is broad. A fireproof plate, such as a glass plate or small mirror, is a candle holder for a pillar style candle. A pedestal of any kind, with the appropriate sized fire proof top, is another option. A large glass bowl with a large flat bottom and tall mostly vertical curved sides is called a hurricane. The pillar style candle is placed at the bottom center of the hurricane. A hurricane on a pedestal is sometimes sold as a unit.

History

A rectangular candle.

The earliest known candles originated in China around 200 BC, and were made from whale fat. Candles did not appear in Europe until sometime after 400 AD, due largely to the availability of olive oil for burning in lamps. The early European candle was made from various forms of natural fat, tallow, and wax. In the 18th century, spermaceti, oil produced by the sperm whale, was used to produce a superior candle. Late in the 18th century, colza oil and rapeseed oil came into use as much cheaper substitutes. Paraffin was first distilled in 1830, and revolutionized candle-making, as it was an inexpensive material which produced a high-quality, odorless candle that burned reasonably cleanly. The industry was devastated soon after, however, by the distillation of kerosene (confusingly also called *paraffin oil* or just *paraffin*). Recently resin based candles that are freestanding and transparent have been developed, with the claim that they burn longer than traditional paraffin candles. They are usually scented and oil based.

Timekeeping

An Advent candle burning on the fourth day of December.

With the fairly consistent and measurable burning of a candle, a common use was to tell the time. The candle designed for this purpose might have time measurements, usually in hours, marked along the wax. The Song dynasty in China (960–1279) used candle-clocks. By the 18th century, candle-clocks were being made with weights set into the sides of the candle. As the candle melted, the weights fell off and made a noise as they fell into a bowl. A form of candle-clock was used in coal-mining until the 20th century.

In the days leading to Christmas some people burn a candle a set amount to represent each day, as marked on the candle. The type of candle used in this way is called the *Advent candle*, although this term is also used to refer to a candle that decorates an Advent wreath.

Candles and religion

Birthday cake candles.

Before the advent of electricity, candles and oil lamps were used for illumination. Until the 20th century, candles were more common in northern Europe. In southern Europe and the Mediterranean, oil lamps predominated.

Today, candles are used mainly for their aesthetic value and scent, particularly to set a soft, warm, or romantic ambiance, and for emergency lighting during electrical power failures. Scented candles are used in aromatherapy.

Candles are used in the religious ceremonies of many faiths.

Sikhism

Lamps are lit in Sikhism on Diwali, the festival of light, as well as being lit everyday by followers of Dharmic religions.

Buddhism

A very large carved Thai candle, similar to those used in the Ubon Ratchathani Candle Festival

Candles are a traditional part of Buddhist ritual observances. Along with incense and flowers, candles (or some other type of light source, such as butter lamps) are placed before Buddhist shrines or images of the Buddha as a show of respect. They may also be accompanied by offerings of food and drink. The light of the candles is described as representing the light of the Buddha's teachings, echoing the metaphor of light used in various Buddhist scriptures.

Hinduism

In almost all Hindu homes, lamps are lit daily and sometimes every day before an altar. In some houses, the oil lamps, or candles, at dawn, and in some, twice a day - at dawn and dusk - and in a few, it is maintained continuously.

A diya, or clay lamp, is frequently used in Hindu celebrations and forms an integral part in many social rites. It is a strong symbol of enlightenment, hope and prosperity. Diwali is the festival of lights celebrated by followers of dharmic religions.

In its traditional and simplest form, the diya is made from baked clay or terracotta and holds oil or ghee that is lit via a cotton wick.

Traditional diyas have now evolved into a form wherein waxes are being used as replacements for oils.

Christianity

Lit narthex candles in a Orthodox Church.

A U.S. Air Force chaplain's assistant lights an altar candle with a BBQ lighter in preparation for a Christian worship service.

Candles are sometimes burned in churches and cathedrals as a sign of remembrance of the departed

Candles at the Notre Dame, in Paris

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Bundle of candles sold in the shops of the Christian Quarter in the Old City of Jerusalem

In Christianity the candle is commonly used in worship both for decoration and ambiance, and as a symbol that represents the light of God or, specifically, the light of Christ. The altar candle is often placed on the altar, usually in pairs. Candles are also carried in processions, especially to either side of the processional cross. A votive candle or taper may be lit as an accompaniment to prayer.

Candles are lit by worshippers in front of icons in Eastern Orthodox, Oriental Orthodox, Eastern Catholic and other churches. This is referred to as "offering a candle", because the candle is a symbol of the worshiper offering himself or herself to God (and proceeds from the sale of the candle are offerings by the faithful which go to help the church). Among the Eastern Orthodox, there are times when the entire congregation stands

holding lit tapers, such as during the reading of the Matins Gospels on Good Friday, the Lamentations on Holy Saturday, funerals, Memorial services, etc. There are also special candles that are used by Orthodox clergy. A bishop will bless using dikirion and trikirion (candlesticks holding two and three candles, respectively). At Pascha (Easter) the priest holds a special Paschal trikirion, and the deacon holds a Paschal candle. The priest will also bless the faithful with a single candle during the Liturgy of the Presanctified Gifts (celebrated only during Great Lent).

