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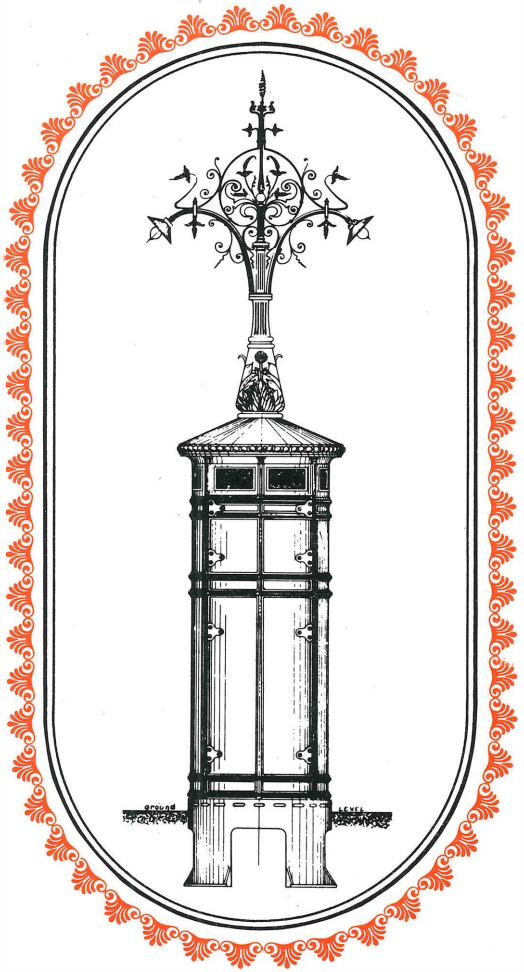
ELECTRICITY IN BRISTOL 1863-1948

by PETER G. LAMB



BRISTOL BRANCH OF THE HISTORICAL ASSOCIATION

LOCAL HISTORY PAMPHLETS

Hon. General Editor: PATRICK McGRATH

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Electricity in Bristol 1863–1948 is the forty-eighth pamphlet to be published by the Bristol Branch of the Historical Association. The author, Mr Peter Lamb, is a Senior Engineer with the South Western Electricity Board.

It is appropriate that this pamphlet should appear in 1981, for a hundred years ago, on 26 September 1881, the town of Godalming in Surrey became the first in the world to generate electricity for public and private lighting, twelve months ahead of New York.

Mr Lamb wishes to express his thanks to all who have assisted in the production of this pamphlet and provided information, especially retired employees of the South Western Electricity Board and the Central Electricity Generating Board. He is particularly grateful to Mr Scovell Whitmore, formerly Deputy Chairman of S.W.E.B., and to Messrs J. W. Dorrinton, G. Eveleigh, I. Davies, F. Jones, E. M. Nuttall, Mrs W. J. Thompson and Mr E. W. A. Edmunds. Mr C. J. Spittal of Bristol University Engineering Library, Dr B. Bowers of the Science Museum, London, and the staff of the Bristol Record Office and the Bristol Reference Library were extremely helpful. Mr David Large read the original manuscript and made a number of valuable suggestions as well as providing information on the gas industry and the tramways.

The Bristol Branch of the Historical Association wishes to thank the South Western Electricity Board and the Central Electricity Generating Board for the help it has given in numerous ways in the production of this pamphlet. Electricity House Photographic Department was very helpful with the illustrations. The front cover was designed by Mr R. A. Farmer. It shows an early decorated metal kiosk substation with incandescent lamps on top.

The next pamphlet in this series will be *The Streets of Bristol* by Elizabeth Ralph.

A list of pamphlets in print is given on the back cover. They can be obtained from most Bristol booksellers, from the shop in the City Museum, from the Porters' Lodge in the Wills Memorial Building or direct from Mr Peter Harris, 74 Bell Barn Road, Stoke Bishop, Bristol 9.

ELECTRICITY IN BRISTOL 1863–1948

The day must come when electricity will be for everyone, as the waters of the rivers and the wind of heaven; it should be not merely supplied but lavished, that men may use it at their will as the air they breathe.

Emile Zola, 1840–1902

ELECTRICITY IN BRISTOL 1863–1948

The first recorded public display of electricity in Bristol was on 10 March 1863 when a Grand Ball and Supper was held at the Victoria Rooms on the occasion of the marriage of the Prince of Wales to Princess Alexandra. A Mr Phillips from Weston-super-Mare put on a display.[1] He was again employed to illuminate the Clifton Suspension Bridge at the celebration of its opening on 8 December 1864. He fitted an arc light at the top of each pier, two more in the centre of the bridge, two lime lights at the base of each pier and four magnesium lamps in between. Press reports suggest that the effect did not entirely live up to expectations. *The Bristol Mercury* remarked that 'at times the effect of the light was exceedingly brilliant, the rays being distinctly pencilled and elongated and all the outlines and tracery of the bridge were rendered clearly visible, while at others the light presented a dim appearance and caused great disappointment.'[2] This may explain why it was another fourteen years before a further experiment was undertaken, and it was not until 1878 that the Cathedral was illuminated for a special Advent musical service.[3] A year later occurred the first recorded commercial use of electricity in the city when the Corporation's Docks Committee in March 1879 allowed Mr Brain of the Pyramid Electric Lighting Company to place lamps at Bathurst Wharf and Prince Street Bridge.[4] In the same year electric lamps were

1 *Western Daily Press*, 11 March 1863.
2 *Bristol Mercury*, 10 December 1864.
3 *Western Daily Press*, 29 November 1878.
4 *Western Daily Press*, 28 March 1879. Five different lamps were used: the Suisse, the Serrin, the Siemens, the Rapieff and the Pyramid Light. For the history of electric lamps, see A. A. Bright Jnr. *The Electric Lamp Industry*, New York, 1949. The power came from the Gramme machines driven by gas engines. The Gramme machine embodied the new invention of using an electromagnetic field energised by the dynamo itself.

used to light the entrance channel and the dock gates at Avonmouth Dock, which was then still in the ownership of a private company.[5]

All these early experiments involved generating power by using small steam or gas engines to drive a generator. Power stations as now known did not exist. Clearly, too, electric light was regarded either as providing a special attraction on a particularly important occasion or as being useful where an unusually powerful light was required in the docks. Otherwise, gas lighting or candles and oil lamps ruled the roost.

Indeed, as early as 1816 the Bristol Gas Light Company had laid the foundation stone of the city's first gas works, and by the following year five main streets were lit by gas. By the mid-century nearly 2,000 lights had been provided in the old city and in Clifton by two rival companies which contracted with the Paving Commissioners to supply public lighting. The very slow advance of gas from the streets, public buildings and shops into the home had begun. The first reliable gas cooker had been invented, and the advantages of gas lighting over candles or oil lamps, in spite of its considerably higher cost, had led the well-to-do to adopt it. The amalgamation of the two companies in 1863 and the impetus provided by the Corporation's Sanitary Committee, armed with powers acquired by the city as a Local Board of Health under the first Public Health Act of 1848, gave a substantial impetus to the spread of gas-lighting to the streets of the hitherto neglected suburbs, which were rapidly expanding.[6] But it is as well to emphasise that in the late 1870s the standard of street lighting was low, even in city centres. The typical street light was the 16-candle power open gas burner which gave much less light than a modern 25 watt bulb. Moreover little gas was sold for cooking and heating: coal was still king in the kitchen and the grate,[7] even though one in four homes in the country in 1881 were lit by gas.

The first signs in Bristol that electricity might challenge gas, candles, oil lamps and coal came in 1880 when the Sanitary Committee decided to spend £500 on an experiment to light the city centre by electricity. In due course, the Brush Electrical Company, the leading company at the time, set up for one month in January 1881 seven street lights using

5 See *The Electrician*, vol. 2, 8 March 1879, p. 181. Two Lancaster lamps at a height of 20ft, were installed on the Pier Head, and Wallace Farmer lamps were fitted at each pair of gates.

6 For the history of gas, see Helen Seal, *The Gas Industry in Bristol, 1815–53*, (B.A.Dissertation, University of Bristol, 1975), which is soundly based on primary materials. See also E. Liveling, *Bristol's Gas Supply, 1811–1823*.

7 I.C.R. Byatt, *The British Electrical Industry 1875–1914*, 1979, pp. 12, 26.

overhead wires to link them and providing power from a 12 hp gas engine installed at the bottom of Broad Street.[8] The Corporation was plainly impressed: in 1882 it vested responsibility for providing the city with an electricity supply in the Sanitary Committee, and it secured the necessary legal powers by obtaining a Provisional Order in 1883 under the Electrical Lighting Act of 1882. This gave the Corporation the right to own and operate an electricity supply system within its boundaries.

It is not easy to understand why Bristol, which was certainly not a city noted for 'gas and water socialism', should have been so anxious to set up municipal ownership of electricity. Its water supply, its gas supply and its trams were in private hands, and long remained so. It could have left electricity to private enterprise, and it is surprising that the council, with its conservative majority, did not do so. It may well be that the Council was carried away by the enthusiasm created by the American C. F. Brush's success in reducing the cost of arc lighting by the use of a high voltage multi-arc dynamo and the concurrent invention of successful incandescent lamps by Edison and Swan in 1879–80. This led to a short-lived somewhat hectic boom. Most large towns, including Bristol, witnessed exhibitions of arc lighting in 1879–80. Sales of equipment soared dramatically; there was a rush by private companies and municipalities, including Bristol, to obtain Provisional Orders and, thanks to an upsurge in the economy, there was much borrowing to finance the new craze. By the time Bristol had obtained its Provisional Order in 1883 the bubble had burst. Everyone was making losses. For instance, the Great Western Company, which had small installations of the Brush type in Bristol and Cardiff, failed to cover more than half its working expenses.[9] The truth was that it had been thought by everyone that electricity could be supplied at the same price as gas. This possibly might have been the case if the demand had been as great as had been expected. It was not, partly because of costs and partly because electricity was less reliable than gas at that time.

