JOS

1828 — 1914

A PICTORIAL ACCOUNT OF A NORTH EASTERN SCIENTIST'S LIFE AND WORK

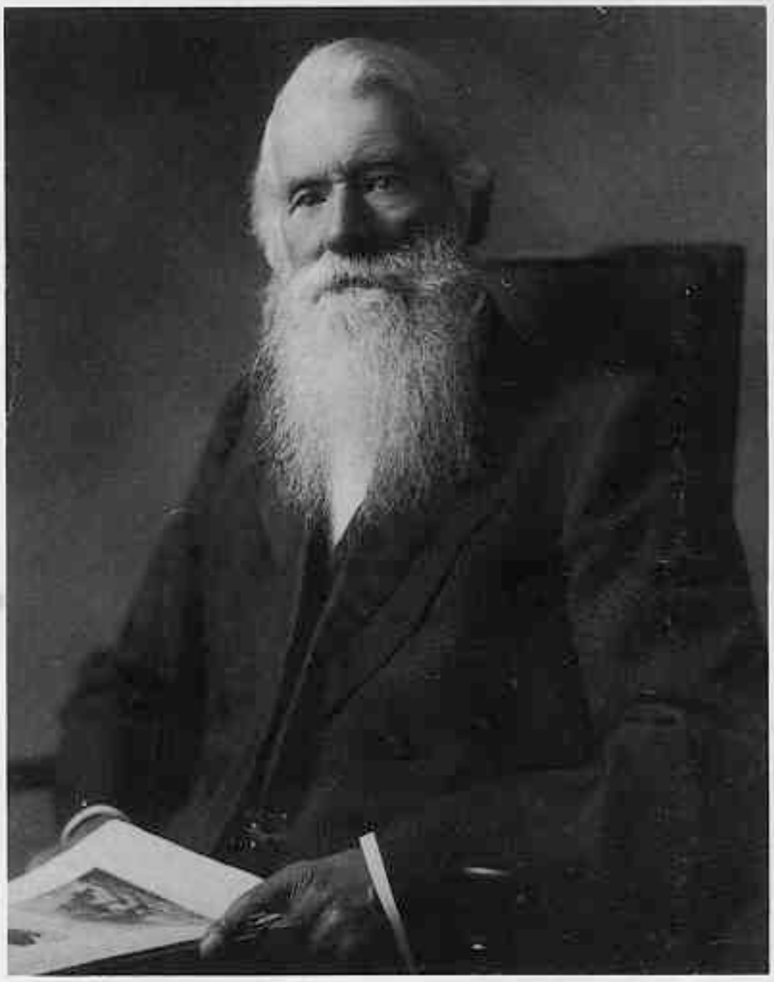
BY

DIANE CLOUTH

JOSEPH SWAN 1828–1914

"If I could have had the power of choice of the particular space of time within which my life should be spent I believe I would have chosen precisely my actual lifetime. What a glorious time it has been! Surely no other 78 years in all the long history of the world ever produced an equal harvest of invention and discovery for the beneficial use and enlightenment of mankind."

J. S. Swan, 1906.



The lifetime of Joseph Swan was an exciting period in British history. Queen Victoria was on the throne ruling an empire which embraced all the continents of the world – the largest empire mankind had known. Trade flourished, fortunes were made and the living standards of ordinary people were steadily improving. There seemed to be no end to the advance of science: everyday something new was being invented. Tyneside was in the forefront of many developments which now we accept as part of everyday life such as the railway system, the oil tanker, hydraulic machinery and electric power supply. The contribution of Joseph Swan to the development of photography and the electric lamp are part of this story.

Joseph Swan could not boast of an intensive formal education similar to that received by the youth of today. Learning to him did not necessitate quietly studying in a classroom for he was far happier scrambling along the banks of the Wear in attempts to discover the heights of the wooden ships and the widths of their sails; watching the glassblowers and blacksmiths at their work. By such activities Swan developed his intellectual curiosity and powers of observation which were to be invaluable assets in his later career as a scientist. The following pages serve as an introduction to the life of an outstanding Victorian gentleman, one of Tynesides many pioneers, Sir Joseph Wilson Swan.

John Swan 1795–1898
A quiet, practical man who made several inventions including an improved anchor, a life-boat and a system of fog signals for directing ships at sea. Unfortunately, his inventions were of little commercial value.

John Cameron 1827–1916
Joseph Swan's closest brother and companion, at the age of 14 John was apprenticed to a firm of drapers in Sunderland which he disliked and was later apprenticed to John Mawson, the chemist. In 1855 he set up as a general merchant eventually specialising in the sale of chemicals and metal.

Joseph Wilson 1828–1914
Major inventions included the carbon process for photographic printing, bromide printing paper for rapid photographic printing, the incandescent filament lamp, artificial cellulose thread for making artificial silk and the cellular lead plate storage battery.

George Henry 1833–1913
At the age of 19 George Henry went to the colonies in search of gold. This venture proved unsuccessful and he eventually set up as a photographer/chemist in Wellington, New Zealand. In 1863, the firm moved to Napier where Swan entered politics and ultimately became Lord Mayor.

Alfred 1835–1919
Alfred began his working life as an apprentice architect but in 1880 he became involved in his brothers lamp business. His major contribution was the perfection of the holders and caps for the bulbs and the development of 'vitrite', an insulating material which became universally adopted in lamp manufacture.

Isabella Cameron 1801–1884
An intelligent and determined woman of Scottish descent, Isabella came from an inventive family. Her eldest brother Robert was one of the earliest pioneers in New Zealand, inventing and making improvements in rope-spinning machinery and lifeboat construction.