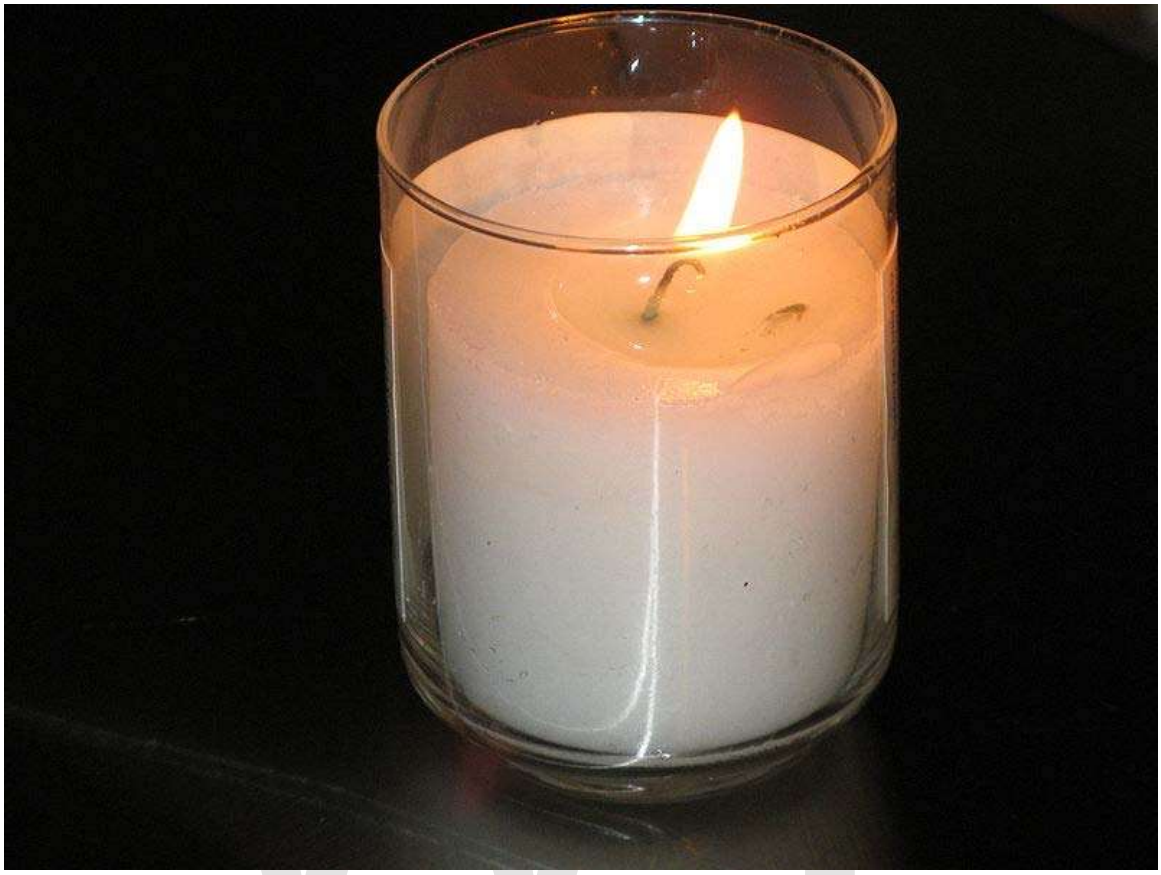
In the Roman Catholic Church a liturgical candle must be made of at least 51% beeswax, the remainder may be paraffin or some other substance. In the Orthodox Church, the tapers offered should be 100% beeswax, unless poverty makes this impossible. The stumps from burned candles can be saved and melted down to make new candles.

In some Western churches, a special candle known as the *Paschal candle*, specifically represents the Resurrected Christ and is lit only at Easter, funerals, and baptisms. In the Eastern Orthodox Church, during Bright Week (Easter Week) the priest holds a special Paschal trikirion (triple candlestick) and the deacon holds a large candle during all of the services at which they serve.

In Sweden (and other Scandinavian countries), St. Lucia Day is celebrated on December 13 with the crowning of a young girl with a wreath of candles.

In many Western churches, a group of candles arranged in a ring, known as an Advent wreath, are used in church services in the Sundays leading up to Christmas. In households in some Western European countries, a single candle marked with the days of December is gradually burned down, day by day, to mark the passing of the days of Advent; this is called an Advent candle.

Judaism



A yahrtzeit candle, lit on the Hebrew anniversary of a loved one's death

In Judaism, a pair of Shabbat candles are lit on Friday evening prior to the start of the weekly Sabbath celebration. On Saturday night, a special braided candle with several wicks is lit for the *Havdalah* ritual marking the end of the Sabbath and the beginning of the new week.

The eight-day holiday of Hanukkah, also known as the Festival of Lights, is celebrated by lighting a special Hanukkiyah each night to commemorate the rededication of the Temple in Jerusalem.

A memorial candle is lit on the Yahrtzeit, or anniversary of the death of a loved one according to the Hebrew calendar. The candle burns for 24 hours. A memorial candle is also lit on Yom HaShoah, a day of remembrance for all those who perished in the Holocaust.

A seven day memorial candle is lit following the funeral of a spouse,parent,sibling or child.

Candles are also lit prior to the onset of the Three Festivals (Sukkot, Passover and Shavuot) and the eve of Yom Kippur, and Rosh Hashana.

A candle is also used on the night before Passover in a symbolic search for chametz, or leavened bread, which is not eaten on Passover.

Kwanzaa

The Candle is also used in celebrations of Kwanzaa, which is an African American holiday which runs from December 26 to January 1. A Kinara is used to hold candles in these celebrations. It holds seven candles; three red candles to represent African American struggles, one black candle to represent the African American people and three green candles to represent African American hopes.

Humanism

For some Humanists the candle is used as a symbol of the light of reason or rationality. The Humanist festival of HumanLight often features a candle-lighting ceremony.

Satanism

During satanic rituals black candles are the only lightsource, except for one white candle on the altar. The dim lighting is used to create an air of mystique and the color of the candles has symbolic meaning.

Unitarian Universalism

A common element of worship in many Unitarian Universalism churches and fellowships is the lighting of candles of joy and concern. Here members of the congregation may come up to the altar or chancel, light a votive or other candle, and share a personal concern or joy with the community. Unitarian Universalism also incorporates candle-lighting ceremonies from other spiritual traditions, from which they draw inspiration. A flaming chalice is the most widely used symbol of Unitarianism and Unitarian Universalism, and is, in reality, usually a candle, not an actual chalice of burning oil.

Wicca

In Wicca and related forms of Paganism, the candle is frequently used on the altar to represent the presence of the God and Goddess, and in the four corners of a ritual circle to represent the presence of the four classical elements: Fire, Earth, Air, and Water. When used in this manner, lighting and extinguishing the candle marks the opening and closing of the ritual. The candle is also frequently used for magical meditative purposes. Altar candles are traditionally thick tall candles or long tapers which are available in many colors. In Wicca, the candles that are used come in a variety of colors, depending on the nature of the ritual or custom at hand. Some Wiccans may use red, green, blue, yellow and white or purple candles to represent the elements.

Raqs sharqi

In raqs sharqi, candles are used as a complementary element in some dance styles. The candles can be held either on the dancer's hand or above her head, depending on what the choreography demands

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Chapter- 7

Oil Lamp

Group of ancient lamps (Hellenistic and Roman)

Traditional Indian earthenware oil lamp or diya

WORLD TECHNOLOGIES

Antique bronze oil lamp with the "Chi Rho", a Christian symbol (replica)

A terra-cotta oil lamp, Antique oil lamp (replica)

Simple contemporary indian clay oil lamp during diwali.

An **oil lamp** is a man-made object used to produce light continuously for a period of time, from an oil-based fuel source. The use of oil lamps began thousands of years ago and is continued to this day.