Fortunately for the Corporation, it had not embarked on establishing a supply. It decided in 1884 that a special committee, the Electrical Committee, should be set up to oversee this. Sensibly, the Committee appointed a consultant, William Preece (later Sir William Preece, Chief Electrical Engineer to the Post Office). His reports to the committee show plainly that he had serious doubts about the wisdom of going ahead. Two questions in particular worried him. Could

8 *The Electrician*, vol. 6, 11 December 1880, p. 37.

9 I.C.R. Byatt, *op. cit.*, p. 19.

electricity compete successfully with gas? Even if this was so, should an A.C. or D.C. system be preferred? Preece put the case for electric light. In December 1884 he reported that 'although electric lighting is twice the cost of gas, people will still take it for they can economise in the number of lamps burning and in the time that these lamps are alight. The electric light can be turned on and off, that is, it is only used when it is wanted and there exists none of the waste that occurs with gas, which is lighted when darkness begins and is only turned out when bedtime arrives. It is also argued that there is no damage done to decorations and that the frequency of internal painting is reduced.'[10]

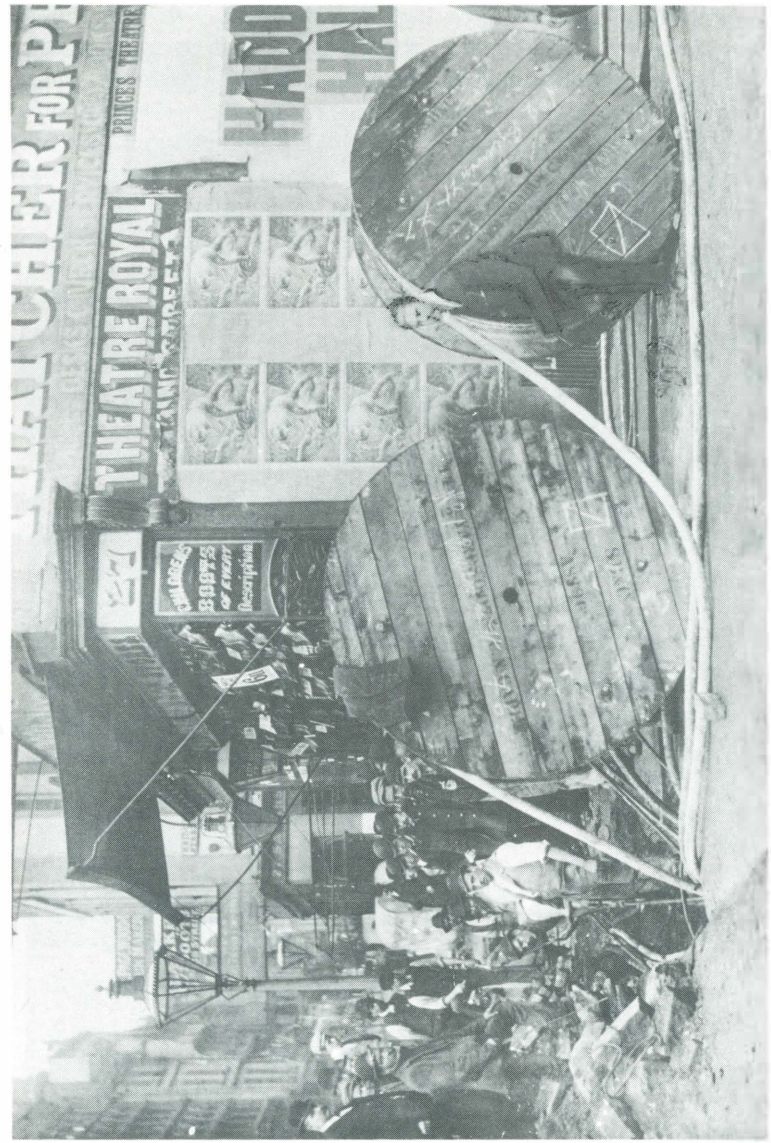
Of course, these were valid points. But Preece nevertheless did not advise the Electricity Committee to go ahead. Pressure to do so was applied, among others, by H. G. Massingham of Bath, owner of a chain of boot and shoe shops in the west country. He had been so impressed by the lighting display at the Cathedral in 1878 that he hired the generator and engine and removed them to Taunton. There he arranged a display in 1880, and in 1886 he made an agreement with the town's Borough Council to provide a permanent supply. He invited Bristol's Electricity Committee to Taunton and submitted to it a plan for setting up a public lighting system in Bristol using overhead wires. When this was turned down, he took his plant to Bath where he succeeded in impressing the Corporation sufficiently for it to sign a contract with him, and a supply began in 1890.[11] Preece, however, was still telling the Bristol Committee in 1887 that he did not think the Corporation would be justified in acting on its Provisional Order 'until electric light can be produced to compete with gas on more favourable terms than hitherto.'[12] This was indeed the crux of the problem. Preece's caution, whether justified or not, certainly delayed the development of electricity in Bristol.

So great was the cost-advantage enjoyed by gas for lighting in the 1880s that by the end of the decade there were only about 700 electric arc lamps in the streets of British towns. Moreover, in the early eighteen-eighties, incandescent electric lighting suitable for indoor use was three times dearer than gas, and even by the late eighteen-eighties

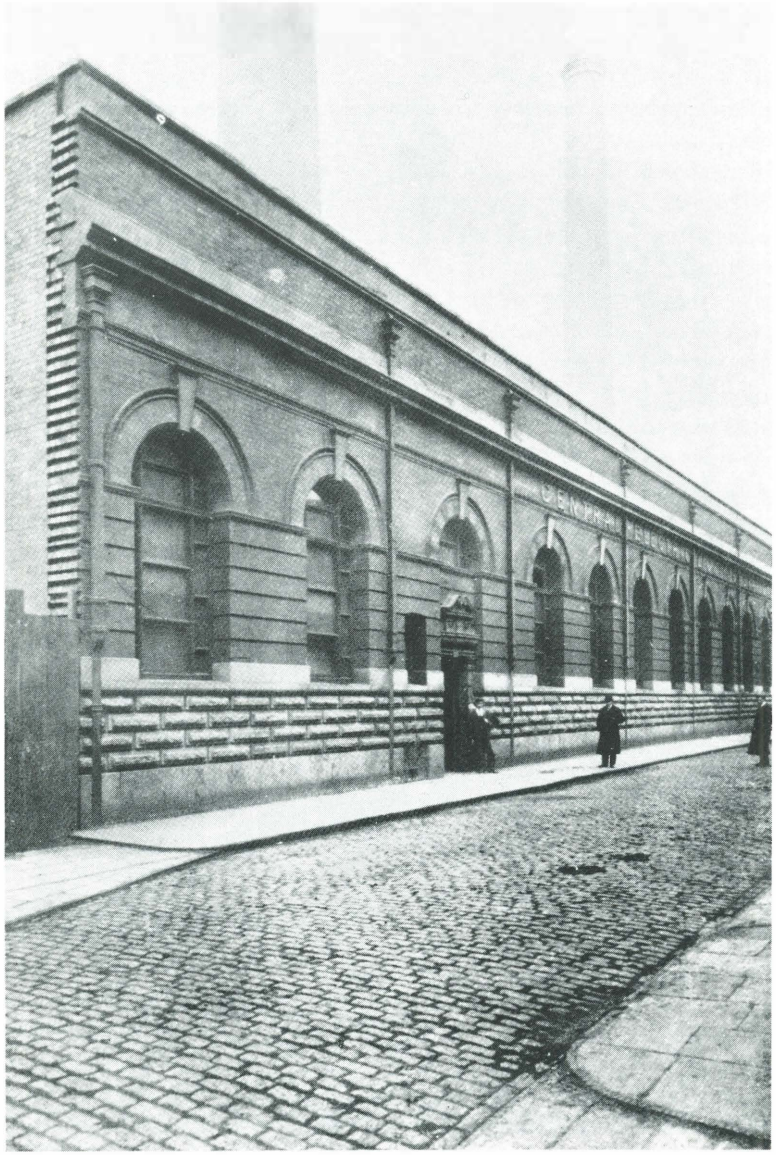
10 Bristol Record Office, Electrical Committee Minutes, Vol. 1. opp. page 17. (also Reports vol. 1. p. 9) 4 December 1884.

11 *The Electrician*, vol. 18, December 1886, p. 126; vol. 20, 13 April 1888, p. 619; W. E. Eyles, *Electricity in Bath*, published by Bath City Council in conjunction with SWEB, 1974.

12 Bristol Record Office, Electrical Committee Minutes, Vol. 1. p. 67, 10 October 1887.



First Cables being laid at High Street in 1893 (S.W.E.B. Avonbank Archives).



