

**How Towns got Electric Light and Tramways;
a case study of Gloucestershire and neighbouring towns.**

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PREFACE

The study described here is in two parts:

Part 1 gives an account of how the five main towns of Gloucestershire (or, at any rate, the first five towns to have a public electricity supply) came to consider, debate and decide whether to permit a company to set up an electricity supply undertaking, to set one up themselves, or to do nothing. Eventually, of course, all five towns got electricity, and we record, as far as possible, what system and what plant were used, and how demand expanded. Proposals for electric tramways are also examined and the beginnings of the tramway undertakings are described.

Part 2 examines the developments described in Part 1, and also those in the neighbouring towns of Bristol, Monmouth, Worcester and Swindon which have been described elsewhere, against the background of the developments taking place in electricity supply and tramway systems in Britain as a whole. It becomes apparent that, in spite of a slightly late start, the 'Gloucestershire Region' is a fairly representative section, in fact a microcosm, of the British electricity scene. It is hoped that this study will illuminate the early history of electricity supply in Britain.

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PART 1 THE BEGINNINGS OF PUBLIC ELECTRICITY SUPPLY AND ELECTRIC TRAMWAYS
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Chapter 1

Introduction

Although there had been some limited development of electric lighting using arc lamps in the years before 1881, it was the successful outcome in 1879-81 of the researches of Swan and Edison into methods of making incandescent-filament lamps that really led to the beginning of the electric era. The first 'central station' for generating electricity for public supply was opened at Godalming in Surrey in November 1881; it was a very small one driven by a waterwheel¹ and it did not endure for many years. The first steam-driven central stations were opened in London (Holborn Viaduct) in April 1882 and in New York (Pearl Street) in September 1882. Thereafter the growth of electricity supply was rapid in most countries, though rather slower in Britain because of our unwise Electricity Act of 1882 which, by providing for compulsory purchase of commercial undertakings by municipal authorities after 21 years, at the valuation of the plant, effectively inhibited investment in the new industry. The amending Act of 1888 extended the period to 42 years, and based the compulsory purchase on the valuation of the business. Investment then started in earnest. Not only did numerous companies apply to the Board of Trade for Provisional Orders (provisional because they had to be confirmed formally by Parliament), but several municipal authorities did also. Statutory authority was necessary if streets were to be broken open for the laying of cables, etc. A few companies managed without such statutory authority by using only overhead wires or cables laid in, or fixed to, private premises.

By 1894 there were about 100 public supply schemes in operation in Britain; the earlier ones were established entirely by companies, but the proportion being operated by municipalities was growing rapidly, and was already about 25% by 1894. At the end of 1893, there was a total of £5m invested in electricity supply works in Britain under statutory powers, of which just under £0.9m was contributed by municipal authorities.²

Among all this development of public electricity supply there was nothing at all in Gloucestershire. Possibly a very minor exception was the extension of a water-powered brewery lighting system at Wickwar in 1888 to provide some limited street lighting in that little town, but the electricity was not on sale to private consumers.³

Of course, there had been talk in Gloucestershire about the provision of public electricity supplies: serious discussions started in 1888 in Cheltenham, in 1889 in Gloucester, in 1890 in Stroud, in 1892 in Tewkesbury, and in 1890 in Cirencester. Nevertheless it was 1895 before Cheltenham got its supply, 1900 for Gloucester, 1909 for Tewkesbury, 1912 for Cirencester, and it was not until the end of World War I that Stroud had electricity; the 30-year gestation period was something of a record. At Cheltenham and Gloucester the systems were municipal; at Tewkesbury, Cirencester and Stroud they were operated by companies.

In the 1890s, street tramways, hitherto horse-drawn (occasionally steam-hauled), were being electrified and extended. It was necessary in each case for the tramway operator to establish a relationship with the supplier of electricity; sometimes this led to battle, as at Bristol⁴ where the tramway

company successfully fought the Corporation's attempts either to purchase the company outright or to force it to buy its electricity from the Corporation. Often the tramway company would buy its electricity from the public supply station, and this is what happened at Cheltenham. In other places where the Corporation operated the public electricity supply, the Corporation would purchase the tramway company and operate it itself using Corporation electricity; this is what happened at Gloucester. Tewkesbury, Cirencester and Stroud never had tramways, although an extensive electric tramway network was planned for Stroud and actually obtained an Act of Parliament in 1902. It was a particularly interesting plan, for it involved the use of trolley buses over part of the network, and if it had materialised, Stroud would have been the first British town to have trolley buses.

The story of these public electricity supplies and tramways in the five Gloucestershire towns mentioned is told in this article. For Cheltenham and Gloucester, the main sources of information are the contemporary technical journals, The Electrician and The Electrical Engineer, which published frequent reports of discussions and progress and gave details of tenders, equipment and buildings. Over 300 such reports have been used, and it has not seemed necessary to give detailed references to all of these. All information on Cheltenham and Gloucester may be assumed to have come from these sources except when otherwise indicated. For the other three towns the reports in the technical press are inadequate for a proper understanding of the history of the electricity supplies, particularly for the complex electricity supply/tramways schemes at Stroud, and Council minute books and local newspapers have therefore been used extensively.

Chapter 2

Cheltenham

Electricity Supply

Cheltenham had some early experience of electric light, because seven years before the Council began to give serious consideration to public electric lighting there was a private venture there. In December 1881 it was announced:

Messrs Woodhouse and Rawson have successfully installed the Brush electric light system in the Winter Gardens at Cheltenham. During the past week, a lawn tennis tournament has been played, the play commencing at half-past four each afternoon, and has resulted in capital sport. The same firm ... has also carried out a somewhat novel experiment at the residence of Sir A Ramsay, the light from two Brush lamps outside the house being so arranged as to light up certain rooms in the interior.

However, in spite of this apparent success, it was not until early in 1888 that the Town Council began to take any steps in the matter of electric lighting. An Electric Lighting Committee was then set up to report on the advisability of lighting the town by electricity. The Committee, or a deputation from it, visited electric light installations at Taunton, Eastbourne and Hastings (and probably also Bath), and visited the works of the Brush Co at Lambeth. They reported first on 7 August 1888:

That in the opinion of the Committee it is desirable to try the experiment of lighting a portion of the town with the electric light ... It is considered that 36 lamps, each of 1200 candle-power, will be sufficient to efficiently light this area, and that about 170 gas lamps will be thereby rendered unnecessary ... That it be referred to the Committee to consider and report as to the best mode of carrying out the foregoing recommendations, whether by the Corporation itself or by contract, and if the former alternative is considered preferable, to report as to the best means of carrying the works into effect; if the latter to procure tenders.

