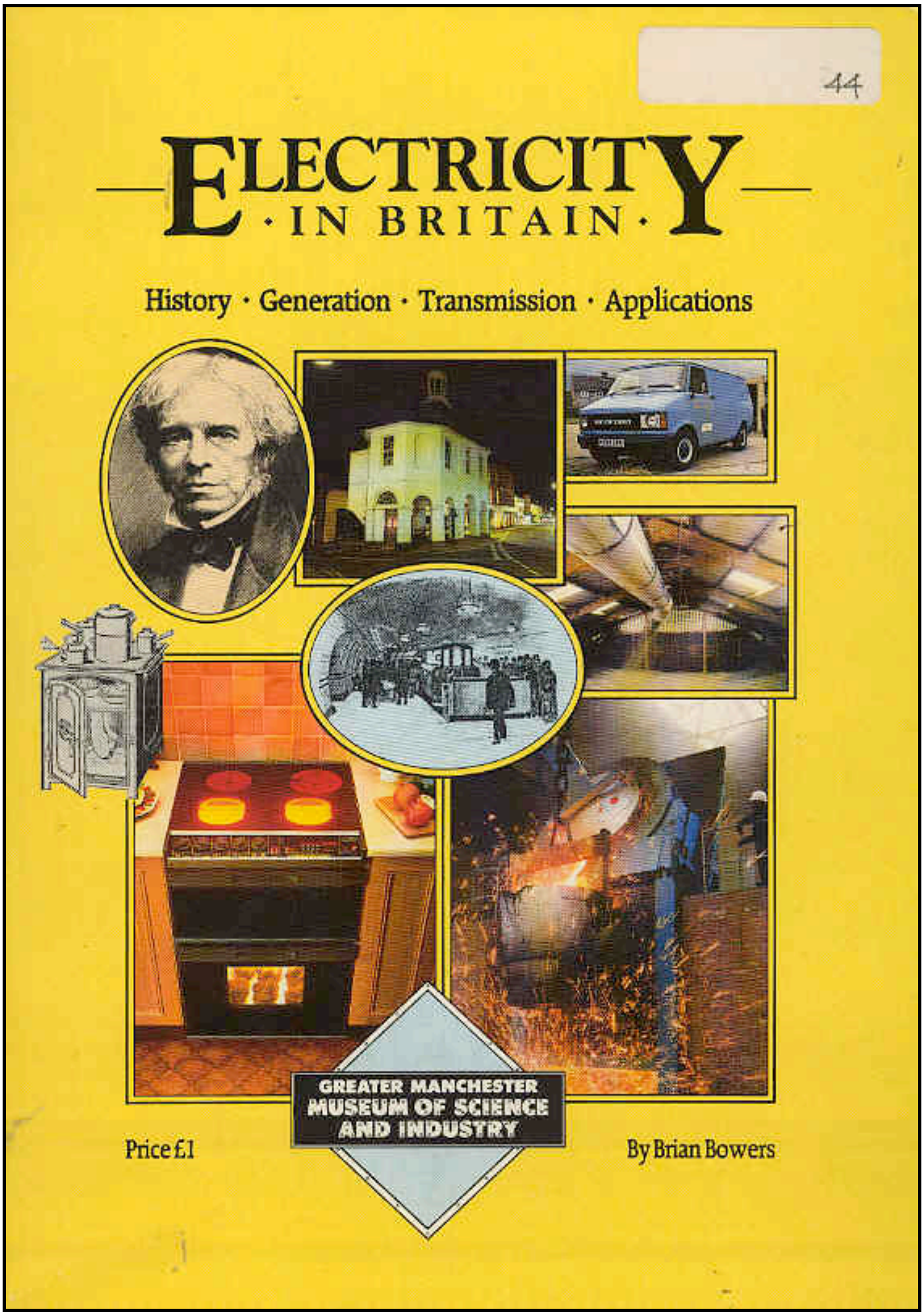


An Electricity Council booklet 1986 (extract)

INTRODUCTION

An electric current was first available in the year 1800, when Volta made the first electric battery. This was known as a 'pile' because it was made up of layers of metal discs, alternating with paper soaked in a salt solution.