The first public supply generating station in Bristol at Temple Back (B.C.E.D. Booklet 1902).

it was still twice as costly. It was not until the late nineties that electricity came down to 'gas price'.[13] By 1889 Preece was becoming more confident as the cost of electric lighting fell. He reported to the Electricity Committee that 'electric light is the light of the future.' He did not, however, think it would 'do the least harm to gas, for the future of gas is in the supply of fuel and heat', and he added 'I have the courage of my convictions for I am not only a gas shareholder but I intend to increase my holding'.[14]

Bristol had, however, gone ahead with the building of a power station well before the end of the century. In December 1890 Preece had put three systems before the committee for their decision. Eventually in 1891 the committee recommended that the Council should spend £66,000 on a power station, two systems to supply 26,000 incandescent filament lamps at A.C. for indoor use, and 100 arc lamps for street lighting at D.C.[15] Much of the detailed design work was done by Gisbert Kapp, an Austrian, who had trained at Zurich as an engineer and then joined Colonel Crompton, the eminent pioneering electrical engineer and manufacturer, at Chelmsford. Kapp's career epitomised the international character of the electrical industry in its early days.[16] The major contracts for generators and mains cables went to Siemens, market leader in these fields in the early nineties. Tinker Brothers supplied the Lancashire boilers. The Brush Electrical Engineering Company, in origin an Anglo-American firm, was responsible for the transformers, and W. H. Allen for the condensers and pumps. The foundations and building works on the site at Temple Back were shared by Durnfords and C. A. Hayes.[17] And so eventually in 1893 Bristol's first permanent supply of electricity was provided.

13 Even then, gas shot ahead again with the widespread adoption of the incandescent gas mantle, which further reduced the cost. It was only when metal-filament electric lamps using about a third as much electricity for the same amount of light as previous lamps came into general use in the last years of Edward VII's reign that electricity was cheap enough to have a decisive advantage over gas for lighting purposes.

14 Bristol Record Office, Electrical Committee Reports, Vol. 1. p. 55, 31 May 1889.

15 Bristol Record Office, Electrical Committee Minutes, Vol. 1. pp. 100–106, 21 January 1891–3 March 1891.

16 D. G. Tucker, 'The Beginnings of the Electricity Supply in Bristol, 1889–1902', *Journal of the Bristol Industrial Archaeology Society*, Volume V, 1973.

17 Bristol Record Office, Electrical Committee Minutes, Vol. 1. pp. 130–177 January 1892–April 1893.

An opportune moment occurred for inaugurating it. A group of philanthropic businessmen had organised an Industrial and Fine Arts Exhibition in 1893 to celebrate the covering over of the river Frome in the city centre. The Electrical Committee agreed to supply electric light and an electrical clock.[18] So on 28 August 1893 when the exhibition was opened, the public supply of electricity in Bristol began. The first private consumers, 26 in all, were connected on 20 October.[19] Among them was Councillor George Pearson, Deputy Chairman of the Electrical Committee, who was to become its chairman from 1894 until 1921 and steer it through the problems of development.

It should be noted that Bristol was among the earliest municipalities to build a power station. Only Bradford (1899), Brighton (1891) and Stanhope Street, St. Pancras preceded it, although other authorities did so at the same time as Bristol.[20]

The Temple Back station was a very modest affair in its early days. Its six machines produced 700 kw which today would only be enough to serve about 200 houses.[21] Preece and his committee plainly did not share the vision of S.Z. Ferranti whose Deptford scheme of 1889 first embodied the modern system using a large generating station and high voltage transmission. Ferranti envisaged 7,500 kw alternators and transmission at 10,000 volts. It was perhaps as well that Bristol's Electricity Committee began on a far more modest scale, since the market for electricity in Bristol was relatively small. As will be seen later, the Corporation's undertaking was not given an opportunity to supply electricity for the running of trams. Moreover, in the nineties there was no significant market for supplying electricity to factories. Such a market did not emerge until the spread of the induction motor

18 20 arc lamps and 3–400 glow lamps were installed. For a photograph showing the clock, see plate 14 in H. E. Meller, *Leisure and the Changing City 1870–1914*, 1976.

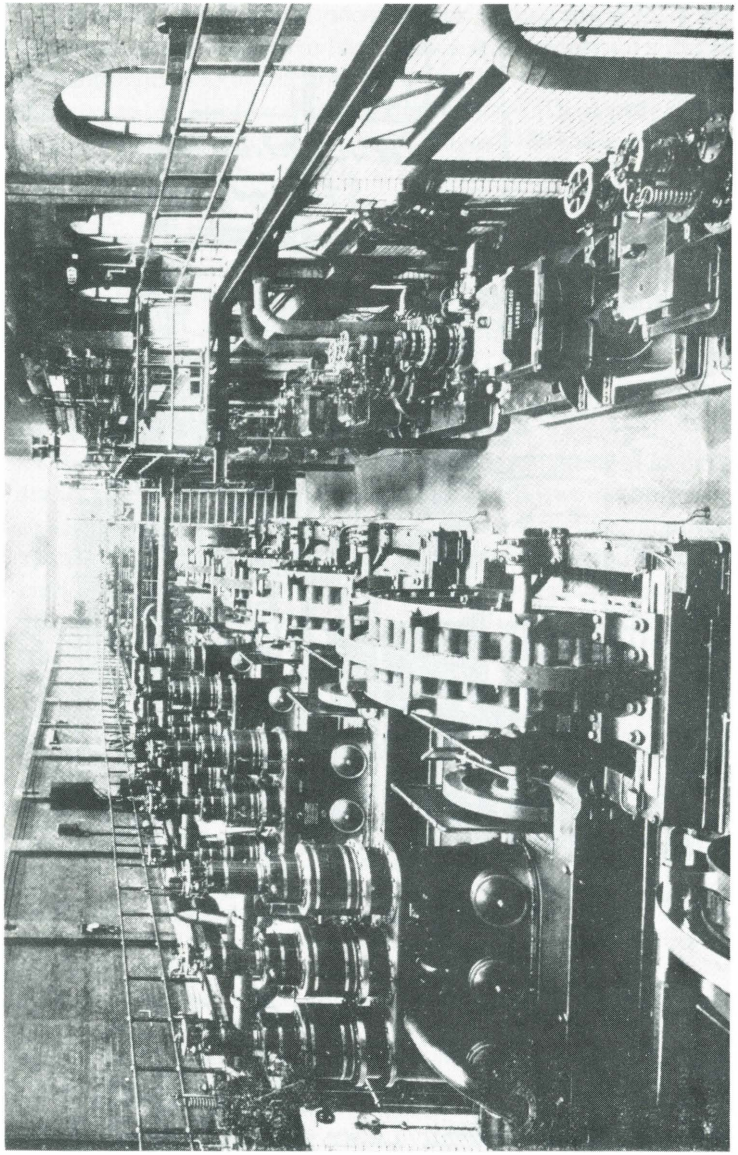
19 Bristol Record Office, Bristol Corporation Electricity Department, Consumer Register No. 1.

20 H. H. Ballin, *The Organisation of Electricity Supply in Great Britain*, 1926, pp. 6–12, for the Act and the Provisional Orders. Blackpool, Burnley, Derby, Dundee, Glasgow, Huddersfield, Hull, Kingston, Manchester, Whitehaven and Woolwich opened stations in 1893. By 1893 there were already 36 power stations established by private companies. See *Electrical Review*, Vol. 32, pp. 40–43, 13 January 1893.

21 The six sets of Willans-Siemens generators comprised 2–52 KW DC, 2–88 KW AC, and 2–210 KW AC. For further details of the systems in the Temple Back Station, see Appendix p. 000.

THE CORPORATION ELECTRIC LIGHT OFFICES, TEMPLE BACKS

Temple Back Offices 1893–1910, a sketch dated 1905 (S.W.E.B. Avonbank Archives).



The Temple Back Engine Room in 1902, completely full with 18 machines installed (B.C.E.D. Booklet 1902).

from about 1905 onwards and the increasing practice that went with this of purchasing electricity from outside the factory instead of generating it on the premises. Even then, the industrial demand in Bristol was not great, as she lacked the heavy industries such as iron and steel, textiles, shipbuilding, heavy engineering and mining, which were substantial users of electricity. Before 1905, electricity was occasionally used in the factory or workshop, but more for lighting than for driving motors, and it was usually generated on the premises. For example, as early as 1886 W.D. & H.O. Wills introduced electric lighting in their Redcliffe Street factory with the advice of Professor Silvanus Thompson of University College, Bristol, and in 1898 a generating plant was installed in the Bristol Waggon and Carriage Works at Lawrence Hill.[22] But as far as the Corporation's undertaking was concerned, lighting was its main market, and, as has been noted, gas remained a formidable competitor. As late as 1907 only about 6–7% of the country's population had electric light in the house. A modest start was sensible policy.

However, the system did grow, even though it was a slow process. Cables were laid through all the main streets in the city centre, and by the end of 1893 twenty miles of cable had been laid connecting 120 consumers and 90 public lamps.[23] By 1900 the consumers had multiplied tenfold, 128 miles of cable had been installed and the maximum demand — at dusk — had risen from the 226 kw of 1893 to 1,676 kw. Increased generating capacity had to be installed at Temple Back. Increased use meant that it was possible to reduce the price from the original 6d per unit to 4d, and thus electricity became more competitive with gas. To achieve all this, a staff had to be recruited.

Mr Harold Faraday Proctor was appointed Resident Engineer in November 1892 to superintend the works and was soon designated Chief Engineer of the undertaking at a salary of £260 per annum. He was descended from scientists on both sides of his family. He was the son of Bernard Proctor of Newcastle, a pharmacist and chief assistant to Joseph Swan in whose laboratories the earliest stages of the creation of the incandescent electric lamp were conceived and carried out. His mother was a niece of Michael Faraday, the discoverer in 1831 of the phenomenon by which electricity is generated. H. Faraday Proctor him-

22 See *The Electrician*, vol. 17 p. 61 4 June 1886, for the Wills installation. See *The Electrician*, vol. 41 p. 744 30 September 1898 for the Bristol Waggon and Carriage Works installation.

