CHAPTER I

THE BEGINNINGS OF THE POWER STATION INDUSTRY

They had no vision amazing
Of the goodly house they are raising,
They had no divine foreshowing
Of the land to which they are going;
But on one man's soul it hath broken,
A light that doth not depart;
And his look, or a word he hath spoken,
Wrought flame in another man's heart.

A. W. E. O'SHAUGNESSY

THE birth of the Power Station Industry was foreshadowed by Faraday's discovery, in 1831, that electricity could be generated by mechanical means, though many years had to elapse before machinery was available for its production on a commercial scale, or apparatus for its utilization had been devised. The development of the dynamo in its present form may be said to have started in 1845 when Wheatstone and Cooke patented the use of electro-magnets in place of permanent magnets for the field. Machines were not, however, made completely self-exciting before 1866 when the brothers C. and S. A. Varley, Dr Werner Siemens and Sir Charles Wheatstone, independently and practically simultaneously, discovered the principle of self-excitation. The production by Gramme, in 1870, of a dynamo with a ring-wound armature then brought matters to a point when the industrial generation of electricity really became a practical question. The following years were prolific in inventions concerning dynamo-electric machinery, notable amongst these being the open-coil dynamo of Brush in 1878, which played a prominent part in the early history of electric lighting. Long before this time, however, serious attempts had been made to obtain electricity from mechanical power by the use of machines of the magneto type.

The first Company to be formed for the exploitation of electric machinery was probably La Société Générale d'Electricité, of

Paris, which was founded in 1853 to develop a machine designed by Professor Nollet for the purpose of generating current for the electrolysis of water. The object was to produce hydrogen and oxygen for making limelight. The project was not successful, but the machine was modified by Professor F. H. Holmes and used for experiments in connection with electric light. Holmes's first machine was tried in the lighthouse at Blackwall in 1857, and on December 8 of the next year, light produced by his second machine was thrown over the sea from the South Foreland Lighthouse. These experiments were so promising that about 1859 another Company, called the Compagnie de l'Alliance, was formed for the manufacture of electric generators of the type in question. The "Alliance" machines, as they were called, produced alternating current, and were used to a considerable extent for lighthouse work by both the French and British authorities. Their characteristic feature was the production of their magnetic fields by means of a large number of permanent magnets of horseshoe shape.

On 1 February 1862, electric light was installed permanently in the Dungeness Lighthouse, the machine and lamp being of Holmes's design. A Holmes machine, dating from 1867, which was installed in the Souter Point Lighthouse in 1871, is preserved by the Institution of Electrical Engineers, to whom it was presented by the Corporation of Trinity House on its removal from the lighthouse in 1915. The machine, which weighs 3 tons, was driven at 400 R.P.M. by an Allen engine. It absorbed 32 H.P., from which a light of 1,520 c.p. was obtained. Alternators of the same type were employed for operating the two lighthouses at Cap la Hêve, near Havre, in 1863 and 1865 respectively.

The fact that a brilliant light could be produced by allowing an electric current to form an arc between a pair of carbon points had been demonstrated by Sir Humphry Davy before the Royal Institution in 1808, the current being obtained from a battery of 2,000 zinc-copper cells. Arc-lighting was for many years the only way of utilizing electricity for illumination. A mechanical arc lamp was produced in 1847 by Staite, who was followed by numerous other inventors, but the first type of arc lamp to achieve success on a large scale was the famous "Jablochkoff Candle"

invented in 1876. This consisted essentially of two carbon rods placed parallel to each other and separated by a plate of kaolin. A bridge of carbon paste connecting the tips of the rods was burned away when the current was switched on, and the arc thus formed maintained itself between the carbon rods, volatilizing the intervening partition as the rods were consumed. Self-regulating arc lamps did not appear until 1878, when von Hefner-Alteneck introduced the differential solenoid type, and Brush devised the clutch mechanism to effect the same purpose.

With dynamos and arc lamps at their disposal, the pioneers of the electric supply industry were able to proceed. They started, as we have seen, with lighthouse installations, as the intensity of the light rendered the arc lamp specially suitable for such work. On land the only field for the new light was in the illumination of large spaces, and one of the first applications for such a purpose was the lighting of the Gare du Nord in Paris in 1875. In May 1877 the Grands Magasins du Louvre, in the same city, put down an installation of 80 Jablochkoff candles supplied with current from Gramme machines driven by a steam engine in the basement. Within the next 18 months, this system of lighting had greatly extended. In 1878 there were several hundred Gramme machines in service, the latest type supplying alternating current, as this was found more suitable for Jablochkoff candles on account of the equal consumption of the two carbons. These machines had eight salient rotating field poles and a fixed armature. The largest absorbed about 16 H.P. at 600 R.P.M. and would serve 16 Jablochkoff candles. The Avenue de l'Opéra was lit by 46 lamps supplied from three 20 H.P. engines in different places; the Place de l'Opéra had 22 lamps, and there were altogether over 300 Jablochkoff candles in Paris.