Oil lamps are a form of lighting, and were used as an alternative to candles before the use of electric lights. Starting in 1780 the Argand lamp quickly replaced other oil lamps still in their basic ancient form. These were, in turn, replaced by the kerosene lamp in about 1850. In small towns and rural areas these continued in use well into the 20th century, until such areas were finally electrified, and light bulbs could be used for lighting.

Most modern lamps (such as lanterns) have been replaced with gas-based or petroleum-based fuels as they are safer to operate when emergency non-electric light is required. As such, oil lamps of today are primarily used for the particular ambiance they produce, or in rituals and religious ceremonies.

Structure and function

Oil lamps were used not only for household lighting, but also for funerary and votive purposes. Lamps were used for domestic purposes in homes and for public purposes in temples and most public buildings.

By studying the lamp's designs, symbols, structure and decorations, and the material of which it is made, we can identify the age and perhaps the locality of the lamp. The lamp can also give us insights into the culture of its users and their social status.

Occasionally the design of the lamps also reveal the female reproductive system. Indian bronze lamps with a protruding central portion are supposed to project the male genitalia on a female womb with light representing 'origin of life' in most cases.

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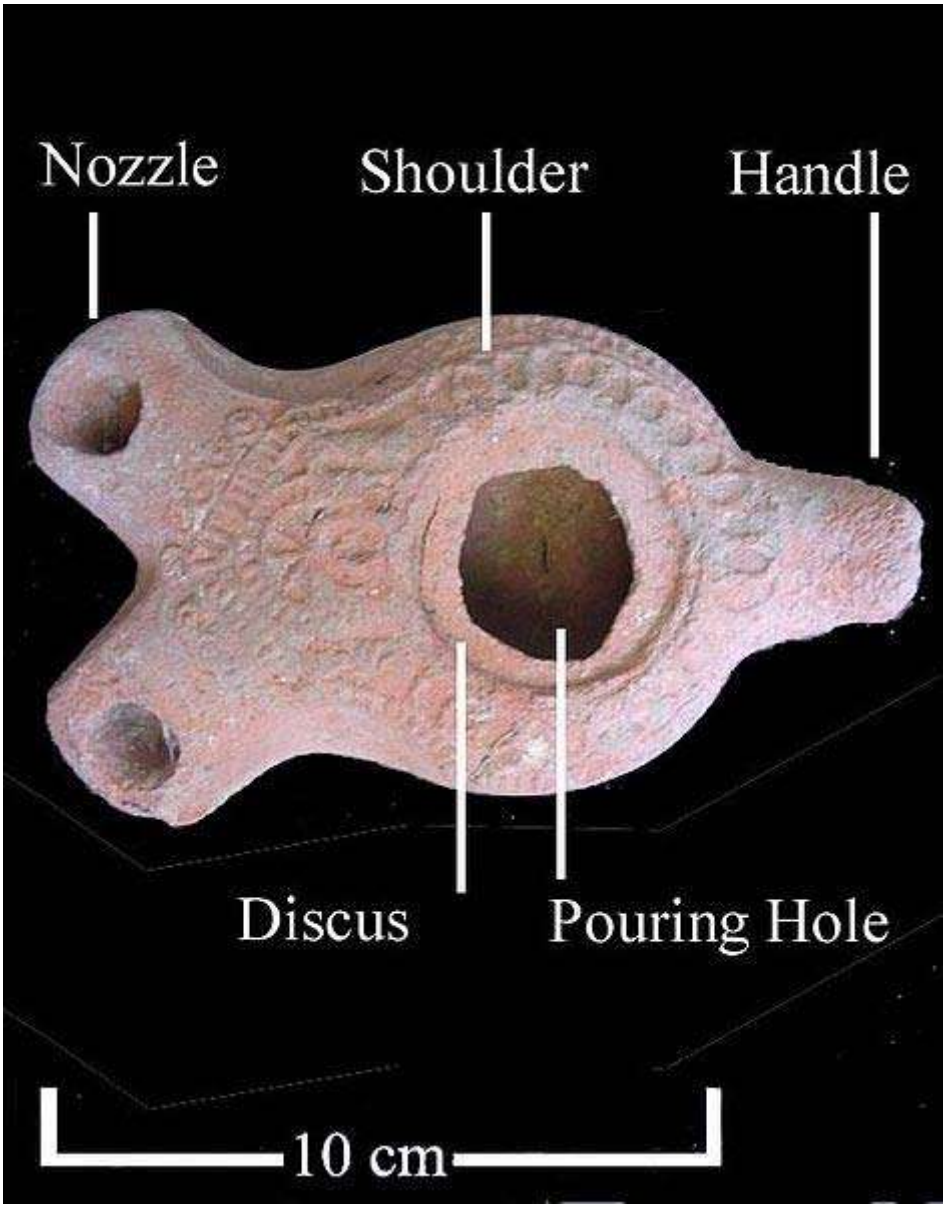
Components



Double-nozzled oil lamp found in Samaria.

The following are the main external parts of a terra-cotta lamp.

- **Shoulder**
- **Pouring hole**

  The hole through which fuel is put inside the fuel chamber. The width ranges from 0.5-5 cm in general. There may be single or multiple holes.

- **Wick hole**, and the **nozzle**.

  It may be just an opening in the body of the lamp, or an elongated nozzle. In some specific types of lamps there is a groove on the superior aspect of the nozzle that runs to the pouring hole to collect back the oozing oil from the wick.

- **Handle**

  Lamps come with and without a handle. The handle comes in different shapes. The most common is ring shaped for the forefinger surmounted by a palmette on which the thumb is pressed to stabilize the lamp. Other handles are crescent shaped, triangular and semi-oval. The handleless lamps usually have an elongated nozzle, and sometimes have a lug rising diagonally from the periphery. The lug may act as a small handle where the thumb rests. Some lugs are pierced. It was speculated that pierced lugs were used to place a pen or straw, called the *acus* or *festuca*, with which the wick was trimmed. Others think that the pierced lugs were used to hang the lamp with a metal hook when not in use.

- **Discus**
- **Volute**
- **Fuel chamber**

  The fuel reservoir. The mean volume in a typical terra-cotta lamp is 20 cc.

Wicks

Various types of cotton wicks for oil or ghee lamps kept for sale in Ulsoor Market, Bangalore.These are primarily used for lighting a diya.

A wick is placed over the nozzle and extends into the fuel chamber. Most lamps come with one nozzle; a few lamps have more, from two to twenty nozzles. However, the more nozzles, the greater the fuel consumption.