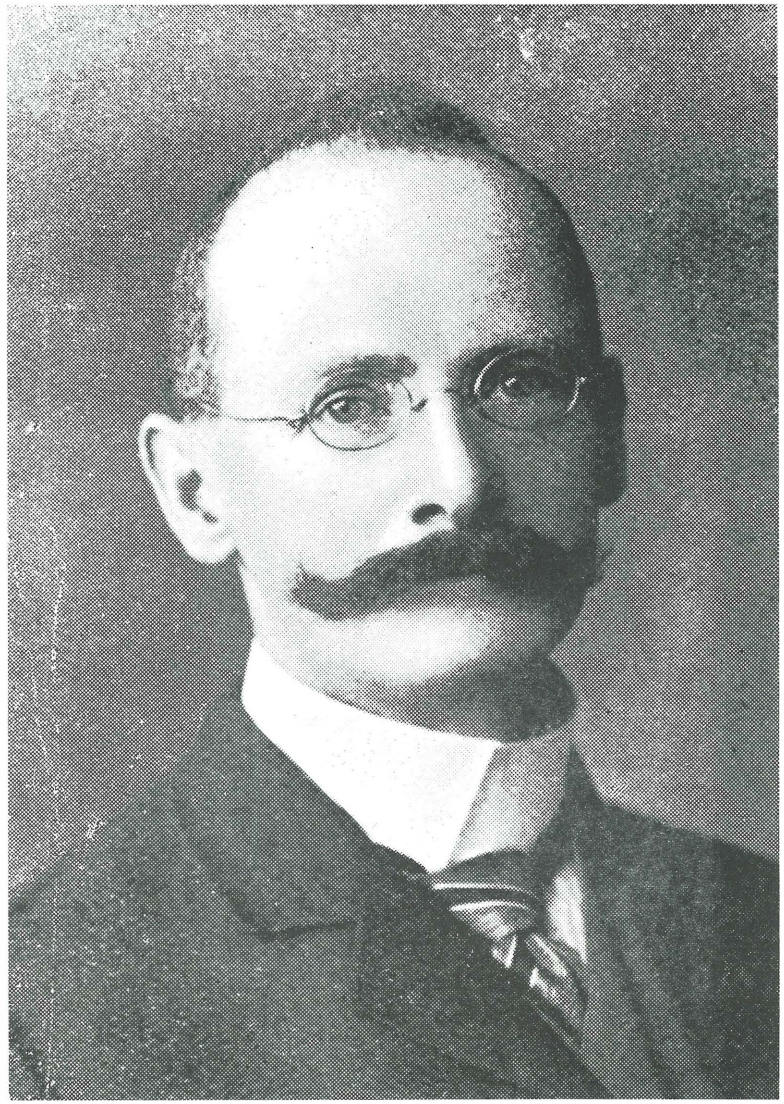
23 See Appendix p. 000.

self was interested in technical development and he registered in 1898, jointly with his deputy J. R. Blaikie, a patent for an improvement to switchboards.[24] On the administrative side, the key figure was Frank Prosser, and he remained the key figure until his retirement in 1928 after 51 years service with the corporation. He was the first Secretary to the Electrical Committee, later called Secretary and Accountant, with a salary of £170 per annum in 1893. The chief artisan was the Mains Foreman, John Duggan, who had come with the cable contractors but who stayed to join the municipal undertaking. He habitually wore a frock coat, bowler hat and a carnation in his buttonhole, as befitted the dignity of someone whose salary (£130 per annum) was on a par with that of the assistant engineer. At first, even the gangers wore bowlers until the cloth cap became the vogue. The pride in their work of these skilled tradesmen was considerable. It is said that one of the first cable jointers, George Elliott, was so dedicated that he used to practise his skill in his own time in his back yard and that his wife and daughters were made to watch.

Not all went smoothly, however. Calamities did occur. For example, in February 1895 the first employee to be electrocuted was Robert Coleman, in a substation in Old Market. His death caused the Committee to provide rubber gloves and shoes, to insulate floors with asphalt and to place guards round terminals.

A serious challenge faced the Electricity Committee in the nineties when the Bristol Tramways and Carriage Company introduced their first electric trams on a line from Kingswood to Old Market in 1895 and built their own power station outside the city boundaries at Beaconsfield Road, St. George. In this way they were not cutting across the rights obtained by the Corporation under its Provisional Order of 1883. Essentially, what the Tramway Company had done was to follow the advice of J. Clifton Robinson and become the first customer (along with the Dublin Tramway Company) of British Thomson-Houston, a company financed from Germany but staffed by American engineers and using American equipment. The Americans had pioneered the vital innovation of the overhead trolley method of bringing power from a central station to a traction motor which made electric trams possible. It was soon apparent that the economic advantages of electric traction over horse traction were substantial:

24 *Bristol in 1898: Contemporary Biographies* (Bristol, 1898, W. T. Pike and Co.) *The Electrician*, Vol. 41 22 April 1898. Patent no. 7057 A.D. 1898. Copy at Science Museum, London.



Harold Faraday Proctor, Chief Engineer of B.C.E.D. from 1892–1932 ("Bristol 1913, Its History, Its Commerce, Its Citizens" Edited by F. G. Warne).

Electricity Committee and Chief Officers in Temple Back Chimney 1897 (S.W.E.B. Avonbank Archives).

electric trams were about half as fast again as horse cars in crowded streets and even faster in the suburbs; the more powerful electric motor meant that trams carrying 60–100 people were possible instead of 25–50 in the horse-drawn car. Moreover, both power costs and capital costs per car-mile were reduced.[25]

Not surprisingly, the Tramway Company wished to electrify all its lines within the city. To achieve this a second power station was necessary which the Company wished to build within the city limits. The Corporation would not agree. Their consultant, Mr Preece, expressed the view that 'the construction, maintenance and working of tramways in a large city is the proper function of the Municipal Authority, that the tramways were best worked by electrical energy and . . . that considerable economy could be affected by combining electrical traction and electric lighting.' Most probably the consultant was influenced by the large-scale activity shown by municipalities up and down the country in the nineties in becoming operators of tramways and, once pioneers like the Bristol Tramway Company had shown the way, electrifying them. By 1903–4 eighty per cent of tramway passengers in the country were travelling in municipal trams. Exceptionally for a large city, this was not the case in Bristol.

The Corporation in effect lost the battle royal which ensued between it and the Tramways Company. The Company threatened to obtain powers to supply electricity to the public from their St. George power station. The council contemplated buying up the Company. Eventually, the corporation virtually capitulated, and in April 1898 agreement was reached. The Company would be allowed to build a second generating station within the city, while the Corporation would be entitled, if it so wished, to purchase the Company on 1 May 1915 or at any seven-year interval thereafter. The Company went ahead with its power station, buying the premises known as Finzel's Sugar Warehouse in Bath Street, Counterslip, and rebuilding them as an imposing, up-to-date power station. The building still stands as one of the more impressive sights in that part of the city. Clearly, the Company owed its victory in some measure to the energy of its managing director, George White, and to its technical efficiency which was vouched for in a favourable report in 1897 on its line from Eastville to Fishponds by the highly respected Board of Trade inspectors, Sir Francis Marinden and Major P. Cardew.[26]

25 I.C.R. Byatt, *op. cit.*, chapter 3; J.B. Appleby, *op. cit.*, pp. 14–21; 'The new electric tramway in Bristol', in *The Engineer*, vol. 79, pp. 197–8.

26 *The Electrician*, vol. 39, 1 October 1897, p. 765, and vol. 40, 11 February

The fact that it did not supply electricity for the trams helps to explain the relatively slow expansion of the Electrical Committee's undertaking. Nevertheless, the demand for electric light was growing, and by 1901 the original Temple Back station could no longer meet it. It was filled to capacity with 18 machines. A year earlier, a ten acre site had been bought at Feeder Road for a second station.[27] Grandiose plans were envisaged for the site, since the initial stage of development was described as 'only 1/33 of the ultimate scheme.' Sir William Preece was re-engaged as consultant, and the Chief Engineer, along with H. J. Williams, the architect of the first station, drew up designs for Sir William's approval. In fact, he strongly criticised the proposals for the foundations. In his view, they provided insufficient stability, but the Chief Engineer in turn thought Sir William's counter-proposals far too costly. Eventually, Sir Benjamin Baker was called in to arbitrate and came up with an economical plan to increase stability which was satisfactory to all — building in old steel rails to form a tie across the whole width of the floor at intervals of 8 or 10 ft. Construction then went ahead, and Avonbank Electricity Works, as it was then known, was commissioned in 1902 with two 745 kw generating sets. The prime movers were Willans single-acting triple expansion steam engines of 1,000 hp each, which were directly coupled to Siemens alternators. Four water tube boilers made by Babcock and Wilcox were installed, each giving 14,000 lbs of super-heated steam per hour, and coal was delivered by barge via the Feeder Canal. The weekly pay was brought by motor launch from the Temple Back offices.[28]

The Feeder Road Power Station, as it came to be known later, served Bristol until as late as 1955 when it was taken out of commission. Originally generation had been at 2,000 volts single-phase 93 cycles. The second stage of construction, however, in 1903 included the innovation of two Parsons turbine sets of 750 kw capacity, though still generating at 2,000 volts. Introducing turbines at this time showed that the Bristol undertaking was abreast of technical advance. The steam turbine, invented by Charles Parsons, was an important capital-saving innova-

1898, p. 531.

