UNIVERSITÀ DEGLI STUDI DI PAVIA
Sistema Museale di Ateneo

Museo della Tecnica Elettrica / *Museum of Electrical Technology*

Un anno al Museo 2009
Museum Year 2009

a cura di Antonio Savini
edited by Antonio Savini

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Editoria scientifica

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Sommario / *Contents*

Presentazione

Ad appena tre anni dalla sua apertura il Museo della Tecnica Elettrica, una delle gemme del Sistema Museale dell'Università di Pavia, è un giovane Museo che si sta affermando. Le sue attività, e quelle del Centro di Ricerca per la Storia della Tecnica Elettrica che è ospitato nel Museo, sono in crescita.

Per questo si è pensato di documentarle annualmente in un Rapporto asciutto e agile, affidato soprattutto alle strade della rete informatica oggi forse più frequentate degli scaffali delle biblioteche.

Museum Year 2009, il primo Rapporto delle attività del Museo che riguarda il 2009, elenca anzitutto gli eventi promossi od ospitati e le principali acquisizioni del Museo nell'anno. Il Rapporto dà conto anche delle pubblicazioni scaturite dagli studi sviluppati dal Centro di Ricerca. Infine esso riporta il testo integrale della Lezione invitata Annuale tenuta nel marzo di ogni anno in occasione del Museum Day da un esperto particolarmente qualificato su uno dei temi che caratterizzano il Museo e che possono interessare anche il largo pubblico.

Nel 2009 Brian Bowers, già al Science Museum di Londra, ha raccontato, in modo magistrale e affascinante, la storia dell'illuminazione e di quella elettrica, in particolare. La lettura o rilettura della sua lezione fa certamente gustare maggiormente la ricchezza dei contenuti , anche se non può rendere l'emozione delle scintillanti dimostrazioni che l'hanno accompagnata.

Senza aver alcuna pretesa di competere con le più grandi istituzioni museali, con le quali peraltro il Museo di Pavia si onora di collaborare, viene licenziato questo modesto strumento di comunicazione on line con lo scopo di far giungere le notizie annuali del Museo anzitutto alla cerchia degli amici del Museo stesso e poi a tutti i visitatori passati e futuri, effettivi e virtuali, e infine a tutti quanti sono interessati alla cultura tecnico scientifica e ai Musei dove tale cultura non solo è conservata ma è continuamente rielaborata e offerta in modo rigoroso, vivace e accattivante.

Ad multos annos

Preface

Three years after its opening the Museum of Electrical Technology, which is part of the System of Museums of the Pavia University, is still a young Museum but it is becoming established. The activities of the Museum and of the Research Centre for the History of Electrical Technology, based in the Museum, are increasing.

It is planned to report them annually in a simple and easily accessible publication mainly intended for visitors on the web and for those using libraries.

Museum Year 2009, the first Report of the activities of the Museum in 2009, basically describes the events promoted by or hosted in the Museum and of the main contributions to the Museum heritage. The Report also lists the results of the studies carried out by the Research Centre. It finally includes the full text of the invited Annual Lecture delivered every year on Museum Day, early in March, by a prominent expert of one of the subjects covered in the Museum and which is also of interest to the general public.

In 2009 Brian Bowers, formerly in the Science Museum London, in a superb and fascinating way, gave a talk about the history of lighting and of electric lighting, in particular. Reading, or rereading, the text of his lecture enables one to capture the very many interesting details, although it cannot reproduce the sparkling demonstrations which accompanied the lecture.

The present publication is not intended to compete with those of the major museums of science and technology, with which, by the way, the Pavia Museum is pleased to cooperate.

Nevertheless, by using the facilities of the web, it aims at providing yearly with quick and easy information first of all the friends of the Pavia Museum, then the past and future, real or virtual visitors and finally all those who have interest in science and technology, the heritage of which is not only preserved in Museums like that in Pavia but is developed in a sound, modern and fascinating way.

Ad multos annos

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Eventi dell’anno al Museo della Tecnica Elettrica
Events in the Museum

2009

Museum Day e Annual Lecture

“Lengthening the Day. Storia e tecnologia dell’illuminazione elettrica”, B. Bowers, London
7 marzo 2009

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Conferenza

“Tidal Energy”, M. Wrigley, France, in collaborazione con IET
24 gennaio 2009

Conferenza

“Stato dell’arte della tecnologia fotovoltaica”, F. Paletta, Milano, in collaborazione con AEIT
26 marzo 2009

Mostra ospitata

“Il contagio vivo”
16 aprile – 4 giugno 2009

Inaugurazione della targa “IEEE Volta Milestone”
Conferenza

“History of computing in Europe: main streams, main questions”, P.E. Mounier Kuhn, Paris
10 giugno 2009

Mostra

“Comunicare senza fili: dai segnali ai suoni / Wireless communications: from signals to sounds”
2 ottobre – 20 dicembre 2009

Serie di conferenze e dimostrazioni
per illustrare la figura di Guglielmo Marconi inventore e imprenditore europeo, il significato della comunicazione senza fili e la rivoluzione portata dalla radio

Ottobre – dicembre 2009

Sabato 7 marzo 2009

Museum Day 2009

Il 7 marzo 2009 il Museo della Tecnica Elettrica di Pavia ha celebrato il suo secondo Museum Day.

Momento centrale del Museum Day 2009 è stata la Conferenza Annuale (Annual Lecture) di Brian Bowers, già al Science Museum di Londra, che ha avuto come tema la storia e la tecnologia dell'illuminazione. Esperimenti dal vivo e materiali audiovisivi hanno reso la Conferenza ancora più brillante.

Nel pomeriggio è stato inaugurato il riallestimento del cuore operativo della stazione ferroviaria di Certosa di Pavia, restaurato e trasferito al Museo a cura di Rete Ferroviaria Italiana.

On March 7 the Pavia Museum of Electrical Technology celebrated its second Museum Day. The highlight of the Day was the Annual Lecture by Brian Bowers, formerly in the Science Museum, London, which dealt with the history of lighting technology. Demonstrations and experiments enhanced the lecture.

In the afternoon the ancient control system of the railway station in Certosa di Pavia was presented, having been restored by Rete Ferroviaria Italiana.

Annual Lecture 2009

Lengthening the Day

How electric light lengthened the day: history and technology of the invention of the electric lamp

Brian Bowers, Centro di Ricerca per la Storia delle Tecnica Elettrica, Università di Pavia, già Curatore del Science Museum, London

Traduzione dell'Introduzione alla Conferenza "Il giorno allungato. Come la luce elettrica ha allungato il giorno: storia e tecnologia dell'invenzione delle lampade elettriche."

La luce quando e dove vogliamo è una delle conquiste della vita civile. In ogni religione la luce ha simbolizzato il bene e la moderna illuminazione elettrica è senza dubbio la più significativa di tutte le conquiste della scienza e della tecnologia.

A parte la luce elettrica, la maggior parte dei sistemi di illuminazione è basata sulle fiamme. Nelle candele, nelle lampade a olio e in quelle a gas particelle di carbone o di composti di carbone sono riscaldate fino ad incandescenza. La luce delle lampade elettriche a filamento incandescente è pure prodotta dal riscaldamento di un materiale finché diventa incandescente, ma il materiale in questo caso è un filamento solido piuttosto che le particelle della fiamma. Più caldo è il filamento, più luce viene prodotta.

Quando si vede la luce emessa da un corpo incandescente attraverso un prisma si nota che consiste di una gamma continua di colori, come un arcobaleno. La proporzione dei vari colori dipende dalla temperatura. Via via che il corpo è riscaldato prima diventa rosso poi, man mano che risulta più caldo, aumenta la proporzione degli altri colori e la luce risultante diventa più bianca. La luce in sé è un'onda elettromagnetica e l'occhio umano è sensibile alle onde luminose dal violetto (lunghezza d'onda di circa 400 nanometri) al rosso (circa 700 nanometri).

Due lampade diverse che consumano la stessa energia elettrica e producono la stessa energia luminosa hanno lo stesso rendimento, ma se una di esse produce luce alla quale l'occhio umano è più sensibile apparirà più brillante. Gli esperti di illuminazione parlano di "efficacia" di una lampada, intendendo il suo rendimento corretto considerando la sensibilità dell'occhio. Nelle lampade elettriche a scarica, in quelle fluorescenti e anche nelle lampade a gas si applicano diversi processi fisici e il colore della luce non è più determinato solamente dalla temperatura. Normalmente la luce è composta da una o più bande di colori distinti. L'esempio più estremo è la lampada al sodio a bassa pressione, comune fino agli anni 1980 per l'illuminazione stradale, che dà una luce gialla (attraverso un prisma si può vedere che sono presenti solo raggi gialli). La luce delle lampade fluorescenti più moderne contiene diverse bande di colori distinti, non uno spettro continuo. Ben progettate, queste lampade possono dare agli oggetti colorati lo stesso aspetto che hanno alla luce del giorno.

Negli ultimi duecento anni la storia dell'illuminazione è stata una storia di continui sviluppi. In molte tecnologie il vecchio è presto sostituito quando si introduce il nuovo. Nel caso dell'illuminazione il vecchio è spesso conservato anche quando si sa che il nuovo è più efficiente. La scelta dell'illuminazione è altamente soggettiva e non è guidata puramente da criteri razionali: ci piacciono le candele e perciò la troviamo nelle feste e nei ristoranti; ci ricordiamo che le prime lampade fluorescenti erano criticabili per il loro splendore e il loro tremolio e perciò molta gente evita di usare quelle moderne migliorate anche se così facendo si potrebbe risparmiare danaro.

1. Introduction

Light when and where we want it is one of the boons of civilized life. In every religion light has symbolized the good, and modern electric lighting is arguably the most significant of all the achievements of science and technology. About one fifth of the electricity generated in the world today is used for lighting.

In the Bible the first act of God after creating heaven and earth was to proclaim "Let there be light". The sun gives us light during the day. We like to extend the day, but until recently the moon has determined what was possible after sunset. One evening event when moonlight was crucial was the Exodus, the escape of the Israelites from Egypt, three thousand years ago. They had a lunar calendar and preparations began on the fourteenth day of the month, when the moon was full. The date of Easter is determined by the date of Passover, so it is always full moon at Easter.

Simple oil lamps gave light indoors, but were of little use for travellers. In towns the men of the Night Watch might have cressets, metal fire-baskets carried on poles to light their way, but most people would only venture out at night if it were moonlight.

'The night watch', drawing by Wenceslaus Hollar (1607-77) showing the night watchmen carrying fire baskets to light their way.

In Jane Austen's novel *Sense and Sensibility,* published in 1811, she tells of a dinner party arranged at short notice. Their host had tried to get more guests, 'but it was moonlight, and everybody was full of engagements'.

Robert Louis Stevenson summed up the whole story of illuminating towns in his essay, *A Plea for Gas Lamps,* written in 1881, "Cities given, the problem was to light them [...] When gas first spread along a city, [...] the day was lengthened out to every man's fancy".

Apart from electric lights, most lighting depends on flames. In candles, oil lamps, and gas flames particles of carbon or carbon compounds are heated to incandescence. Light from the electric incandescent filament lamp is also produced by heating a material until it glows, but the material now is the solid filament, rather than particles in a flame. The hotter the filament, the more light it produces.

When light from an incandescent body is viewed through a prism it is seen to consist of a continuous range of colours, like a rainbow. The ratio of the various colours depends on the temperature. As a body is heated up it first glows red, then as it gets hotter the proportion of other colours increases and the resulting light becomes whiter. Light itself is an electromagnetic wave and the human eye is sensitive to light ranging from violet (with a wavelength of about 400 nanometres), to red (about 700 nm). The eye is not equally sensitive to all colours, but is most sensitive to light with a wavelength of 555 nm, which is in the green part of the spectrum and is the wavelength of the strongest rays which reach the earth's surface from the sun. The relationship between the energy in a beam of light and its perceived brightness varies with the wavelength, or colour. At both ends of the spectrum the sensitivity falls to zero. Consequently, a lamp which converted a certain quantity of energy into green light would appear brighter than another lamp which converted the same amount of energy into red or violet light. Two different lamps using the same electrical energy and giving out the same light energy have the same efficiency, but if one of the lamps produces light to which the human eye is more sensitive it will appear brighter. Lighting engineers refer to the 'efficacy' of a lamp, meaning its efficiency adjusted by reference to the sensitivity of the eye. In electric discharge lamps, fluorescent lamps, and also gas mantles, different physical processes are at work and the colour of the light is no longer determined solely by the temperature. Usually the light is composed of one or more bands of distinct colour. The most extreme example is the low pressure sodium lamp, popular until the 1980s for street lighting, which gives a yellow light, and viewed through a prism it can be seen that only yellow rays are present. The light from most modern fluorescent lamps contains several bands of distinct colour, not a continuous spectrum. With good design such lamps can give coloured objects the same appearance as they have in daylight.