Elizabeth 1822–1905
The eldest daughter who, upon the failure of her father's business, helped by teaching with mother in their home. Elizabeth was devoted to her family and stayed with them until her marriage to John Mawson in 1848.

Isabella 1830–1913
Little is known about this daughter except that she married a Mr. Thomas Atkinson on August 2nd 1885 and bore him one child – a daughter.

Mary Jane 1832–1914
Mary married John Pattinson one of Joseph's closest friends. Pattinson, a reknowned analytical chemist, was appointed public analyst to Newcastle, an appointment which later encompassed the counties of Northumberland, Durham and Berwick upon Tweed.

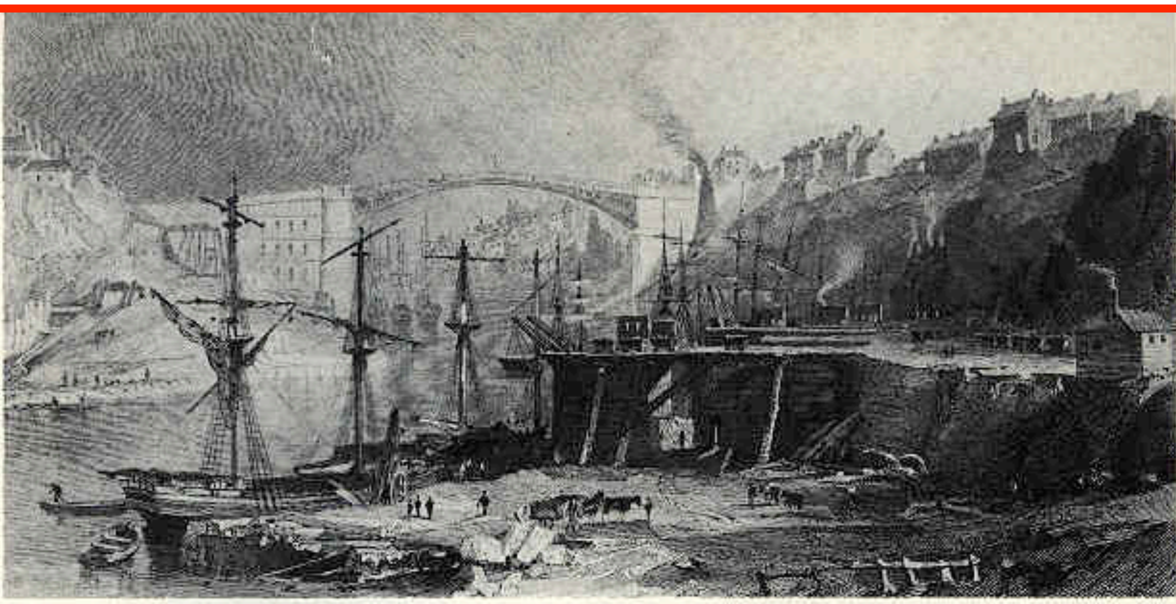
Emma 1837
Emma married Carl Frederick Leyel, a Swede employed by the shipping firm Borries, Craig and Company of Newcastle. Her husband's death in 1876 proved a great loss to Emma who after the death of her parents moved to London. It is not known when she died.

Hannah White (1837–1918)
In 1870 Swan decided to remarry, this time to Hannah who had, upon the death of her sister Fanny, come to the aid of the Swan family. The couple waited for a Bill, legalizing the marriage with a deceased wife's sister to be passed; it failed to pass. Joseph and Hannah then went to Switzerland, a country where there was no legal bar on such a union, and were married in Neuchatel on October 3rd 1871.

Elizabeth Mawson (1822–1905)
Upon the death of her husband Mrs Mawson was made a partner in the business of Mawson & Swan, this ensured her an income and an interest for the remainder of her life. The mother of five children she was an extremely active woman maintaining to her death an interest in all the great social and political questions of her day – in particular the anti-slavery movement and the temperance league. A generous and loving member of the Swan family she died in 1905 at the age of 73.

Francis White (died 1868)
A teacher and friend of the Mawson family it was upon her visits to Newcastle that she met Joseph Swan. They became engaged and in 1862 were married. Four children were born to the young couple but it was a short illness after the birth of twin sons which proved fatal for Fanny. She died in 1868 – a few months later the twin babies followed her to an early grave.

John Mawson (1815–1867)
He was Joseph Swan's friend and relative also partner in a successful chemist and druggist business. Mawson married twice. Firstly to Swan's aunt Jane who was, apparently, a very beautiful and saintly woman but possessed of a very delicate disposition. She died when only thirty leaving behind a daughter, Lydia Jane. John's second marriage was to Elizabeth, Swan's eldest sister. A methodist and tee-totaller Mawson was a pillar of society; a much loved and respected man he was appointed Sheriff of Newcastle. It was whilst carrying out his duties as sheriff that he was killed in an unfortunate explosion of nitro-glycerine on the town moor. An active worker in the cause of national peace and the abolition of slavery Mawson died aged 52.