Progress in England was slower. In its issue of 20 July 1878, *The Electrician* bewailed the fact that although the use of the electric light was daily extending in Paris, "yet in London there is not one such light to be seen". Londoners, however, had not very much longer to wait, for in the following month six Lontin lamps, installed by French engineers, were employed to illuminate the Gaiety Theatre, this being the first public building in

London to be electrically lighted. The effect was described at the time as that of "half a dozen harvest moons shining at once in the Strand". The Jablochkoff system, so successful in Paris, was introduced in this country on October 15 of the same year by Messrs Wells and Co., of the Commercial Iron Works, Shoreditch, who put up four lamps inside their showroom and two more at the entrance to their works, current being furnished by a Gramme machine.

The first move of importance by a Public Authority with regard to electric light was made on 18 October 1878, when, on the recommendation of their Works and General Purposes Committee, the old Metropolitan Board of Works accepted an offer of the Société Générale d'Électricité of Paris to instal an experimental system of lighting along the Thames Embankment. The Company were to supply 20 Jablochkoff lamps and the necessary electrical machinery, while the Board would bear the cost of providing the motive power, cables, standards, labour, etc. Within a week of this decision the City of London Authorities came to an agreement with the same Company to try the electric light along the Holborn Viaduct and in front of the Mansion House. Before, however, either of these schemes could be realized, the Billingsgate Fish Market, controlled by the Markets Committee of the City Corporation, was lit both inside and outside by electricity. The inauguration of the new system took place on 29 November 1878, thus giving Billingsgate the credit of affording the first demonstration of electric lighting by any Public Authority in London. The installation, which comprised 16 Jablochkoff candles in opaline globes, was also carried out by the Société Générale d'Électricité.

The Victoria Embankment was illuminated by electricity for the first time on 13 December 1878. The lights, which were along the river wall of the Embankment between the Waterloo and Westminster bridges, consisted of 20 Jablochkoff lamps spaced about 45 yards apart. On the other side of the Embankment, just west of Charing Cross Bridge, was a wooden shed containing a semi-portable steam engine constructed by Messrs Ransome, Sims and Head, having two cylinders each 10 in. diameter by

13 in. stroke. The engine, which worked with steam at 60 lb. pressure, was capable of developing about 60 I.H.P. at 160 R.P.M. It was belted to a countershaft from which were driven a direct current Gramme dynamo at 650 R.P.M. and its separate exciting dynamo at 700 R.P.M. The lamps were arranged five in series on four circuits, the eight conductors of bare wire being led through a 4 in. drain-pipe to the subway and thence to the lamp standards. The farthest lamp in the direction of Waterloo Bridge was 470 yards from the engine-house, and the farthest in the other direction was at a distance of 700 yards from the house. The original engine, after running nearly 5 years, was replaced by a Davey Paxman engine in August 1883. The system was extended on 16 March 1879, to a total of 40 lamps, and on October 10 following, a further extension brought the number of lamps to 55, the mains then extending from a point 6,092 ft. below Waterloo Bridge to a point 6,007 ft. above it. In June 1881 an agreement was entered into between the Metropolitan Board of Works and the Jablochkoff Electric Light and Power Co., by which the Company should maintain 40 lights on the Embankment and 10 on Waterloo Bridge for the price of $1\frac{1}{2}d.$ per lamp-hour. After the termination of this arrangement in 1884, the Company went into liquidation, as the price had been an unremunerative one, and as no other Company could be found willing to undertake the work on terms satisfactory to the Board, gas lighting was then reverted to.

The Holborn Viaduct installation was put into commission before the end of 1878, but the lighting of the Viaduct by electricity was discontinued on 9 May 1879, as being too costly, the expense being stated to be about four times that of adequate lighting by gas. It comprised 16 Jablochkoff lamps distributed over a distance of 473 yards, and supplied with current from a Gramme dynamo driven by a Robey undertype engine, the details of the work being generally similar to those of the undertaking on the Embankment.