Over the last two hundred years the story of lighting has been one of continuous development. In most technologies the old is quickly superseded when the new is introduced. With lighting the old is often retained from choice even though we know the new is more efficient. Our choice of lighting is a highly subjective matter and is not guided purely by rational analysis: we *like* candles, so we have them at parties and in restaurants; we remember that early fluorescent lamps were objectionable because of their glare and flicker, so many people avoid the improved modern ones even though their use could save money.

The first lighting device used by man must have been fire, or a branch taken from the fire, a primitive torch. Homer's *Odyssey*, probably written the eighth century BC but drawing on earlier oral tradition, describes a party which went on late so 'they set up three braziers in the hall to give them light, heaped them with faggots of dry wood thoroughly seasoned and newly split'.

A 'fire-brand', a piece of resinous wood, could be taken from the fire to serve as a torch for moving about. A 'link' or 'flambeau', usually of rope impregnated with tallow, pitch or resin, lasted longer. In medieval cities 'link boys' earned a living by escorting people through the streets at night . They were still part of the London scene in 1821 when Cruickshank drew 'Outside of the opera House at Night'. Conical 'link extinguishers' may still be seen outside a few older houses.

'Link boy' carrying a flaming torch to guide people in nineteenth century London.

2. Oil lamps and candle

When fires were first used for cooking meat people must have noticed that fats and oils will readily burn, giving light: so the idea of the oil lamp was born. A simple lamp needs only a container for the oil and a piece of fibrous plant for a wick. Provided the wick is well adjusted, the lamp will give as much light as a candle. In classical Greek and Roman times pottery lamps were made in large numbers. The varied shapes and patterns make lamps useful for dating archaeological sites and for tracing patterns of trade.

A larger wick will give a larger flame and more light, but consume more oil. Hence the exchange between master and servant in Aristophanes' play, *The Clouds*, of 423 BC. Having run out of oil, Strepsiades rebukes his slave for putting "such a hungry wick in the lamp". Experiment with cooking oil in a saucer, and different thicknesses of string for a wick, shows that a thick wick may burn twice as much oil as a thin wick, without giving much more light.

Early pottery lamps, probably Roman, burning olive oil.

Both glass and metal have been widely used for oil lamps. Glass lamps have the advantage that they cast less shadow. The wick would usually hang over the edge of the vessel in order to give some light downwards. A common refinement was a second vessel underneath to catch drips from the wick.

A burning candle is an oil lamp. The wick stands in a pool of oil where the candle has melted. Until the late eighteenth century most candles were made of either beeswax or tallow, but then spermacetti, derived from oil from the sperm whale, came into use. Beeswax is in limited supply and expensive. Tallow, which is the more solid part of animal fats, is cheaper – but smelly. Tallow melts at just over 50°C and softens on a hot day in England, whereas beeswax melts at 62°C. Tallow candles have therefore been used more in northern Europe than around the Mediterranean. The Romans had separate words for wax candles (*cerii*) and tallow candles (*lebacii*). Since the later nineteenth century most candles have been made of paraffin wax.

A variant on the candle is the rushlight, used for thousands of years and made by peeling off some of the outer bark from a rush to expose the pith. The rush is then dried and dipped in melted fat to make a candle with the pith as its wick. Held in a simple clamp, rushlights can burn steadily for an hour, but they are fragile. The prophet Isaiah illustrated the character of the suffering servant, comparing his patience with that needed to tend rushlights and lamp wicks: ‘A bruised reed he shall not break, and the smoking flax he shall not quench’.

Wicks were traditionally made of twisted cotton and, as the candle burnt away, the wick tended to hang out of the flame and cause smoking. To prevent this the wick had to be ‘snuffed’ occasionally. The original meaning was cutting off the charred end of wick, *without* extinguishing the candle. The fact that ‘snuffing’ has come to imply extinguishing is a measure of the difficulty of snuffing a candle successfully. It was found that if the wick were made of plaited cotton, rather than twisted, and if the candle itself were made of one of the newer materials which burnt hotter than tallow, then the wick would burn away, making snuffing unnecessary.

Painting from school of the Dutch painter Gherardo delle Notti, in the Palazzo Doria, Rome, showing a girl removing vermin by the light of a hanging iron lamp.

The importance of candles in Victorian England may be illustrated by the way two prominent public speakers used them as illustrations. Faraday’s theme for the 1848 Royal Institution Christmas Lectures was chemistry, and his illustrations were from the manufacture and use of candles. The lectures were published as *The Chemical History of a Candle*. At his Pastors’ College, the preacher Charles Haddon Spurgeon (1834-1892) stressed the importance of good illustrations in a sermon. He said a candle could provide many illustrations, and he subsequently published a book, *Sermons in Candles*.

Candlelight continued in common use well into the twentieth century. Notwithstanding all the developments in electric lighting, candles were sometimes preferred. In 1921 the distinguished electrical engineer, A.P. Trotter (1857-1947) wrote in his *Elements of Illuminating Engineering* “For domestic lighting, nothing can compare for comfort, beauty, and efficiency with good candles” though he admitted that they were expensive compared with electric light.

The first real advance in the design of oil lamps came towards the end of the eighteenth century when François-Pierre Ami Argand (1750-1803) realized that one way to improve a lamp was to ensure that the fuel was fully burned in the flame. He made a wick from a wide flat ribbon bent into a cylinder, and arranged for air to reach the flame from inside the cylinder as well as outside, greatly increasing the burning efficiency. Argand also introduced a glass chimney which produced an updraught and drew more air through the lamp, and a mechanism for winding the wick up and down.

Eighteenth century lamp oils were heavy, like modern cooking oil, and would not flow up a wick easily. In simple lamps the oil was drawn up the wick by capillary action from a reservoir underneath, but would not flow very far or very fast. The Argand lamp burnt much more oil and could not be supplied adequately by a wick dipping into the oil. The first solution was to place the reservoir higher than the wick and allow the oil to flow down.

Pumped lamp. Oil is forced up to the burner by the clockwork driven pump in the base.

The lamp patented in 1800 by Bernard Guillaume Carcel, a French clockmaker, had a pump in the reservoir to pump oil up to the wick. The Carcel lamp was popular in France and, because its output was steady, it was often used as a standard for light measurement. The preferred fuel was colza oil (also known as rape-seed oil), produced in large quantities by crushing the seeds of certain brassicas, such as kale, or rape. Whale oil was also used. Carcel’s mechanism conveyed fuel to the wick satisfactorily, and surplus oil ran back into the reservoir. In the ‘Moderator’ lamp, a strong spring pressed down a piston which squirted oil up a narrow tube to the wick.

A three-wick oil lamp of about 1800. Note the tweezers for adjusting the wicks and the small container for charred bits removed from the wicks. The square plate at the top is an adjustable eye shield so that when using the lamp to read a book on the table the user is not dazzled.

To obtain a better light, various ‘burning fluids’ began to be tried from about 1830 in the USA. These were mixtures of camphene and alcohol and produced a white, smokeless flame. It was a cheap fuel, but dangerous, and many people were killed and injured in accidents with it. Camphene was distilled from turpentine, obtained from the pine forests of North Carolina and the alcohol was obtained by distilling whisky. Burning fluids were very volatile, with a low flash point, and the wick tubes were designed to keep the flame well away from the fuel and not to conduct heat into the reservoir, in contrast to the lamps for the heavier colza oil and whale oil which were arranged to warm the fuel. Burning fluid lamps were usually made with two wick tubes because, as Benjamin Franklin observed, two flames close together emit more light than the two flames well separated.

Mineral oil, or petroleum (from Latin *petra,* 'rock', and *oleum,* 'oil'), had been obtained in small quantities from surface seepages and used in the Middle East for thousands of years. The large scale production of paraffin (known in America as kerosene) and also of paraffin wax for candles, began with the American oil industry in the 1860s. The name 'paraffin' comes from the Latin *parum* and *affinis* and means having a low chemical affinity; 'kerosene' comes from κηρός, Greek for 'wax'. Paraffin was both cheaper and cleaner than animal or vegetable oils, and burnt with less smell. Being very light it flowed readily up the wick by capillary action, so no pumping mechanism was necessary. Inventors turned their attention to improving the efficiency and convenience of oil lamps. The most significant improvement was probably the 'duplex' lamp, which had two flat, parallel wicks giving most of the advantages of the Argand circular wick, but being simpler to manufacture.

Late Victorian paraffin lamps were often highly ornate, and some were given fancy trade names, such as the 'aneucapnic' lamp, a name derived from Greek words meaning 'without smoke'. John Betjeman wrote a children's story, *Archie and the Strict Baptists,* in which he poked gentle fun at the idea that a paraffin lamp had no smell. Archie was a teddy bear who had been brought up to attend a Strict Baptist Chapel lit by aneucapnic lamps. The family moved, and went to a new chapel which had different lamps and did not smell right. Archie solved his problem by making cardboard wings and flying back. Light without smell was only really possible with the coming of electric light.

One special form of lamp is the miner's safety lamp, devised by Sir Humphry Davy (1778-1829), professor of chemistry at the Royal Institution in London. Methane gas, or 'firedamp', often accumulates in coal mines, and most explosions in coal mines occur when air and methane mix in certain proportions. Davy had noted that a flame will not pass through a wire mesh, provided the mesh is kept cool. The Davy lamp is an oil lamp arranged so that the only way in for the air and the only way out for the exhaust gas is through screens of wire mesh.

3. Gas

When gas lighting is mentioned today we think of the gas mantle, but for most of the nineteenth century gas light was the light of a gas flame. Typical domestic gas lights gave as much light as several candles and made an enormous difference to the lives of many people who no longer had to clean and trim the wicks of oil lamps, or to replace candles. Gas light made it easier to do things at home in the evening and it brightened up the streets, making it safer and easier to go out at night.

The first person to use gas lighting successfully was William Murdoch (1754-1839), in his cottage at Redruth, Cornwall, about 1792. Gas light was demonstrated publicly in London on 4 June 1807, the King's birthday, by Friedrich Albert Winzer (1763-1830), a German entrepreneur who had moved to England and Anglicized his name to Winsor. In 1812 Winsor established the world's first gas lighting company, the Chartered Gas Light and Coke Company.

Gas lighting was studied scientifically by William Thomas Brande (1788-1866), who succeeded Davy as professor of chemistry at the Royal Institution in London and he introduced gas lighting there in 1816. Michael Faraday, who was then Brande's assistant, must have seen gas lighting in Paris when there in 1813, but it is not mentioned in Faraday's diary. In the 1830s Marc Isambard Brunel consulted Faraday on gas lighting for the Thames Tunnel. Faraday advised that, suitably ventilated, it would be safe

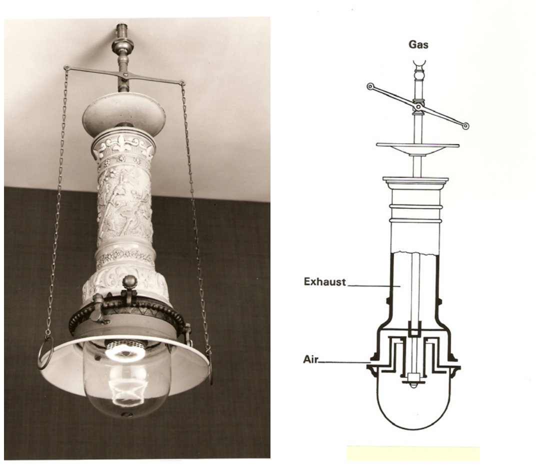
Gas for lighting can also be produced from oils. Robert Faraday (1788-1846), Michael's elder brother, worked with a company which supplied gas made from whale or codfish oil and in 1843 he obtained a patent for ‘Ventilating Gas and Lamp Burners’. His idea was to have a double glass chimney on a gas or oil lamp arranged so that the exhaust gases from the flame first passed up the inner glass and were then carried by a draught down the outer glass and into a tube which carried the gases out of the room. The effect of fumes from gas lighting was studied in 1859 by a Government Commission, including Faraday, appointed to consider lighting picture galleries by gas. In their published report they said “There is nothing innate in coal gas which renders its application to the illumination of Picture Galleries objectionable”.