Joseph Wilson Swan was born on 31st October, 1828, at Pallion Hall, Sunderland. His father, a quiet practical man, was an anchorsmith by trade but upon the failure of his business he became manager of the lime kilns at Pallion. Joseph was an inquisitive child finding much to occupy his active and observant mind in the surrounding neighbourhood. He later recalled:

> *'Before I was four I had visited all the works in the neighbourhood and I had been to the glasshouse and seen the process of glass-blowing, and looked into the square pits of the copper works. There was a fine view of the river from the end windows of our house which looked across it from a considerable height enabling me to see the shipbuilding going on on the opposite side of the river, and boats coming up and down.'*

Joseph's formal education began at the preparatory school run by the Misses Herries at Sunderland, 'three funny ladies' who taught reading, writing, sewing and knitting. According to an interview given in 1906, Swan was not a good boy at school – in fact he had the reputation of being idle and mischevious and was glad when school was over. However, there was one occasion when Swan was spellbound:

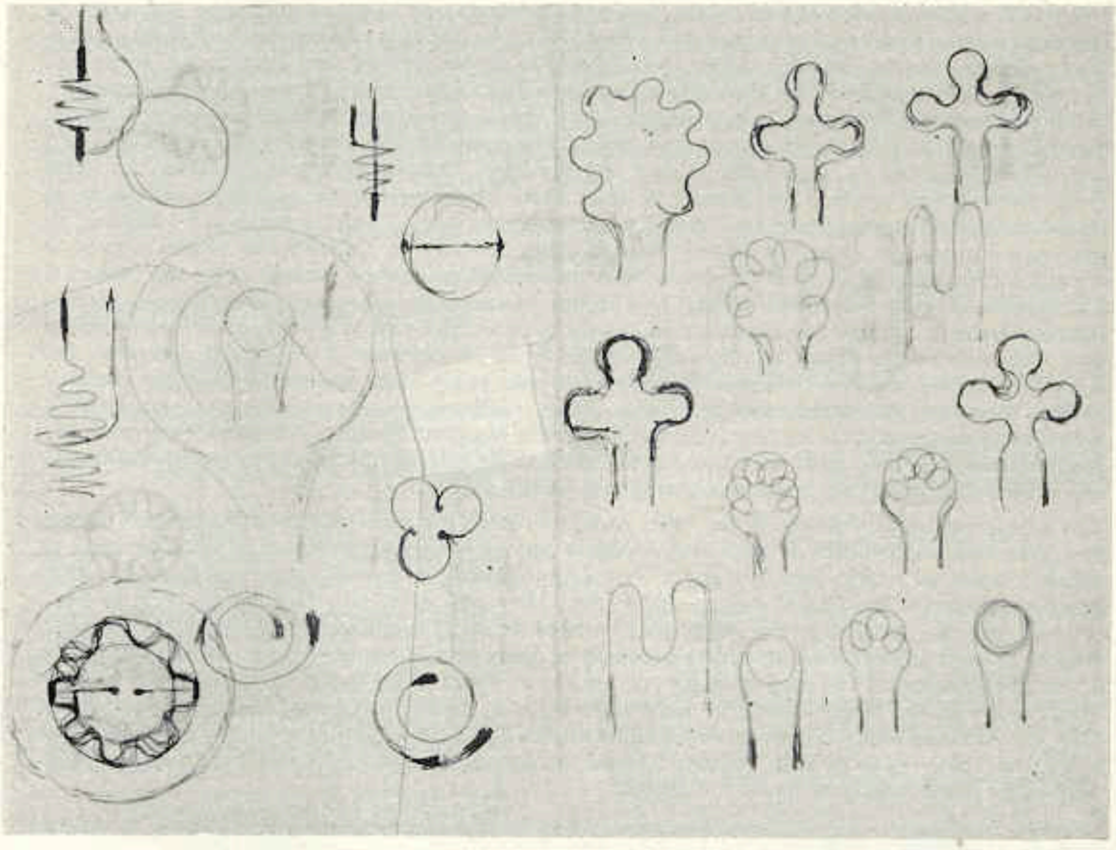
> *'One day there came into the classroom an old gentleman wearing a long dressing-gown, he looked just like the pictures of wizards. He had in his hand a glass prism and he held it so that the sunshine fell on it and made a rainbow on the schoolroom wall. I thought it very beautiful and have never forgotten it.'*

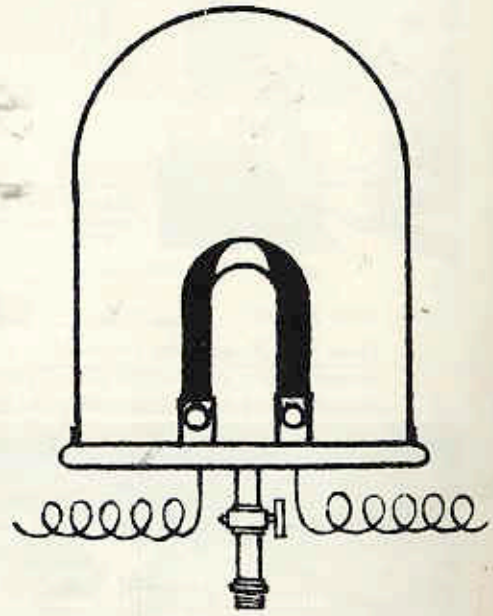
Swan was initiated into the mysteries of electricity by a friend of the family, Mr. Ridley, who had constructed an electrical machine and used the young Joseph Swan to aid him in his experiments. Joseph had to stand on a stool with a chain in his hand. The machine was set in motion and the electricity generated caused his hair to stand on end and sparks of electricity to be emitted from the tips of his fingers! This introduction to electricity could well have discouraged a boy of his age from further research but it served only to increase Swan's interest in electricity.