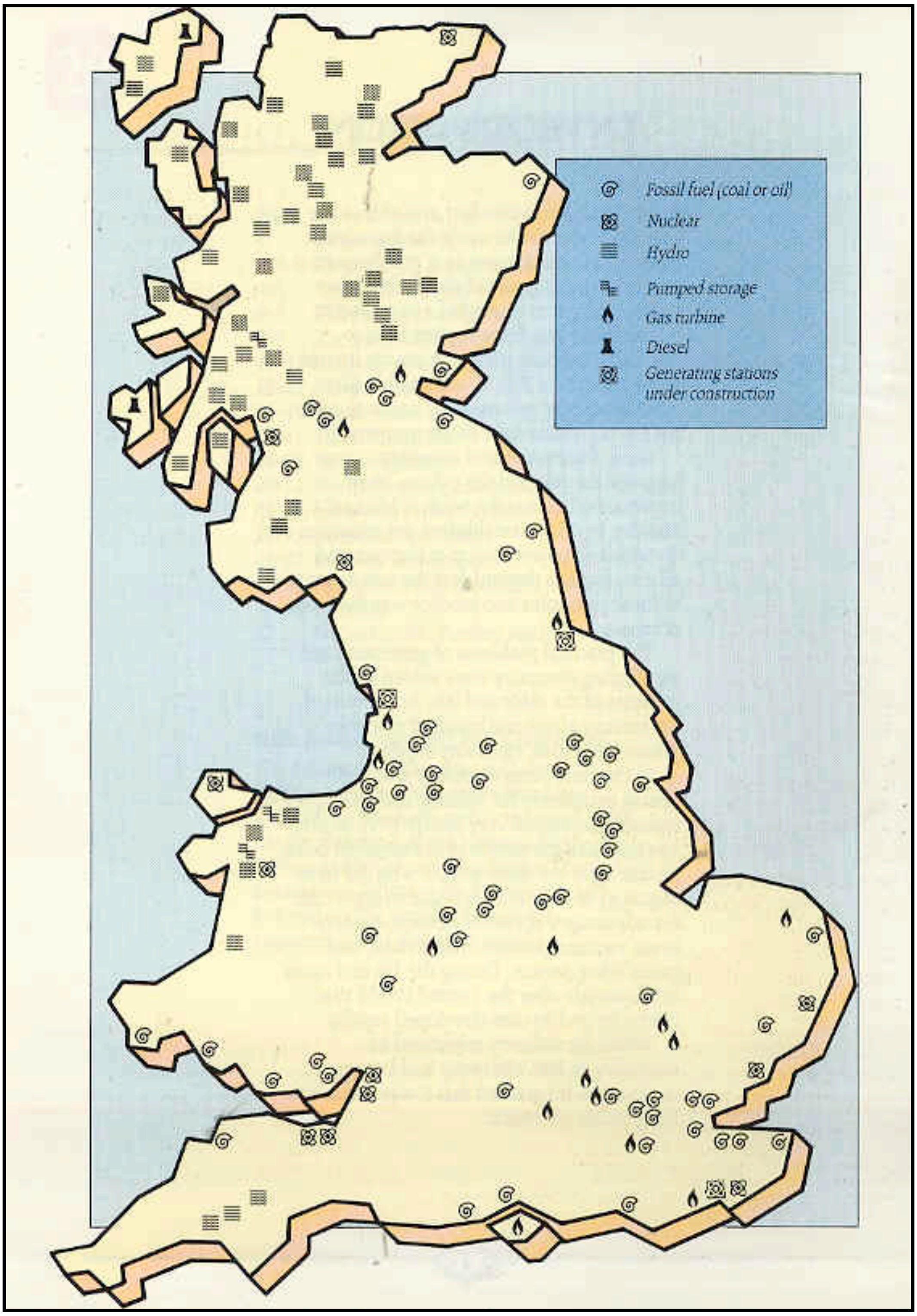
Electricity was first supplied from a 'central' generating station to private houses in the autumn of 1881. It was another fifty years before the pylons of the national grid became a familiar sight in the countryside.

Many discoveries and inventions came between the pile and the pylons. Most important of all was the work of Michael Faraday. In 1831 he established the principles on which all power station generators and all transformers depend, but the translation of those principles into practice was the work of others.

The practical problems of generating and distributing electricity were solved by the pioneers of the 1880s and 90s. At the turn of the century about one hundred places in Britain had public electricity supply.

In the early years electricity was used almost exclusively for lighting, and the supply industry developed very slowly. Even in 1931 less than half the homes of Britain could boast electric light, but those people who did have electricity in their homes began to appreciate the advantages of electric heaters, cookers, irons, vacuum cleaners, mains radio, and many other devices. During the 30s and again in the decade after the Second World War, electricity and its uses developed rapidly.

When the industry celebrated its centenary, in 1981, electricity had become so much taken for granted that it was difficult to imagine life without it.


Fossil fuel (coal or oil)
Nuclear
Hydro
Pumped storage
Gas turbine
Diesel
Generating stations under construction

ELECTRICITY IN BRITAIN TODAY

Our daily lives depend on electricity. Everyone uses electric light. Many people cook by electricity and use electricity for heating and hot water. In most homes there will be radio and television, an electric iron, a kettle, and a fridge. There may be an electric fire, a record player, vacuum cleaner, washing machine, food mixer and a variety of other appliances.

We may go to work on an electric train, though many people go by car along electrically lit streets with junctions controlled by electric traffic signals. In factory or office there will be electrically driven machines to ease our work. Or we may go shopping, and appreciate the warm air curtain at the door in winter or the air conditioning in summer, as well as the electric lights to see what we are buying before paying at the electrically operated check-out.

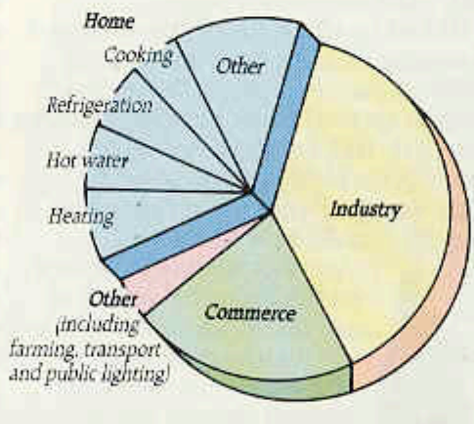
The power that serves us in all these ways comes from the power stations of the electricity supply industry, through the national grid, and through the local distribution network.