The Chairman of the Committee, Mr George Norman, made a grand speech in presenting this report; the only point of substance he made was that he thought the cabling should be underground, rather than overground as at Bath; he also thought the Corporation should undertake the work itself.

The Committee had two meetings in August 1888; on the 15th they resolved that the Corporation should undertake the work rather than contract with a company, that the Town Clerk be requested to report on the legal position and that the Borough Surveyor be requested to report on available sites for generating stations. On the 31st the Town Clerk and the Surveyor reported and the Committee was asked by the Council to prepare an approximate estimate of the cost.

The Committee reported on costs on 11 March 1889. They had consulted 'two of the largest electric lighting companies in the world'. They had come to the conclusion 'that the cost of the public lighting would be very materially reduced by combining it with the supply of the light to private consumers'. The figure they had reached for site, machinery, circuits, lamps, etc., for 60 arc lamps each of 1200 c p and 2300 incandescent lamps each of 16 c p, was

£11,900, with an annual cost for running of £3,300 to £3,700. There would, however, be a saving on gas lamps, and a profit on the private lighting. (The editors of The Electrician thought that the last item was grossly overestimated, but details are not now important). The Committee recommended that tenders be invited. Council, by a majority vote, adopted the report and approved the recommendation.

Matters were hurried along by the receipt shortly afterwards of notices of intention to apply for a Provisional Order (P O) to supply electric light in Cheltenham from no less than five companies (The Electrical Construction and Maintenance Co., Laing, Wharton and Down Construction Syndicate, Anglo-American Brush Corporation, Midland House-to-House Electricity Supply Co., and a company about to be formed). Consequently, on 21 October 1889, the Council resolved to apply for a P O itself, and to object to the applications of the companies.

The details of the P O were worked out, modified by the Board of Trade and the Local Government Board, and finally agreed in mid 1890. The Order specified that the Council's scheme must be fully formulated within two years.

Little was done during the following twelve months. The reason for this is not clear, but the Board of Trade had to remind the Council, during 1891, of its responsibilities. Under this pressure, a site was chosen for the generating station. It was at the site of the dust-destructor ('dust' here meaning refuse) near where the Tewkesbury Road crossed the Midland Railway line, (grid ref SO 935 233).

Early in 1892, Mr Joseph Hall, the Borough Surveyor, prepared a report describing the area of supply, the reasons for the choice of site for the generating station, the recommended system of generation and distribution, its scale, and its cost. It was an excellent report.

The area of supply included High Street, Ambrose Street, Clarence Street, Manchester Street, the road to G W R station, Colonnade, Promenade, Queen's Circus, thence to Westal Green, Montpellier Walk, Pittville Street, Portland Street, Evesham Road, Winchcombe Street, to Pittville Gates, and extensions which might be demanded under certain conditions.

The reasons for the choice of site were:

1. the site was already in the possession of the Corporation;
2. the chimney stack was already built (for the dust-destructor);
3. there was 60-70 h p available from the dust-destructor in the form of steam generated by the heat of burning refuse;
4. it was next to the railway, which saved the cost of carting coal;
5. there would be a large saving of costs in administration, supervision and labour by having two or more services on the one site. (A sewage works was also built on the site).

The recommended system of generation and distribution was high-voltage (2000V) alternating-current, using transformers at sub-stations to convert the

2000V to 100V for consumers' use. Hall explained that low-voltage direct current was suitable only for high-density towns of very limited area. The arc lamps for public lighting were to be suspended from chains in places where posts were not convenient; they would be in two separate circuits, one including about two-thirds of the lamps could be switched off before mid-night, while the other, including the lamps at street intersections, could remain on all night. The machinery was to have a capacity of 280 kW, which would provide for 38 arc lamps and 7100 incandescent lamps of 8 c p; only 180 kW would be installed initially.

Hall estimated the running costs as £2,587 in the first year and £3,776 in the second after extensions had been made, the sales as £2,239 and £4,920 in the two years, leaving a loss of £348 in the first year and a profit of £1,144 in the second. The charge for electricity was to be 6d per unit (kWh).

It was at this stage that the Council decided to refer the matter to a consulting electrical engineer. Professor W E Ayrton, FRS, of the City and Guilds of London Institute at Finsbury, was invited to examine Hall's report. He reported first in June, and finally in December 1892. His final report was long and technical, he went deeply into the pros and cons of high-voltage a c, into the costs associated with the use of the dust-destroyer site as compared with a more central one, into the public lighting question, and so on; but the general conclusion was that he entirely supported Hall's recommendations.

With the caution of which only public bodies are capable, the Council decided to postpone a decision until they had obtained another consultant's report on the previous reports. Mr W H Preece, FRS, Engineer in Chief of the Post Office and a well-known consultant in his spare time, was engaged for this. He reported in time for a personal interview with the Council on 8 August 1893. He supported Hall and Ayrton, told the Council that he found Cheltenham a most promising place for electrical business, and assured them that the first year's receipts would pay at least the working expenses (and so they did in the event!). Members of the Council, particularly Mr Norman, cross-questioned him carefully on costs, including the relative cost of gas and electricity, and on the true cost of generating electricity, which Preece said should not exceed 4d per unit. He estimated the saving due to the combined dust-destroyer scheme as effectively 0.5 to 0.75d per unit. He emphasised that nothing was to be gained by delay, as the machinery was now already 94 to 98% efficient, leaving little room for improvement (this was, of course, not exactly true, efficiencies were probably nearer 75-80%, but he was expressing the generally held view of those days, when the techniques of measuring machine performance had not been adequately developed).

As a result of this meeting, the Council decided at last to proceed with Hall's scheme, to inform the Board of Trade accordingly, and to apply to the Local Government Board (L G B) for sanction for a loan not exceeding £16,000. Tenders were to be sought for the buildings, machinery and plant.

The L.G.B. enquiry regarding the loan was held on 15 November 1893, and their approval was given in April 1894.

Invitations to tender for the generating plant were put out in January 1894, and the results made known in March. The tenders did not range as widely as was often the case, covering a range of only about 4:3. The tenders accepted were those of Siemens Bros. for machinery at £4245 and that of Galloways for the boilers at £877.10s. Tenders for the cables were invited in June 1894, and that of Callender's Bitumen Telegraph and Waterproof Co. was accepted in July at £1031.8s.4d., subject to the high voltage cables being guaranteed for 10 years. At the same time, Messrs. Malvern's tender of £1,799 for erecting the building was accepted. In July 1894, tenders for the transformers were invited. There were to be six transformers of 12 kW rating, and ten of 6 kW. The Brush Co.'s tender was accepted in September. As a final act of preparation, the mayoress, Mrs Wethered, laid the foundation stone of the generating station in October 1894. The only thing omitted from the plan was the public lighting; at first only private consumers were to be supplied, at 6d. per unit.