When Joseph was ten he moved to a larger school run by a Scottish minister in Hylton castle and it was here that Swan's interest in scientific experiments was observed and nurtured. Upon leaving school he was articled to a firm of chemists, Messrs. Hudson and Osbaldiston of Sunderland:

> *'It was October 31st, 1842 and I was fourteen when I entered on my apprenticeship as a chemist and druggist. This occupation gave me many opportunities for making chemical experiments and these were turned to account in the attainment of various objects that from time to time arrested my attention.'*

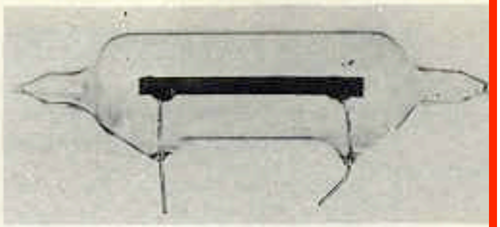
Unfortunately, both partners died within the first three years of Swan's apprenticeship leaving him free to join a friend and future brother-in-law, John Mawson, who had a chemists business in Newcastle. Work with Mawson proved enjoyable since Swan was allowed to pursue his own scientific research. Often he would work late into the night in the photographic studio on the upper floor of the premises in Mosley Street as the then new art of photography held a great fascination for Swan:



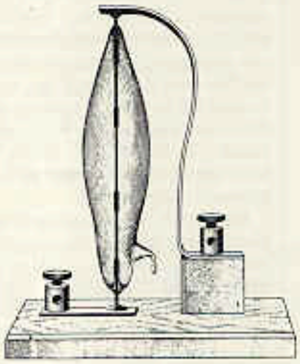


The page from Swan's note book reproduced above shows doodles of the various shapes for his carbon filaments. Over a period of several years successful durable and flexible filaments were produced. The next step was to render the strips incandescent which in turn meant the construction of a lamp. The diagram opposite of Swan's lamp of 1860 shows that the lamp was then nothing more than a glass bell jar inverted over a brass tray with a carbon arch clamped to two brass screws. In order to make the carbon arch glow the air within the jar had to be evacuated and a surge of electricity passed through the carbon. The experiment was not entirely successful for two reasons. At this point of time high vacuum techniques were relatively undeveloped: vacuum pumps working off a series of pistons and barrels were not very efficient. The second problem was electric power. In the 1860's primary batteries were the only source of current and they were not powerful enough to make the longer strips of carbon incandescent. It was not until the dynamo of Gramme became a commercial success in the 1870's that the problem of supply a constant source of sufficient power was solved.

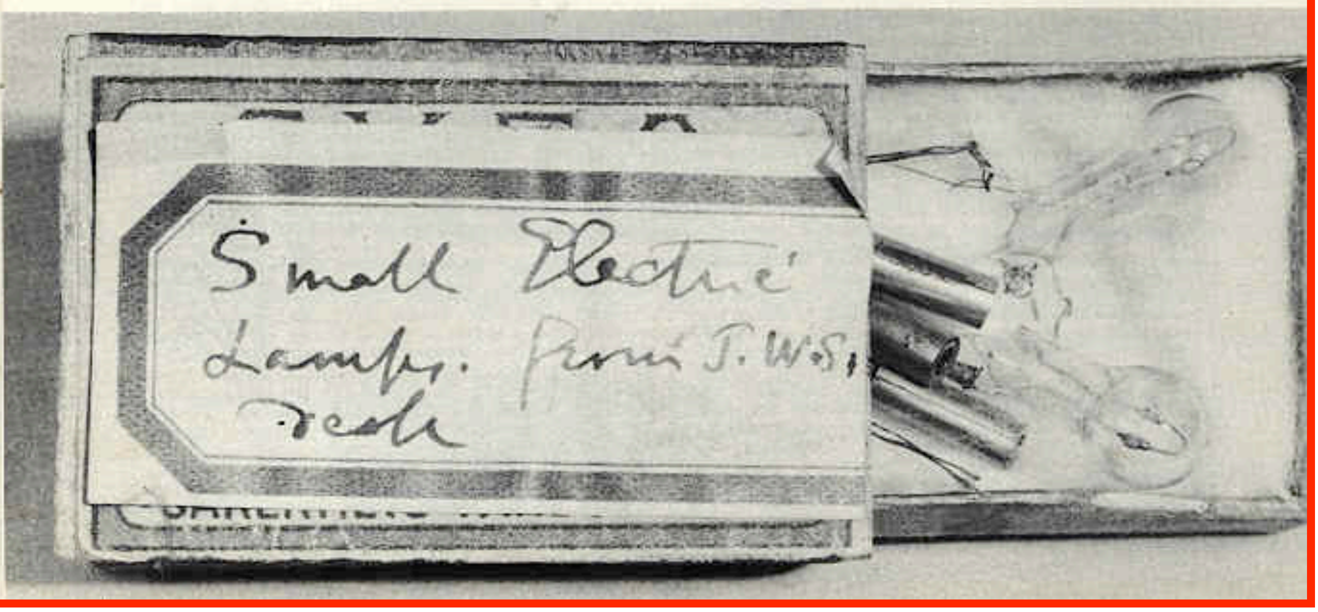
An advertisement in a newspaper of 1877 alerted Swan to the recent developments in high vacua technology by Mr. Stearn of Birkenhead. Swan immediately wrote off to Stearn asking if he would be interested in carrying out various tests on the carbon filaments. Stearn agreed and with the assistance of an expert glass blower, Fred Topham, he started to experiment. Difficulties arose over the mounting of the carbon strips in the glass bulbs and Stearn discovered that it was very difficult to exhaust the whole of the air from the bulb for the carbon itself was acting as a reservoir in which was stored air and other gases. The illustration opposite shows the experimental lamp of 1877: note the black strip of carbonised paper.



This observation proved to be a turning point in the research work. Swan solved the problem in a simple but ingeneous way: the lamp was evacuated as completely as possible and when this point was reached a strong electric current was passed through the carbon strip thereby rendering it incandescent whilst simultaneously evacuating the bulb. An extract from Swan's notes records that 'it was found that the carbon in a lamp this perfectly exhausted and sealed did not waste away and, provided the contact with the platinum was good, the bulb did not blacken.' On February 3rd 1879, Swan showed his lamp (illustrated opposite) in operation at a meeting of the Literary and Philosophical Society of Newcastle upon Tyne. This was an historic occasion. A month later the demonstration was repeated at Gateshead Town Hall in the presence of the mayor.