The map shows the power stations of England, Wales and Scotland. Those in England and Wales belong to the Central Electricity Generating Board, and the electricity they produce is distributed to the consumers by the local Area Electricity Boards. The activities of all these Boards are co-ordinated through the Electricity Council, a body whose membership includes all the Chairmen of the Boards.

In Scotland the industry is organised differently. Two separate bodies, the South of Scotland Electricity Board and the North of Scotland Hydro-electric Board, are responsible for both the generation and the distribution of electricity within their areas. All these systems, however, are interconnected through the national grid. It would be quite impossible to show all the wires connecting the industry's millions of customers. The main lines of the national grid are shown on pages 16 and 17.

In 1984 the 81 power stations in England and Wales supplied 203 thousand million units. Of this 36% was used in the home, 38% in industry and 22% in commerce. The remaining 4% was used in diverse applications such as farming, transport, and public lighting.

Of the electricity used in our homes, 21% was used for space heating and 18% for water heating. A further 11% was used for cooking, but perhaps the most surprising statistic is that 17% of all domestic electricity consumption was for refrigeration.



In 1920 the supply industry in England and Wales had just under one million customers. This figure reached ten million by 1945 and fifteen million by 1960. The latest available figures show an increase to twenty one million customers using just over two hundred thousand million units of electricity each year.

THE EARLY STUDY OF ELECTRICITY

'Volta's Pile' was first described in March 1800 when Alessandro Volta, an Italian Professor, wrote to Sir Joseph Banks, the President of the Royal Society of London.

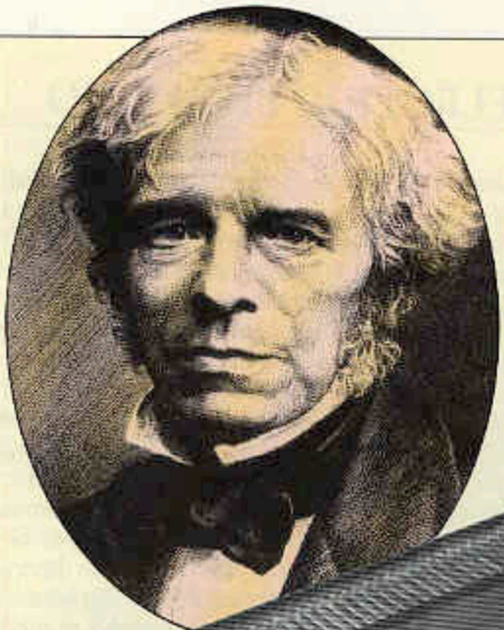
The pile was made of metal discs, any two different metals alternately, interleaved with paper soaked in salt water. Volta recommended silver and zinc. It produced the first continuous current of electricity. It was the first electric battery. Previously electricity had been known only as brief sparks produced by friction. It could be stored in a 'Leyden jar', but appeared only as a brief spark or shock, never a steady current.

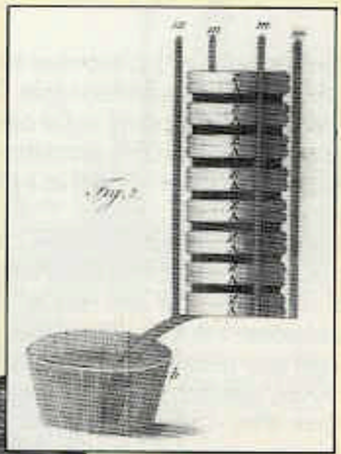
A few years later a boy called Michael Faraday read about Volta's work and made his own pile in his mother's kitchen. His discs were alternately pieces of zinc and halfpenny coins, which were mostly copper.

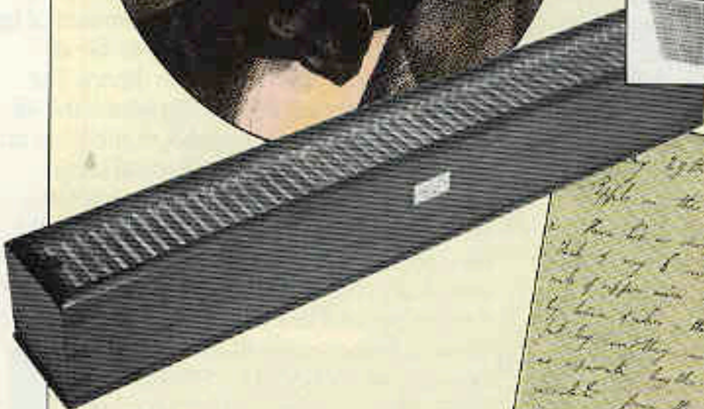
Michael Faraday (1791–1867) spent most of his working life at the Royal Institution in London. A number of people had studied particular electrical effects, including Humphry Davy (1778–1829) for whom Faraday first worked at the Royal Institution. Faraday sought a comprehensive understanding of electricity. The climax of his electrical researches was a series of three experiments in the autumn of 1831 in which he established the principles of electro-magnetism – the relationship between electrical and magnetic effects. The generators and transformers used by the modern electricity supply industry depend on those principles, though public electricity supply did not begin for another 50 years. Probably Faraday never even dreamed of electricity being supplied to our homes.