27 The site was bounded by a GWR line, Feeder Road and Bennett's colliery belonging to the Bedminster company.

28 Bristol Corporation Electricity Department: *Inauguration of Avonbank Electricity Works*, Bristol, 1902; G. Watkins, 'Bristol Electricity Supply' in *Journal of the Bristol Industrial Archaeological Society*, vol. 3, 1970; *The Electrician*, vol. 48, 14 Feb. 1902, pp. 643–8; *Electrical Review*, vol. 50, 21 March 1902, pp. 473–7.

tion. It enabled smaller dynamos to be used, and because it was able to run for a short time at very high loads, it could cope with brief periods of peak load without it being necessary to instal extra capacity to meet such a peak. Only six were installed before 1904, although in the following years most of the new generating capacity was turbine-powered. Indeed, in 1905 the first 1,000 kw turbine sets were installed at Avonbank, and this time generation was at 6,600 volts three-phase 50 cycles, which was to become the national standard. The new station was connected to the original Temple Back Station, and 6,600 volts feeders were connected to Underfall Yard in 1906 and to Avonmouth in 1908 where rotary substations were established to provide D.C. supplies to the city and Avonmouth Docks respectively.

For public lighting in central Bristol right down to 1924 arc lights on D.C. were used, and it was not until after the blitz that these lamps were connected to the A.C. system. The early arc lights were far from trouble-free: indeed men called 'trimmers' were employed to visit them frequently, since the carbons on the early models could only last six hours before burning out. A second pair was then supposed to come into use automatically but did not always do so. Gradually, however, arc lamps that would burn for longer than twelve hours, provided by two sets of carbons, were brought into use.[29] Arc lights served their purpose better than incandescent lamps in the early days by providing a brighter light. Nevertheless, with the development of the Tungsten filament lamp from 1911, incandescent lamps were being used for street lighting to a much greater extent because they were efficient and equal in output to the arc lamp and required less attention.[30] So it would appear that the Bristol undertaking was very conservative, to say the least, in keeping the arc lamp in service for over ten years.

The Bristol Corporation's ability to provide a proper supply of electricity was challenged on a number of occasions in the early life of the Electricity Department. The most serious challenge came in 1903 when a new Company called the Somerset and District Electric Power Company was established by Act of Parliament. It was empowered to

29 Bristol Corporation Electricity Department *General Description of the Undertaking 1911*. The early arc lights were the Brockie Pell type. In 1910 a new lamp with six pairs of carbons, lasting 36 hours, was introduced. In 1906, of nine firms canvassed by the Corporation, only three made lamps which burned for more than 16 hours. The new lamp in 1910 is of particular interest as it is not known to be in common use elsewhere.

30 I.C.R. Byatt, *op. cit.*, p. 22. Also *The Pageant of the Lamp*, published by Edison Swan Electric Co. Ltd. 1950.

give a supply over a much larger area than Bristol, including parts of North Somerset and Wiltshire. The initiator was Philip Napier Miles, who lived in Kingsweston House. However, the 'try-on', as it was affectionately known by the Corporation officials, never succeeded. As the Company had not generated a supply by 1909, an Order was issued by the Board of Trade revoking its powers, and the Corporation officials breathed a sigh of relief.

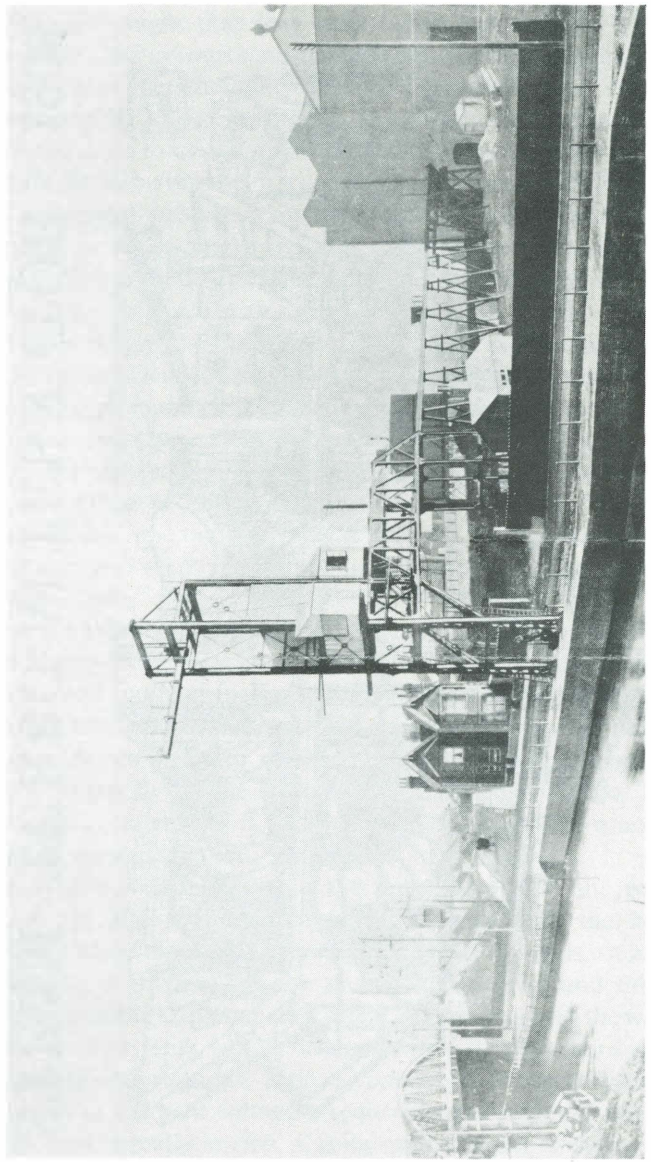
The year 1903 which saw the first emergence of this challenge was also memorable for another reason in the history of the municipal undertaking. On Wednesday 23 December 1903 at 5.15 p.m. a serious fire at Temple Back destroyed the 2,000 volt switchboard. A complete shutdown followed, plunging Christmas shoppers into darkness throughout the city. An offer of help was received from the Tramways Company, and it was reported that 'the Tramways Company supplied, erected and connected five arc lamps in the engine room, running cables from their Counterslip Power Station close at hand.' The main power was back by 2.30 a.m. on Thursday.

The Edwardian age was notable not only for the building of a second power station, but also for innovations in the sale of electricity. A special power tariff of 1½d per unit was introduced in 1900, and a cooker tariff of 1d per unit in 1912. In that year, too the first demonstration in Bristol of cooking by electricity was arranged in the unlikely setting of the Museum Lecture Theatre. Earlier than that, in 1908, the Bristol Corporation Electricity Department, to cite its official title, opened its first showroom at No. 4 Colston Street. From here canvassers were employed at a wage of 25/– a week, plus commission of 1d for every 30 watt lamp installed. As the enterprise expanded, it became necessary to move the offices from near the original Temple Back Station to the Corn Exchange in Corn Street and the showroom was also moved here in order to be near the principle shopping centre which was Castle Street.

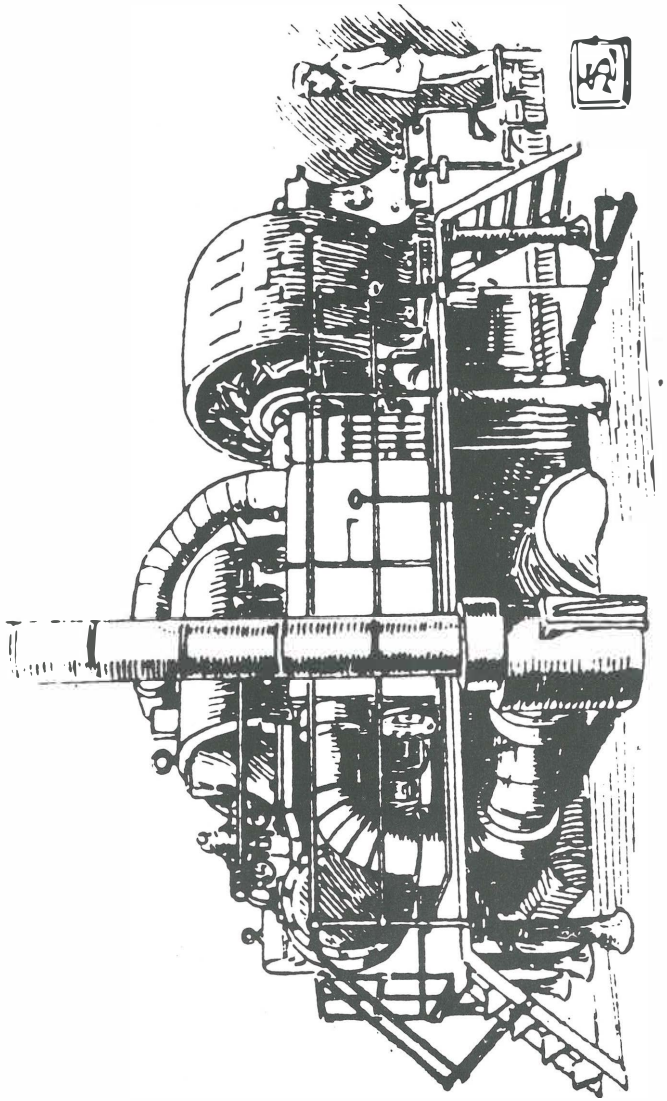
By 1911 there were 3,600 customers, three times as many as in 1901. The maximum demand was now 6,000 kw, and nearly 400 miles of cable had been laid. The Corporation had also begun the process of taking over smaller undertakings when it absorbed the Avonmouth Docks Generating Station in 1907/8.[31]

The Minutes of the Corporation suggest that in the Edwardian age

31 Keynsham Electric Light and Power Company was taken over in 1921 and the Almondsbury undertaking in 1929. High voltage supplies were afforded to the North Somerset Supply Company at Bower Ashton in 1918 and at Whitchurch in 1926.