The wick was made of different materials, linen, flax, papyrus, tow, or ordinary rush. The thickness of the wick is an important factor too; thin wicks burn fuel more slowly than thick ones. However, the thickness of the wick does not have much effect on the size of the flame.

Fuel

Fuels used for oil lamps depend on such variables as the location, time period and perhaps the reason for the lamp's use; ceremonial use of lamps for instance may require a particular oil or fragrance to be used. The main fuel in Western nations was olive oil in ancient Mediterranean cultures, though extracts from fish, crude fish oil, nuts, and cheese were also used. In much later times whale oil was favoured for its cleaner burning flame. Oozing crude petroleum was also used. The fuel was poured into the fuel reservoir via the pouring hole in the discus.

Castor oil was used by the ancient Egyptians. In Africa, carrot oil, peanut oil, mustard oil and nettle oil are used. Indian lamps, especially for use in puja, almost exclusively use ghee as fuel.

Among other fuels used have been coal oil and paraffin/kerosene in paraffin lamps (also called kerosene lamps and coal oil lamps). Oil lamps can use many other fuels including jathropa seed oil and biodiesel along with wvo, soybean oil, canola oil, hemp seed oil, sunflower seed oil, and olive oil.

Lamps were usually put in lamp holders when in use, partly to avoid the risk of fire. They might be fastened to a wall by a nail or a wooden wedge, hung suspended from brackets, placed in a candelabra, placed in niches in the wall, put on lamp stands of different shapes, or carved as part of stone lamp pillars.

Production methods

Oil lamp found in Lascaux, made in red sandstone. 17,000 BP.

Before the invention of the wheel in the Middle Bronze Age, lamps were made by hand. An early form of the potter's wheel was invented and introduced in the Middle Bronze Age and used to manufacture lamps until around the 3rd century BCE. The use of molds was first developed in Greece and Egypt during the 3rd century BCE. In Roman times, stone, clay, or plaster molds were utilized on a large scale across the Roman Empire until around the 8th century CE.

To make a lamp, two molds are needed: one for the upper part and one for the lower part. Some pairs of molds have knobs and corresponding holes to fit the two molds together. In order to create the mold, an archetype or patrix is first made. Plaster or clay is then formed around the patrix, which dries and hardens into a mold. Clay molds are removed from the patrix before they are fully dried. They are then kiln fired, thus they may deviate or shrink from their original form. Clay molds need more labor than plaster ones. However, clay molds are more durable. Plaster molds are dried completely and then removed from the patrix. Plaster thus makes an accurate replica, but it has the disadvantage of leaving some surface granular artifacts. Due to the perishable nature of plaster, it has proven difficult to find remains of ancient plaster molds. Several clay

molds, however, have been recovered. By studying the surfaces of surviving lamps it seems that plaster was preferred to clay.

Lamp typology

Lamps can be categorized based on different criteria, including material (Clay, Silver, Bronze, Gold, Stone, slip), shape, structure, design, and imagery (e.g. symbolic, religious, mythological, erotic, battles, hunting).

Lamp typological categories

Typologically, lamps of the Ancient Mediterranean can be divided into six major categories

Wheel made: This category includes Greek and Egyptian lamps that date before the 3rd century BCE. They are characterized by simple, little or no decoration, and a wide pour hole, a lack of handles, and a pierced or unpierced lug. Pierced lugs occurred briefly between 4th and 3rd century BCE. Unpierced lugs continued until 1st century BCE.

Volute, Early Imperial: With volutes extending from their nozzles, these lamps were predominately produced in Italy during the Early Roman period. They have a wide discus, a narrow shoulder and no handle, elaborate imagery and artistic finishing, and a wide range of patterns of decoration.

High Imperial: These are late Roman. The shoulder is wider and the discus is smaller with fewer decorations. These lamps have handles and short plain nozzles, and less artistic finishing.

Frog: This is a regional style lamp exclusively produced in Egypt and found in the regions around it, between ca. 100 – 300 CE. The frog, (Heqet), is an Egyptian fertility symbol.

African Red Slip lamps were made in North Africa, but widely exported, and decorated in a red slip. They date to the second century CE and comprise a wide variety of shapes including a flat, heavily decorated shoulder with a small and relatively shallow discus. Their decoration is either non-religious, Christian or Jewish. Grooves run from the nozzle back to the pouring hole and it is hypothesized that this is to take back spilled oil. These lamps often have more than one pour-hole.

Slipper lamps are oval shaped and found mainly in the Levant. They were produced between the 3rd to 9th century CE. Decorations include vine scrolls, palm wreaths, and Greek letters.

Factory lamps: Also called *Firmalampen* (from German), these are universal in distribution and simple in appearance. They have a channeled nozzle, plain discus, and 2

or 3 bumps on the shoulder. Initially made in factories in Northern Italy and Southern Gaul between 1st century and 3rd centuries CE, they were exported to all Roman provinces. The vast majority have been stamped to identify the manufacturer.

Oil lamps in religious contexts

Judaism

Lamps appear in the Torah and other Jewish sources as a symbol of "lighting" the way for the righteous, the wise, and for love and other positive values. While fire was often described as being destructive, light was given a positive spiritual meaning. The oil lamp and its light were important household items, and this may explain their symbolism. Oil lamps were used for many spiritual rituals. The oil lamp and its light also became important ritualistic articles with the further development of Jewish culture and its religion.

- "And you shall command the people of Israel that they bring to you pure beaten olive-oil for the light, that a lamp may be set to burn continually". Exodus 27:20
- "When you set the lamps, the seven lamps shall give light in front of the lamp stand (menorah)." Numbers 8: 1 -4
- "There I shall cause pride to sprout for David; I have prepared a lamp for my anointed." (Psalms 132:16);
- "For a commandment is a lamp and the Torah is light; and reproving discipline is the way of life." (Proverbs 6:23);
- "A man's soul is the lamp of God, which searches the chambers of one's innards." (Proverbs 20:27).
- "A lamp is called a lamp, and the soul of man is called a lamp." (Babylonian Talmud, Shabbat 30B)

Chanukah

The Temple Menorah, a ritual seven branched oil lamp used in the Second Temple, forms the centre of the Chanukah story and centers on the miracle that during the cleansing of the Jewish temple in Jerusalem after its looting, the lamp was supposed to burn continuously, forever, but there was only oil enough for one day, and no more oil would be available for 8 days; miraculously the oil expected to last for only one day instead burnt for 8 full days.

Christianity

Oil lamp burning before the icon of St. Mercurius of Smolensk, Kiev Pechersk Lavra, Ukraine.