Various improvements followed most notably the development of the parchmentised thread filament which was made from cotton converted by the action of sulphuric acid into a plastic condition. The first commercial lamp of 1881 was the outcome: this is illustrated opposite. Early in 1881 the Swan Electric Light Company was formed and the process of lamp manufacture which had previously been carried out at Swan's home in Low Fell and Stearn's workshop at Birkenhead were brought under one roof at South Benwell, Newcastle. Some indication of the impact of these developments upon the society of the day can be gleaned from the newspaper articles reproduced on the next four pages.



THE NEWCASTLE DAILY CHRONICLE, TUESDAY,

THE ELECTRIC LIGHT.

Last night our townsman, Mr. J. W. Swan, lectured at the Literary and Philosophical Institute, Newcastle, on the subject of the electric light. There was a crowded audience. Sir William Armstrong occupied the chair, and, in introducing the lecturer, said that the subject was one which had excited a great amount of public interest. He felt sure they would be exceedingly glad to hear it treated by so able an investigator as Mr. Swan. Being a fellow-townsman, Mr. Swan needed no introduction at his hands; he had only to assure him on their behalf that they would listen to what he had to say with the greatest interest. (Applause.)

Mr. SWAN, who was received with great applause, said that during the last few months no subject, scientific or even popular, had occupied so large an amount of public attention as the electric light. Not only had men of science been discussing it, but almost everybody had been talking about it from one end of the country to the other. The subject had, for some considerable time before, been gradually acquiring importance, and gaining more and more attention both from scientific and practical men; but the crisis, if he might so call it, was reached in October of last year, when the following telegram from Mr. Edison to his London agent was fulminated:—"I have just solved the problem of the subdivision of the electric light indefinitely." This was immediately followed by the telegram:—"When the brilliancy and cheapness of the lights are made known to the public—which will be in a few weeks, or just as soon as I can thoroughly protect the process—illuminating by carburretted hydrogen gas will be discarded. With fifteen or twenty of these dynamo-electric machines, recently perfected by Mr. Wallace, I can light the entire lower part of New York City, using a 500 horse-power engine. I propose to establish one of these light centres in Nassau Street, whence wires can be run up town as far as the Cooper Institute down to the battery and across both rivers. These wires must be insulated and laid in the ground in the same manner as gas pipes. I also propose to utilise the gas-burners and chandeliers now in use. In each house I can place a light meter whence these wires will pass through the house tapping small metallic contrivances that may be placed over each burner. Then housekeepers may turn off their gas, and send the meters back to the companies whence they came. (Laughter.) Whenever it is desired to light a jet it will only be necessary to touch a little spring near it. No matches are required." The effect of the publication of these telegrams was electrical. For some time before these sensational telegrams were issued certain things of a very startling character had happened in connection with electrical science. Within a period of forty years this obscure branch of physics, previously unknown to practical people, or if known despised by them as useless, had in its results in several ways assumed an importance of the very highest degree. It was known that Mr. Edison was a man of extremely inventive genius, that he had invented an electric pen, a talking machine, a telephone, and no end of other wonderful things. Hence it happened [illegible] these telegrams were published the [illegible] world was struck [illegible] unquestioning amazement. Gas shares were immediately greatly depreciated in value, and those who possessed them were in the greatest state of alarm and even panic. He described various forms of electric light which the old-fashioned electrical machine produced, and gave an experiment to illustrate the kind of light producible by the ancient electrical machine. The discovery of the Voltaic battery, commonly but erroneously termed the galvanic battery, constituted the real starting point of the history of his subject. Up to the time of Volta, no means of producing a large quantity of electricity continuously were known. Hitherto it had been produced by friction, and in very small quantity. Volta discovered the means of producing electricity by chemical action, and in very large quantity. The lecturer explained the voltaic arc apparatus, by means of which he gave several wonderful experiments. The voltaic battery, efficient as it was, so far as concerned the production of electrical effects, was yet quite a hopeless means of obtaining these effects at a moderate cost, and so long as the production of electricity was expensive, so long would it be impracticable to apply electric lighting to common purposes. All the available forms of voltaic battery, so far devised, had in common this inherent vice, that the production of a certain quantity of electricity involved as a matter of necessity the oxydisation, in effect the burning of, a corresponding quantity of zinc. Zinc in the voltaic battery played the same part in the production of electricity that coal in a gas works did in the production of light and heat. Zinc, however, with us, was about fifty times the price of coal, and yet its possible effectiveness, weight for weight, was much less than that of coal; therefore, to use zinc as a fuel either for the production of light or heat; and whether by direct combustion, or indirectly by first producing electricity by its means, was to use a fuel at least fifty times more costly than coal. Cheap electricity—the one thing needful for the practical utilisation of electric light—had been obtained as the result of a discovery made by Faraday forty years ago; and he here gave an example of how a current of electricity was developed by motive power. The merit of first producing a machine that, by the action of motive power, would produce a perfectly continuous current, in all respects like that of the voltaic battery, belonged to M. Gramme, whose machine, and also that of Mr. Siemens, he described. They could now produce electricity by means of coal instead of zinc, and although they did not get really the full equivalent in electricity of the potential energy resident in coal and evolved as heat (because they only got it second-hand, the heat being first applied to produce motive power and the motive power to produce electricity), yet the advantages in point of cost, as compared with zinc-produced electricity, was so great as to completely change the position. Electro-lighting now rested on a new foundation. They had at last got a cheap source of electricity. He next referred to the various contrivances for applying the current most effectively to the production of light. There were two broadly distinct modes of producing electric light, one by means of the voltaic arc, and the other by means of the incandescence of an imperfect and infusible conductor such as platinum or carbon, both of which methods he minutely described. Next to the discovery of the principle of the Dynamo electric machine, nothing had given such a strong impulse to the industrial application of the electric light as the invention of the Jablochkoff candle, of which he had a few specimens for inspection. The light produced by the voltaic arc was so splendid that it was no wonder that great efforts had been made to utilise it and to overcome its chief defect, unsteadiness. It was wonderful how near an approach to perfect success in overcoming this defect had been achieved. Quite a sufficient degree of steadiness had been realised to render it serviceable for a number of purposes where a pure and very powerful light was required. So far, the most that had yet been done in the way of [illegible] by the Jablochkoff candle. What did electric light cost? This was a question difficult to answer, except in the most general terms, for the cost varied exceedingly with variation of circumstances. For example, what electric light would cost depended primarily upon what motive power cost, and that depended upon whether it was produced by the steam-engine, and in that case upon the cost of coal, or whether some other motive power was used, as, for example, a gas engine or a waterfall. In the one case it might be rather expensive, and in the other very economical. Then it greatly depended upon whether the power was expended in producing a very few powerful lights, or a great number less powerful. There was great loss in dividing electric light. If in one case they had one light equal to 10,000 candles, and in another 10,000 candle light