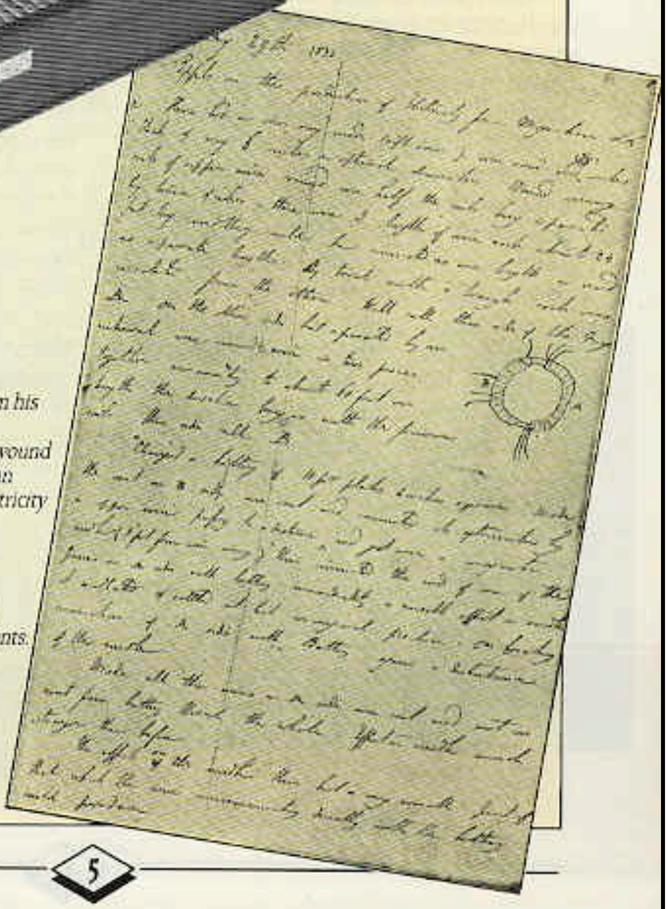
Many people made small generators with permanent magnets after his discoveries of 1831 became known. The power of these 'magneto-electric machines', or 'magnetos', was limited by the strength of the magnets. Many magnetos were used in electric telegraph systems, a few supplied lights, and a few were used for electroplating, an industry that began in the 1840s. None were powerful enough for people to think of building 'power stations' and distributing power to several users.

More powerful generators were developed in the 1860s, and from about 1870 it was possible to buy machines of several horsepower. By that time there were already firms in business producing cables, insulators, and other components for the telegraph. So when similar items were needed for electricity supply there was no problem about producing them. Equally important, the telegraph industry had created a group of practising electrical engineers with experience of long distance circuits. The Institution of Electrical Engineers was originally founded as The Society of Telegraph Engineers in 1871. By then the electric telegraph, with its wires on poles along the roads, was making people aware of electricity. Occasional demonstrations showed the possibilities of electric light, but public electricity supply could not begin until people wanted electricity at home. For that, one further invention was needed – a practical electric light. Several makers exhibited practical lights, suitable for the home, at the first International Electrical Exhibition, held in Paris in the summer of 1881.









An early battery (above) with zinc and copper plates in a wooden trough.

Michael Faraday (top left) and a page from his laboratory note-book (right)
His sketch shows an iron ring with coils wound on it. He found that starting or stopping an electric current in one coil "induced" electricity in the other coil.

The coil and horse-shoe magnet (far left) were used in the same series of experiments.

Volta's drawing of his pile (top right).

THE FIRST ELECTRIC LIGHTING

An electric spark, or arc, between two pieces of carbon produces a brilliant light. Davy discovered that very early in the nineteenth century, but until suitable generators were available it could not be used as a practical source of light.

In most arc lamps two rods of carbon are held end to end. The arc passes between the ends of the rods. The heat makes the carbons incandescent, but it also burns them away. If the light is to remain steady, the carbons must be moved together. Some early lamps, for theatres, were controlled by hand. For wider use an automatic regulator was needed.