The first gas burners were little more than holes in the iron gas pipe, and these corroded. An early improvement was the introduction of brass burners, or jets, screwed into the gas pipe. A particularly good burner was the ‘union jet’ in which two equal jets of gas, both inclined at 45° to the vertical, impinged on each other so that the gas spread out in a flat sheet giving a maximum area of flame. Metal burners conducted heat away from the flame, reducing its temperature and brightness. In the 1850s William Sugg introduced a burner made from steatite, or soapstone, a mineral that is easily machined to form jets and has a low thermal conductivity.

For many people, gas was important for street lighting before they had it in the home. London led the world with gas lighting. Flora Tristan, from Paris, visited London several times between 1826 and 1839 and wrote ‘it is really at night that London must be seen! London, magically lit by its millions of gas lights, is resplendent!’ Gas lighting was installed in 1838 in the chamber of the House of Commons, but heat was a problem and they soon returned to using candles.

For ordinary rooms a single gas jet might provide all the lighting, but for large rooms in big houses a lighting fitting comprising many jets playing horizontally, and a ventilating system, would be used.

An important later refinement was the ‘regenerative’ or ‘recuperative’ burner in which the heat of the waste gases was used to preheat the incoming gas and air, thus increasing the overall efficiency of the system.



A 'regenerative' gas lamp. The incoming air is heated by the exhaust gas thus increasing the overall efficiency.

The source of light in a gas flame is particles of carbon or hydrocarbons made luminous by the heat of the flame. Inventors tried adding substances to the gas in order to increase the light given by the flame. The best additive was naphtha, also used as an illuminant in its own right. Some users of gas lighting had apparatus installed for ‘naphthalizing’ their gas to brighten the lights.

Gas lighting was rapidly adopted in towns. By the end of 1815 there were twenty-six miles of gas mains in London. Five years later gas light was available in fifteen major towns in Britain, and by 1840 two hundred British towns had their own gas supplies. By 1849 there were few towns in the country where a gas company had not been established, and by the end of the century there were almost one thousand gas works in Britain. In 1933 the streets of London had equal numbers of gas lights and electric lights, but gas lighting then declined in favour of electricity. The gas industry, originally a provider of light, found its modern role as a provider of heat.

Gas was occasionally used for illuminations on public buildings. Before electric lighting was installed on the Eiffel Tower the platforms were edged with gas flames, and a photograph taken in 1920 shows the Bournemouth Pavilion outlined in the same way.

Ernest Shepard, the illustrator of children’s books including *The Wind in the Willows* and *Winnie the Pooh,* recalled the gas lighting on London underground trains, where the first trains were pulled by steam engines. The coaches were lit by gas carried in rubber bags on the roof, pressed down by weights. He described going from Baker Street to Gower Street by Underground, and concluded 'We did not go very often by Underground, it was much nicer by bus'.

A different kind of gaslight was Limelight, the brilliant white light obtained by playing a very hot gas flame on a piece of lime (calcium oxide). This was first observed by the Cornish engineer, Goldsworthy Gurney (1793-1875). It was first put to practical use by Thomas Drummond (1797-1840), an officer in the Royal Engineers who was engaged in mapping Ireland in 1826-27. When making a basic triangulation survey of the island, they experienced great difficulties with observations over long distances. Drummond installed limelights at the triangulation points, and these were easily seen at night over great distances. Limelight, which also became known as the Drummond light, created much interest in the scientific world. This very bright light, coming from a small source, was ideal for theatre spotlights and could be used with coloured filters to produce novel effects. Limelight was used in theatres in the 1860s and 1870s, then superseded by the electric arc. Although in use for a relatively short period, it has left its mark on the English language with the phrase "in the limelight".

If the electric arc had not been introduced, the limelight might have been used more widely. About 1850 Professor Nollet of Brussels had a scheme for using a magneto-electric generator to electrolyse water on a commercial scale. The hydrogen and oxygen produced were then to be used in a limelight apparatus. An Anglo-French company, la Compagnie de l'Alliance, was formed to develop the process, but Nollet died and the project was abandoned. It is an interesting thought that the first 'electric' lighting company intended to use electricity to produce gas for limelight!

Although it could not have been appreciated at the time, limelight utilizes the principle of 'selective emission'. Most substances when heated first glow red and then, as they get hotter, give off light with a full spectrum of colours so that ultimately the light is white and all colours can be seen. When a selective emitter is heated, light is given out preferentially at one or more specific wavelengths. The result is that much more light is produced for a given degree of heating than would otherwise be expected. Selective emission was to be exploited later, first in the gas mantle and then in various electric lights.

If gas light had continued to mean the light from a gas flame then electricity would quickly have replaced gas as the preferred means of getting light, but the invention of the gas mantle gave gas lighting a new lease of life. Carl Auer von Welsbach (1858-1929) discovered accidentally that certain salts produced a bright light when heated in a gas flame. He was boiling a solution of salts of some of the rare metals in a beaker when the solution boiled over and dried on the asbestos mat between the beaker and his Bunsen burner. As the salts dried in the asbestos fibres, and then became hot, they became luminous. After experimenting he found that he did not need the asbestos. He used a fine cotton fabric impregnated with a solution of the oxides and dried. The cotton was burnt off, leaving a fine 'mantle' of the oxides. The mantle was too fragile to be transported, so it was soaked in collodion (a gluey solution of cellulose nitrates in alcohol and ether) which made the mantle firm enough to be handled when dry. When the mantle was first used the collodion burnt off, leaving the mantle which was too fragile to be handled but which could remain in use for a long time. Gas mantle manufacture became a new industry which, like electric filament lamp manufacture later, provided employment for women's delicate fingers.

The mixture of oxides that Auer von Welsbach finally adopted was 99.1% thorium oxide and 0.9% cerium oxide. The first advertisements in Britain for his mantles appeared in December 1890 with the slogan 'Electric Light Surpassed'. Mantles were first used for street lighting in Kensington, London, in January 1895. The first mantles were 'upright'. They were held on a support, often a piece of fireclay, above the flame. Since the hottest part of a flame is the surface area where the flame meets the air, it is important that the mantle should have the same shape as the flame. The final stage in the development of the gas mantle was the ‘inverted’ mantle which hung downwards. Lighting by gas mantles was used widely in the first third of the twentieth century, only gradually giving place to electric lighting as electricity supplies spread in the 1930s and 1940s.

Gas street light fitting of about 1930, with three mantles.

4. Electric arc

The principle of the arc lamp is that two pieces of carbon, usually rods, are connected to an electricity supply, touched together, and then pulled a few millimetres apart. A spark, or ‘arc’, is drawn across the gap and so much heat is produced that the ends of the carbons become white hot.

Michael Faraday showed the principle of the arc in his Christmas Lectures for Young People at the Royal Institution in 1853. He used a battery and two pieces of carbon, probably just held by hand. For an audience who were not used to any artificial lighting brighter than a candle it would have been an impressive demonstration. Even modern audiences, well accustomed to bright lights, are usually impressed by demonstrations of the brilliant light of the electric arc.

Apart from the expense of batteries as a source of current, the main problem was that in the heat of the arc the ends of the carbons burnt away. It was therefore necessary to move them regularly to keep the gap constant. For some applications, such as theatre spotlights, the man employed to direct the spot could also adjust the carbons.

The Jablochkoff Candle was the one arc lamp that needed no regulation. The Russian engineer Paul Jablochkoff (1847-1894) met Louis Bréguet (1804-1883) who was interested in arc lighting. The recent development of practical generators by Gramme meant that powerful electric currents could be readily obtained. Jablochkoff devised a lamp that required no mechanism. He called it a ‘Candle’ (‘Bougie’ in French). His Candle had two parallel carbon rods separated by a thin layer of plaster of Paris. The bottom ends of the rods were

Four Jablochkoff Candles.

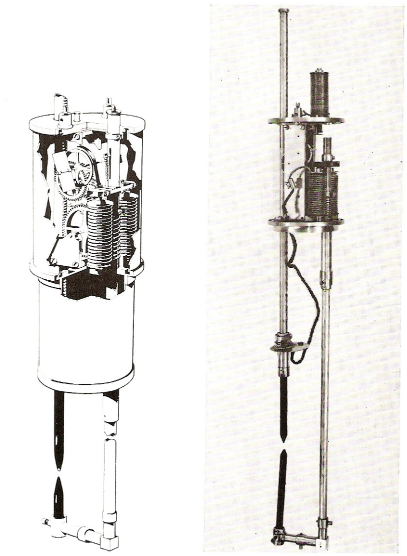
mounted in short brass tubes which held the candle and provided electrical connections. A thin connecting link of graphite joined the upper ends of the carbons. When the circuit is switched on the current fuses the connecting link and an arc is struck between the upper ends. As the carbons burn in the heat of the arc, the plaster crumbles away. Typically sixteen lamps would be connected in series and supplied from one generator. A major disadvantage was that, once the light had gone out, the candles had to be replaced before the light could be switched on again. That did not matter when all was working well: the lamplighter who used to turn on the gas was engaged to change the candles ready for the next evening's lighting. In the event of a temporary failure of the supply, however, he had to go round again changing all the candles.

In 1878 Jablochkoff Candles were installed along the Avenue de l'Opéra in Paris. In London the Victoria Embankment was lit with Jablochkoff Candles from December the same year. The Candle was superseded when reliable arc lamps with automatic regulators became available, but during the brief period in which they were used the public became aware of the possibility of electric light.

The Avenue de l'Opera, Paris, lit by Jablochkoff Candles.

The basic requirements for a satisfactory arc lamp mechanism are easily stated. The carbon rods must be in contact initially, but then drawn apart quickly when the current is turned on. The spacing between the carbons must then be kept constant as their white hot tips burn away. The movement of the carbons must be smooth to avoid causing flicker. Renewal of the carbons must be easy even if the lamp normally operates high in the air, and the mechanism must be robust, reliable, and cheap. All regulated arc lamps have, connected in series with the arc, an electromagnet whose function is to pull the carbons apart initially and so strike the arc. Either the same electromagnet or another one is used to regulate the spacing of the carbons. Usually the upper carbon can fall under gravity but is restrained by a brake which is itself under the control of the regulating electromagnet.

The first really satisfactory arc lamp was made by the Frenchman, V.L.M. Serrin. In his lamp the upper carbon was held in a carrier arranged so that, as it fell, the lower carbon was raised at half the speed of the upper one. Since the lamp was used on direct current, one carbon was consumed at twice the rate of the other and the arc remained in the same position. The English engineer R.E.B. Crompton (1845-1940) redesigned Serrin's lamp, placing all the mechanism above the lamp so that little downward shadow was cast, and lightening the mechanism so that the regulating action took place more often but in small steps, resulting in less flicker.



Early arc lamps by Crompton.

Crompton had an engineering business in Chelmsford, Essex, but he soon became interested in electric lighting and within a few years his business was entirely electrical. One of his first lighting products was a portable set consisting of a steam engine and generator on a horse-drawn trailer and a lamp mounted up a pole. This was hired out for evening events and for contractors working at night.

There was an important development in the autumn of 1881 when a small company, Calder & Barrett, entered into a contract with the Town Council of Godalming, in the south of England, to install and supply arc lamps for lighting the main streets of the town, which had previously been lit by gas. They also provided Swan filament lamps to light some of the side streets, and they were allowed to sell electricity to any of the householders whom they could persuade to accept the new service. It was the start of the public electricity supply industry. In the event very few people in Godalming took up the offer and the undertaking closed after a few years, but the engineers involved learnt much about the practical problems of supplying electricity.

The demand for arc lighting grew rapidly. In 1890 there were seven hundred arc lamps in British streets and probably a similar number in railway stations, markets, factories, etc. During the following twenty years about 20,000 were installed, but there was little further growth although some arc street lighting continued until the 1950s. Shopkeepers sometimes had arc lamps arranged outside their shops to light the window displays. In that way they obtained the benefit of well-lighted windows, without the risk of heat and fumes spoiling their wares. The military also saw a use for arc lamps as flood lights and as anti-aircraft search lights.