In addition to the installations mentioned, the year 1878 also witnessed much enterprise by industrial undertakings and private individuals with regard to electric lighting, and various munici-

palities also commenced to take an interest in the subject. Before the close of the year *The Times* was using the new light in its printing office, and it was also being employed in such establishments as Messrs Pullar's Dye Works at Perth, the Steel Works of Messrs Cammell and Wilson at Dronfield, and Messrs Shoolbred in London. In Woolwich Arsenal it was installed in various departments, the Trafalgar Colliery in the Forest of Dean was using it for pit-head lighting, the London, Brighton and South Coast Railway had electric light in their London Bridge terminus, and St Enoch's Station in Glasgow was lit by Crompton arc lamps. Electricity had been tried for street lighting at Westgate-on-Sea, a game of football had been played by electric light before 30,000 spectators at Sheffield, and Sir William Armstrong had put down a small hydro-electric plant to generate current for the lighting of his picture gallery at Craigside, a mile and a quarter away.

An even greater activity prevailed during the year 1879. Messrs W. D. and H. O. Wills put down an electric light plant for their tobacco factory at Bristol under the advice of Professor S. P. Thompson who was then at the Bristol University. The Reform Club, the Langham Hotel, St George's Pier Head at Liverpool, the Avonmouth Docks, the sea front at Blackpool, etc., were all provided with the new form of illumination, which was also installed in the Reading Room of the British Museum, while the constructional work on the great railway bridge across the Severn at Lydney was also much facilitated by the electric light.

The generating units most commonly employed in those days were the Gramme and Siemens machines belt-driven from some simple kind of steam engine which was almost invariably combined with its own boiler. The makers of agricultural machinery seem first to have appreciated the field for electric light engines. The power for the Embankment lighting was furnished, as already mentioned, by a semi-portable engine constructed by Messrs Ransome, Sims and Head; that for the lighting of the Holborn Viaduct and the Billingsgate Market by Robey engines; Messrs Wallis and Steevens of Basingstoke supplied the semi-portable engine for the British Museum lighting; while Messrs

Clayton and Shuttleworth's portable engines were employed for the lighting of the Thorncliffe Works of Messrs Newton Chambers and Co., and a Garrett portable engine for the lighting of the front at Westgate-on-Sea. Messrs Marshall, Sons and Co. of Gainsborough exhibited a portable engine provided with a wheeled forecarriage on which was a dynamo, at the Kilburn Show of the R.A.S.E. in 1879, and indeed hardly a maker of agricultural engines seems to have neglected the opportunity for business afforded by the coming of the electric light. The earliest attempt to produce a high-speed direct-coupled unit was made by Mr Peter Brotherhood who arranged his recently invented three-cylinder engine to drive a dynamo directly from either end of the crank shaft. A machine of this kind was used for the experimental lighting of the terminus of the P.L.M. Railway in Paris by means of Lontin arc lamps on 7 September 1877, and according to an advertisement that appeared in 1879, dynamos by Wilde, Siemens and Gramme had all been driven directly by Brotherhood engines.

When no convenient cellar or other place existed for the accommodation of generating machinery, the latter was often housed in a wooden building which was the prototype of the power station of to-day. The nature of one of these early installations is well described in a paper entitled "Three Months' Experience of Electric Lighting at Blackpool", read in 1880 by Mr W. Chew before the Manchester Institution of Gas Engineers. The plant in question was put down for the illumination of the sea front by means of six arc lamps, and went into commission on 18 September 1879. The station consisted of a substantial timber building 60 ft. long by 25 ft. wide. On the ground inside was a wooden framing which formed the foundation for the machinery, the interspaces being filled with concrete and then boarded over to prevent dust rising. Upon this were fixed two Robey portable engines, each of 16 H.P., and at the opposite end were seven Siemens dynamos all driven by belts from a countershaft overhead between them and the engines. To quote Mr Chew's own words:

> From each of the six machines a distinct wire is led to its own lamp, and one common return wire so to speak, answers for the whole. You

will no doubt wonder what the additional machine was for. Well, at first the whole of the six machines had to perform the duty of producing their own electricity, but that duty is now taken from them by specially devoting a dynamo electric machine to the purpose solely, and this was found to be better for the lights.

The "wires", it may be mentioned, were first laid underground in 2 in. and 3 in. cast-iron pipes, but sea water got in the trenches while the work was proceeding and destroyed the insulation. The whole length of 1500 ft. had therefore to be withdrawn and carried on poles overhead.

As regards the operation of the plant, Mr Chew says:

> One engine man and his assistant look after the engines and boilers which require very great attention in their stoking, for a variation of 5 lb. pressure of steam will throw all the lights out of order. Another man is kept to oil the machines and keep all going right in that department as well as to look out for any light going out, which in some cases instantly shows itself at the machines, but always on a dial-board on which all the connections are made and on which we have suitable tell-tale apparatus.