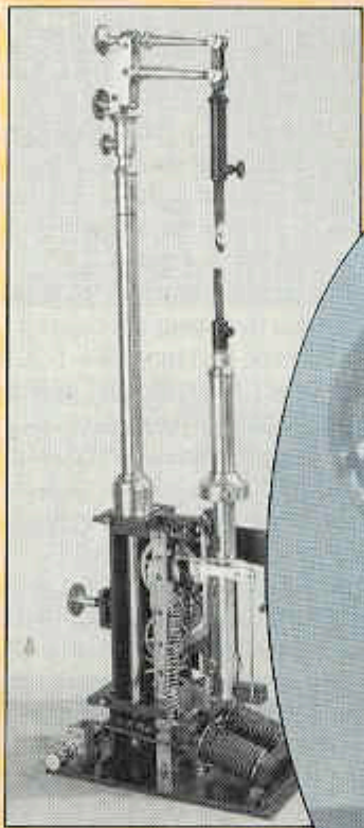
One type of arc lamp did not have any mechanism and was used for a few years for street lighting. This 'Jablochkoff Candle' consisted of two parallel carbon rods separated by a strip of plaster. A small bridge of carbon linked the ends of the rods. When the current was switched on the bridge fused and an arc started between the ends. As the rods burned the plaster between them crumbled, exposing fresh carbon. The disadvantage was that the candle could only be used once, for without that initial bridge it would not start. For street lighting that was acceptable–the man who had previously lit the gas went round changing candles instead.

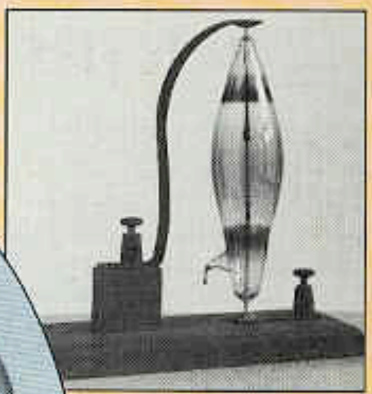
Jablochkoff candles gave the public a taste for electric lighting. Mechanisms which could be switched on and off were soon developed. The British electric lighting industry began when R E B Crompton imported Serrin lamps and Gramme generators from Paris, but from 1879 he made them himself at Chelmsford. Arc lamps were good for outdoor use, and in large buildings such as markets and railway stations, but they were too large, too bright, and too complicated for home use.

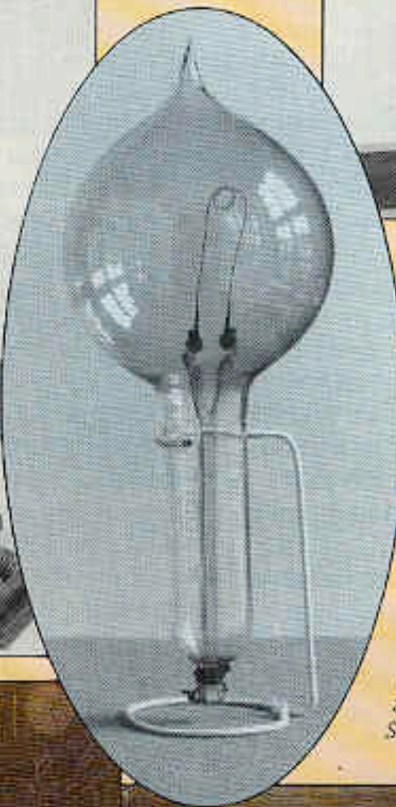
A smaller light was needed. People spoke of 'subdividing the electric light' when referring to the search for something smaller. One idea had been around for many years. A thin piece of wire could be made to glow by passing a current through it, but if it were made hot enough to give a useful amount of ligh then the wire melted or burnt up in the air.

The solution was obvious–in theory. The wire should be sealed in a glass vessel and all the air pumped out. Many people tried, but no one succeeded in making a practical lamp until about 1879. Probably the first was the Newcastle chemist Joseph Swan. He used a filament made from cotton thread, treated chemically to make it hard and smooth, and then carbonised in a furnace. In America Thomas Edison made filaments from carbonised strips of paper. They were very fragile and, after trying many substances he adopted fibres of a bamboo leaf.

In 1881 Swan, Edison, and two other inventors, St George Lane-Fox and Hiram Maxim, showed their lamps at the first International Electrical Exhibition. All four went into commercial production. The Swan and Edison interests in Britain were merged in 1883, and the united company dominated the industry, through the patents they held, until 1893.



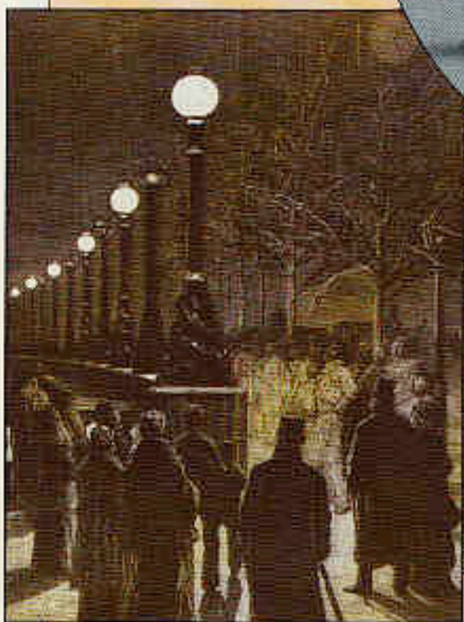




Two of Joseph Swan's experimental filament lamps. The long stem kept the heat of the filament away from the glass.

A Serrin arc lamp (far left) showing the regulating mechanism.

Electric light in London. The 'Jablochkoff Candle' 1878 illustrated (bottom left) on Victoria Embankment near Westminster Bridge and (below) the Royal Exchange and Mansion House lit by Siemens arc lamps in 1881.



