The extraordinary inventions of Sir Joseph Swan

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One hundred years ago he gave the first public demonstration of the incandescent-filament lamp. Together with Edison, his name is incorporated in the trademark of Ediswan light globes — produced to this day by the Thorn Electric Company.

His invention brought about the establishment of the electrical engineering industry. Apart from that he contributed much to the technology of photography — he patented bromide printing paper, as still used today — he greatly improved the secondary cell and worked on early fuel cells. His contribution to 20th century technology has been far-reaching.

THE BRITISH ASSOCIATION for the Advancement of Science recently sponsored celebrations in Newcastle-upon-Tyne, North East England, to commemorate the centenary of the first-ever public demonstration of an incandescent-filament electric lamp.

The man who gave the demonstration in 1879 was Joseph Swan, a North-country Englishman who was to prove one of Britain's most remarkable inventors, responsible for innovations that are still with us today and for the start of the electrical engineering industry.

He had but a rudimentary education, which pleased him because the casualness of it all allowed him to learn, while very young, about a wide range of crafts from ironwork to rope-making, about coal-gas and about electricity. He learned by very close observation and through the friendly interest craftsmen showed to an eager, wide-eyed, knowledge-seeking boy. On leaving school at 13 he was apprenticed to a firm of druggists and so began to learn chemistry.

He grew up with several brand new branches of technology – photography, electro-plating, batteries and the production of vacuum.

"The elation created by the announcement of a great discovery and first acquaintance with its results," he wrote later on, "is a sensation of an extraordinarily uplifting character, and I can never forget its effect as a stimulus to experimental effort."

The electric lamp

It was in Sunderland, his birthplace that, at the age of 17 the seed was planted that led him to his most famous inventions in electric lighting. He read about a new type of electric lamp, patented in 1845, that made use of an electric current passing through a wire in a vacuum. He also heard about it in a lecture and saw the principle demonstrated.

In 1846, at the age of 18, he joined a friend in a chemist and druggist business in Newcastle-upon-Tyne, where all his subsequent work on incandescent lighting was done until 1883.

The seed of 1845 germinated because of a remarkable development in vacuum technology from 1855 onwards, starting with the German inventor Heinrich Geissler. It was the invention of the mercury pump. Before this was available all efforts to make a conductor incandescent in an evacuated bulb failed because the conductor either melted or burned away in the oxygen of the remaining air.

The pressure attainable up to 1855 was about 13 mm of mercury (13 torr in modern terms). The mercury pump achieved 10^{-3} torr, which seemed (naively as we now know) nearly a perfect vacuum.

It inspired Swan to start experimenting. He realized that a material of very high melting point was needed and he chose carbon. He also knew that he needed the carbon very thin so that more power could be concentrated in a small space, to make a sort of super candle so to speak, or to achieve the 'subdivision' of the electric light, as it was quaintly expressed in those days. He also needed the carbon to be flexible so that it could be bent into shape. It was a great challenge to his ingenuity and his considerable manipulative skill.

In the 1860s he succeeded in 'carbonizing' strips of paper by a technique of his own, which was what we would today call pyrolysis. That is, heating to a very high temperature in the absence of oxygen. The resulting strips were remarkable, being flexible and metallic.

Adsorbed air

Lamps made with the strips were, nevertheless, a failure. There were difficulties in connecting the strip to the platinum wires used to bring the ▶

electricity into the glass bulb. In addition, carbon was deposited on the inside of the glass when the lamp was running, making it opaque. Against the opinion of all colleagues and academic judgement he decided that this was caused by the poor degree of vacuum and the release of adsorbed air during incandescence.

He then had a flash of intuition that solved the problem. Towards the end of the evacuation process by mercury pump he flashed a high current through the carbon. It removed adsorbed gas and created a higher vacuum. This leap in technology was made in 1878 and the technique has been used ever since.

He was still searching for a better conductor that would lend itself to mass production and be easily connected to the platinim leads. He made at first very thin carbon rods and he showed his first successful lamp with a carbon rod one millimetre in diameter to the Newcastle-upon-Tyne Chemical Society on 18 December 1878. On 3 February 1879 he gave a public lecture-demonstration to an audience of some 700 people in the premises of the Literary and Philosophical Society of Newcastle.

The possibility of the 'subdivision' of electric light was by this time a subject for public discussion in newspapers. Swan's name became widely known. He continued his work on a new type of conductor and eventually produced a remarkable carbon filament, though he did not use the word.