There are several references to oil lamps in the New Testament:

- “Your eye is the lamp of your body; when your eye is sound, your whole body is sound, your whole body is full of light; but when it is not sound, your body is full of darkness.” (Luke 11:34);
- “He was a burning and shining lamp, and you were willing to rejoice for a while in his light.” (John 5:35);
- “And night shall be no more; they need no light of lamp or sun, for the Lord God will be their light, and they shall reign for ever and ever.” (Rev 22:5).

In the Orthodox Church and many Eastern Catholic Churches oil lamps (Greek: kandili, Slavonic: *lampada*) are still used both on the Holy Table (altar) and to illuminate icons on the iconostasis and around the temple (church building). Orthodox Christians will also use oil lamps in their homes to illuminate their icon corner.

Traditionally, the sanctuary lamp in an Orthodox church is an oil lamp. It is lit by the bishop when the church is consecrated, and ideally it should burn perpetually thereafter. The oil burned in all of these lamps is traditionally olive oil.

Islam

"God is the Light of the heavens and the earth. The parable of His light is, as it were, that of a niche containing a lamp; the lamp is [enclosed] in glass, the glass [shining] like a radiant star: [a lamp] lit from a blessed tree - an olive-tree that is neither of the east nor of the west the oil whereof [is so bright that it] would well-nigh give light [of itself] even though fire had not touched it: light upon light! God guides unto His light him that wills [to be guided]; and [to this end] God propounds parables unto men, since God [alone] has full knowledge of all things".

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Paavai vilakku. Anthropomorphic oil lamp from Tamil Nadu. Brass.

Blessing at a Durga puja celebration.

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A Deepalakshmi oil lamp from Kumbakonam.

Oil lamps are commonly used in Hindu temples as well as in home shrines. Generally the lamps used in temples are circular with places for five wicks. They are made of metal and either suspended on a chain or screwed onto a pedestal. There will usually be at least one lamp in each shrine, and the main shrine may contain several. Usually only one wick is lit, with all five burning only on festive occasions. The oil lamp is used in the Hindu ritual of Aarti.

In the home shrine, the style of lamp is usually different, containing only one wick. There is usually a piece of metal that forms the back of the lamp, which has a picture of a Hindu deity embossed on it. In many houses, the lamp burns all day, but in other homes, it is lit

at sundown. The lamp in the home shrine is supposed to be lit before any other lights are turned on at night.

A hand-held oil lamp or incense sticks (lit from the lamp) are also used during the Hindu puja ceremony. In the North of India, a five-wick lamp is used, usually fueled with ghee. On special occasions, various other lamps may be used for puja, the most elaborate having several tiers of wicks.

In South India, there are two types of oil lamps that are common as offerings in temples. They both have only one wick:

- **Deepalakshmi**, a brass lamp with a depiction of goddess Sri Lakshmi over the back piece. they are usually small-size.

- **Paavai vilakku**, a brass or bronze lamp in the form of a lady holding a vessel with her hands. This type of lamp comes in different sizes, from very small to almost life-size. There are also large stone versions of this lamp in Hindu temples of Tamil Nadu and Kerala, especially at the base of columns and flanking the entrance of temples.

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Chinese folk religion

Traditional Chinese shrine in Petaling Jaya, Malaysia, containing an oil lamp.

Oil lamps are lit at traditional Chinese shrines before either an image of a deity or a plaque with Classical Chinese characters giving the name of the deity. Such lamps are usually made from clear glass (they look similar to normal drinking glasses) and are filled with oil, sometimes with water underneath. A cork or plastic floater containing a wick is placed on top of the oil with the bottom of the wick submerged in the oil.

Such lamps are kept burning in shrines, whether private or public, and incense sticks or joss sticks are lit from the lamp.

Archaeological chronology

It is very difficult to say when and where the first oil lamp was used. This is partly because it is difficult to draw a line detailing when the primitive forms of creating a continuous source of light from fire can be termed a lamp. The first lamps were made of naturally occurring objects, coconuts, sea shells, egg shells and hollow stones. Some believe that the first proper lamps were carved from stones. Curved stone lamps were found in places dated to the 10th millennium BCE. (Mesolithic, Middle Stone Age Period, circa 10,300 - 8000 BCE)

Some Archaeologists claim that the first shell-lamps were in existence more than 6,000 years ago. (Neolithic, Later Stone Age, c. 8500 - 4500 BCE). They believe that the alabaster shell-shaped lamps dug up in Sumerian sites dating 2,600 BCE were imitations of real shell-lamps that were used for a long time. (Early Bronze, Canaanite / Bronze I-IV, c.3300 - 2000 BCE)

It is generally agreed that the evolution of handmade lamps moved from bowl-shaped to saucer-shaped, then from saucer with a nozzle, to a closed bowl with a spout.

Chalcolithic Age, c.4500 - 3300 BCE.

The first manufactured red pottery oil lamps appeared. These were of the round bowl type.

The Bronze Ages (3200-1200 BCE)

Lamps were simple wheel-made bowls with a slight pinch on four sides for the wick. Later lamps had only one pinch. These lamps vary in the shape of the rim, the general shape of the bowl and the shape of the base.

- Intermediate Bronze Age lamps (EBIV/MBI)

The earliest lamps known from Intermediate Bronze Age lamps (EBIV/MBI) With the four wick lamps. These lamps are made from large bowls with four shallow pinches for wicks.

- Middle Bronze Age lamps (MB)

The four-wick oil lamps persist into this period, most of the lamps now have one wick. Early in this period the pinch is shallow, while later on it becomes more prominent and the mouth protrudes from the lamp's body. The bases are simple and flat. The crude potter’s wheel is introduced, transforming the handmade bowls to a more uniform container. The saucer style evolves into a single spout shape.

- Late Bronze Age lamps (LB)

A more pronounced, deeper single spout is developed, and it is almost closed on the sides. The shape is evolving to be more triangular, deeper and larger. All lamps are now wheel-made. The base is simple, usually flat.

The Iron Age (1200-560 BCE)

The rim becomes wider and flatter with a deeper and higher spout. The tip of the spout is more upright in contrast to the rest of the rim.

The lamps are becoming variable in shape and distribution. We still find lamps similar to the Late Bronze period. In addition, other forms evolve, such as small lamps with a flat base and larger lamps with a round base. The later form continues into the Iron Age II.

In the later Iron Age, we encounter variant forms. One common type is small, with a wide rim and a wide base. Another type is a small, shallow bowl with a thick and high discus base.