THE BIRTH OF ELECTRICITY SUPPLY

Electricity was first supplied to the public at Godalming, Surrey, in late 1881. The council adopted electric street lighting, and the contractors also supplied a few private houses. The generator was in a water-mill whose owners allowed their water wheel to be used in exchange for free light.

The main streets were lit by Siemens arc lamps, and the side streets by Swan filament lamps. The installation created much public interest, but the River Wey was neither adequate nor reliable, and a steam engine was brought in. One problem discovered then has concerned supply engineers ever since: the lamps close to the generator were brighter than those further away. This problem of voltage drop in the wires was solved at Godalming by putting resistances in series with the nearer lamps.

Public electricity supply came to London in January 1882, when the English Edison company opened a station on Holborn Viaduct. They supplied one thousand lamps, for street lighting, in shops and offices, and in the City Temple–the first church in the world to use the public electricity supply.

Both these undertakings closed within a few years, but the supply which Robert Hammond began in Brighton in February 1882 was more lasting. Brighton has had an electricity supply longer than any other place. At first it was only in the evenings, but from 1887 it was day and night. Hammond first used direct current (DC), changing to alternating current (AC) in 1887 (see p.17), with high voltage distribution at 1800 volts. Transformers near the customers' premises reduced the voltage to 100. This made voltage control much easier. Originally there was a boy to watch a meter in the power station and adjust the generator as necessary, but he was soon replaced by an automatic mechanism. Possibly that boy was the first person to lose his job through automation!

Two major technical advances prepared the industry for the twentieth century. Sebastian Ziani de Ferranti (1864–1930) born in Liverpool but of Italian descent, was engineer to Sir Coutts Lindsay's Grosvenor Gallery Company. This generated electricity for an art gallery, but neighbours were impressed and asked for a supply. Soon wires spread over a substantial area of West London.

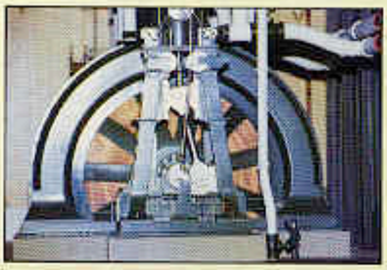
Ferranti planned a large power station on the bank of the Thames at Deptford. He designed engines and generators of 10 000 horse power, and made cables to transmit electricity at 10 000 volts–quite unprecedented.

The cables were successful, some remaining in use to 1933, but the generators were less satisfactory. The directors lost confidence, and Ferranti resigned.

The early coal-fired power stations used reciprocating steam engines. A major problem was vibration, and neighbours often complained. The solution was the steam turbine. The practical steam turbine was due to the Hon Sir Charles Parsons (1854–1931). Parsons was a son of the Earl of Rosse, himself a distinguished scientist. After degrees at Dublin and Cambridge, and an engineering apprenticeship, he joined Clarke Chapman & Co of Gateshead where he made his first turbine in 1884.

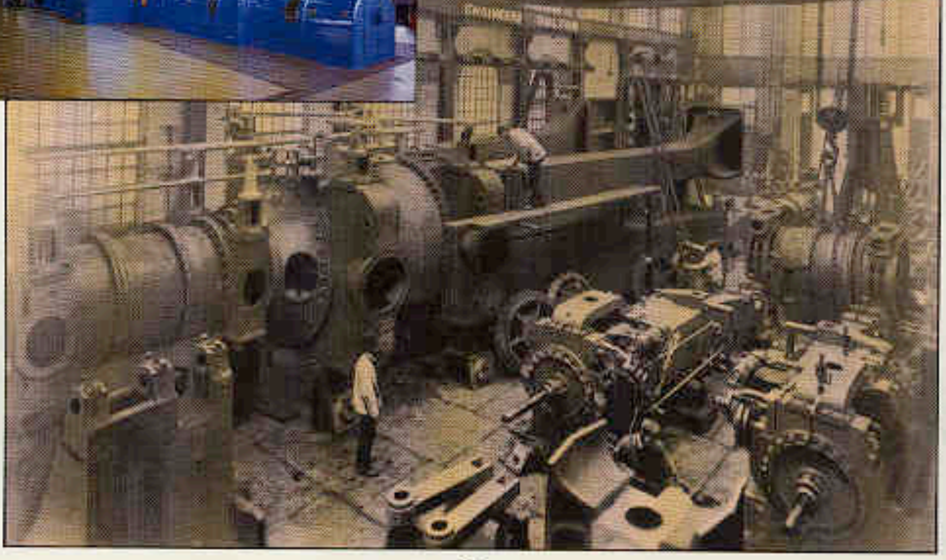
Turbines were first used because of their smooth running, but in larger sizes they are more efficient than reciprocating engines and have been used in all steam power stations since 1904.

Godalming in 1881 (above), lit by electric arclights, with inset showing Godalming today, lit by high pressure sodium lamps.