Progress thereafter was rapid, and the station was formally opened on 16 May 1895. The opening was followed by dinner at the Plough Hotel. It was a good thing that it was not at the Fleece Hotel, for that hotel had not waited for the Corporation's electricity supply, but had provided its own the previous year in conjunction with the adjacent brewery! A full-time electrical engineer, Mr H. Kilgour, had been appointed by the Council in July 1894 at a salary of £200 p.a., rising to £250. Further increments were given, and by 1900 he was being paid £400 p.a.

The electric light in Cheltenham was a great success, and orders poured in. By mid-August 2160 lamps of 8 c p had been connected; by mid-October, 3030; by mid-December, 4300; by September 1896 over 8000, by September 1900 about 25,000. Obviously extensions of plant were needed, and as early as the first week in August 1895, less than three months after the opening, it was resolved to apply to the Local Government Board for sanction to borrow another £10,000. By the following March, the Council decided to apply for another £15,000. Sanction for the total of £25,000 was obtained in June 1896.

We have noticed that the question of public lighting had been deferred; surprising in view of the fact that it was the desire for electric public lighting that had started off the whole development, but the Council had it under consideration again by August 1895 and decided in September to fit 50 arc lamps along the Promenade to the Gordon lamp, Clarence Street to the G W R station, Ambrose Street, High Street, and from Ambrose Street to the Royal Hotel. These lamps would replace 311 gas burners. Alternating current would be used for the arc lamps directly, without prior conversion to d c. The first instalment of this public lighting (29 lamps in High Street, Clarence Street, and St Georges Place) were switched on by the mayoress (by that time Mrs Rogers had taken office) on 6 February 1897.

With continued demand for electric light, the Council had soon to consider extending the area of supply, and by the beginning of November 1898 it was decided to take in the whole of the borough.

Financially the undertaking did quite well. In the year 1 April 1896 - 31 March 1897, the receipts of £1,945 exceeded the total working costs by £54, which left a net loss of £501 after the interest on loans and the contribution to the sinking fund had been paid. By the following

year this net loss had been converted to a net gain of £110, and the receipts of £3,980 exceeded the working expenses by £1,262.

The capital expenditure reached £36,416 by 31 March 1897 and £55,691 a year later.

The number of units of electricity generated in the year up to 31 March 1897 was 179,031; in the following year, 344,010. The basic charge was 6d per unit. Growth over the subsequent 15 years is discussed in Chapter 8.

One other point worth mentioning is that the use of the dust-destroyer to provide steam for the electricity generating sets was found to be very effective in reducing the cost of electricity generation.

Description of the Cheltenham Generating Station as at May 1895

A very full description was given in The Electrical Engineer, Vol 15, 17 May 1895, pp 553-563 and 566-7, and only a brief summary will be given here.

The buildings were designed by Mr Hall: "there is no attempt made to attain external artistic beauty, but the general appearance is neat" as can be seen from Fig 1. The engine room was about 60 ft x 25 ft. Here, and in the boiler room, was provision for extension, the end of the rooms being closed only with a matchboard partition. Fig 2 shows the plan of the station.

The engines were all Willans high-speed type, the large one being a type II and the two small ones being of type GG, directly-coupled to the Siemens alternators, one of 110 kW and two of 33 kW, which carried their exciters on their own shafts. Belliss condensers were used. The boilers were by Galloways, each 24 ft x 7 ft. The dust-destroyer was by Manlove, Alliott & Co of Nottingham, using Fryer cells, and was reckoned to provide enough steam to drive one of the 33 kW sets. The switchgear was supplied by Siemens Bros.

The frequency of supply was 94 Hz (or cycles per second).

Remains of the generating station in 1974

There are practically no remains of the generating station; the site is now completely open ground. Small heaps of waste indicate where the dust-destroyer was, and there is the platform of a 20-ton weighbridge made by Ashworth Son & Co Ltd of Dewsbury, in the approach roadway.

The principal sub-station at the corner of St George's Place and Clarence Street remains as an old brick building of most interesting and attractive architectural design. (See Fig 3).

Tramways at Cheltenham

Cheltenham, unlike so many other towns, did not have horse-powered street tramways, so that when an electricity supply became available, it was natural to think that here was an opportunity to build a tramway with electric traction from the very beginning. The first announcement of the idea seems to have been in May 1896:

A scheme is on foot to run a light railway to Cheltenham, taking in the Cleeve Common Golf Links, and then on to Winchcombe.

The Town Council discussed the proposal in July, viewed the proposal generally with favour, but did not like the route chosen. This was soon straightened out (the problem, not the route!) and it was disclosed that the proposal came from Mr Thomas Nevins, of Nevins Park, Gorey, Ireland, who wanted to construct and operate the tramway as a commercial proposition. In September, the Street and Highway Committee proposed, and the Council approved, that the route be from the Midland Railway Station (Lansdown) along Queens Road, Lansdown Place, Bayshill Road, St George's Parade, St George's Place, St James's Parade, St James's

Square, G W R Station, Ambrose Street, St George's Street, St Margaret's Road, North Place, North Street, Albion Street, Portland Street, Prestbury Road, and thence to the borough boundary.

The gauge was to be 4 ft $8\frac{1}{2}$ in and goods traffic was to be carried. By the end of November 1896 notice was given by Nevins of intention to apply to the Light Railway Commissioners for an Order authorising the construction of a light railway from the Midland Railway station to the village of Winchcombe, a distance of about 9 miles, using, 'electricity, air or other motive power', as should be agreed with the Corporation.

In December, the Council decided that, after all, the gauge should not be 4 ft $8\frac{1}{2}$ in but 3 ft 6 in, and that electricity was the only acceptable motive power, unless two-thirds of the Council should subsequently agree otherwise. They were clearly worried about the possibility of the tramway being used as an extension of the railway for goods traffic. In February 1897, however, Nevins stipulated that there must be communication with the G W R premises, and the Council accepted this provided it was confined to parcel traffic. There must be two services an hour, and the route was to be changed slightly by taking in Pittville Gates and, more seriously, the western end, between the Midland and G W R stations was to be omitted. Nevins agreed to this and to the reduced gauge. It was then agreed that the parcels traffic should be confined to the period between 10 p m and 9 a m. Finally, by March 1897, the draft of the Provisional Order was agreed.