Persian

These large lamps have thin sides and a deep pinch, which flattens the mouth and makes it protrude outward.

Greek

Lamps are more closed to avoid spilling. They are smaller and more refined. Most are handleless. Some are with a lug, pierced and not pierced. The nozzle is elongated. The rim is folded over to make the nozzle, so it overlaps and is then pinched to make the wick hole.

They are round in shape, wheel-made.

Early Roman

Jewish oil lamps from Sardegna in the Museo Naziona Sanna Sassari

Production of oil-lamps shifted to Italy as the main source of supply. Molds used. All lamps are closed in type. Lamps produced in large scale in factories. The lamp is produced in two parts, the upper part with the spout and the lower part with the fuel chamber. Most are of the characteristic Imperial Type. It was round with nozzles of different forms (volute, semi-volute, U shaped), with a closed body and with a central disk decorated with reliefs and its filling hole.

Late Roman

The High Imperial Type. More decorations. Produced locally or imported in large scale. The multiple-nozzled lamps appear. Different varieties.

In this period we find the frog type lamps. These are kidney or heart shaped or oval. With the motif of a frog or its abstraction, and sometimes with geometrical motifs. They were produced around 100 AD. They are so variant that it is seldom that two identical ones are found.

Byzantine

Byzantine period oil lamp. Found in Samaria in a tomb.

Slipper shaped. Very decorative. The multiple nozzles continue. Most with handles. Some are complex in external anatomy.

Early Islamic

Early Islamic oil lamps (11th c.), found in Southern Portugal

There is a transition period from Byzantine to Islamic lamps. Lamps of this transition period changed from being decorated with crosses, animals, human likenesses, birds, fish, etc., to being decorated with plain linear, geometric, and raised dot patterns.

The early Islamic lamps are a continuation of Byzantine lamps. Decorations were initially a stylized form of bird, grain, tree, plant or flower. Then they became entirely geometric or linear with raised dots.

The first kerosene lamp was described by al-Razi (Rhazes) in 9th century Baghdad, who referred to it as the "naffatah" in his *Kitab al-Asrar* (*Book of Secrets*).

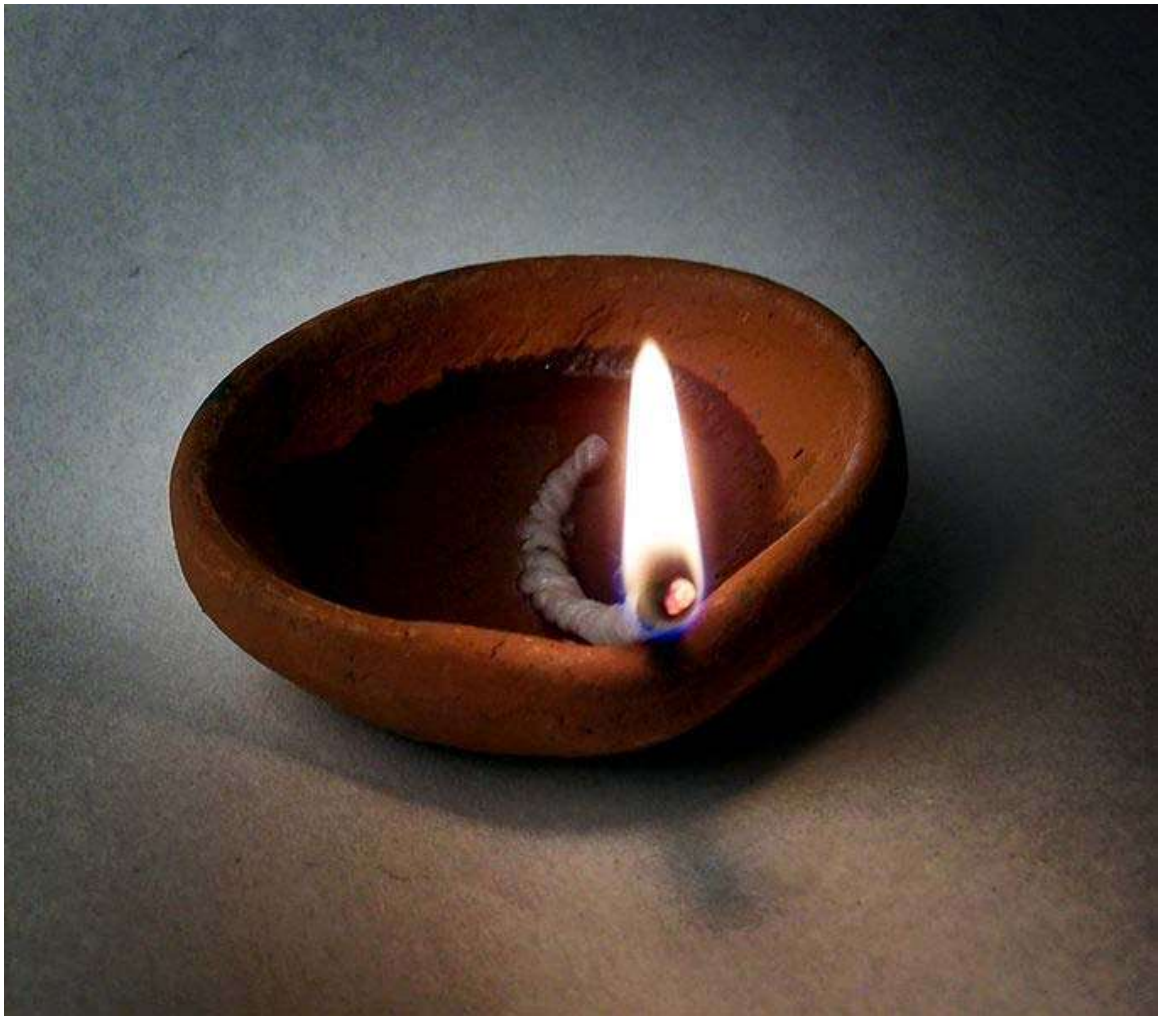
In the transition period some lamps had Arabic writing. Then, writing disappears until the Mamluk period (13th - 15th centuries CE).