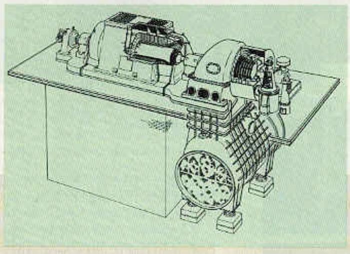


(Left) Model of one of the generators Ferranti designed for his Deptford Power Station.

Contemporary photo of Deptford Power Station under construction. (below): with inset showing a generator in a modern power station.



AN EARLY POWER STATION

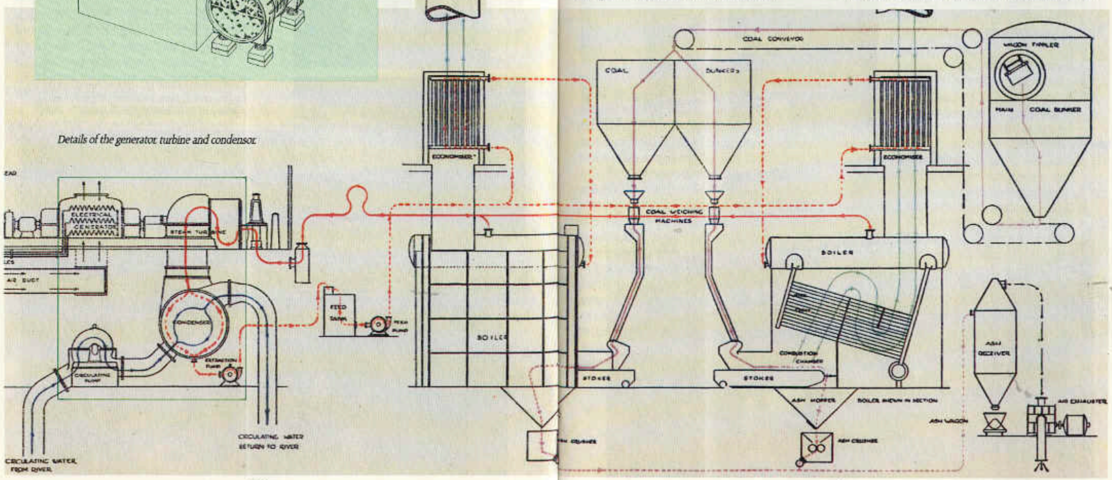


Most power stations in Britain burn coal. In 1983/84, 82% of the electricity generated by the Central Electricity Generating Board came from coal-fired power stations, which used 77 million tonnes of coal.

The drawing below shows the general arrangement of a typical coal-fired power station, 'Back o' the Bank', Bolton, as it was in the early 1920s. Only one turbine and generator are shown, though in 1923 there were six sets. The largest, made by English Electric with a capacity of 13.75 MW, is now a central feature of the Electricity Gallery at the Greater Manchester Museum of Science and Industry. Two coal-fired boilers were needed to supply the steam. The railway wagons bringing the coal were tipped over to drop the coal into the main bunker.

Electricity supply came to Bolton in 1894, though the original power station ceased generating after Back o' the Bank opened in 1914. By 1925 there were 10 000 customers who used 48 million units of electricity. Many of the customers used electricity only for lighting; there were fewer than 6000 domestic appliances connected.

By 1935 there had been considerable expansion. There were 30 000 customers with 35 000 domestic appliances, but although the number of customers had trebled the total consumption had risen only to 75 million units, less than twice the figure ten years earlier. This pattern of growth, with many more customers but using less electricity each, was repeated across the country as less affluent households adopted electric lighting.



Details of the generator, turbine and condensor.

THE NATIONAL GRID

The pylons of the national grid have been a familiar sight in the countryside since the 1930s. The grid was suggested by a Government committee under Lord Weir in 1926. They recommended that the various electricity supply undertakings should continue to own and operate power stations, and to distribute electricity within their own areas. A new Central Electricity Board would build and operate a 'national gridiron' linking selected power stations. The Board would buy electricity from those stations which could provide it most cheaply and then resell it to the supply undertakings. Less efficient power stations would close.

At the time there were 438 power stations in Great Britain. Weir thought about 50 were of suitable size and efficiency, though in the event the CEB selected 140 stations.

Initially the grid had 4800 km (3000 miles) of 132 000 volt overhead line when completed in 1933. Such a massive enterprise was bound to generate opposition and the CEB commissioned Sir Reginald Bloomfield RA to help design the pylons.

The grid soon proved its worth. It reduced generating costs by 11%, and reduced the need for reserve plant: the failure of a generator in one part of the country could be covered by drawing supplies from elsewhere. Nationally, spare plant was reduced from 75% to 15%.