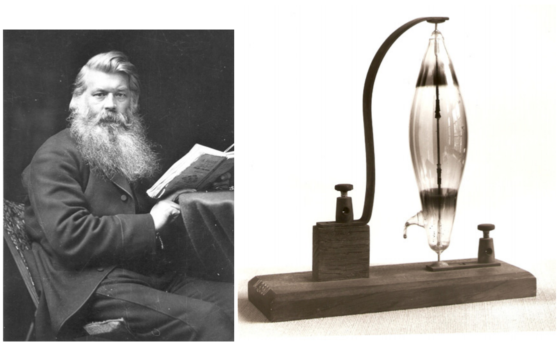
5. Incandescent filament

The brilliant light of the arc lamp was good for illuminating large areas such as markets and railway stations, and for street lighting. For domestic use, however, a much smaller light was needed. Was this possible without loss of efficiency? Lighting by incandescence seemed to offer the best hope. In an incandescent filament lamp, the heated wire, or filament, is now always made of tungsten, a metal with a very high melting point, but the first practical lamps had carbon filaments.

The essential requirements for an incandescent lamp are a filament material that can be heated and cooled repeatedly without breaking, connections sealed through a glass bulb without cracking when hot, and an adequate vacuum pump to remove enough air to prevent oxidation.

There was no single inventor of the incandescent filament lamp. The basic ideas were old and people had tried to make such a lamp since the 1840s, but it was only in the late 1870s that advances in materials and in air pumps made it possible. The filament material had to be either carbon or platinum, because there was nothing else could stand the heat, and platinum was too expensive to be widely used. Platinum had to be used for the 'lead-in' wires connecting to the filament because it was the only electrical conductor with a coefficient of expansion approximately the same as that of glass and could therefore be sealed through the glass without causing cracking. All the lamp inventors made carbon filaments from strips of organic material which were 'carbonized' by heating in a closed furnace to drive off the oxygen and hydrogen present. The main thing that distinguished the different inventors was their choice of starting material. Swan used cotton, Edison used a bamboo fibre, Lane Fox used a fibre from a variety of grass, and Maxim used thin card.

With the development of the mercury vacuum pump by Hermann Sprengel in 1865 an adequate vacuum could be attained, and before long several inventors independently had made successful lamps. Filament lamps were first shown in public on a large scale at the International Electrical Exhibition in Paris from August to November 1881. Four inventors displayed their products. Best known were Joseph Swan from Britain and Thomas Edison from the USA, but another Englishman, St George Lane Fox, and another American, Hiram Maxim, also had lamps on display. Edison's exhibit was the most ambitious, and his lamps received the most attention from the French press, probably because Edison worked hardest on publicity. The Exhibition Jury made measurements on the various lamps exhibited and reported that Edison's lamps gave 196 candlepower of light per horsepower applied to the generator (in modern units about 3.30 lumens per watt). The figures for the other inventors were Swan 178, Lane Fox 174 and Maxim 151.



Joseph Swan and one of his first experimental lamps.

Thomas Edison and one of his first experimental lamps.

Edison's lamps were the most efficient, though not by much, and his private correspondence reveals that he was not satisfied with the life of his lamps, though the jury did not measure how long the various lamps lasted.

Swan's first commercial lamps were made partly at his house in Newcastle and partly at the workshop of Charles Henry Stearn who helped him with the pumping. It was time to establish a company, and Swan arranged to meet Crompton, from whom he had bought arc lamps. Crompton recalled that meeting fifty years later: 'When I first saw Mr Swan's beautiful lamp I felt for a moment as if I were a gas shareholder'. But he realized there was a place for both arc lighting and filament lighting, and he joined Swan's Electric Light Company Ltd as Chief Engineer. The company had a capital of £100,000 and established a factory near Newcastle. Business expanded rapidly and a larger company, the Swan United Electric Light Company Ltd, was registered in London on 19 May 1882, with a capital of one million pounds. Edison's British representatives also established a company which set up an electric lighting station on Holborn Viaduct, in London. The station was the first steam-powered electricity generating station in the world. It was operating in January 1882, although the formal opening did not take place until 12 April, several months ahead of Edison's first American power station, Pearl Street, New York, which opened that September. By April 1882 the station was supplying lamps in the premises of thirty customers. By far the largest customer was the City Temple, a Congregational church just across the road from the generating station. The congregation there welcomed the new lights because the previous gas jets had made the gallery too hot in warm weather.

The very early 1880s were a boom time for electric lighting companies in Britain, but the boom soon turned into a slump, and sales fell in 1883. There was a demand for electric lighting, but the manufacturers had still to develop reliable generating machinery, and the whole infrastructure of public electricity supply had to be put in place before electric lighting could be adopted on a wide scale.

Swan made one further major contribution to lamp development: the 'squirted' filament. Swan sought to make his filament more uniform than was possible using natural cotton and he applied his chemical expertise to the problem. Cotton is mainly cellulose, which reacts with nitric acid to give nitrocellulose which will dissolve in acetic acid. Swan found that if he squirted the nitrocellulose solution into alcohol the cellulose was reconstituted and he could produce a thread finer, longer and more uniform than the original cotton. He patented the process in December 1883, although it was not introduced commercially for several years.

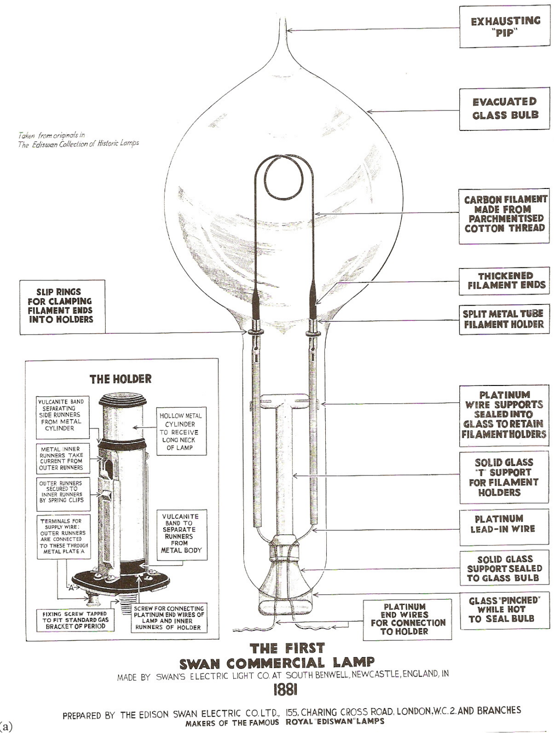
As the electricity supply industry developed, bringing electricity into more people's homes, and when the early lamp patents expired, several new companies began the manufacture of carbon filament lamps but the new gas mantle was a serious competitor in the lighting market. Lamp manufacturers appreciated that if a lamp could be made with a metal filament it could be run at a higher temperature than was possible with carbon and therefore be more efficient. Several metals with very high melting points were tried, including vanadium (melting point 1,680°C) and niobium (1,950°C).

Metals generally have a much lower electrical resistance than carbon, and so metal filaments have to be much longer and thinner than carbon ones. Furthermore, the refractory metals are rather brittle, and difficult to draw into fine wires by conventional wire-drawing techniques. The solution adopted initially was to use the metal in powder form, mix it with a binder, squirt the mixture through a fine die, and then heat the resulting thread to drive off the binder material and sinter the metal particles together. Osmium has a melting point of 3,000°C and osmium lamps were made in that way from 1902, and used for a few years mainly in Europe. They were extremely fragile and quite expensive to make because the very long filament (typically 700 mm) had to be wound on an elaborate ‘squirrel cage’ support. Osmium lamps were first made by Carl Auer von Welsbach, already mentioned for his development of the gas mantle. Some lamps were made using an alloy of osmium and tungsten, and sold under the name ‘Osram’, from *os*mium and wolf*ram*, the latter being the German name for tungsten. The lamps were not a success, but the name was kept.

Tantalum melts at 2,996°C, and has the advantage that it be drawn readily into a fine wire. In 1905 Siemens and Halske in Germany began making tantalum filament lamps. Tantalum filaments were stronger than osmium ones and were widely used for a few years, but a disadvantage soon appeared: on alternating current circuits the tantalum metal recrystallized and the filaments quickly became brittle.

Tungsten is an obvious choice for the filament because it has a higher melting point than any other metal, 3,410°C. Tungsten filament lamps were first produced in Vienna by Alexander Just and Franz Hanaman, using a sintering process similar to that used for osmium lamps. When Hugo Hirst, of the (British) General Electric Company, heard of this, he obtained agreement for a factory to be built at Hammersmith, in west London to make both osmium and tungsten lamps. It was soon found that the tungsten lamps were best and they alone were made. The sintered tungsten filament gave the best lamps so far, but the manufacturing process was complex. After much research William Coolidge found that tungsten could be drawn if the powder were first compressed then heated and hammered.

Early lamps all had the bulb evacuated as completely as possible, but it was found that the presence of a little gas discouraged the evaporation of the filament, increasing the life of the lamp (or allowing the lamp to be run hotter for the same life). The gas cooled the filament by convection, reducing the overall efficiency, but that problem could be reduced by winding the filament into a coil. The first gas-filled, coiled-filament lamps were marketed in 1913. The gas used at first was nitrogen, but subsequently argon was adopted.

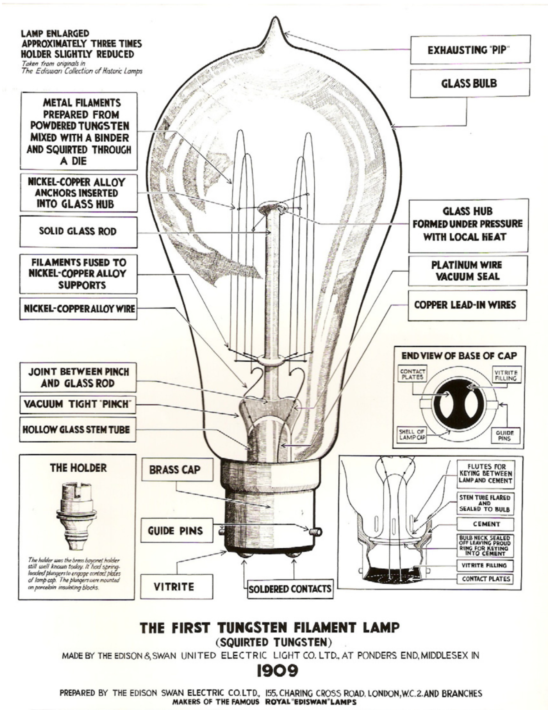


(a)

One of a series of posters produced by the Edison Swan Company showing Swan’s first commercial lamp.

Until the early 1920s lamps were evacuated through the end opposite the cap, leaving a characteristic ‘pip’ where the bulb was sealed. This pip was easily broken and lamps are now evacuated through a tube at the cap end so that the fragile point where the bulb is sealed can be enclosed within the cap and protected. From 1934 the coiled filament was often coiled again upon itself, giving the modern ‘coiled coil’ filament, and an efficiency of up to fifteen lumens per watt.

A metal filament lamp lasts, with only a little loss of efficiency, until the day when, quite suddenly, it fails. That was not the case with the carbon filament lamp: its bulb would become blackened by a sooty deposit of carbon evaporated from the filament and it was often worth replacing a carbon lamp with a new one, even though the original continued to work. The blackening was studied by J.A. Fleming in the mid 1880s in research that led ultimately to the development of the diode valve. Attempts were made to prevent the blackening by including a small amount of chlorine in the bulb. The idea was that the chlorine would react with the evaporated carbon and form a transparent compound.



A poster from the same series showing the first tungsten filament lamp.

The idea was not very successful with carbon lamps but has proved very useful in extending the life or the efficiency of tungsten lamps. Any of the halogens (iodine, bromine, chlorine, and fluorine) will react with tungsten vapour in the bulb and, if the conditions are right, the compound formed will break down in the region near the filament. Consequently material which has been evaporated from the filament is returned automatically and redeposited on or close to the filament. For the process to work, the bulb temperature has to be considerably higher, typically 250°C higher, than that of an ordinary lamp at which temperature the glasses used for ordinary lamps would soften. The solution is to make the bulb of a harder glass, which has a higher softening temperature, or to make the bulb of fused silica (‘quartz’) which can be used at even higher temperatures. The bulb is usually much smaller than that of a conventional lamp and is often enclosed in an outer bulb of ordinary glass. Halogen lamps first went on the market in the USA in 1960. They were tubular, rated at 1.5 kW and used for floodlighting. They had a life of 2,000 hours and their efficiency was 22 lumens per watt.