FEBRUARY 4, 1879.

divided over 100 lamps, much more power would be expended to produce the same total quantity in the case of the divided light. If they took as the datum of cost of motive power that of the most economical working steam engine, consuming say 3lbs. of coal per horse-power per hour, and if they put one horse-power, at that rate of cost, into one light, they could get a light equal to at least 1,250 candles. The cost of maintaining this powerful light was therefore exceedingly small, looking at the matter in the abstract. The fuel consumed might be roughly estimated as about the same as that consumed in the same time in a good house fire, such as they were accustomed to in the North; and the money cost per hour would be sufficiently covered by that now obsolete coin, a farthing. This estimate took no account of the cost of the engine and apparatus, nor of attendance. These were very considerable additions to cost in working electric light on a small scale, but were much less serious in large operations. Neither did it include any charge for waste of carbons going on at the lamps; that waste might be looked upon as avoidable. If the current generated by the one-horse power were divided over tan lights, probably only one-tenth of the light would be obtained; but that would be 125 candles, or equal to eight large gas burners, an ample light for a large room, and which could be obtained for the small cost he had named. Was electric lighting going to supersede gas? He thought there was little probability of that, as there were many advantages in favour of gas. Gas could be stored in a reservoir, while electricity could not. Gas could be used for heat as well as light, whereas it was doubtful whether electric heat could be used instead of gas heat. It was evident that both gas light and electric light had their special uses. Gas would continue to be largely used, perhaps as largely as ever, and electric light would also come into extensive use in its own special field. Among the many uses to which the electric light was put, he mentioned the lighting of Sir William Armstrong's picture gallery at Cragside, Rothbury. In an abstract of a report by two engineers on the cost of working for a month on a small scale the Jablochkoff candle system at Westgate-on-the-Sea, the relative cost of electric light and gas light was put at four to one. The Jablochkoff candle system was coating not so much on account of the power expended in producing the light as on account of the candles themselves, which cost 7½d. each, and lasted nominally an hour and a half. What was required to make electric street lighting, and shop and house lighting, successful was an electric lamp in which there was no waste of carbon and no machinery. Mr. Edison said he had invented such a lamp. Mr. Sawyer said he also had. If this were true, and if, along with these advantages, those lamps gave a satisfactory return in light for the electricity spent, then the chief problem was solved, and they would not have to wait long for a very extended development of electric lighting. But in any event, even if it should happen that those inventors had not accomplished quite so much as we had been led to expect, the problem of a simple and an economical lamp would, he did not doubt, be ultimately solved, and with its solution electricity would become a common means of illumination. (Applause.)

Sir Wm. Armstrong moved a cordial vote of thanks to Mr. Swan for his highly interesting lecture, which was carried by acclamation.

The lecture throughout was rendered additionally attractive by the introduction of various experiments with the electric light, all of which passed off with an unusual degree of success.

NOXIOUS VAPOURS.—A special meeting of the North-Western Association of Medical Officers of Health has been held in Manchester, under the presidency of Dr. H. H. Vernon, of Southport, for the purpose of considering the report of the Royal Commission on Noxious Vapours. As the result of the meeting, it was decided to memorialise the President of the Local Government Board, and to urge upon him the desirability of amending and

THE ILLEKTRIC LEET

Written on Mr. J. W. Swan, the inventor of the incandescent lamp, lighting with electricity his (Mawson & Swan's) chemist shop, Mosley Street. The first shop in Newcastle lighted by electricity (1880).

Tune – 'Billy O'Rookes the Boy'

Aave seen some queer things in maw time,
When gas did oil eclipse, sor,
For aa remember Neshim's men,*
Whe myed wor mowls an'dips, sor,
The tinder box an' rag isteem'd
Begat the loosifors, sor;
Yit still wor greet inventive brain
Is floorie as the Gorze, sor.

Chorus:
The Illektric leet! the illektric leet!
The pet ov all the seasin;
We'll he'd hung up th' morrow neet
Or else we'll knaa the reasin.