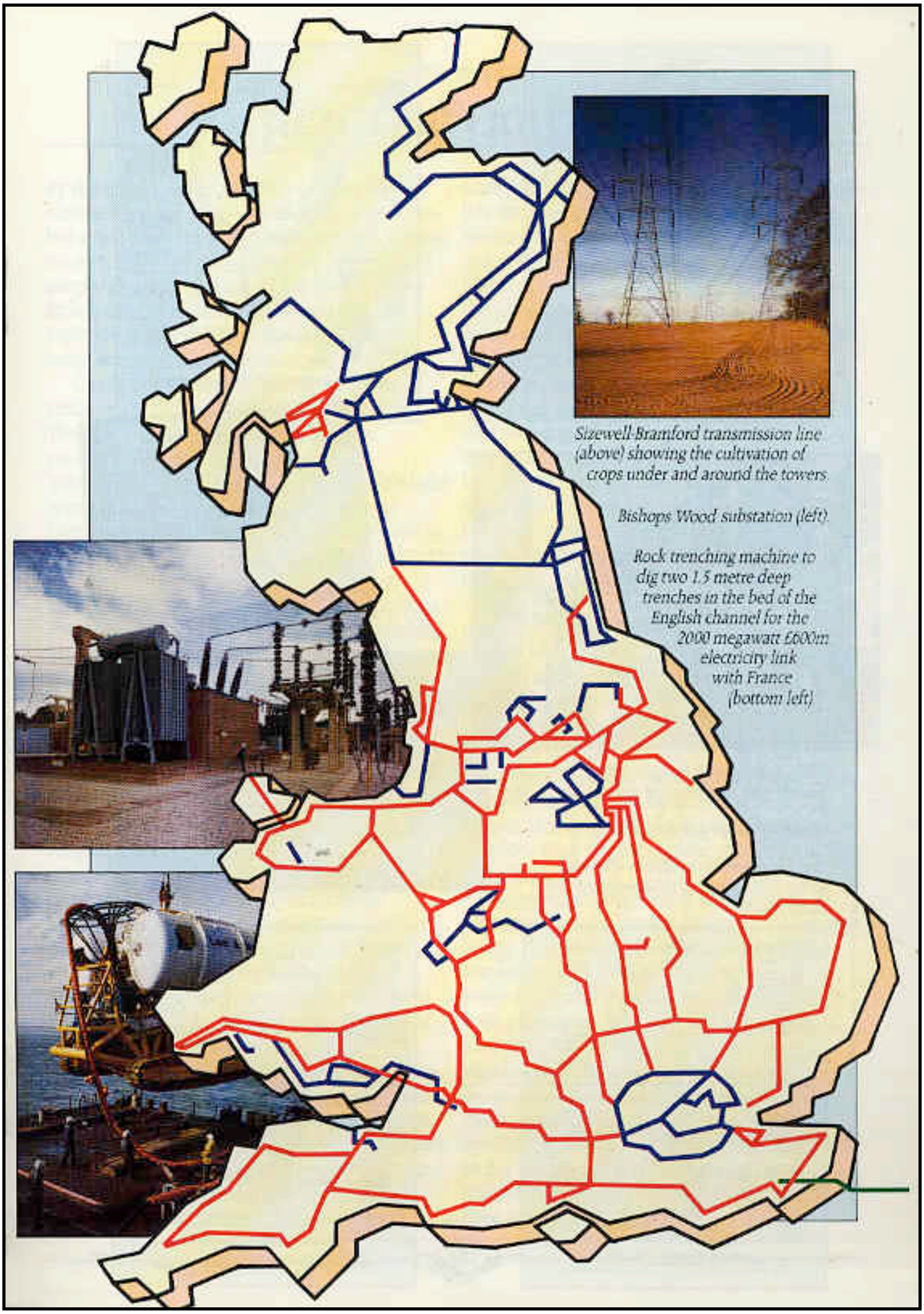
The original concept was for the country to be divided into seven self-sufficient grid areas, linked by tie lines. However, since October 1938 the grid has been operated as a single, national system.

The grid helped maintain industry during the Second World War. Damaged power stations could be replaced by bringing in supplies from elsewhere. The grid lines themselves were not often damaged by enemy action. However, many faults were caused when barrage balloons broke their moorings and their anchor wires became entangled in overhead lines.

After the war the demand for electricity continued to grow. In 1950 the decision was made to build a 'supergrid' operating at 275 000 volts but designed to be upgraded later to 400 000 volts. The map shows this higher voltage network. (The 132 000 volt lines, which are too numerous to show on a map of this size, now belong to the Area Electricity Boards.)

The grid has now become international. From 1961 to 1982 Britain and France were linked by cables capable of transmitting 160 MW in either direction. The patterns of demand are different in the two countries, so exchanging power provided each country with additional flexibility and security. The link was a technical and economic success, but had one weakness. The cables were laid on the bed of the English Channel, and often suffered damage from ships' anchors and trawls. A new 2000 MW link has cables buried 1.5 metres deep in the seabed.

The Channel cables carry direct current (DC) which is converted to and from alternating current (AC) in convertor stations at each end. There are two reasons for using DC. It is difficult to transmit AC through very long cables because of the electrical capacitance of the cable. Secondly, an interconnected AC system requires all the generators to keep in step with each other. Thus all the generators in Britain are kept in step by being connected to the grid. If an AC Channel link were used then all the generators in Britain and France would have to be kept in step, which would be very difficult to achieve through the single connection.



Sizewell-Bramford transmission line (above) showing the cultivation of crops under and around the towers.

Bishops Wood substation (left).

Rock trenching machine to dig two 1.5 metre deep trenches in the bed of the English channel for the 2000 megawatt £600m electricity link with France (bottom left)