A general view of Avonbank Electricity Works from the Feeder Canal 1902 (B.C.E.D. Booklet 1902).



STEAM TURBO-ALTERNATOR ; 1908.

Illustration of a steam turbine in 1908 at Avonbank (by S. J. Loxton from "Bristol As It Was and As It Is" G. F. Stone 1909).

the officials thought that they were faced with a major expansion which taxed their resources to the full, and yet Bristol did not in fact have to face an overwhelming demand for supplies, as did some other corporations. By 1907, for example, Manchester was at its wit's end to know what to do to meet demand and was driven to plan extensions to one of its plants before the first part was actually open. Unlike the only really successful private company, the Newcastle Electric Supply Company, or major municipal undertakings such as Manchester or Glasgow, Bristol had little chance of finding customers in a heavily populated hinterland, for this did not exist.

Not surprisingly, the First World War had a considerable impact on the Electricity Department. Men released for active service were replaced by women who worked as clerks, typists, meter readers, showroom assistants and, eventually, on some engineering duties such as switchboard attendants.[32] 102 men served in the armed forces, nine were killed in action, seventeen were wounded, five won the Military Medal, one the Meritorious Services Medal, one the *Croce di Guerra* and two were mentioned in despatches. It is a record that speaks for itself.[33]

After the War in 1922, great excitement was caused by the purchase of two Morris Cowley cars, which were bought especially for the use of engineers and foremen for standby duties (i.e. out of normal hours). Up to that time the Department had relied upon bicycles, hand carts and horse-drawn carts for transporting men and equipment around the City. Originally bicycles had been purchased as far back as 1898 for the foremen, and engineers had been authorised to hire a horse and trap when required.

The War not only hastened the improvement in the transport facilities but also had demonstrated beyond doubt the need for increased electrical power in industry. An expansion of its use had been experienced, particularly in the munitions factories and other war industries, and the Government's attention was drawn to the weakness of Britain's electricity supply undertakings. Briefly, there were too many small undertakings, little co-operation between them and a multiplicity of different voltages, frequencies and systems. The pricing systems were equally varied. Capital and running costs were high compared with Germany and U.S.A. where generation was being centralised in large-scale stations, as Ferranti had predicted. A large

32 SWEB Avonbank Archive Library. BCED *Staff Register*, 1893–1917.
33 '*Bristol and the Great War*', G.F. Stone and C. Wells, 1920.

number of unconnected small units ensured a greater total of extra capacity to meet the peak demands than was really necessary.[34] The obvious answer was to link the stations in a grid, so that electricity could be shunted about to where it was most needed at any particular time.

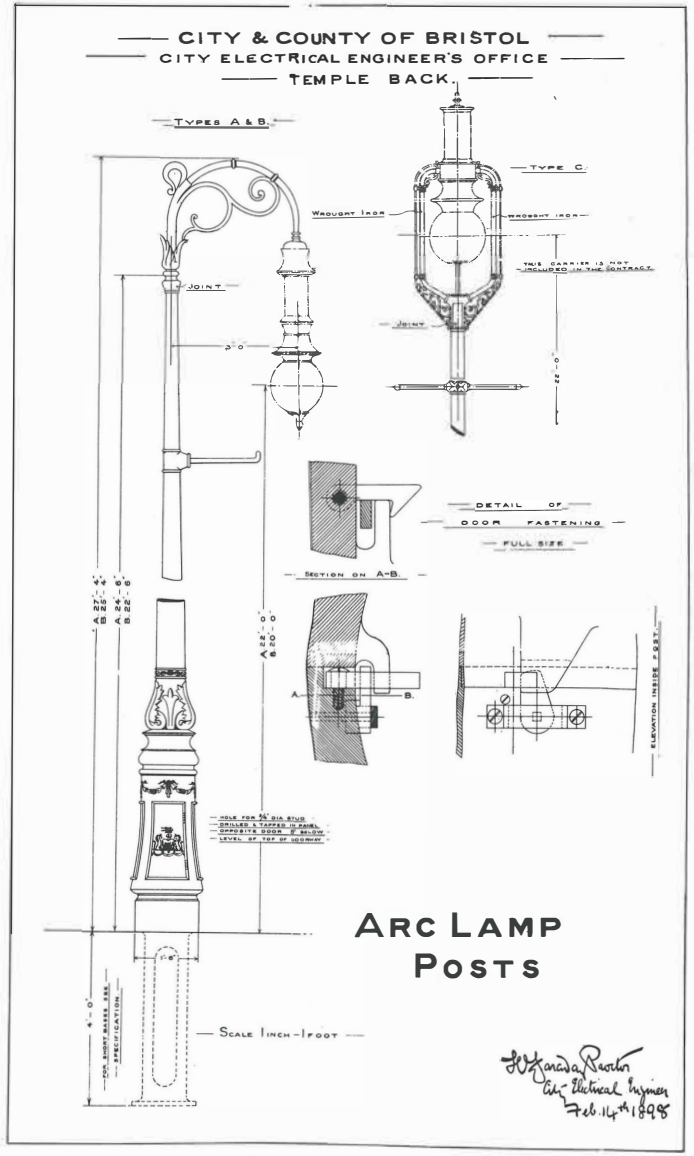
In 1919 the Electricity (Supply) Act took a tentative step towards such a rational ordering of affairs. The Act established a central body of technical experts, the Electricity Commissioners, germ of the present Electricity Council, to act as a planning board for the whole industry. Its existence limited the independence of the Corporation's undertaking. In future Bristol's Electricity Department would have to have the Commissioners' approval for borrowing money for expansion, for building any new power station or main transmission line, and for the prices it charged for supplying electricity. It was a tentative step towards establishing a national rather than a local system of electricity generation. How tentative it was is shown by the fact that the Commissioners did not have the power to compel undertakings to group themselves into joint electricity authorities in order to supply a wider area than a single town or county. The Act left this to voluntary action by the undertakings themselves.[35] Such action was rarely forthcoming. Indeed, this was the case in Bristol. A meeting was called locally by the Lord Mayor on 2 January 1920 with representatives from other undertakings and adjoining County Councils with the aim of forming a joint authority to be known as the Lower Severn Electricity Joint District. However, although meetings were held until as late as 1925 no agreement could be reached. No regional authority emerged. Parochialism triumphed over commonsense.

Fortunately, this was not to be the case for long. A new Electricity Act in 1926 established a public corporation, the Central Electricity Board, with power to control the generation of electricity throughout the country and to establish a National Grid system. All supply undertakings were compelled to co-operate with the new Board. This certainly had its repercussions in Bristol.

The C.E.B. purchased in 1930 Alderman Maggs' house in Oakfield Road, Clifton, naming it 'Grid House', in which they established a grid control centre for the South Western area. The first manager was Mr J. W. Beauchamp who had previously established temporary offices for a few months in Queens Road with a handful of staff.

34 P.E.P. Report on the supply of Electricity in Great Britain (1936) p. 14. Also I.C.R. Byatt, *op. cit.* p. 127.

35 H. H. Ballin, *op. cit.*, pp. 136–7.



An early street light drawing, embodying an Arc Lamp, personally signed by the Chief Engineer Mr. H. F. Proctor in 1898 (S.W.E.B. Avonbank Archives).

Jointers Cart pictured in Shirehampton Road 1912 (S.W.E.B. Avonbank Archives).

Prior to this in 1925, it had become clear to Bristol's Electrical Committee that the growing demand would outstrip the capacity of the two existing power stations. The Committee's minutes recorded that 'additional plant was imperative by Winter 1927'. Discussions had been held previously with the Electricity Commissioners who were anxious to establish a capital station in the western area to supply a future grid system. The chief Engineer H. Faraday Proctor was requested by the Commissioners to head a team of engineers from the West to select and recommend a suitable site. Portishead Dock was chosen as the site which was already owned by the Corporation. The Bristol Corporation Act of 1926 gave the Electricity Department the necessary legal powers for establishing and working a generating station at Portishead, which would supply into the C.E.B.'s new National Grid. This was achieved in record time with the commissioning of the new station in 1929.

The new Portishead station, such a familiar landmark that it is difficult to imagine the district without it, was for the time quite a bold undertaking. The 23 acre site had much to be said for it: proximity to the Welsh coalfields, a rail link by which North Somerset coal could be obtained, and access to ample cooling water from the Severn estuary. But to obtain the water, extensive boring under a hill was necessary. Four concrete, brick-lined culverts 7½ ft in diameter had to be driven to a length of 1,800 feet and well out into the estuary where a 30 foot trench had to be dredged in its bed to avoid silting. The first phase involved a capacity of 40,000 kw, quite dwarfing the puny initial capacities of the earlier two stations. Two 25,000 KVA Metropolitan-Vickers turbine sets, generating at 11,000 volts, 50 cycles, and five Vickers steel-cased water tube boilers evaporating 80,000 lbs per hour of superheated steam at 300 p.s.i. were installed. Chain grate stokers were fitted, and smoke was carried clear through steel chimneys 102 feet high.

To convey power to Bristol, a 33,000 volt system had to be established for the first time, and cables at that voltage were laid the thirteen miles to Feeder Road and to Avonmouth. The second phase of the project was a pioneering development involving the installation of 50,000 KVA generators. With one exception they were the largest to be constructed in the country at the time (1930). A later phase brought with it the twin 380 feet tall brick-cased chimneys which still stand. Not surprisingly, the new station was the pride and joy of Bristol's Electricity Department.[36] Consequently it was somewhat mortifying that on Christmas Eve 1930 a major disaster occurred at Portishead.