We've had sum clivor cheps it hyem,
Ye'll knaa what they wor worth, sor;
The lion gob ov the North, sor
The glory ov the North, sor.
Its ingins push the ships aboot
Faster nor the breeze, sor;
It helps to win wor wives and bairns
Thor bits ov breed and cheese, sor.

Chorus:
The illektric leet! the illektric leet!

Noo Stevinson an' Watt, ye knaa,
Sent Geordies ower the seas, sor,
To teach mankind to de the trick,
Myek steam de as they please, sor.
Ye'll find wors in Astrillia,
In aal the isles aboot, sor;
Fur aa'll be bund ne class ov men
Mair blabbed the secret oot, sor!

Chorus:
The illektric leet! the illektric leet!

So here's te Swan, wor canny man;
His 'llektric leet is fine, sor,
That burns away an' rivals day
In honour ov wor Tyne, sor.
The aud wax candles had thor time,
The gas wor sarvant, tee, sor;
But seun Swan's leet 'll blink like stars
Frov Sanget te The Kee, sor.

Chorus:
The illektric leet! The illektric leet!

"Weekly Chronicle," 1880.

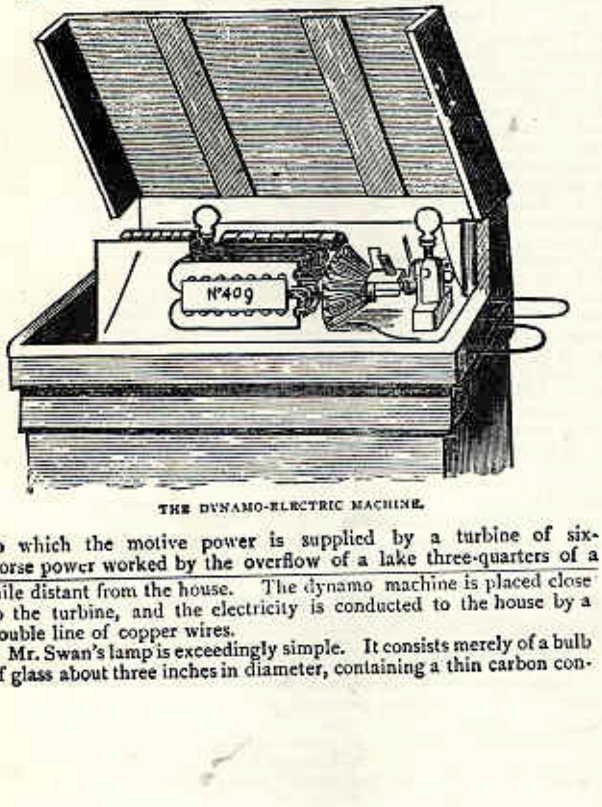
*About fifty years ago Mr. Nesham had a famous tallow-chandler's works on the site of Handyside's shops in New Bridge Street.

From The Graphic april 2nd 1881

SWAN'S ELECTRIC LIGHT AT CRAGSIDE

Two years ago Mr. Swan, of Newcastle, exhibited before the Literary and Philosophical Society, under the presidency of Sir William Armstrong, a new form of electric lamp, in which the light was produced by the white heat of a continuous carbon conductor enclosed in a small hermetically-sealed glass bulb. Many previous attempts had been made to utilise the incandescence of carbon, but never before had the difficulty of preventing the wasting of the carbon been so effectually surmounted. The distinguishing features of Mr. Swan's lamp were: its extreme simplicity, the durability of the carbon filament, and the economy with which light was produced.

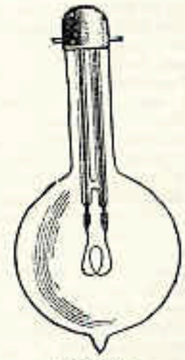
Since then Mr. Swan has devoted himself assiduously to improving his lamp, and he now has succeeded in bringing it into actual use for house and shop-lighting. Mr. Stearn, of Birkenhead, who aided Mr. Swan in the elaboration of his lamp, has lighted his house in this manner for several months past, and the business establishment of Mawson and Swan at Newcastle has been thus lighted uninterruptedly since October. But the largest and most complete application of the system has been the lighting of Sir William G. Armstrong's mansion at Cragside, which is depicted in our illustrations. At Cragside the electric current is generated by one of Siemens' dynamo-electric machines shown below,



THE DYNAMO-ELECTRIC MACHINE.

to which the motive power is supplied by a turbine of six-horse power worked by the overflow of a lake three-quarters of a mile distant from the house. The dynamo machine is placed close to the turbine, and the electricity is conducted to the house by a double line of copper wires.

Mr. Swan's lamp is exceedingly simple. It consists merely of a bulb of glass about three inches in diameter, containing a thin carbon conductor supported by two platinum wires, which, where they pass out of the bulb, are hermetically sealed into its wall by fusion of the glass around the wires. The air contained in the bulb is thoroughly exhausted.