After all this activity during 10 months, it was disappointing that the application for the Provisional Order had to be withdrawn after a preliminary inquiry by the Light Railway Commissioners in May 1897. This was because the original plan for the tramway to run on the public road throughout had been rejected by some of the local authorities concerned and there were administrative difficulties over the acquisition of separate land for the tramway.

By mid-1898, other people were beginning to see the possibility of successful commercial development of tramways in Cheltenham, and several proposals were made to the Council, including one from Canada and a renewed proposal by Mr Nevins. The Council thought Nevins should have preference in view of their previous agreement, and decided to support a renewed application, adding the condition that power should be taken from the Corporation's electricity generating station and specifying that the paving of roads in which rails were laid should be hardwood blocks or MacDougall bricks.

Things did not go smoothly this time either. It was not until mid 1899 that the County Council withdrew its opposition, although the Rural District Council continued to oppose the tramway outside the borough because the Prestbury representatives considered the main street of that village too narrow. By now the plans had changed somewhat. The application was in two sections, and consideration was being given at this stage for the first section only of the tramway, from Pittville to the summit of Cleeve Hill. By December 1899 the Light Railway Commissioners approved the application, stating that, in their opinion, the road through Prestbury was wide enough for safe working of the tramway; and the Order was issued. Nevins decided not to proceed with construction until he had approval for the second section of the tramway; the part running through the town. This was approved and the order issued in April 1900.

At last construction started. Nevins's son took a house near Cheltenham so that he could superintend the work. The Corporation ordered equipment for

their generating station so that direct current could be supplied for the tramway, and this was ready by June 1901. The tramway was completed in July 1901 and trial runs were made.

It was unfortunate that the trials were marred by a very serious accident. A car making a trial run up the slope of Cleeve Hill had nearly reached the summit when the current failed (so it was said), the car ran backwards, the brakes failed to hold it, it overturned in Southam corner and crushed two workmen to death.

In spite of this mishap, which led to improvements being made in the brakes, the tramway was inspected on behalf of the Board of Trade by Col von Donop, R E, and approved. The public service started on Saturday 17 August 1901.

The tramway was so successful that extensions were soon under consideration. In October 1901 a proposal was made for a southern extension to Charlton Kings and Leckhampton. There was a lot of argument about this, and it was not until October 1902 that the Order was confirmed by the Board of Trade. Unfortunately Nevins died a few days before the Order was issued but his son, T A Nevins, announced that he would carry on and honour all agreements. However, there was still a lot of quarrelling between the Council and the company (known as the Cheltenham and District Light Railway Co), and it was not until March 1905 that the extension was completed and opened.

Other aspects of the story of the Cheltenham tramways, and their later history, are discussed in the booklet Cheltenham's Trams and Buses Remembered by J B Appleby (Transport Publishing Co., Glossop, 1973) and in the article The Tramways of Gloucestershire by A E Fielder in GSIA Journal 1973, pp 17-30.

Chapter 3

Gloucester

Electricity Supply

It was in the spring of 1889 that the Town Council of Gloucester first had to consider the question of electricity supply, because four companies had given notice of their intention to apply to the Board of Trade for Provisional Orders which would authorise them to supply electricity in the city of Gloucester. At the end of September the Town Clerk advised the Council that if they proposed either to apply for a P O themselves or to consent to the granting of a P O to any of the companies, it would be necessary to call a special meeting. It was resolved to proceed with such a meeting, which was held in October. The Council provisionally decided to apply for a P O itself, and being required to state in its application what streets were to be lighted by electricity within two years of the commencement of the order, named The Cross, Northgate Street, Southgate Street, Eastgate Street, Barton Street from Eastgate Street to the level crossing, Westgate Street, George Street, Clarence Street and the road from there to the railway station. However, it was felt that before making the application the matter had to be investigated more thoroughly, and things moved very slowly. The Council's lack of decision can be well seen in its turning down of a proposal, in May 1891, to take the opportunity to wire the Guildhall for electricity while other major work was in progress on the building so that electric light could be provided later without having to cut the building about. Again, in May 1893, there was debate as to whether the streets should be lit electrically in view of the increased price of gas. In August 1894, notice was received that two companies intended to apply for a P O and, in debating whether these applications should be opposed, members of the Council were uncertain whether or not the Corporation had itself applied for a P O. The companies' applications were not proceeded with anyway, and nothing was done.

In August 1895 yet another company gave notice of intention to apply for a P O for supplying electricity in Gloucester, and the City of Gloucester Tramways Co proposed a combined scheme for electric lighting and traction. At last the Council did more than talk; it sent a deputation to Bristol to see the generating stations of the Bristol Corporation and of the Bristol Tramways Co. The combined scheme of lighting and traction was being seriously considered and a special meeting was held on 12 November 1895. Council decided to apply for a P O themselves, agreeing to commit themselves in the application to light only a small central area; this could be extended later if desired. This area was from The Cross to Hare Lane in Northgate Street, to the Shire Hall in Westgate Street, to Commercial Road in Southgate Street, and a short distance along Eastgate Street. The application was this time actually made, and the Order granted, being confirmed in October 1896. However, action was still dilatory and it was not until February 1897 that a committee was appointed to consider what action to take under the Order.

In June 1897, Mr Robert Hammond, a well-known consulting electrical engineer, was appointed as consultant and asked to report on the general question of electric lighting of the city. His report which was presented in August that year, recommended the Corporation to proceed with the provision of an electricity supply and proposed that, in contrast to the system at Cheltenham,

a low-voltage d c supply should be provided, using the three-wire system of distribution with 440 V between the outer conductors. He recommended that the initial installation should comprise one 150 kW generator, and one of 300 kW to be kept initially in reserve; as demand increased, another 300 kW generator could be added. Storage batteries would be installed. The ultimate capacity, including reserves, would be 27,500 lamps of 8 candle-power. The estimated costs for the generating station were:

High-speed engines and dynamos of total capacity 300 kW	£5,650
[or if 450 kW]	£6,720]
Buildings	£7,200
Boiler-house plant	£1,500
Miscellaneous	£1,250
	<hr/>
Total	£15,600
	[or £16,670]

The use of slow-speed engines was estimated to increase the cost by about £3000. Hammond also reported on the Council's suggestion that a dust-destroyer be combined with the electricity works (as at Cheltenham); to deal with 30 tons a day this would cost, including boiler, £6000, but would result in a saving of £1200 on the electricity works. He recommended the Council to accept the combined scheme.