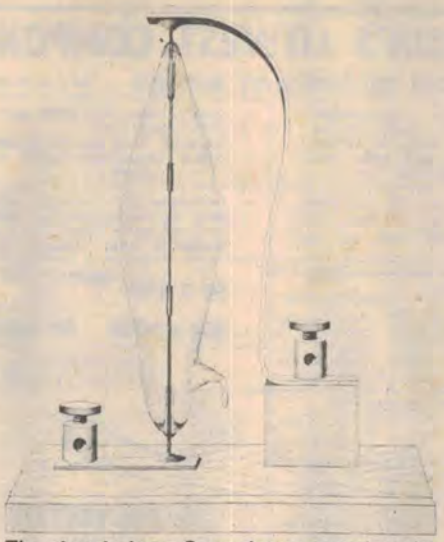
By this time he had a rival, the young American inventor, Thomas A. Edison, who early learned the value of publicity. Reports, later shown to be premature, flashed across the Atlantic to the effect that Edison had finally solved the problem of the 'subdivision' of electric light, and the confident news at first caused a slump in gas-company shares.

It is interesting that Swan did not patent his first electric lamp of 1878-9 because he considered that the basic idea was well known and therefore not patentable. Edison had no such self-restraint and on 10 November 1879 he applied for, and gained, a British patent embodying the idea of a carbon filament. Legally, therefore, he is the inventor of the incandescant-filament electric lamp, though the word 'inventor' is misleading here, for the basic notions were well established.

Swan was not being naive in this, for he had started patenting his inventions in 1864. However, spurred on by Edison's sharp rivalry he rushed to patent his flash technique of evacuation two years after he had invented it.

Lighting homes

With his own lamp development he was very successful. He converted cotton into a transparent resin by means of sulphuric acid, a process he called parchmentizing. The resin was easily cut and shaped into filaments that were strong and flexible and could be carbonized by pyrolysis to make carbon 'wire'. He formed a company in Newcastle to make the new lamps. There were problems still of outside connectors and easy replacement and so on, but he lighted the homes of several eminent people as well as the shop of and enterprising Newcastle linen-draper. The Royal Navy took up his electric lighting. Many public buildings were lighted.



The electric lamp Swan demonstrated to the Newcastle Literary and Philosophical Society in February, 1879. The conductor was a carbon rod about 1 mm thick.

The incandescent lamp had arrived.

At that time anyone wishing to have the new electric lamps needed his own generator, driven by gas or steam. There was no general supply of electricity. But the demand raised problems of generation, transmission and distribution, involving the making of cable; there were problems of switching, too. The solution of these problems established the electrical-engineering industry. The first power station in the world was built at Holborn Viaduct, in London, at the beginning of 1882 by Edison's company.

This lively inventor's aggressive attitude led to a period of litigation, real or threatened. It is not necessary here to go into all the details of the confrontation. It is enough to say that Swan led the field and Edison was very quick to catch up. Eventually, the two men joined in the Edison and Swan Electric Lamp Company.

The trade name *Ediswan* still survives in lamps now manufactured by Thorn Electric in Britain.

Up to 1883 Swan's filaments, made by carbonizing cellulose, controlled the market while Edison's commercial filaments were carbonized slivers of bamboo. Then Swan produced yet another remarkable invention. He created a cellulose plastic and squirted it through a fine hole so that it formed a fine continuous fibre.

This process was suitable for mass production and the pyrolysed fibre made carbon filaments that were homogeneous and of constant diameter. From 1884 onwards all Swan lamps had these carbon filaments. They were the basis of all electric incandescent lamps until tungsten came into use in about 1905. The carbon filaments continued to produce blackening of the glass but only after a useful length of life.

Swan in this process was in fact producing cellulose acetate fibre, the first 'artificial silk'. Mrs Swan crocheted some of the finer fibres into table mats but Swan himself took the matter no further. Some of his assistants – he was shrewd in his selection of them – were later involved in the artificial-silk industry for a long time.

Patents

In outline something should be said about his other inventions. He first produced collodion successfully in 1856 for use in photography and his method is still used. He patented the so-called carbon process for making accurately-graded prints from negatives in 1864. He applied the method to copper-plate etching. He patented the chrome treatment of leather in 1866. He contributed original discoveries to the development of dry photographic plates and he patented bromide printing paper, as still used to-day, in 1879.

Swan greatly improved the then new secondary cell, or accumulator, by introducing the cellular lead plate filled with spongy lead; he patented it in 1881. After his move to the London area in 1883 he continued work on a range of problems including the behaviour of dielectrics under electric discharge, leading to improvements in induction coils and transformers. He tried for years, with great skill but no success, to create an electric cell with an imperishable electrolyte, anticipating the modern fuel cell by using oxygen and hydrogen as electrodes and a ceramic as a porous electrolyte.

By the 1890s he was a famous man, called upon to serve on councils and committees. Many scientific societies awarded him medals. He was elected Fellow of the Royal Society in 1894, when he was 66 years old; King Edward VII knighted him in 1904. He remained mentally alert throughout his life and was experimenting to the end. He died in his 86th year in May 1914. ●