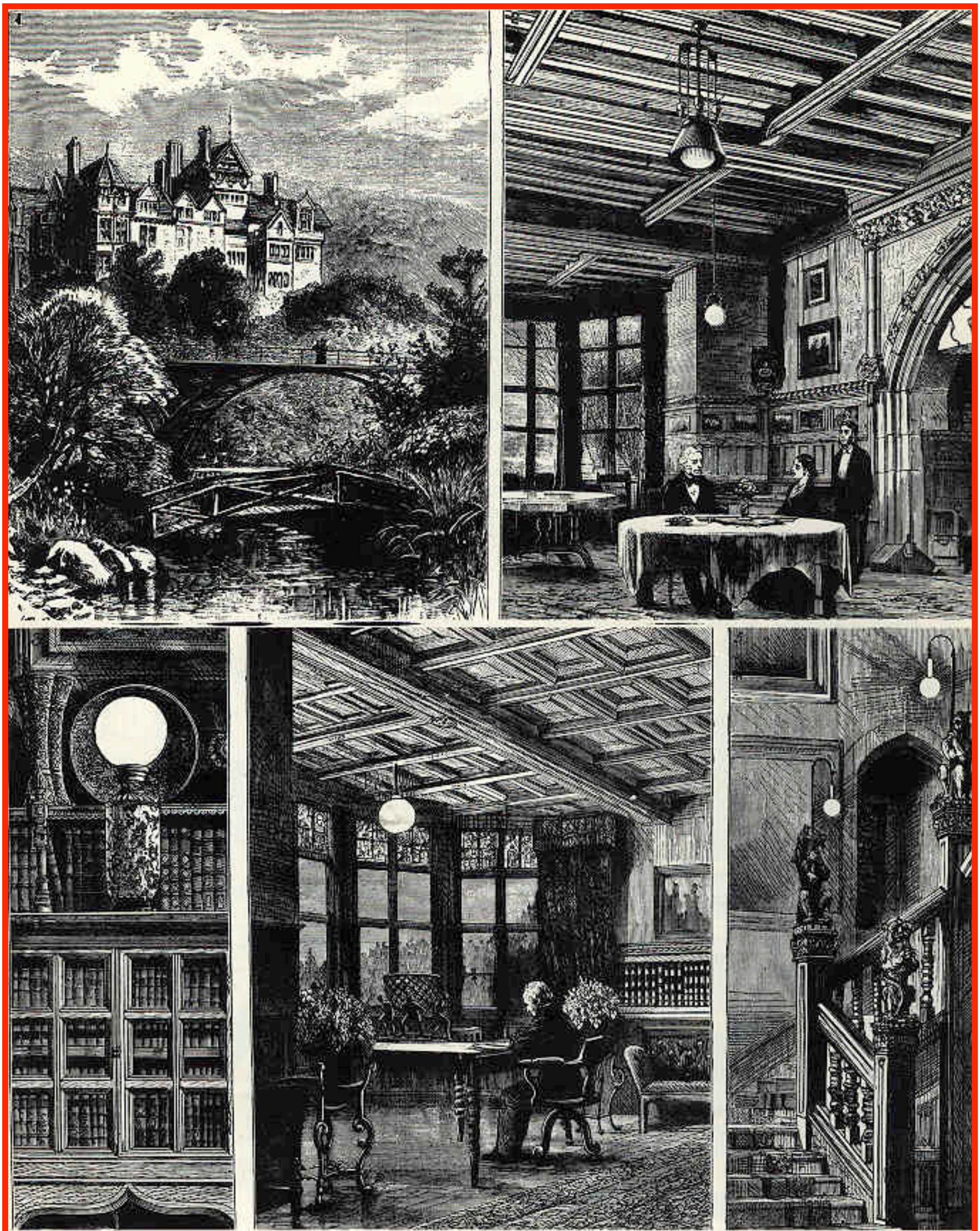


THE LAMP

The chief peculiarity of this lamp is the wonderfully thin and elastic filament of carbon, as thin as a hair, and almost as hard and springy as a steel wire. When the electric current traverses this filament it becomes white hot, and emits a soft and perfectly steady light. As the bulb contains no air or other gas capable of combining with carbon the filament does not burn away, but lasts without change for many months,—indeed, it becomes harder by continued use. The power of the light depends on the size of the carbon filament—the "wick" so to speak—and on the quantity of electric current flowing through it. The light emitted is totally devoid of that dazzling brilliancy which has generally characterised electric light of the old style, and therefore does not necessitate the screening of the light by opal or ground glass, though slightly frosted globes are mostly used at Cragside. Unlike the ordinary form of electric light, the Swan system can be divided absolutely to any extent without sacrifice of economy. Each lamp at Cragside has the power of two or three large gas lights. But it is just as easy, and no less economical, to make the lamps either much smaller or much more powerful. There are forty-five lamps in position. The current is turned on or off the lamps by small switches attached to the wall. It suffices to give one of these a slight turn, and the lamps immediately light up, and to reverse the movement and they all as quickly die out.

Sir William Armstrong has taken a warm interest in the installation of the light, and has himself directed all the details, and brought his wonted ingenuity to bear in adapting the new lamp to previously existing fittings; for example, the centre pendant in the dining-room was formerly used for an oil-lamp, this has been utilised to hold six Swan lamps; when these are lighted the effect on the table beneath is most beautiful. The pendant in the bay of the dining-room holds two other lamps.

A similar and equally happy adaptation of old lamp-fittings is shown in the vase lamp, Fig. 3, one of four (in addition to the pendant in the bay, which contains four lamps) employed for lighting the library. Each of the vase lamps has its proper place around the room, but is removable; they are so arranged by Sir William as to be lighted and extinguished by an exceedingly simple mechanical action. The picture gallery is lighted by twenty lamps contained in five frosted glass globes hanging from the arched roof. The peculiar suitability of a Swan lamp to the lighting of pictures is here demonstrated under the best possible conditions, for the pictures contained in the Cragside gallery are all of them masterpieces, the "Chill October" of Millais and a lurid sunset by Vicat Cole appear to equal advantage seen by the pure and steady light emitted by these lamps. There is a total absence of the prevailing violet light which characterises the ordinary electric light.



1. View of Cragside.—2. The Dining Room.—3. The Library.—4. The Bay Window in the Library.—5. The Staircase.

ELECTRIC LIGHTING BY THE SWAN SYSTEM AT SIR WILLIAM ARMSTRONG'S RESIDENCE, CRAGSIDE