An oil feed pipe to the bearings of No. 2 turbine fractured, thus filling the pit with oil which at once ignited. Flames shot 70 feet in the air to the wooden roof which soon caught fire. The station was quickly shut down so that the fire brigades could put the fire out, but not before half the roof was destroyed and the city was blacked out at 7.10 p.m. The local press reported that the Bristol Fire Brigade — at that time still part of the police establishment and controlled by the Watch Committee — 'had rushed from the City to Portishead in under half an hour'. Emergency action was taken by switching consumers to the Feeder Road Station, and light was restored in about half an hour. Within four days temporary roofing had been put up, the turbine hall cleared up and all the turbines except the one were operating again.[37]

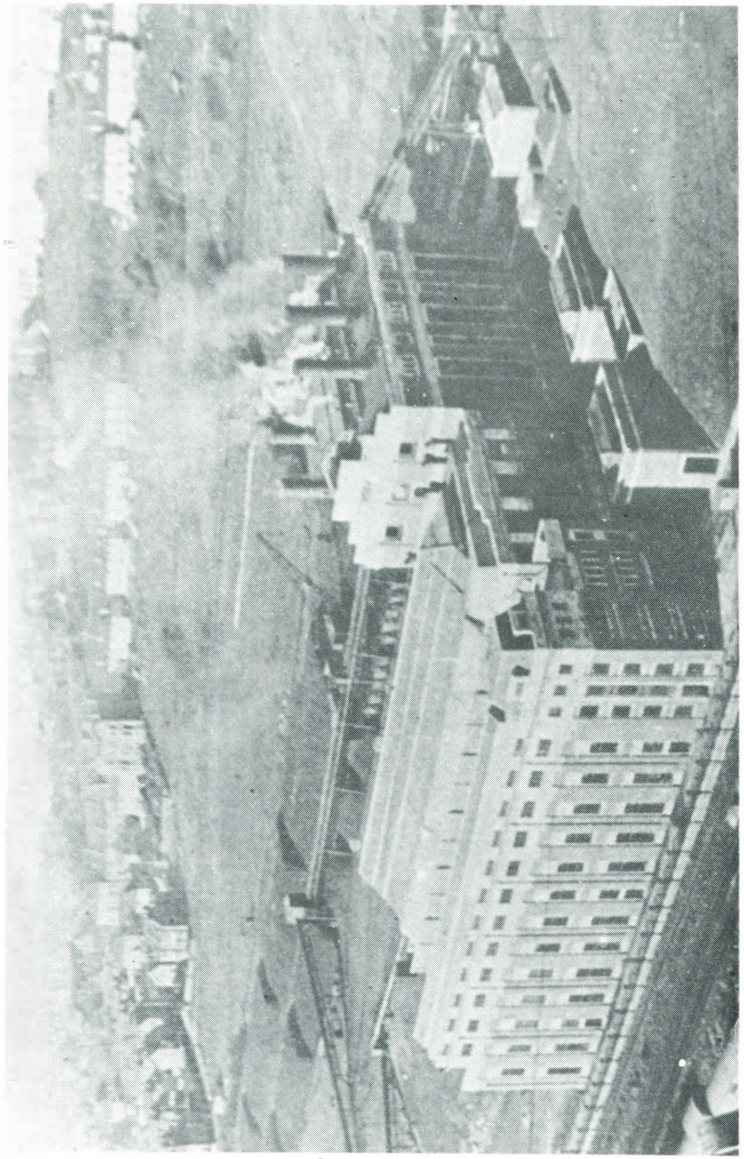
The later years of H. F. Proctor's time as Chief Engineer (he retired in 1932) were marked not only by the major project of bringing Portishead into service but also by what was known as 'the change-over', something which veteran staff still talk of in awed tones. To the general public this meant the digging up of most of the streets of the city over a period stretching from December 1924 to June 1930. To the Electricity Department, however, it represented a mammoth task costing what for that time was the very large sum of £736,170.[38] What in fact was happening was the replacement of the single-phase high voltage and low voltage A.C. distribution system by the more efficient three-phase A.C. systems and substations. Originally, the majority of A.C. systems in the country had been single-phase until the superiority of the three-phase system came to be realised. The Bristol Electricity Department accepted this before the Electricity Act of 1926 demanded its adoption to enable interconnection between systems particularly at the higher voltages. Bristol chose a complete replacement of the existing system rather than superimposing three-phase on to the existing systems, as was often done elsewhere. Both decisions suggest that the Electricity Department under Proctor's leadership was prepared to look ahead and not shrink from what was a major undertaking.

The work was interrupted for a short time by the General Strike of 1926. The manual workers came out on strike from 4 May to 13 May, but volunteers from the office staff were sent to Feeder Road to shovel

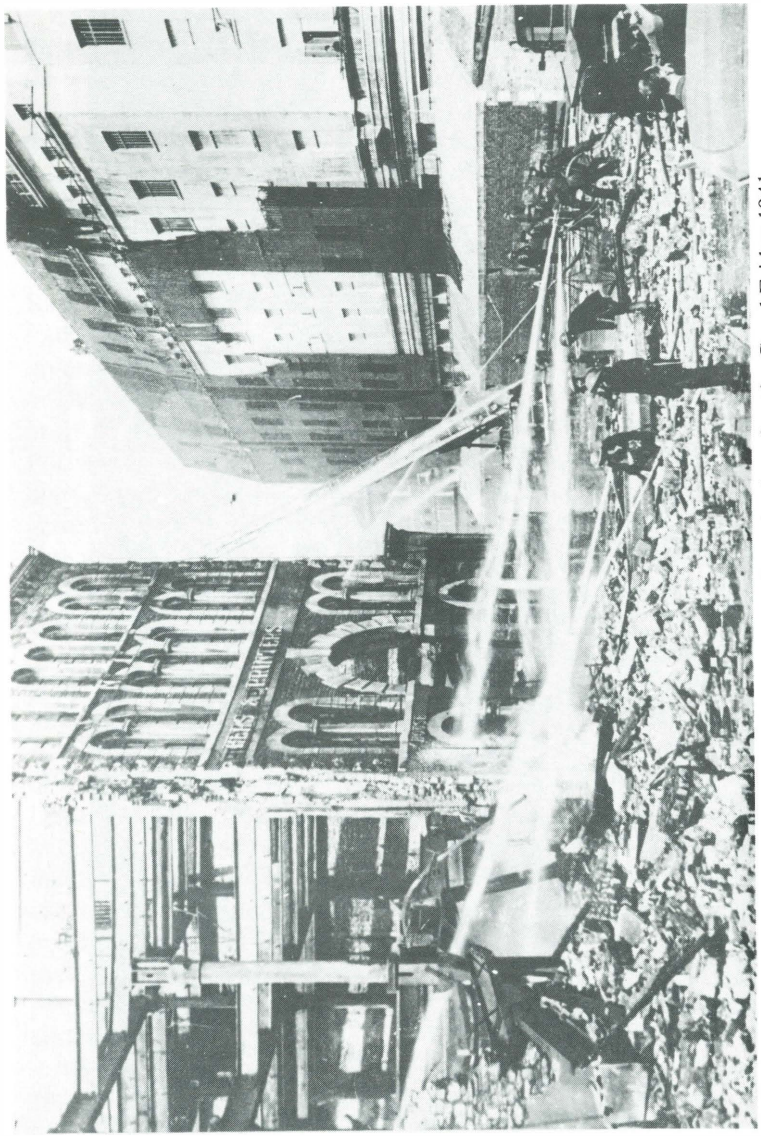
36 B.C.E.D., *Portishead Generating Station*, Bristol, 1929; *The Electrical Review*, vol. 106, 14 and 21 March 1930, pp. 482 531.

37 *The Electrical Review*, vol. 108, 16 January 1931, p. 113.

38 Bristol Corporation Electricity Dept, *Annual Accounts 1948*, including statistics back to 1893.



Aerial View of Portishead Power Station, stage 1 complete, 1929 (S.W.E.B. Avonbank Archives).



Electricity House, swathed in camouflage the day after the Good Friday 1941 Bombing Raid (Reece Winstone Collection).

coal and man the station. These volunteers were protected by the army. Union representatives requested the Electrical Committee to stop supplying electricity, but it refused to do so. Instead, it gave an understanding that every workman who remained at his work should be safeguarded from victimisation and given in future every consideration and suitable acknowledgement of his loyalty. However, only one man refused to strike. Nevertheless, supplies were lost only twice and on both occasions for only short periods.[39]

Substantial as progress had been in the twenties, this was also the decade when, thanks to introducing the hiring of cookers and other appliances, electricity as a source of power as well as light in the home really began to spread. In 1929, there was established in Bristol a branch of the Electrical Association for Women, presided over by the Hon. Mrs J. H. Inskip, wife of the chairman of the Electrical Committee, to encourage women to take an interest in electricity. In 1930 the price of electricity came down to ½d a unit. Nevertheless the 1931 Census showed that less than half Bristol's households used electric light. Of 113,000 households in the Bristol area of supply, just over 50,000 were connected to the electricity supply.