The Council decided to set up a special committee to consider the report and to visit a number of other towns to see what experience had been obtained of various systems. This committee reported in October. They had done their work very thoroughly and their report is a most useful document. They left open for further investigation the matter of high versus low-speed engines, but accepted that the Corporation should itself establish and manage the undertaking, and that although the low-tension system was by now not widely used, its use in Gloucester was justified by the compactness of the area.

The Council, after a full discussion on this report, accepted Hammond's recommendations, and engaged him to prepare the detailed plans and specifications and to superintend the carrying out of the works. His fee was to be 5% of the outlay on buildings and plant for the electricity works and 150 guineas for the dust-destroyer. The Council also decided to apply to the Local Government Board for sanction to borrow up to £50,000 for these works and the site, and for the associated cables and wiring.

It is interesting to note, in passing, that Hammond's fee was unusually large; from the limited data available a more normal fee would seem to be $2\frac{1}{2}$ - 3%.

One matter of crucial importance which was left undecided at this stage was that of the site for the works. It was not until 1 March 1898 that a decision was reached, and in the meantime there had been disagreement and fruitless negotiation. One party in the Council wanted the old gasworks site to be chosen; this was only a quarter of a mile from the city centre. The site was cheap - only £2500 - but would necessitate an extra £2000 expended on foundations, and also the purchase of adjoining properties to give a large enough area. Another group wanted to use a site near the depot in Seymour Road, about a mile from the centre. Hammond estimated the extra costs of cables in the various cases and seemed himself to prefer a completely central site which would necessitate separating the dust-destroyer from the electricity works, since the former clearly could not operate in the city centre. The argument that the saving on cables would compensate for the loss of the steam from the dust-destroyer evidently did not appeal to the Council and they eventually decided, against much opposition, on a site called the Beanland Estate near the docks. The asking price was £10,000, but the Mayor negotiated a provisional contract at £7125. A further £325 had to be paid to get possession from a firm which had a lease on the site.

By the end of March, Hammond had drawn up plans for the use of the site and obtained the approval of the Electricity Supply Committee.

In September 1898, the Council, with unusual wisdom, agreed to purchase an additional piece of land adjoining the site for £4000, this being an investment for surplus Corporation funds.

The Local Government Board's inquiry in relation to the application for sanction to borrow £50,000 was held on 21 December 1898 and the report makes interesting reading, being concerned mainly with the question of the possibility of noxious fumes from the dust-destroyer. Approval was given at the end of March 1899, with sanction to borrow £43,450 repayable with interest over 25 years. The purchase of the site was completed at about this time.

The foundation stone was laid on 26 July 1899 by the then Mayor, H R J Braime.

Progress thereafter was good. By December it was announced that the demand for lighting had exceeded expectations and that the capacity of the initial generating plant was already exceeded so that extensions would have to be made. Consequently another application had to be made to the Local Government Board for sanction for a further loan, this time £18,000.

The official opening had been planned for 24 May 1900 but the schedule was not quite kept and in the event the ceremony took place on 19 July, followed by a banquet in the Guildhall, presided over by Councillor Clutterbuck the Chairman of the Electricity Supply Committee and a leading figure in the long discussions and negotiations over many years.

By 31 August 9230 lamps had been connected and 4000 more were in hand or being negotiated. In addition, the public street lighting amounted to the equivalent of 730 lamps of 8 cp, but as Hammond explained in his first post-opening report in October 1900, this was well below the intended amount and £2300 of the authorised money for street lighting still remained unspent. Only when the additional generating equipment had been installed could

public lighting be extended. The new plant would double the capacity of the works and allow for 20,000 lamps of 8 cp all burning at the same time.

The money expended or committed was stated by Hammond to have been £51,025 (including the extension) as compared with £51,005 sanctioned by the Local Government Board (leaving out of account the £2300 not yet spent on public lighting). This seems too close to be credible and quite untypical for this kind of work.

The first $7\frac{1}{2}$ months working, up to the end of the financial year at 31 March 1901, showed a similar remarkable result. 188,334 units (kWh) were generated, of which 10,500 were used in the works and the remaining 177,834 were sold, ordinary consumers paying £2275 and the street lighting account £681. Rental of meters and wiring provided £77, miscellaneous receipts £75, but discounts subtracted £57, leaving net receipts of £3051. Outgoings were £1009 for generation, £273 for repairs and maintenance, £125 for rates and taxes, etc, £234 for management costs, £1139 for interest, and £283 for one year's repayment of loan, making the total outgoings £3063; that is, equal to the receipts within one-third of one percent!

The breakdown of the capital expenditure may be of interest. It was buildings £9371; machinery £15,500; accumulators (batteries) £1365; mains and laying £19,442; meters £1893; electrical instruments etc, £1915; stores etc, £171; public lamps £1530; engineer's commission £2339; general expenses £509; legal charges £62; cost of obtaining Provisional Order £286.

Charges were initially 7d per unit for lighting up to 100 hours use per quarter, thereafter 2d per unit. For motive power the rate was $4\frac{1}{2}$ d per unit up to the equivalent of 100 hours' use per quarter of the maximum demand recorded by the demand indicator, and $1\frac{1}{2}$ d per unit after that during the remainder of the quarter. Growth of business over the first ten years is discussed in Chapter 8.

Description of the Gloucester Generating Station as at July 1900

A very full description was given in The Electrical Engineer, Vol 26, 20 July 1900, pp 78-85, and only a brief summary will be given here.

The dust-destroyer was not built until after the generating station had been opened, but the site plan of Fig 4 shows where it was intended to go. Fig 5 shows the elevation of the station. The buildings were designed by Mr H A Dancy of Gloucester. The engine house, shown in the plan, was 54 ft x 37 ft, with a height of 28 ft. Only three of the four Lancashire boilers were fitted initially, and only the small 150 kW generating set and one of the 300 kW sets.

The larger engine, for the 300 kW set, made by Belliss and Morcom of Birmingham, was a triple-expansion engine with one high-pressure and two intermediate-pressure cylinders placed above three low-pressure cylinders. At 160 lb/in² steam pressure, 500 i h p should be generated at 350 rev/min. The smaller engine, by the same maker, was a 2-cylinder compound of 250 i h p at 130 lb/in². The dynamos were a pair of Silvertown 150 kW machines for the larger set, and a pair of 75 kW machines (also Silvertown) for the smaller set. The larger generating set, with the smaller one behind it is shown in Fig 6.

The switchboard was by Crompton of Chelmsford. The two batteries were supplied by the Electrical Power Storage Co, each containing 140 cells and able to supply 210 A for two hours or 80 A for 10 hours.