Early halogen lamps were known as ‘quartz iodine’ lamps because the halogen used was iodine and the bulbs were made of quartz. Within a few years the quartz was superseded by hard glass and other halogens, usually bromine, were being used. The name ‘tungsten halogen’ lamp was then adopted.

In the 1970s manufacturers began to use fluorine as the halogen. The compound tungsten hexafluoride only breaks down above 3,000°C and this temperature is achieved only at the filament itself. Consequently the evaporated tungsten is actually redeposited on the filament and mostly at the hottest parts where it is thinnest. Thus the tungsten fluorine lamp has a self-healing operation, whereas the earlier halogen lamps merely kept the glass clean. The quantity of fluorine in one of these lamps is extremely small, typically about 25 micrograms. Since about 1990 tungsten halogen lamps have been marketed for domestic use, both as general-purpose, mains-voltage lamps giving higher brightness and a longer life than ordinary lamps, and also as low-voltage spotlights, usually working at twelve volts and rated at fifty watts, to give a very compact source of bright light. Because the voltage is low and the current high compared with mains lamps, the filament is quite thick and can be operated at a higher temperature, significantly increasing the efficiency.

6. Discharge and fluorescent lamps

Apart from lightning and sparks caused by static electricity, the first electric light to be studied was that produced by an electric current passing through gas at low pressure. In 1675 the French astronomer, Jean Picard (1620-1682), was carrying his mercury-in-glass barometer in the street and noticed a glow at the top of the tube as the mercury slopped about. Francis Hauksbee (c. 1666-1713), the Curator of Experiments at the Royal Society in London, investigated the phenomenon and concluded that the effect must be electrical, with the electricity being produced by the friction of the mercury on the glass. In the 1850s, when the Rühmkorff induction coil was available, several investigators studied electrical discharges in gases, especially the German J. Heinrich Geissler (1815-1879). It was found that the discharge through a low-pressure gas gave light with a spectrum characteristic of the gas. By suitable choice of gases, light of almost any colour could be produced. Multicoloured 'Geissler tubes' and a Wimshurst machine to supply the high voltage, were a favourite late Victorian scientific amusement.

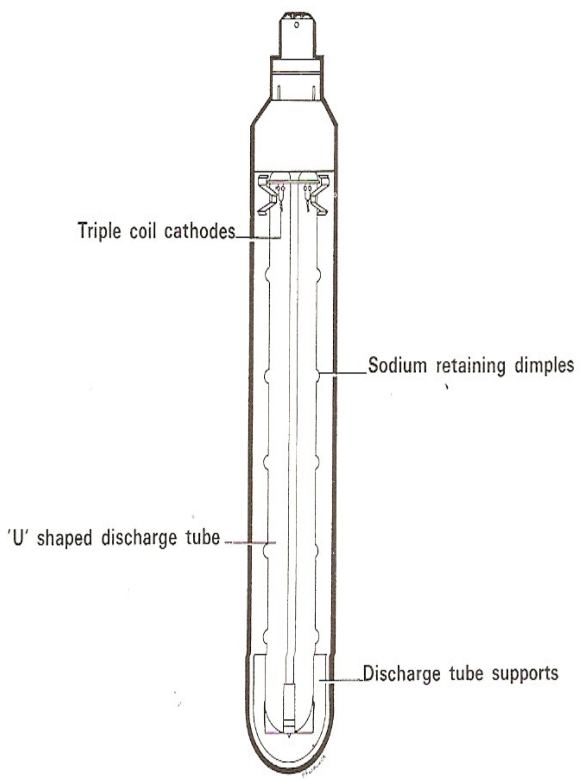
The first discharge lamps used for practical lighting employed mercury vapour. About 1900 Peter Cooper Hewitt introduced lamps with glass tubes 100 cm long and 2.5 cm diameter. The tubes were mounted horizontally and contained enough liquid mercury to make an electrical connection between electrodes at each end. To start the lamp, a voltage was applied across the tube and the tube tipped slightly, so that the mercury ran to one end and an arc was struck as the mercury connection broke. The lamp was very efficient, giving about 40 lm/W, but it had two problems, a tendency to flicker, and an unattractive colour. The flicker arose because the point where the arc made contact with the pool of mercury moved around; Cooper Hewitt's solution was a porcelain cylinder on top of the mercury with a small hole in it which held the arc in one place. The light was bluish-green, with virtually no red rays.

Discharge lamps using other gases were introduced by D. Macfarlane Moore who was convinced they would replace filament lighting. In 1895 he demonstrated lamps 2½ to 3 m long and operating on the 110 volt mains. His first commercial installation, in 1904, was in a shop in Newark, New Jersey. This had a glass tube about 50 metres long and 45 mm in diameter containing air at one thousandth of an atmosphere pressure. He applied 16,000 volts between carbon electrodes at each end of the tube, and obtained a pale pink light. The efficiency was about ten lumens per Watt, or about three times the efficiency of a carbon filament lamp. When carbon dioxide was substituted for air in the Moore tube, it gave a very white light, although the efficiency dropped.

In 1907 the French inventor, Georges Claude (1870-1960), developed the technology for liquefying air and separating its constituents. Seeking a use for these by-products, he studied electric discharges in the gases, noting, especially in the case of neon, that he could obtain a light which, although reddish in colour, was more economical than the light from a filament lamp since little energy was wasted in heat. In 1910 he made neon tubes which were used on the façade of the Grand Palais in Paris and the church of St Ouen at Rouen.

Early discharge lamps were more efficient and therefore cheaper to run than carbon filament lamps, but their size, high operating voltage, and poor colour were such serious disadvantages that they were never used on a large scale. The use of fused quartz instead of glass made possible lamps which could operate at higher temperatures and gas pressures, and by 1920 mercury lamps were being used with fairly short tubes – typically 15 cm long and 1 cm diameter.

C.C. Paterson, the head of the General Electric Company's research laboratory at Wembley, became president of the Institution of Electrical Engineers in October 1930. In his inaugural address he discussed the various gas discharge lamps then in use, and how they might be improved. There was no hint, however, of the high pressure mercury vapour lamp, which his own company was to introduce commercially less than two years later. The first installation for street lighting was in July 1932, on the road outside the GEC Research Laboratories at Wembley, Middlesex. The first lamps were rated at 400 Watts and gave about as much light as a 1,000 Watt tungsten filament lamp. They had an arc 160 mm long in an alumino-silicate glass discharge tube 34 mm in diameter. The discharge tube contained a little argon and sufficient mercury to give a vapour pressure of one atmosphere at the operating temperature of 600°C. To reduce heat losses, the discharge tube was mounted in an outer bulb which was an evacuated tubular glass envelope 50 mm in diameter and 300 mm long.

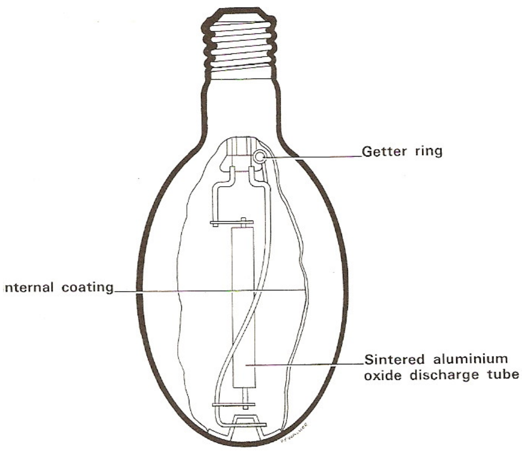


Low pressure sodium discharge lamp. The actual discharge is in the 'U' shaped inner tube.

At the same time sodium discharge lamps were being introduced. Everyone is familiar with the intense yellow glare of the low-pressure sodium lamp, which works in the same way as the mercury lamp, except that the medium in which the discharge occurs is sodium vapour. Sodium is solid at ordinary temperatures, so a lamp containing only sodium cannot be started unless another substance is present. Sodium lamps usually contain a little neon, in which a discharge starts easily, which is why sodium street lamps glow red when first turned on. As the tube warms up, which takes several minutes, the sodium vaporizes and takes over the arc. As the current rises the voltage across the lamp falls and the neon ceases to play any part. To reduce heat losses and improve efficiency the lamps are enclosed in a vacuum jacket.

The major problem in the development of the sodium lamp was finding materials able to withstand hot sodium, which is highly reactive chemically. This applies both to the envelope containing the discharge and to the electrodes. Glasses containing silica are attacked and blackened by hot sodium; silica-free aluminoborate glass will withstand hot sodium, but is attacked by atmospheric moisture and is difficult to work. The solution adopted for sodium lamps is an envelope of soda-lime glass coated on the inside with a very thin layer of aluminoborate glass. The electrodes are of oxide-coated tungsten, similar to those in the high pressure mercury lamp. The sodium resistant glass was developed in Germany, though sodium lamps were first produced commercially by Philips in Holland in 1932.

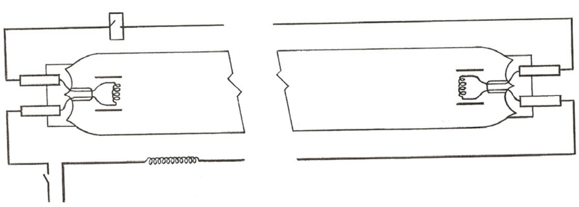
A later development, introduced commercially in the 1970s, was the high pressure sodium lamp, which is nearly as efficient as the low pressure lamp and gives a wide-spectrum light, sometimes described as 'salmon pink', in which most colours are readily seen. The development which made it possible is a translucent ceramic material for the arc tube. The ceramic in question is alumina (Al_2O_3) which is ground to a very fine powder and then pressed and sintered in the required tubular shape. Alumina, which melts at 2,050°C, is one of the most stable substances known, occurring naturally as sapphire and ruby, and is unaffected by hot sodium. The resultant lamp is more compact



High pressure sodium discharge lamp. The actual discharge is in the small cylindrical tube.

than the low pressure lamp, and is being widely used for street lighting and also occasionally indoors. Development work on high pressure sodium lamps continues, the major objective being to make a lamp which contains no mercury. Such a lamp would be environmentally friendly: although hot sodium is highly corrosive, once exposed to air or water it becomes harmless soda and there are no toxic by-products.

The electric light most commonly found in shops and offices, and increasingly in the home, is the fluorescent tube, now available in a wide range of shapes, sizes, and colours. The basic principle of the fluorescent lamp is that an electric discharge in mercury vapour produces ultraviolet light, which a phosphor coating on the inside of the glass tube converts into visible light. The glass itself is transparent to visible light but opaque to ultraviolet, so no ultraviolet light escapes. Although efficient, early fluorescent lamps were often disliked because of their poor colour rendering and tendency to flicker. The need for special control equipment, which made their initial cost much greater than that of filament lamps, was also a discouragement to people who might otherwise have adopted fluorescent lighting. The best modern fluorescents, however, have largely overcome these problems and, with their low running costs when compared with the conventional filament lamp, they are rapidly increasing their share of the market.



Construction and circuit of a conventional fluorescent lamp.

The first phosphors to be used in fluorescent lamps were based on fluorescent minerals and were mainly sulphides, such as cadmium sulphide and zinc sulphide. Better phosphors were considered so important that research into them continued during the Second World War, and a new group of fluorescent chemicals, the halophosphates, were discovered in 1942 by British lighting researchers. From the late 1940s they were replaced by halophosphates, and from about 1970 alkaline-earth silicate phosphors have been developed. The later are more efficient than the halophosphates, but whereas the halophosphates give a broad spectrum of light most of the newer materials give light with a single line spectrum. Most modern fluorescent lamps employ several narrow band phosphors of distinct colours – as the reader may check by looking at the light from such a lamp through a prism.

The compact fluorescent lamp was launched publicly on 28 March 1980 at press conferences held by Philips in Amsterdam and New York. They described the new lamp as ‘a revolutionary type of lamp which can replace an incandescent lamp with the existing type of base’ and they emphasized its efficiency. The new lamp required only one quarter of the electrical input taken by a filament lamp giving the same light output, it could be put straight into the same lampholder without needing any separate control gear, and would have five times the life. They were marketed as ‘energy saving’ lamps, and the lamp-buying public was receptive.