The thirties was also noteworthy for the beginning of Electricity House, still one of the landmarks of Central Bristol. The expanding business had found the Corn Exchange too cramped as early as 1924 and had moved its offices and showroom to a building in Colston Avenue at its junction with Rupert Street. Only ten years later this too proved insufficiently spacious. Consequently, in 1934 the Corporation approved the purchase for £29,000 of an island site bounded by Rupert Street, Nelson Street and Christmas Street on which J. S. Fry and Son owned a building. In addition there was a pub and also offices known as Demerara House. On the front of Demerara House, giving its name to the property, was an elaborate wooden figurehead in the form of an Indian chief. This had been rescued from the *S. S. Demerara* whose wreck on its maiden voyage down the River Avon had been among the most spectacular accidents of this kind in the city's history. Conservationists will be unhappy to learn that the figurehead fell apart when the building was being dismantled. The Electrical Committee was evidently determined to erect a prestige building on the site. The Chairman of the Committee, Alderman John Inskip (later Sir John) suggested the choice of the architect of Liverpool's massive Anglican cathedral, Sir Giles Scott R. A. for the new Electricity House.

39 *Western Daily Press*—reports 8 and 11 May 1926.

Construction began in 1936 and was still in progress when the war began. Only the shell was then complete.

The Second World War involved the Electricity Department in challenges of a different order from that of the earlier war, chiefly because it was in the front line when air attack came. It had been foreseen that this might be so. Before the war, basic training of the staff in first aid, fire-fighting and A.R.P. duties had been carried out, as well as instruction in complex high voltage network-switching schemes which proved most effective in later emergencies. A special A.R.P. unit was formed which was eventually stationed at a major substation at Cairns Road, Redland from which, by a private telephone system, links with the power stations at Feeder Road and Portishead, the offices and all major substations were available. The telephone exchange at the former Temple Back power station, now a rotary substation, was a major receiving point for air raid messages to be passed to the Electricity Department. This had to be manned continuously since calls on the line reserved for such messages had to be answered within five seconds. Key establishments were guarded by the Home Guard or protected by monitored wire fences or even by fire watchers. The incomplete Electricity House, the basement of which housed the undertaking's transport, was requisitioned. The Charge Engineer at Temple Back, Mr Dorrinton, received a telephone call from the garage duty driver saying 'some bloke' had produced a requisition form requiring the building to be vacated within two hours. On investigation 'the bloke' turned out to be a brigadier representing Lord Beaverbrook, Minister of Aircraft production. The vehicles were duly moved and Electricity House was turned into a factory, swathed in camouflage, for producing aircraft engines.

The Central Electricity Board at Oakfield Road seems to have been slightly less prepared. The Grid Control Room had been moved in 1932 to a new building built in the grounds at the rear of the house. It was not considered necessary to man the old building at night during raids, maybe because they considered the situation at Clifton to be safer. So that when an incendiary bomb fell on the older building, police had to break open the doors to put it out. No bombs, however, dropped on the strategically important control room which had been heavily protected with girders and sand bags and with the addition of a concrete shelter actually built in the room. Emergency control rooms were established both in a cellar in the centre of Bristol and at Warmley, but these were never used. The major problem with which control engineers had to contend, was the tripping out of grid lines on

windy nights caused by trailing cables of barrage balloons which had broken loose from their moorings.

The most eventful time for the Electricity Department in the war was during the heavy raids from November 1940 to April 1941. The first heavy raid on the city was on the night of 24–25 November 1940. A great deal of damage was inflicted on the heart of the city, and most supplies of electricity were not restored until 28 November. The main stores and meter department in Rupert Street received a direct hit and within minutes became a white hot shell. Meters were being tested again at another location within a fortnight. On 6–7 December the Feeder Road power station sustained the first of its direct hits. Severe damage was done to the main switchboard and to some of the transformers. Only a crater was left to show where one of the transformers had been. Not surprisingly it took a few days before supplies could be restored. On the night of 16–17 January 1941 there was a further direct hit. This time power was restored, albeit temporarily, within 24 hours, a remarkable effort in the circumstances. The degree of damage at Feeder Road may be gauged by the fact that permanent repairs involved almost completely recabling the station.

The final heavy raid of 11–12 April 1941 known as the Good Friday Raid destroyed the main offices at Colston Avenue which caught fire from the premises next door. By the time help arrived, including Mr Newman, the Chief Engineer, the top floors were well alight. Very fortunately the indispensable Mains Record maps had previously been removed from their normal office to a fireproof brick and concrete room in the yard below. However, as the whole building was about to collapse, this room was considered inadequate to protect the irreplaceable maps. They were bundled out in extreme haste to the nearby fish and chip shop, only to have to be moved yet again due to the presence of an unexploded bomb. During this raid St Philip's Bridge was damaged beyond repair. By daylight it was seen to be supported only by the cables owned by both the Tramways and the Electricity Department. As soon as these were cut the bridge subsided into the water below. After the loss of these cables, the central D.C. street lighting system was never re-energised. Perhaps this was as well, since the D.C. switchboard at Temple Back was very old. Staff manning it had to keep well clear during air raids as lumps of molten copper were often blown out of the switches when a cable received a direct hit, and on one or two occasions the whole switch was blown across the engine room.[40]

After the Good Friday raid, the main offices at Colston Avenue had

to be evacuated, and temporary accommodation was found at Dorset House on the Promenade, Clifton.

Later in the war, the Electricity Department was involved in some degree with two projects associated with D Day. The first was the provision of temporary welding supplies for oil storage tanks and pipe lines at the Hallen complex, and the second was the provision of a complete sub-station with a quarter of a mile of cable to provide a non-standard supply to a package aircraft assembly hangar. This was required at two days notice. The requirement was met, without the necessary paper work, and for this the engineer involved was reprimanded.

During the war the Chief Engineer and Manager, Mr A. J. Newman, who had been the first Chief Engineer's Deputy, retired, and was replaced by Newman's deputy, Mr I. A. D. Pedlar. He was forced to resign in 1945 after only nine months in office owing to ill-health. Up to this time engineers had been appointed as the chief executive of the undertaking, as was usually the case in electricity supply concerns. In 1945, however, the Electrical Committee broke with precedent. They believed the most suitable person for the job was their Secretary and Sales Manager, Mr E. C. Willis. He was not a qualified engineer. He had started in the Electricity Department in 1919 as an agreement clerk and worked his way up, concentrating on the commercial and administrative side of the business. He was appointed General Manager, and a separate job of Chief Engineer was created. The Association of Municipal Engineers strongly objected to the appointment of a non-engineer as general manager, and blacked the subsequent appointments.

The committee had every confidence in Mr Willis who proved to be a very able General Manager. He was a keen grower of carnations, and was characterised by the fresh bloom in his buttonhole every morning. But the end was near for the Bristol Corporation's Electricity Department as an independent concern. In 1948 its sales and distribution activities were absorbed by the new South Western Electricity Board (SWEB), one of the fourteen area boards created for this purpose, and the generating capacity of the Corporation's business passed under the ownership of the Central Electricity Authority, later to become the C.E.G.B.

40 Bristol Reference Library: 'Bristol Alert', the story of the Blitz by the *Western Daily Press* 1946, together with reports by Messrs A.H. Proctor and J.W. Dorrinton held in SWEB Avonbank Archive Library.

Mr Willis attended the last meeting of the Corporation's Electrical Committee on 18 March 1948. He was immediately appointed Sub-area Manager in SWEB for an area including Bristol, Bath and Weston, and he was later to become SWEB's Deputy Chairman. Electricity House, the Corporation's prestige project, was not de-requisitioned until 1948 and only then in order to become the headquarters of SWEB. Thus ended fifty-five years of municipal enterprise.

Of course this by no means ended the connection between Bristol and the electricity industry. Demand in the city for electricity continued to grow substantially after 1948 and in many ways Bristol remained the capital of the South Western region of the nationalised industry in spite of the decentralisation of its functions such as the emergence of Plymouth as the centre for customer accounting and, of course, the spectacular development of nuclear-powered generating stations at Berkeley and Oldbury, which are now in effect Bristol's 'local' power stations. But if Bristolians pay their bills to Plymouth and receive much current from outside the city, the nerve centres of operations both on the generating and distribution side remain the familiar Electricity House, Avonbank, and the highly sophisticated headquarters building of the Central Electricity Generating Board that has arisen on the western edge of the city.

BIBLIOGRAPHICAL NOTE

The principal sources are the minutes and reports of the Corporation's Electrical Committee, occasional publications by the Electricity Department itself, the annual accounts and the staff and consumer registers. In addition, the valuable technical press, including *The Electrician, The Electrical Review* and *The Engineer* provide a number of specific references as well as general guidance. The legislative framework within which the industry operated is well surveyed in H. H. Ballin, *The Organisation of Electricity Supply in Great Britain* (1946). P.E.P.'s *Report on the Supply of Electricity in Great Britain* (1936) is valuable for the interwar period. I.C.R. Byatt, *The British Electrical Industry, 1875–1914* is an outstanding monograph particularly useful for its concentration on the economic returns of the new technology.

APPENDIX

TEMPLE BACK STATION

The two systems available were: (a) Public Lighting. Direct current at 600 volts supplied 12 arc lamps per circuit using 2 wire concentric cables. Two cables were laid in each street with alternate lamps connected to each cable. Thus if one cable failed, only half the lights were extinguished. (b) Consumers' Supply. Alternating current at 105 or 210 volts 3 wire 93 cycles supplied the domestic consumers. Generation was at 2,000 volts single-phase transmitted by two wire concentric cables, insulated with guttapercha, to small substations, the majority of which were underground or in cellars. Distribution from these substations was by 3 wire concentric cables. It is believed that the machines were ordered for use at 100 cycles, but would only parallel (run together) at 93 cycles, so that was adopted thereafter. The D.C. System was later changed in 1907 to a 500/250 volts 3 wire system to accommodate the motor supplies, and the lamps were then connected as 10 per circuit.