The mains were supplied and laid by Callender Cable and Construction Co. They were of the bitumen-filled trough type, so that the cable was solidly embedded in bitumen.

Remains of the generating station in 1974

The station was built on a site on the west side of Ladybellegate Street, Gloucester, almost in the corner between that street and Commercial Road; indeed there was access to the station from both streets. The buildings still stand, but retain none of the old electrical generating equipment. The boiler and generator houses are used by Priestley Studios as an adjunct to their more modern works (and older offices) in the actual corner of the two streets. The 10 ton weighbridge and weighhouse are still intact at the main entrance to the station in Ladybellegate Street. The buildings have a floor level corresponding to the level of Commercial Road, and from the higher level of Ladybellegate Street one looks down into the buildings. The chimney has gone. The view of the buildings to the N E shown in Fig 4 is impossible to obtain because it is obscured by other buildings, but some of it can be seen through the gap between Priestley's offices and the old offices of the Stoke Prior Salt Works in Commercial Road. The site still has a small connection with electricity, as the Midlands Electricity Board has a transformer sub-station in the yard.

Tramways at Gloucester

With the opening of the electricity generating station, it was natural that the citizens of Gloucester should think about the possibility of the tramway system being electrified and extended as in so many other towns. The City of Gloucester Tramways Co had been operating a horse-drawn system on a fairly small scale, with about $3\frac{1}{2}$ miles of route, since 1879 (including two years of unsuccessful operation by the original company which they took over in 1881); and there had been a good deal of negotiation with the City Council since the company had obtained an Order for extensions and modern traction in 1889. In October 1900 the Council considered whether they should attempt to purchase the tramway undertaking. Desultory negotiations led to a Council resolution in January 1902 to purchase the undertaking for £26,000 subject to the sanction of the Board of Trade and to the granting by the Light Railway Commissioners of an order similar to that already obtained by the Company which would, 'empower the Corporation to construct and work an extended system of electric trains (sic) in the city and environs'. It was estimated that the cost of conversion from horse to electric traction, together with the cost of purchase, and with some extensions, would be about £120,000. Thus financially this was a bigger affair than the provision of the generating station and electric light. On 12 March 1902 the proposal was finally agreed by Council.

The scheme was then considered by the County Council. The Chairman of the Highways Committee said that great inconvenience would arise if the Corporation were allowed to work tramways in the county area, and the

County Council therefore agreed to a proposal by Mr Nevins (who, it will be recalled, was the sponsor of the Cheltenham tramways) to construct part of the tramway. The Highways Committee had offered terms to the Corporation which they had refused. The County Council approved the actions of the Highways Committee, so that the County and City Councils were now at loggerheads.

The Corporation applied to have the tramway company's Provisional Order transferred to them, but the County Council opposed this transfer. Much argument followed and the matter had to be referred to the Light Railway Commissioners. But it would be many months before the Commissioners would get around to dealing with the matter and in the meantime the parties proceeded with their own plans independently.

In June 1902 it was announced that the County Council were planning their own line from the City boundary to Brockworth (3-4 miles to the east of the city) at an estimated cost of £40,000. By the beginning of August the City Council had obtained the Board of Trade's approval for the purchase of the tramway company, and by the end of September the agreement between the Corporation and the Company for purchase at £26,000 was confirmed. However, a month later the company complained that the Corporation had neither taken over the tramways nor paid over any money. As the company was running at a loss, this delay was serious, and it stated the loss would be charged to the Corporation. In fact the company was not taken over until 1 January 1903.

The Light Railway Commissioners held their inquiry in Gloucester in August 1902 and announced their decision at the beginning of November. It was a judgement of Solomon! They granted the application of the Corporation for tramways within the City and the application of the County Council for tramways outside the City; however, they did insist on through services.

Fortunately, wiser counsels eventually prevailed at the local level and in March 1903 the County Council tentatively agreed that the Corporation should construct and own the tramways outside the City, subject to wayleave payments and the right to purchase after 30 years. The final agreement, reached at the end of April, was rather different and perhaps more satisfactory. The County Council were to construct the line outside the City and then lease it to the Corporation for 99 years. All was now set for action.

The Corporation appointed Robert Hammond, together with a Mr Dickinson, as consulting electrical engineers to the tramway undertaking. By December 1903 plans had been made for the expansion of the electricity generating station to provide power for the 30 tramcars. Two 200 kW, 550 V, d c generator sets, with Willans engines, were to be installed by G E C to meet the traction load. On 9 November 1903 the first rail of the old tramway to be lifted and the first new rail to be laid were ceremoniously handled by the retiring and incoming mayors respectively, and by the beginning of May 1904 practically the whole of the new tramway was completed and opened for traffic. The Mayor himself drove the first tramcar.

The track was laid by the contractor George Law of Kidderminster for £47,655, using rails made at Barrow in 50 ft lengths, 90 lb per yard. In the centre of the city, the roads were paved with jarrah wood blocks; in other parts stone setts were used, being obtained chiefly from Law's quarries at Caernarvon and, like the rails, brought by ship to Gloucester Docks.

The cars were 25 ft long, 6 ft 6 in wide, with seats for 18 passengers inside and 23 outside. A photograph of one is reproduced in Fig 7. The four-wheel trucks were by the Brush Co, with a wheelbase of 6 ft 6 in; the electrical equipment by Dick, Kerr & Co included two four-pole series-wound iron-clad motors. Current collection was by overhead trolley.

The service interval on the tramway was 5 to 10 mins. Evidently it proved popular, for in the first 20 weeks the number of passengers carried was 1,846,000, of whom about 40% took $\frac{1}{2}$ d tickets, 40% 1d tickets and 20% paid higher fares.

The total cost of construction and equipping came to £147,000 which was not very much higher than the first estimate of 1902, and was indeed claimed to be £26,000 less than the finally-agreed estimate.

Other aspects of the story and a map are given by A E Fielder in The Tramways of Gloucestershire, GSIA Journal 1973, pp 17-30.