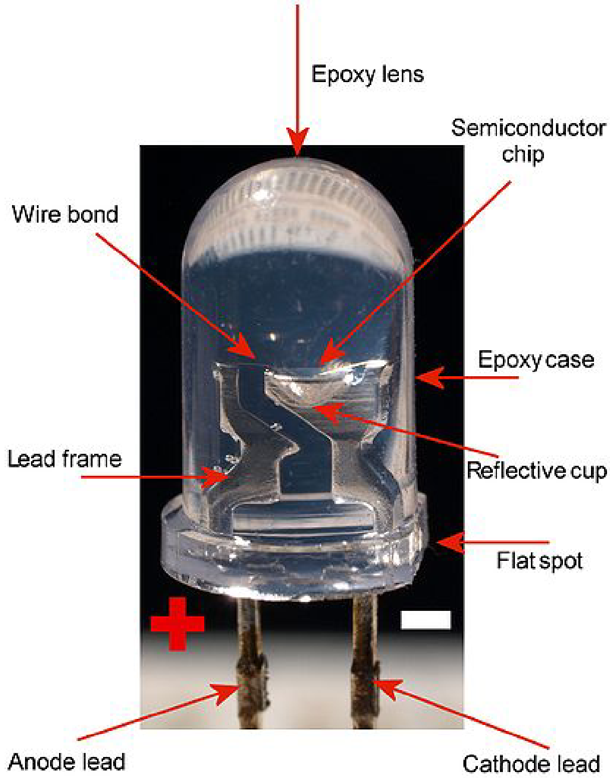
Early compact fluorescents had an iron-cored inductance in the cap, to limit the current taken. The final development which made the modern light-weight compact fluorescent lamp possible was the electronic ballast. As well as reducing weight, electronic control has other advantages: the lamp starts without flicker, and it runs at a frequency of about 25,000 Hertz (compared with the mains frequency of 50 Hertz) at which the lamp operates more efficiently. There is a delay of about half a second after the lamp is switched on before it starts. In that period the electrodes are pre-warmed before the full voltage is applied across the lamp. If the electrodes are not pre-warmed they can be damaged by ion bombardment: failure of the electrodes is the usual cause of failure of fluorescent lamps.

Other types of lamp include the metal halide lamp (which must not be confused with the tungsten halogen lamp) which was introduced in the 1960s. These lamps contain metal vapours to improve the colour of the light, and may be regarded as a logical development from high pressure mercury lamp.

7. Lighting in future

At the start of the twentieth century the filament lamp and the gas mantle were in competition, but with developments in metallurgy making the tungsten filament possible, and further refinements such as the coiled filament, the coiled-coil filament, and halogen gas fillings, the filament lamp was clearly the best source of light. Later in the century discharge lamps and fluorescent lamps, and lamps combining both, were coming to the fore. In the second half of the century discharge lamps were the favoured light source for lighting streets and other large areas, and fluorescent lamps were preferred for most commercial premises. For domestic use the filament lamp remained dominant until nearly the end of the century, but the compact fluorescent lamp incorporating its own control gear so that it can directly replace a filament lamp is rapidly taking over.

In the last few years, however, the light emitting diode – the LED – has been coming into use for general lighting. The fact that some semiconductor devices can emit light has been known for many years, and LEDs giving red light have been used as indicators since the late 1960s.



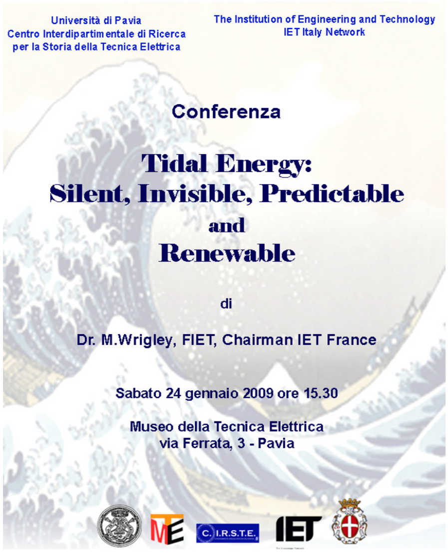
Construction of a light-emitting diode, 'LED'.

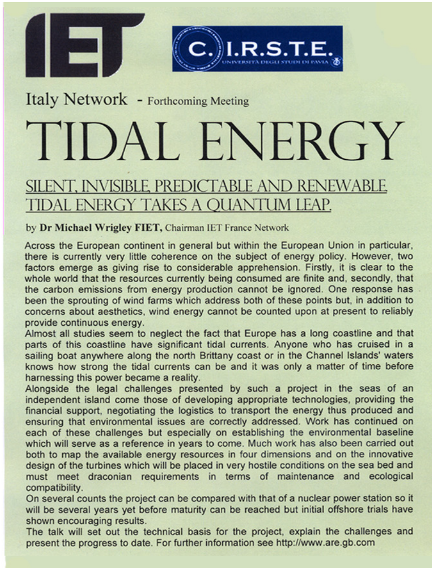
For general illumination white light is required, but LEDs give light only at a single wavelength determined by the semiconductor material used. The Japanese physicist Shuji Nakamura studied the physics of LEDs and was able to make a blue LED of high brightness. Adding a suitable phosphor to a blue LED makes possible a LED giving white light and, since the efficiency is better than that of any fluorescent lamp, they do not get very hot. LEDs are rapidly coming into widespread use, both for mains voltage lighting and, since the individual LED requires an input of only a few volts, for torches and as substitutes for wax candles with a tiny battery incorporated in the 'candle'.

If you have been round this Museum you will already have seen illumination by LED lights. The Museum has many wonderful things in the showcases – but one of the most wonderful is on top of the cases where LED lamps are now illuminating the contents.

Sabato 24 gennaio 2009

Energia elettrica dalle maree





Italy Network - Forthcoming Meeting

TIDAL ENERGY

SILENT, INVISIBLE, PREDICTABLE AND RENEWABLE
TIDAL ENERGY TAKES A QUANTUM LEAP.

by **Dr Michael Wrigley FIET,** Chairman IET France Network

Across the European continent in general but within the European Union in particular, there is currently very little coherence on the subject of energy policy. However, two factors emerge as giving rise to considerable apprehension. Firstly, it is clear to the whole world that the resources currently being consumed are finite and, secondly, that the carbon emissions from energy production cannot be ignored. One response has been the sprouting of wind farms which address both of these points but, in addition to concerns about aesthetics, wind energy cannot be counted upon at present to reliably provide continuous energy.

Almost all studies seem to neglect the fact that Europe has a long coastline and that parts of this coastline have significant tidal currents. Anyone who has cruised in a sailing boat anywhere along the north Brittany coast or in the Channel Islands' waters knows how strong the tidal currents can be and it was only a matter of time before harnessing this power became a reality.

Alongside the legal challenges presented by such a project in the seas of an independent island come those of developing appropriate technologies, providing the financial support, negotiating the logistics to transport the energy thus produced and ensuring that environmental issues are correctly addressed. Work has continued on each of these challenges but especially on establishing the environmental baseline which will serve as a reference in years to come. Much work has also been carried out both to map the available energy resources in four dimensions and on the innovative design of the turbines which will be placed in very hostile conditions on the sea bed and must meet draconian requirements in terms of maintenance and ecological compatibility.

On several counts the project can be compared with that of a nuclear power station so it will be several years yet before maturity can be reached but initial offshore trials have shown encouraging results.

The talk will set out the technical basis for the project, explain the challenges and present the progress to date. For further information see http://www.are.gb.com

Sabato 24 gennaio il Museo della Tecnica Elettrica di Pavia ha ospitato un evento di rilievo internazionale organizzato insieme a IET (Institution of Engineering and Technology, London).

L'incontro è servito a illustrare un progetto franco-britannico per sfruttare l'energia silenziosa, invisibile, prevedibile e rinnovabile delle maree nel Canale della Manica. Sono state esposte le basi tecniche del progetto, illustrate le sfide affrontate e presentate le fasi già realizzate.

Protagonista dell'evento è stato il dr Michael Wrigley, Fellow IET e Presidente di IET France. Hanno preso la parola anche, tra gli altri, Barry Brooks, Vice Presidente Generale di IET, Brian Bowers, storico della tecnologia, e un rappresentante del Consolato britannico di Milano.

Il folto pubblico era rappresentato da persone giunte da varie località italiane ed estere, amici del Museo, tecnici, professori e studenti universitari, tra i quali un gruppo di dieci studenti dell'Università Roma Tre.

On Saturday 24 January the Pavia Museum of Electrical Technology hosted an event of international relevance, jointly organized with IET (Institution of Engineering and Technology, London).

A French-British project to exploit the silent, invisible, predictable and renewable power of tides in the Channel was presented. The technical grounds of the project along with the challenges faced and the results already gained were shown.

The main speaker was dr Michael Wrigley, Fellow IET and President of IET France. Among other speakers were Barry Brooks, Vice President of IET, Brian Bowers, historian of technology, and a representative of the British Consulate in Milan.

A numerous audience attended the meeting, including a group of ten students coming from Roma Tre University.

Mercoledì 10 giugno 2009

Dalla pila al calcolatore


Università degli Studi di Pavia

C.I.R.S.T.E.

IEEE Celebrating 125 Years of Engineering the Future

In occasione delle celebrazioni per i 125 anni di attività di IEEE
Institute of Electrical and Electronics Engineers
e per i 50 anni dalla fondazione di IEEE Italy Section

mercoledì 10 giugno 2009
alle ore 17

presso il
Museo della Tecnica Elettrica,
via Ferrata 3, Pavia

verrà inaugurata
una targa commemorativa
dell'invenzione della pila, IEEE Milestone

Seguirà la Conferenza
del prof. Pierre Mounier-Kuhn,
Université Paris-Sorbonne

"History of computing in Europe: main streams, main questions"

Al temine, rinfresco

Si prega, di confermare la partecipazione
(tel. 0382 984104; info@museotecnica.it)

Promosso dall'Università di Pavia e dalla Sezione italiana di IEEE, il 1° giugno un evento di carattere internazionale ha avuto luogo al Museo della Tecnica Elettrica di Pavia nell'occasione delle celebrazioni per i 125 anni dalla fondazione di IEEE (Institute of Electrical and Electronics Engineers) e per i 50 anni della IEEE Italy Section.

Per iniziativa di IEEE nell'ambito del progetto Milestones, alla presenza del prof. Angiolino Stella, Magnifico Rettore dell'Università, e del prof. Silvano Donati, Presidente di IEEE Italy Section, è stata scoperta nel Museo una targa commemorativa, donata da IEEE, in riconoscimento del contributo di Alessandro Volta, inventore della pila elettrica, allo sviluppo della tecnologia elettrica.

È seguita una conferenza sula storia della tecnologia dell'informazione in Europa tenuta dal prof. Pierre Mounier Kuhn dell'Università di Parigi-Sorbona, studioso di fama internazionale.

Promoted by the University of Pavia and by the IEEE Italy Section, on 10 June an event of international relevance took place at the Pavia Museum of Electrical Technology on the occasion of the celebrations for the 125th anniversary of the IEEE (Institute of Electrical and Electronics Engineers) and the fiftieth anniversary of the foundation of IEEE Italy Section.

Upon the initiative of IEEE as part of the Milestones project, in the presence of prof. Angiolino Stella, Rector of the University of Pavia and prof. Silvano Donati, Chairman of IEEE Italy Section, a plaque, donated by IEEE, was unveiled commemorating the contribution by Alessandro Volta, the inventor of the electric battery, to the development of electrical technology.

The ceremony was followed by a lecture on the history of computing in Europe delivered by prof. Pierre Mounier Kuhn, University of Paris Sorbonne, a scholar well known internationally.