Regional variations

Land of Israel

- Jerusalem oil lamp: Characteristic black color of the clay because the clay was burned without oxygen. Usually of high quality.
- Daroma oil lamp:
- Jerash oil lamp:
- Nabatean oil lamp:
- Herodian oil lamp: Considered to be used mainly by Jews. Wheel made, rounded. Nozzle with concave sides. The lamps are usually not decorated. If there is decoration, it tends to be simple. Very common throughout all of Israel, and some lamps have also been found in Jordan. Date from 1st century BCE to the end of the 1st century AC.
- Menorah oil lamp, 7 nozzles: Rare and are associated with Judaism because of the numerical connection with the seven branches or arms of the Menorah.
- Sumerian oil lamp: Characterized by a seal filling-hole marked by a ridge. A wider spout, and the concavities flanking the nozzle are almost always emphasized with a ladder pattern band. In general the lamps are uncoated. The decorations are linear and/or geometric.
    -
    - Type I: A distinct channel running from the pouring-hole to the nozzle, a small knob handle, a ladder pattern around the nozzle and shows no ornamentation on the bottom of the base.
    - Type II: Pear-shaped and elongated, lined channel that extends from the filling-hole to the nozzle, continued to be used through to the early Muslim period.
- Candle Stick oil lamp: Menorah design on the nozzle and bunch of grapes on the shoulders.
- Sumerian oil lamp: The upper parts are covered with braided patterns and their handles. All are made of a dark orange-red clay. A rounded bottom with a distinct X or cross appears inside the circled base.
- Early Islamic oil lamp: Large knob handle and the channel above the nozzle are dominant elements. The handle is tongue-shaped. Decoration is rich and elegant. The lower parts are extremely broad and the nozzles are pointed.

Importance of oil lamps in India



A basic earthen oil lamp used for Diwali

In vedic times, fire was kept alive in every household in some form and carried with oneself while migrating to new locations. Later the presence of fire in the household or a religious building was ensured by an oil lamp. Over the years various rituals and customs were woven around an oil lamp.

Deep Daan, the gift of a lamp was and still is believed to be the best daan. During marriages, spinsters of the household stand behind the bride and groom, holding an oil lamp to ward off the evil. The presence of oil lamp is an important aspect of ritual worship (the shodashopachar puja) offered to a deity. Moreover, a day is kept aside for the worship of the lamp in the busy festival calendar, on one amavasya (no moon) day in the month of Shravan. This reverence for the deep is based on the symbolism of the journey from darkness and ignorance to light and the knowledge of the ultimate reality – 'tamaso ma jyotirgamaya!'

The earlier lamps were made out of stone or seashells. The shape was like a circular bowl with a protruding beak. Later they were replaced by earthen and metal lamps. In the epics Ramayana and Mahabharata, there are references of gold and silver lamps as well. The simple shape evolved and the lamps were created in the shapes of the matsya (fish), kurma (boar) and other incarnations of god Vishnu and also in the shape of the many attributes of gods like conch shells, lotuses and so on. The birds like swans, peacocks, parrots and animals like snakes, lions, elephants and horses were also favorites while beautifying a lamp. For lighting multiple lamps, wooden and stone deepastambhas (towers of light) were created. Erecting a deepastambha in front of a temple is still a general practice in western and southern India. For adapting the design to the households and smaller spaces, the deepavriksha (tree of light) was formed. As the name suggests, it is a metal lamp container with aesthetically curvi-linear lines branching out from the base each holding a lamp. The Deepalaxmi is another favorite design where goddess Laxmi holds the lamp in her hands. Kuthuvilakku is another typical lamp traditionally used for house hold purposes in South India.

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Chapter- 8

Safety Lamp

Modern flame safety lamp used in mines, manufactured by Koehler

A **safety lamp** is any of several types of lamp, which are designed to be safe to use in coal mines. These lamps are designed to operate in air that may contain coal dust, methane, or firedamp, all of which are potentially flammable or explosive. The use of open lamps, rather than the safety lamps that were then available, was one cause of the Naomi Mine explosion and the Darr Mine Disaster in Pennsylvania in December 1907.

First safety lamps

The first safety lamp was invented by William Reid Clanny, an Irish physician, who announced his discovery on May 20, 1813 at the Royal Society of Arts in London, but it was not tried out in a colliery until 1815. Within months of this demonstration, two improved designs had been announced: one by George Stephenson, which later became the Geordie lamp, and the Davy lamp, invented by Sir Humphry Davy. Most later lamps are constructed on the principle discovered by Davy, that a flame enveloped in wire gauze of a certain fineness does not ignite firedamp.

Both the Davy and Stephenson lamps were fragile. The gauze in the Davy quickly rusted in the moist air of a coal pit, and so became unsafe, while the glass in the Stephenson was easily broken, and could then allow the flame to ignite firedamp in the atmosphere. Later designs, the Gray, Mueseler, Marsaut, and other lamps, tried to overcome these problems by using multiple gauze cylinders, but the glass remained a problem until toughened glass became available.

Also, the light that all these gave was poor and this was not solved until the introduction of electric lighting in mines around 1900. But it took until 1930 for the introduction of battery-powered helmet lamps to finally solve the problem.