Stroud

Early proposals

A proposal for public lighting by electricity in Stroud was made in September 1888:

A ratepayer of Stroud has recently suggested the lighting of that town by electricity by means of the water and steam power in the neighbourhood, which is abundant and could easily be utilised. He suggests the spreading of the lighting over the district by means of dynamos in the various mills and breweries, which should light the public ways while illuminating their own factories The suggestion gathers weight from the fact that the little town of Wickwar, near Stroud, of about 1000 inhabitants, has just been lighted in this manner from a dynamo machine in the neighbouring brewery. (5)

This suggestion was not followed up, but in November 1890 a meeting, prompted by Messrs V A Lawson and E N Witchell of Stroud, was held at the Subscription Rooms to consider a new proposition for the electric lighting of Stroud. (6) It was a concrete proposal for a high-voltage a c system, involving about £15,000 of capital expenditure, and supplying about 2000 incandescent lamps initially. If the proposal went forward, the House-to-House Electric Supply Co would provide 25% of the cost, and indeed had already applied for a Provisional Order. The meeting approved of the proposal and recommended that a committee be formed to go into the matter. But somehow, after this promising start, the whole business faded out. Admittedly the Lighting Committee of the Stroud Local Board, although primarily concerned with the existing system of gas lighting in the streets, did in July 1891 suggest that the cost of electricity should be looked into and that Mr George Norman of Cheltenham (who was Chairman of the Electric Lighting Committee there) should be consulted. (7) But again nothing came of this.

There were numerous private electrical installations in the mills around Stroud, and it is possible that as their number grew this made the public supply of electricity much less attractive commercially than it would otherwise have been in such a populous area. As an example of a private installation, (put in during 1896) we can take the case of Marling and Co's Ebley Mills. (8) Here a 35 h p high-speed engine drove an 18 kW, d c dynamo to provide electricity for 350 lamps in the mill. In many mills, however, the surplus power of the existing mill engine or water-wheel was used to generate the electricity for lighting, at an apparently very low cost.

Nevertheless, further proposals for a public electricity supply did come forward. In July 1900 the United Electric Light and Traction Co gave notice to the Stroud U D C of their intention to apply for a Provisional Order, and stimulated the Lighting Committee to the following recommendation: (9)

The Lighting Committee having considered the notice received from the United Electric Light and Traction Co Ltd of their intention to apply for a Provisional Order authorising the supply of Electricity for Public and private purposes in the Council's area are of opinion that it would not be to the interests of the Ratepayers of Stroud to permit the electric light to be supplied otherwise than by the Council and recommend the Council to obtain at once a Provisional Order for the purpose of supplying electric light within the Urban District area.

The Council considered the matter on 3 October and again on 17 October 1900. The Clerk was instructed to oppose the granting of a P O by the Board of Trade to any company on the ground that the Council was contemplating applying for a P O itself.⁽¹⁰⁾ There was a suspicion that what the Council had in mind was that they could, by obtaining a P O themselves at a relatively modest cost (perhaps £150), prevent a company getting one and thus be able to postpone having to bother with the question of electric light. The editor of the Electrical Engineer was very outspoken on the iniquity of this.⁽¹¹⁾ The Council accepted Messrs Medhurst and Lloyd's offer to prepare a report for 25 guineas, this to include the question of a dust-destroyer. The report came before the Lighting Committee in June 1901, but in August that year it was announced that the matter was being held over for a time.⁽¹²⁾ Whatever the Council's intentions may have been, they had an excuse for delay in that the Gloucestershire Electric Power Bill was already being proposed. This created an important and interesting diversion in Stroud's slow progress towards electric light and power.

The Gloucestershire Electric Power Company and its Bill

By January 1902 the Council had unanimously resolved to oppose the Bill in order to obtain some concessions,⁽¹³⁾ so details must have been available to them in 1901. The earliest details published appear to be in January 1902, when under the heading Gloucestershire Electric Power Company, the Electrical Engineer⁽¹⁴⁾ reported as follows:

A Bill has been deposited by this Company for the purpose of supplying electricity in bulk for power only in Stroud, Dursley, Wheatenhurst, Westbury-on-Severn, Aylburton, Alvington, St Briavels and Hewelsfield, Hill, Ham and Stone, Alkington, Berkeley, Breadstone, Hamfallow and Hinton, and so much of the unions of Monmouth and Tetbury as lie within Gloucestershire. The Company will supply electricity to authorised undertakers and to persons requiring a supply for power. The Company will not supply any electricity for lighting purposes except through authorised undertakers, provided that any persons taking electricity for power purposes may light the premises on which the power is utilised. The Company's capital is to be £250,000 in 250,000 £1 shares.

The Company are also prohibited from supplying energy within the area of supply of any authorised distributors without their consent, 'which shall not be unreasonably withheld'. For the purpose of this Bill, power is sought to erect generating stations in the Parish of Cainscross, Stroud, and in the parish of West Dean, near Parkend Station ... The Bill, however, prohibits the Company from putting

into force any of their powers for the compulsory taking of land until £25,000 of the capital of the Company has been fully subscribed, and until the expiration of 4 years from the date of the passing of the Act power is sought to pay 4% interest out of capital on the amount from time to time paid up on any shares. The dividend payable by the Company is proposed to be limited to 10%, but subject to a sliding scale based on the standard price of 3d per unit. The promoters of the Company named in the Bill are Sir William Henry Marling, Bart, Mr James Grainger Bellamy, Mr John Hamlyn Borrer, Mr Thomas George Clissold, Mr James Evans, Mr Thomas Newcomen, Mr Archibald Grove, Mr William John Paley Marling, Mr John Drummond Robertson, Mr James Henry Stephens, Mr Athol Thorne and Mr Edward Weeden Winterbottom.

Mr Winterbottom was a Stroud solicitor and solicitor to the Company. The name Thomas Newcomen is also worthy of note!

The map (15) of the company's area is shown in Fig 8. Detailed plans (16) show the proposed sites of the generating stations: at Cainscross in the angle between the Stroudwater Canal and the River Frome (grid ref SO 833047) and at Parkend between the Square and the railway station (grid ref SO 616079).

It should be pointed out that bulk schemes of this kind had already been proposed and authorised elsewhere, (17) and some of these actually came into operation. (18) During 1900-01 no fewer than ten schemes came before Parliament, so that by the time the Gloucestershire Bill was introduced, Parliament had acquired a good deal of experience in this kind of matter.

The Bill had its first reading in the Commons on 31 January 1902 and went through its numerous steps smoothly, receiving the Royal Assent on 23 June 1902. (19) The various local Councils, which had all registered opposition to the Bill initially, more-or-less on principle, withdrew their opposition after minor though time-consuming negotiations with the company.

A Gloucestershire Electric Power Syndicate Ltd had been registered (20) on 22 March 1902, 'to carry on the business of an electric power supply company', etc, and the G E P Company Ltd, which was set up by the Act of Parliament, had substantially the same directors as the Syndicate. No doubt the Syndicate was the 'Steering Committee' which got the Bill through Parliament and got the company organised, but it remained in being for some years, and indeed, in 1909 gave notice of intention to apply for a Provisional Order. (21)

The company never built its power stations nor did any commercial business. Its powers were formally revoked on 22 March 1920. The reasons for this failure are not clear. The company was connected to some extent with the Stroud District and Cheltenham Tramways Company, which also failed to build or sell anything, and as the two failures may have been connected, we must briefly consider the tramway company before proceeding with the story of electricity at Stroud.