2 ottobre – 20 dicembre 2009

Progetto Marconi 09

Il contributo di Guglielmo Marconi, Premio Nobel 1909, allo sviluppo della telegrafia senza fili e della radio

Comunicare senza fili: dai segnali ai suoni
Wireless communications: from signals to sounds

Una Mostra e una serie di conferenze

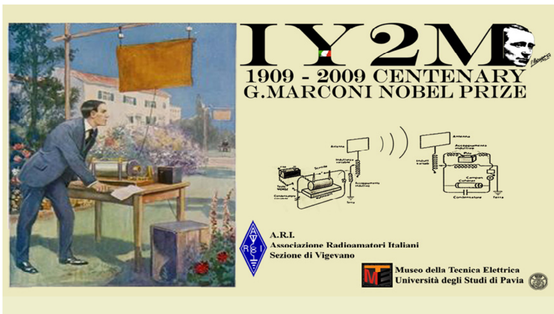
2 ottobre 2009

Inaugurazione della mostra con l'intervento di:

Angiolino Stella – *Rettore dell'Università di Pavia*
Rodolfo Faldini – *Assessore all'Istruzione del Comune di Pavia*
Vittorio Poma – *Presidente della Provincia di Pavia*
Gabriele Falciasecca – *Comitato nazionale per le celebrazioni marconiane*

Mostra realizzata con il contributo di:

Regione Lombardia
Comune di Pavia
Fondazione Comunitaria della Provincia di Pavia
Selex Communications



con il patrocinio di:

Regione Lombardia, Provincia di Pavia
Comune di Pavia
IEEE Italy Section
IET Italy
Federazione AEIT

e con la collaborazione di:

Comitato nazionale per le celebrazioni del centenario del Premio Nobel a G. Marconi
Associazione Italiana Radio d'Epoca
Associazione Radioamatori Italiani – Vigevano
Radio Campus – Pavia
Associazione Nazionale Genieri e Trasmettitori – Milano

La mostra, rivolta al largo pubblico con particolare attenzione alle scuole di diverso grado, ha messo a fuoco la grande rivoluzione della comunicazione senza fili. Scaturita dalla scoperta delle onde elettromagnetiche di Heinrich R. Hertz intorno al 1887-88, questa rivoluzione venne portata avanti tra Ottocento e Novecento da diversi inventori. Marconi diede il contributo fondamentale, trasformando in breve tempo la telegrafia senza fili in un mezzo efficace di comunicazione di segnali a breve e lunga distanza.

La nuova tecnologia delle comunicazioni, che ben presto fu applicata anche alla trasmissione di suoni e della voce, fu anche uno straordinario successo commerciale. Nel 1897 Marconi fondò in Inghilterra la Marconi Wireless Telegraph Company, che si affermò come leader nella produzione di impianti e attrezzature per radiocomunicazioni. Si avviò allora l'era della radio e il suo impiego si diffuse dal settore commerciale a quello militare e civile. Con la trasmissione dei suoni la radio entrò nelle case private, inizialmente come mezzo di lusso di intrattenimento e poi via via di uso più comune.

Rievocata la figura di Marconi e messo in luce il suo contributo allo sviluppo della telegrafia senza fili riconosciuto con il premio Nobel, la mostra, curata da Antonio Savini e allestita da Enrico Valeriani, ha delineato un breve percorso storico della telegrafia senza fili e poi della radio, cercando, attraverso dimostrazioni, di far comprendere l'idea della comunicazione senza fili.

Il centro della mostra era costituito da una pregevole collezione di radio ricevitori civili prodotti da Marconiphone a partire dal 1922 e poi, con lo stesso marchio Marconiphone, da Gramophone (La Voce del Padrone) a partire dal 1929 e da EMI (Electric and Musical Industries) dopo il 1931.

The exhibition, designed to appeal to a wide public, especially schools at various levels, was intended to highlight the great revolution of wireless communications. Originated by the discovery of electromagnetic waves by Heinrich R. Hertz (1857-1894) about 1887-88, this revolution was carried out at the turn of the century by several inventors. Marconi gave a fundamental contribution so that soon wireless telegraphy became a valuable tool to communicate signals to and from short and long distances.

The new communication technology, which soon was extended to the transmission of sounds and voices, got an extraordinary commercial success. In 1897 Marconi in England founded the Marconi Wireless Telegraph Company, which became a leader in the production of equipment and devices for radio communications. Then the era of radio started with applications in the commercial domain and also in the military and civil one. By broadcasting sounds radios entered into private houses, initially as luxury entertainment tools and then as popular appliances.

Starting from the life and activity of Marconi, the exhibition, conceived by Antonio Savini and designed by Enrico Valeriani, outlined a short historical journey across wireless telegraphy and radio and included demonstrations of experiments of wireless communication.

The core of the exhibition was represented by a valuable collection of non-industrial radio receivers produced by Marconiphone starting from 1922 and then, with the same trade mark Marconiphone, by Gramophone (His Master's Voice) starting from 1929 and by EMI (Electric and Musical Industries) after 1931.

Sabato 3 ottobre 2009

Il giovane Marconi e la sua impresa

Le prime due conferenze della serie che il Centro di Ricerca per la Storia della Tecnica Elettrica ha previsto durante lo svolgimento della Mostra hanno messo in luce la figura di Marconi giovane inventore e imprenditore.

Barbara Valotti, della Fondazione Marconi di Bologna, nella sua conferenza su "Il giovane Marconi" ha ricostruito l'ambiente familiare di Marconi e ha evidenziato aspetti anche inediti della sua formazione di giovane inventore.

Successivamente Anna Guagnini, dell'Università di Bologna, ha riferito dei suoi studi sull'attività di Marconi imprenditore europeo agli inizi del Novecento, tenendo una brillante conferenza dal titolo "Da Londra a Stoccolma: un'impresa che portò al Nobel".

The first two lectures of the series planned by the Research Centre for the History of Electrical Technology during the Exhibition emphasized the life and activity of Marconi as a young inventor and entrepreneur.

Barbara Valotti, Fondazione Marconi in Bologna, in her lecture on "The young Marconi" outlined, in particular, the family life of Guglielmo Marconi and his education, offering also new information.

Then Anna Guagnini, University of Bologna, reported her studies on the activity of the companies founded by Marconi starting from the end of the 19th c., delivering a brilliant lecture entitled "From London to Stockholm: an enterprise leading to the Nobel prize".

Sabato 23 ottobre 2009

Marconi inventore e imprenditore europeo

Il 23 ottobre due conferenze di assoluto rilievo internazionale hanno illustrato la figura di Guglielmo Marconi inventore e imprenditore europeo.

Dopo i primi esperimenti di telegrafia senza fili a Bologna, Marconi si trasferì a Londra dove diede vita alla Marconi Wireless Telegraphs Company, un'impresa che continuò la sperimentazione e avviò la produzione di componenti e apparecchi radiotelegrafici. L'impresa si estese presto in vari paesi del mondo. In Germania nacque la AEG Telefunken che percorse strade simili, entrando però in competizione con la Marconi Company.

Il programma del pomeriggio al Museo della Tecnica Elettrica è stato il seguente:

- 14.30 ripetizione degli esperimenti di Marconi (a cura di Claudio Gilardenghi);
- 15.15 Brian Bowers, Science Museum, London "Marconi in Britain";
- 16.30 Friedrich Heilbronner, Deutsches Museum, Munchen "Marconi and the Germans".

Le conferenze dei due illustri studiosi sono state curate dal Centro di Ricerca per la storia della Tecnica Elettrica e hanno avuto il sostegno della Regione Lombardia.

On October 23 two lectures highlighted Guglielmo Marconi as an European inventor and entrepreneur. After the first experiments of wireless telegraphy in Bologna, Marconi moved to London where he founded the Marconi Wireless Telegraphs Company which continued experiments and started to produce wireless components and devices. The company then spread in various countries. In Germany AEG Telefunken started to compete with Marconi Co.

The afternoon programme at the Pavia Museum of Electrical Technology included the performance of the early Marconi experiments by C. Gilardenghi, followed by the lecture of Brian Bowers, Science Museum London, on "Marconi in Britain" and the lecture of Friedrich Heilbronner, Deutsches Museum Munchen, on "Marconi and the Germans".

The lectures by the two prominent scholars were organized by the Pavia Centre for the History of Electrical Technology with the support of Regione Lombardia.

Venerdì 13 novembre 2009

Una applicazione innovativa della tecnologia radio per la identificazione di oggetti

Nel quadro delle manifestazioni marconiane (Progetto Marconi 09) venerdì 13 novembre il Museo della Tecnica Elettrica di Pavia ha ospitato un incontro organizzato da IET (The Institution of Engineering and Technology) Italy Network in collaborazione con il Centro di Ricerca per la Storia della Tecnica Elettrica dell'Università di Pavia.

Sono state presentate strategie innovative di impiego di tecnologie radio per la lettura a distanza di contrassegni identificativi di oggetti. Attualmente nel mondo dell'industria e del commercio si pensa a questa applicazione per il futuro con l'obiettivo di ottimizzare i processi, ridurre i costi e aumentare la sicurezza. Probabilmente la lettura ottica tradizionale dei codici a barre non verrà immediatamente messa da parte ma le due tecnologie entreranno in competizione.

Nel corso dell'incontro sono stati illustrati i principi della tecnologia innovativa e mostrate soluzioni vincenti nel campo della logistica.

Le relazioni sono state tenute da A. Polemi, F. Testi, P. Guidi e A. Costi.

In the course of the Marconi 09 Project on Friday 13 November a seminar was arranged jointly by the IET Italy Network and the Pavia Research Centre for the History of Electrical Technology. The seminar was focused on a description of the Radio Frequency Identification principles and basic components and showed some winning solutions in warehouse and logistic. Thanks to this technology, data identifying objects can be transmitted via radio waves without physical or line of sight contact. Today industry and trade are committed to this new technology competing with barcodes because it optimises process, lowers process cost and increases product safety.

Lectures were delivered by A. Polemi, F. Testi, P. Guidi and A. Costi.

Sabato 28 novembre 2009

Marconi e le radio d'epoca

Sabato 28 novembre Claudio Gatti dell'Associazione Italiana di Radio d'Epoca (AIRE) ha tenuto una conferenza su "La radio come oggetto di collezionismo e restauro".

Il tema ha richiamato i collezionisti e, in particolare, quelli di AIRE. Non ha mancato di interessare però anche coloro che magari soltanto ricordavano una vecchia radio nei salotti dei loro nonni o che ne conservano una nella loro soffitta.

On Saturday 28 November Claudio Gatti, Associazione Italiana di Radio d'Epoca (AIRE), delivered a lecture on collections of vintage radios. The subject attracted collectors and the general public interested to know more of radios which were normally present in the sitting room of grandparents and still can be often found in attics.

Sabato 19 dicembre 2009

Marconi e le trasmissioni radio militari

Sabato 19 dicembre si è concluso il ciclo di conferenze che hanno accompagnato la mostra "Comunicare senza fili. Il Contributo di Guglielmo Marconi, premio Nobel 1909".

Il maggiore Ernesto Colombo dell'Associazione Genieri e Trasmettitori di Milano ha presentato le applicazioni militari della comunicazione senza fili a partire dai primi esperimenti della stesso Marconi, prima nella marina e poi nell'esercito. In un percorso storico dalle origini fino ad oggi sono state illustrate le applicazioni prodotte dalle innovazioni tecnologiche via via succedutesi: dai primitivi trasmettitori a scintilla e ricevitori a cristallo attraverso le valvole termoioniche e i dispositivi a semiconduttore per arrivare fino ai complessi sistemi attuali di telecomunicazione satellitare.

On Saturday 19 December the last lecture of the series accompanying the Exhibition on Wireless communication was delivered by Major Ernesto Colombo, Associazione Genieri e Trasmettitori, Milan. He highlighted military applications of wireless communication since the early experiments made by Marconi, first in the Italian Navy and then in the Army, in a journey through the various technological innovations: from the spark transmitters to crystal receivers and then to valve and semiconductor devices up to the complex modern satellite communication systems.