Early illumination

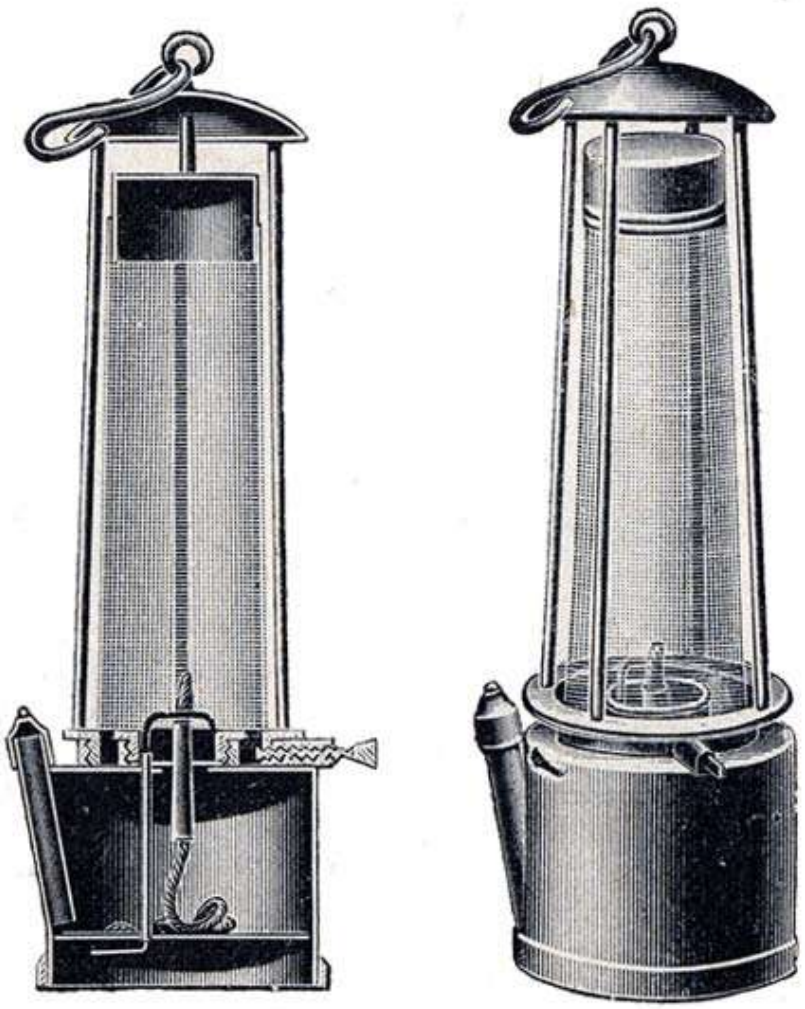

Fig. 192. Davyſche Sicherheitslampe

A Davy lamp, an early example of a safety lamp

Prior to the invention of these safety lamps, miners used candles with open flames or phosphorescent sources of light and later flint or steel mills designed by 'Spedding.' Later, barometers were used to tell them if atmospheric pressure was low (in which case more methane seeped out of the coal seams into the mine galleries).

The use of small mammals or birds was used much later at the end of the Victorian age to warn of the presence of the deadly carbon monoxide present after underground fires or explosions, the so-called afterdamp. The method was introduced by the noted physiologist and disaster investigator, John Scott Haldane after the Laxey lead mine disaster. Such animals are much more susceptible to the gas, and will die before a human, so giving an early warning of the problem. There were numerous deaths caused by carbon monoxide from a small fire near one of the shaft bottoms. An alternative method of removing a different gas, known as firedamp (methane) involved igniting the gas deliberately to cause explosions, thus evacuating the mines of the majority of explosive or easily flammable material present.

The lack of good lighting was a prime cause of a painful eye affliction (nystagmus).

Modern lamps

Nowadays, safety lamps are mainly electric, and traditionally mounted on miners' helmets (such as the wheat lamp) or the Oldham headlamp, sealed to prevent gas penetrating the casing and being ignited by electrical sparks.

Although its use as a light source was superseded by electric lighting, the flame safety lamp has continued to be used in mines to detect methane and blackdamp, although many modern mines now also use sophisticated electronic gas detectors for this purpose.

As a new light source, LED has many advantages for safety lamps, including longer burn time and less energy required. Combined with new battery technologies, such as the lithium battery, it gives much better performance in safety lamp applications. It is replacing conventional safety lamps.

Type of Safety Lamps: -

Davy lamp

Davy lamp (photo)

The **Davy lamp** is a safety lamp with a wick and oil vessel burning originally a heavy vegetable oil, devised in 1815 by Sir Humphry Davy. It was created for use in coal mines, allowing deep seams to be mined despite the presence of methane and other flammable gases, called *firedamp* or *minedamp*.

Davy had discovered that a flame enclosed inside a mesh of a certain fineness cannot ignite firedamp. The screen acts as a flame arrestor; air (and any firedamp present) can pass through the mesh freely enough to support combustion, but the holes are too fine to allow a flame to propagate through them and ignite any firedamp outside the mesh. The first trial of a Davy lamp with a wire sieve was at Hebburn Colliery on 9 January 1816.

Gas Detector

The lamp also provided a test for the presence of gases. If flammable gas mixtures were present, the flame of the Davy lamp burned higher with a blue tinge as shown by the gauge. Miners could place the safety lamp close to the ground to detect gases, such as carbon dioxide, that are denser than air and so could collect in depressions in the mine; if the mine air was oxygen-poor (asphyxiant gas), the lamp flame would be extinguished (*black damp* or *chokedamp*). A flame is extinguished at about 17% oxygen content, air which will still support life, so the lamp gave an early indication of a problem. So miners had a warning of asphyxiation before it actually happened.

Comparison with Geordie lamp

There was some controversy, since George Stephenson also produced a similar safety lamp in 1816 called the Stephenson generally and locally within the North East coalfields the Geordie.

Supporters of each man seem to have regarded the other as having plagiarised their man's idea. The Geordie lamp had a glass inside the tubular gauze with a copper cap; the air was fed from below. The Davy lamp was simpler and cheaper, and was popular with mine owners.

There were safety arguments on both sides: in principle, a poorly maintained (or badly designed) Davy lamp could overheat the gauze if it met a high concentration of methane. The gauze rusted easily in the damp mines, making the lamp hazardous. The Geordie lamp could become unsafe if the internal glass was broken (as it became an oversize Davy). Both original lamps were faulty, and led to attempts at improvement, by using multiple gauzes above the flame, and with a glass surround to improve illumination. They were poor sources of light and the situation did not improve until the introduction of electric hand lamps in the Victorian period.

Accident rate

The introduction of the Davy lamp actually led to an increase in accidents in mines, as the lamp encouraged working mines that had previously been closed for safety reasons. The bare gauze was easily damaged, and once just a single wire broke or rusted away, the lamp became unsafe. Illumination from the safety lamps was very poor, and the problem was not resolved until electric lamps became widely available in the late 19th century.

One reason why the lamp caused an increase in the accident rate was that the men continued to work in unsafe conditions due to the presence of methane gas. The other reason why there was an increase was that there should have been an installation of extractor ventilation fans installed at each mine to reduce the concentration of methane in the air. This would have been expensive, and thus they were not installed by mine owners. The lamps also had to be provided by the miners themselves, not the owners, as traditionally the miners bought their own candles at top price in the company store. The installation of fans became required after laws requiring minimum air quality standards were introduced.

Modern Lamps

The modern day equivalent of the Davy lamp is the Protector Garforth GR6S flame safety lamp which is used for firedamp testing in all UK coal mines. A modified version of this lamp is used to transport the Olympic Flame for the torch relays. They were used for the Sydney, Athens, Turin, Beijing, Vancouver and Singapore Youth Olympic Games relays. They were also used for the Special Olympics Shanghai, Pan American and Central African Games relays. They will also be used for the London 2012 relay. The lamps are still made in Eccles. A modified version of the lamp has recently been produced which will burn ghee, as used in Hindu flame ceremonies.

Electronic gas detectors are now widely used in collieries and detect methane by its slow combustion on a catalyst chip. The rise in temperature is detected and a warning emitted by the device, known as a methanometer. However it is still a legal requirement in operating a UK coal mine that a Protector Flame Safety Lamp is used for gas testing. These are carried by Pit Deputies who are usually responsible for 15 men.