The "dial-board" is clearly the original form of the modern switchboard, but it would be interesting to know the nature of the "suitable tell-tale apparatus". In a priced schedule of the equipment of the station, we find a "Strophometer" costing £10, a "Velocimeter" costing £2, and a "Galvanometer battery and Leclanché" priced at £5, these items apparently covering the whole of the instruments employed.

In October 1878 it was announced by Edison that he had "solved the problem" of "subdividing the electric light", the solution being, of course, the employment of incandescent lamps in parallel. To show how firmly the arc lamp was then established, in the minds, even of the best informed authorities, as the only practical source of electric light, it is interesting to recall the words of so famous an engineer as Professor Sylvanus P. Thompson, uttered in the course of a lecture on "The Electric Light" which he delivered on November 8 in the Colston Hall at Bristol. Referring to the recently reported announcement of Edison, Professor Thompson said:

> I cannot tell you what Mr Edison's particular method of distributing

the current to the spirals may be, but this I can tell you as the result of all experience, that any system of lighting by incandescence will utterly fail from an economic point of view, and will be the more uneconomical the more the light is subdivided.

The general disbelief that incandescent lamps would ever be able to displace arc lamps, or even to come into use on a practical scale for any kind of lighting, was also illustrated by the absence of any direct reference to incandescent lighting in the evidence given by such men as Sir William Thomson, Dr Hopkinson, Siemens and others before the Select Committee of the House of Commons in 1879, when an enquiry was being held in view of legislation concerning the new form of illumination.

Edison's first experiments with incandescent lamps were made with filaments of the rare metals, and it was not till later that he resorted to the use of filaments of carbon. Meanwhile, Mr Joseph Swan, who had been experimenting with carbon filaments since 1860, had been developing lamps with such filaments in Newcastle, and the question of priority in the use of this, the only really practical material at the time, was warmly debated. Swan's lamps were certainly well established in England before those of Edison, but litigation between the two parties concerned was wisely avoided by an agreement to amalgamate their interests. To this end the Edison and Swan United Electric Light Co. was registered on 26 October 1883, with a capital of £1,000,000, to acquire the British business and properties of the Edison Co. and the Swan Co. The claims of Swan were stated by the inventor himself in his paper on "Electric Lighting by Incandescence" read at the York meeting of the British Association in 1881, in the course of which he said:

> This simple form of lamp I showed lighted at a lecture which I delivered before the Philosophical Society of Newcastle in February 1879. Very soon after this, and I am quite sure, without knowing what I was doing, Mr Edison produced a lamp identical with mine in all essential particulars. It, too, consisted of a simple bulb from which the air had been exhausted by the Sprengel pump and which, like mine, had no screw-closed openings nor complications of any kind, but contained simply the ingoing and outgoing wires sealed into the glass with the carbon attached to them.

The first public demonstration of electric lighting on a large scale by means of incandescent lamps was given in Newcastle on 10 October 1880, and during the next year many installations of Swan lamps were put into service, one of the most noteworthy being for the lighting of the Savoy Theatre in London, which was inaugurated on 28 December 1881. This constituted the first example of a theatre being entirely lit by electricity. The power plant consisted of a pair of Fowler engines arranged to drive six Siemens A.C. generators which supplied current for the 1,200 lamps.

A further striking proof of the fallacy of Professor Thompson's prediction was soon to be given. On 2 January 1882, Mr E. H. Johnson, Edison's agent in London, obtained the permission of the City Authorities to undertake the lighting of Holborn Viaduct and the neighbouring thoroughfares by means of Edison incandescent lamps. Once again, therefore, the Viaduct was destined to play a prominent part in the history of electric lighting. At the time in question the original gas lighting had been restored, and the object of the Edison enterprise was to demonstrate the advantages of the then novel system of incandescent lighting by replacing the gas burners by electric lamps mounted on the existing gas standards. The agreement with the Edison Co. provided that the Viaduct and adjacent streets should be lighted free of cost to the City for a period of three months commencing on 1 February 1882, and although the City Corporation had no power to authorize a supply being given to private consumers in the vicinity, it was understood that they would raise no objections to such a proceeding. Work was started almost at once, and it is recorded that the plant was running by January 12 but for various reasons the opening ceremony did not take place until April 12, and the commencement of the three months' free trial period was deferred until April 24. At its conclusion the Edison Co. made an arrangement with the City Authorities to continue the lighting for a further period of six months, at the same price as gas lighting. This period was subsequently extended and service was continued until the station was shut down in 1886.

The power station was in a building (No. 57) on the north side of the street, a few doors east of the end of the Viaduct. The first