Eventi dell’anno al Museo / *Events in the Museum*

2008

Annual Lecture

“L’età dell’elettricità: radici e interpretazioni” Giuliano Pancaldi, Bologna
8 marzo 2008

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Inaugurazione del banco di comando della Stazione di Certosa di Pavia

“Treni in transito al Museo”
28 marzo 2008

Spettacolo teatrale

“Parallelismi: geometrie euclidee e non”
18 maggio 2008

Visita al Museo

ET 2008 – XXIV Riunione Annuale dei ricercatori di Elettrotecnica
19 giugno 2008

Visita notturna e concerto “Notte bianca al Museo”

6 settembre 2008

Incontro

“Automazione: la figura professionale dell’ingegnere” in collaborazione con ANIPLA
8 ottobre 2008

Eventi dell'anno al Museo / *Events in the Museum*

2007

Inaugurazione del Museo

1 marzo 2007

Proiezione cinematografica

"Storie e paesaggi di acque motrici"
19 maggio 2007

Convegno Nazionale Tecnologia ed Economia della Domotica

18 settembre 2007

Inaugurazione del generatore eolico donato da Edison SpA

25 settembre 2007

Sessione del Convegno Nazionale di Storia della Tecnica Elettrica

26 settembre 2007

Spettacolo

Cinema muto con accompagnamento musicale
28 settembre 2007

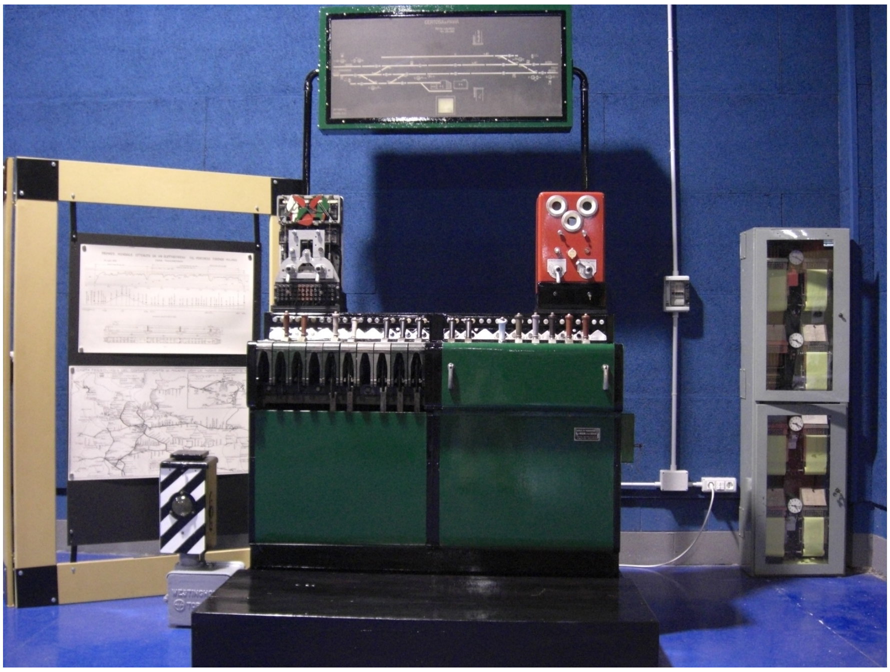
Apertura notturna

"Una notte al Museo"
29 settembre 2007

Mostra ospitata

"Animali dal mondo"
13 ottobre – 20 dicembre 2007

Nuove acquisizioni / *New exhibits*



Nel corso dell'anno il Museo ha ricevuto molte donazioni. Una delle acquisizioni è stata presentata durante il Museum Day.

Nel pomeriggio del 7 marzo è stato inaugurato il riallestimento del cuore operativo della stazione ferroviaria di Certosa di Pavia, restaurato e trasferito al Museo a cura di Rete Ferroviaria Italiana. Una introduzione agli aspetti storici e tecnici del banco elettromeccanico di comando e degli strumenti di blocco ad esso collegati, a cura dell'ing. Francesco Abate, e la successiva dimostrazione del funzionamento del sistema restaurato hanno messo in luce le caratteristiche di questo prezioso reperto di archeologia industriale (1939) destinato permanentemente al Museo.

I visitatori del Museo potranno così finalmente entrare nella cabina di regia di una stazione e immaginare di assistere al transito dei treni sulla linea ferroviaria Milano-Genova, una delle principali d'Italia inaugurata nel 1848.

During the year the Museum received many contributions. One of them was shown on 7 March afternoon and consisted of the operating core of the railway station in Certosa di Pavia. It was restored and transferred to the Museum by Rete Ferroviaria Italiana.

The technical and historical aspects of the electromechanical system for controlling and monitoring the operation of the station were illustrated by eng. Francesco Abate. Then the restored system was operated, showing the characteristics of the important piece of industrial heritage (1939) permanently located in the Museum.

From then on visitors of the Museum can enter into the control room of a railway station where they can virtually see transits, arrivals and departures of trains along the Milan-Genoa railway, one of the main railways in Italy, opened in 1848.

Pubblicazioni del Centro Interdipartimentale di Ricerca per la Storia della Tecnica Elettrica (CIRSTE)

Publications of the Research Centre

2009

SAVINI A. – GALDI R. – PIETRA F. (a cura di)

Museo della Tecnica Elettrica, Guida
Museum of Electrical Technology, Guide Book

TCP Tipografia Commerciale Pavese, Pavia, 2009.

The booklet aims to lead visitors of the Pavia Museum of Electrical Technology in a journey from the earliest discoveries of electricity to the latest developments of its application. The five main sections of the exhibition are described and it is shown how people came to understand electricity, how it is produced and distributed and how it is used for both power and communication.

DONATI S. – SAVINI A.

Across the past 50 years of IEEE presence in Italy

IEEE Conference on the History of Technical Societies (Philadelphia, 5-7 August 2009).

The paper is the first attempt to outline a short history of IEEE Italy Section on the basis of the documentation available. Founded in 1959 as the Milan Section of the IRE, it then spread over the country and followed the evolution of the US based Institute with the merging of the IRE with the AIEE in 1963 and the creation of Regions, Societies and Chapters. In 2009 the IEEE Italy Section celebrated its fiftieth anniversary year, while the celebrations of the 125th anniversary of foundation of the IEEE were under way.

BOWERS B. – GALDI R. – JESZENSZKY S. – PIETRA F. – SAVINI A.

Three-phase railway electrification: a product of Hungarian-Italian co-operation

IET 36th History of Technology annual weekend meeting (Mulhouse, 10-13 September 2009), Pres. 2.
ISBN 978-1-84919-160-9

The paper investigates the “Italian system” of railway electrification which was a co-operative effort between Italian and Hungarian engineers pioneering ac technology. In 1897 the Italian Government decided to make four experiments with electric traction. One of these was the use, for the first time anywhere in the world, of three-phase high-voltage ac technology as successfully demonstrated in Frankfurt six years earlier. The resulting large scale experiment of the Valtellina line, which proved to be very successful, soon gained international notice.

Prossime pubblicazioni / *Forthcoming publications*

Marconi 09. Comunicare senza fili: dai segnali ai suoni

Pavia, 2010

2008

GALDI R. – PIETRA F. – SAVINI A.

Due secoli di storia della tecnica elettrica nel nuovo Museo di Pavia

Rivista AEIT, 1/2 (2008), pp. 46-49.

L'articolo descrive le caratteristiche principali e propone una breve introduzione alla visita del nuovo Museo della Tecnica Elettrica inaugurato a Pavia il 1° marzo 2007.

SAVINI A. – ROVIDA E.

Una macchina quasi centenaria per il sollevamento e la navigazione

In *La gru galleggiante Langer Heinrich dal 1915 ad oggi, storia, tecnologia e conservazione*, a cura di Rosato G., Erga, Genova, 2008, pp. 33-43.

Il Langer Heinrich, già Maestrale, è una gru galleggiante costruita in Germania nel 1915 che vicende complesse hanno portato dal 1990 a ormeggiare nel Porto antico di Genova. L'articolo descrive la macchina e le sue funzioni originarie di sollevamento e di navigazione e illustra gli apparti elettromeccanici di questa testimonianza irripetibile della tecnologia navale ed elettromeccanica del Novecento europeo.

SAVINI A.

Il Museo della Tecnica Elettrica di Pavia: più musei in uno

In *Economia e cultura: il Museo dell'industria e del lavoro Eugenio Battisti*, a cura di Poggio P.P., Fondazione Musil, Brescia, 2008, pp. 124-126.

Nell'articolo si ripercorre brevemente la storia che ha portato alla costituzione del Museo di Pavia che si compone di tre collezioni: quella universitaria, quella del Museo dell'Energia Elettrica di Roma e quella del Museo delle Telecomunicazioni di Milano. Sono quindi illustrate le caratteristiche del Museo di Pavia: museo universitario, museo specializzato, museo tradizionale di oggetti.

SAVINI A. – GALDI R. – PIETRA F. – ZANETTA L. – BOWERS B.

The SIRTI Collection of Telephones in the Pavia Museum of Electrical Technology

Proc. IEEE HisTelCon 2008 Conference (Paris, 11-12 September 2008), pp. 124-130.

Between 1978 and 1986 SIRTI, a leading Italian telecommunication engineering company established in 1921, assembled a collection of telephone equipment and instrumentation that is now exhibited in the Museum of Electrical Technology in Pavia. The paper describes the magnificent SIRTI collection of telephones composed of about three hundred items, which illustrates the history of telephone technology from the last decades of the 19th century to the present day.

2007

SAVINI A.

Il Museo della Tecnica Elettrica di Pavia: una sfida

In *Ingegneri a Pavia tra formazione e professione*, a cura di Cantoni V. –Ferraresi A., Cisalpino, Milano, 2007, pp. 627-641.

L'articolo è una dettagliata descrizione del percorso che ha portato all'ideazione e alla realizzazione del Museo della Tecnica Elettrica di Pavia. L'iniziativa è stata una sfida contro gli scetticismi e le difficoltà, non solo economiche. Attualmente è una sfida anche la vita futura del Museo appena inaugurato.

SAVINI A. – GALDI R. – PIETRA F.

La casa elettrica nel Novecento

Atti del Convegno Nazionale Tecnologie ed Economia della Domotica, AEIT (Pavia, 18 Settembre 2007), pp. 1-5.

La casa elettrica ha sempre rappresentato un mito, sospeso tra realtà e sogno, per la gente in visita alle varie esposizioni dedicate al futuro che hanno segnato il Novecento. Pochi magnati, innamorati di tecnologia, hanno potuto realizzare loro case elettriche, veri e propri paradisi (o inferni) di tecnologia. Nell'articolo sono illustrate alcune tappe della storia della casa elettrica, con particolare attenzione alla tecnologia.

SAVINI A.

Il Museo della Tecnica Elettrica di Pavia

In *Atti della Giornata di studio "Oggetto industriale, soggetto di memoria",* Provincia di Milano, 2007, pp. 94-97.

L'articolo delinea inizialmente la nascita dei musei della cultura materiale che sono un segno dei tempi recenti. Successivamente descrive il nuovo Museo appena nato a Pavia che ha un patrimonio cospicuo di oggetti. Questi ultimi hanno una duplice funzione, di testi e pretesti: testi di storia particolare e, al contempo, pretesti per raccontare storie più generali.

Ad appena tre anni dalla sua apertura il Museo della Tecnica Elettrica dell'Università di Pavia è un giovane Museo che si sta affermando. Le sue attività, e quelle del Centro Interdipartimentale di Ricerca per la Storia della Tecnica Elettrica che è ospitato nel Museo, sono in crescita. Per questo si è pensato di documentarle annualmente in un Rapporto asciutto e agile, affidato soprattutto alle strade della rete informatica oggi forse più frequentate degli scaffali delle biblioteche.

Museum Year 2009, il primo Rapporto delle attività del Museo che riguarda il 2009, elenca anzitutto gli eventi promossi od ospitati e le principali acquisizioni del Museo nell'anno. Il Rapporto dà conto anche delle pubblicazioni scaturite dagli studi sviluppati dal Centro di Ricerca. Infine esso riporta il testo integrale della Lezione invitata Annuale, tenuta nel marzo di ogni anno, in occasione del Museum Day da un esperto particolarmente qualificato su uno dei temi che caratterizzano il Museo e che possono interessare anche il largo pubblico.

Nel 2009 Brian Bowers, già al Science Museum di Londra, ha raccontato, in modo magistrale e affascinante, la storia dell'illuminazione e di quella elettrica, in particolare. La lettura o rilettura della sua lezione fa certamente gustare maggiormente la ricchezza dei contenuti, anche se non può rendere l'emozione delle scintillanti dimostrazioni che l'hanno accompagnata, quando è stata tenuta.

Senza aver alcuna pretesa di competere con le più grandi istituzioni museali, con le quali peraltro il Museo di Pavia si onora di collaborare, viene licenziato questo modesto strumento di comunicazione on line con lo scopo di far giungere le notizie annuali del Museo anzitutto alla cerchia degli amici del Museo stesso e poi a tutti i visitatori passati e futuri, effettivi e virtuali, e infine a tutti quanti sono interessati alla cultura tecnico scientifica e ai Musei dove tale cultura non solo è conservata, ma è continuamente rielaborata e offerta in modo rigoroso, vivace e accattivante.

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