The Stroud District and Cheltenham Tramways Company and its Bill

The story of this company and its most interesting proposal to operate trolleybuses at Stroud, years before they were operated anywhere in

Britain, has been told in some detail and with full references in a separate article. (22) Briefly it was Thomas Nevins, who had successfully completed the electric tramway system at Cheltenham in June 1901, who in July of that year proposed an electric light railway linking Stroud to Painswick, Chalford, Nailsworth and Stonehouse. The proposal was supported by all the local councils and traders' organisations. Nevertheless, the Light Railway Commissioners rejected the proposal in August 1902 on the sole ground that it competed with the existing railways. Another setback was Nevins's death early in October 1902.

The scheme was taken up again immediately; a company was formed and a Bill prepared for submission to Parliament for the incorporation of the company to construct and operate the tramway. The Bill successfully proceeded through Parliament from 23 February until it received the Royal Assent on 14 August 1903. The plans (in great detail, showing also other interesting industrial works), together with the books of reference, are in the Gloucestershire County Record Office. (23)

The proposal to work some of the less busy routes by trolleybuses was first announced in February 1903, and was fully explained in evidence to the Parliamentary Select Committee on 29 and 30 April and 1 May 1903. The routes envisaged are shown in Fig 9, where the way in which they radiate from Stroud is apparent, and where I have made a clear distinction between those routes in the more densely-populated areas which were to be ordinary tramways, and those in more sparsely-populated areas which were to use trolleybuses. Mr Balfour Browne, K C, opening for the promoters at the Select Committee's enquiry, said in reference to the trolleybus proposal:

Whereas an ordinary tramway cost £7000 a mile, this would only cost £1000 a mile. This cost was comparatively a small matter, and for the development of these country districts it was very important that places which could not bear the large expense of tramways should be given accommodation at once.

Mr A A Campbell Swinton, consulting engineer to the promoters, said:

The motor omnibuses [trolleybuses] he saw in France were about three tons, and they were rather too heavy. Something lighter was required in this scheme. The omnibuses should carry 16 to 20 people.

It also transpired that there was some suggestion that the public might be allowed to use the wires for trolley electric locomotion, and this idea appealed to the Select Committee. It was, however, decided to defer this matter for possible later development.

Nothing came of the scheme. This was a pity, for it was a most interesting one. There was a strong implication that the electric traction proposal was part of an effort to provide a load for the electricity supply scheme. The two companies had three directors in common. It was necessary for both companies to be successful in raising capital for either of them to go ahead. Presumably this extra constraint proved too much for the companies.

The Provisional Order of 1903

We have referred to the Gloucestershire Electric Power Bill as a 'diversion'. It really was no more than this, for the Stroud U D C resumed its consideration of the possibility of a local electricity supply within a year. Had the Power Bill led to a bulk supply of electricity becoming available, the U D C would have had to change its thinking only to the extent of replacing a local generating station by a bulk supply purchased from the power company.

It was the United Electric Light and Power Co that once again stimulated the Council to consider applying for a P O, for in July 1902 the company informed the Council that they intended to apply for a P O to supply electricity within the Urban District. (24) The Clerk was instructed to inform the company that the Council had already resolved to apply for a P O. It is to be feared that this was not an altogether truthful statement, for the resolution was not in fact passed (25) until 7 January 1903. However, the Council seemed to be in earnest this time, and their various negotiations (26) for wayleaves for cables and so forth are evidence of their apparent intention to go ahead with an electricity scheme. The P O was granted by the Board of Trade towards the end of 1903. Unfortunately the Council then seemed to forget all about the matter.

They were reminded of it by a letter (27) from the B O T dated 18 October 1906, pointing out that the P O had required certain works to be carried out within a specified period, but nothing had been done and, 'it devolves on the Board to determine whether the order should be allowed to remain any longer in force'. The Council was not by now thinking in terms of building its own generating station and system, but thought it just possible that the Gloucestershire Electric Power Co might still do something, and that it would be wise to keep the P O in force; so they requested an extension of time on the grounds that the question of extending the boundary of the Urban District was being considered and the B O T agreed to defer revocation of the P O for 12 months. (28) However, the Council did no more, nor did the Power Co, and the Order was eventually revoked. Nothing more of significance happened until about 1912.

The Provisional Order of 1913: The Stroud Electric Supply Co and Messrs Edwards and Armstrong

During 1912-13 several companies gave notice of intention of applying for a P O, and one application, made by Mr J H Edwards on behalf of what became registered as the Stroud Electric Supply Co Ltd, was encouraged by the U D C. The Order was obtained in 1913. The company purchased five acres of land at Cainscross for their station and depot, (29) but the Great War came and they were unable to proceed. They had, however, some applications for electricity which they felt deserved special treatment, and they were able to arrange to obtain a small supply of electricity using the power available at one of the local mills. This did not prove satisfactory for long, and they set up a temporary generating station. Unfortunately I have no information as to its location or equipment. It carried on for some years apparently.

After the war the idea of bulk generation of electricity was revived and a new scheme (30) for a large area of the West of England was put forward without success. (31) The Stroud Co had hoped that bulk supplies would become available, and had therefore built only another temporary generating

station. When the bulk scheme failed in 1921, the temporary plant was augmented, but apparently did not give complete satisfaction to consumers. It had to suffice, however, until the West Gloucestershire Power Co, was able to supply electricity in bulk a year or two later.

The Stroud Electric Supply Co Ltd, was one of at least 13 electricity supply companies which were eventually either owned, managed or serviced by the Stroud firm of Edwards and Armstrong Ltd, of Bedford Street, Stroud. The others included the companies at Tewkesbury and Cirencester in Gloucestershire, together with those at Chippenham, Trowbridge, Melksham, Malmesbury, Warminster, Abingdon, Wantage, Leominster, Ledbury and Ruthin. (32) Some if not most, of these undertakings had their own generating stations. The directors of the Stroud Co were, in 1922, J H Edwards (managing), A A Douglas and C A Apperly.

The West Gloucestershire Power Co Ltd

On 23 March 1922 the Norchard Syndicate Ltd was registered, changing its name to the West Gloucestershire Power Co Ltd in September of the same year. (33) Its stated object was to construct an electricity generating station at Lydney and to supply electricity in West Gloucestershire. Its directors were J Davidson (Chairman), R M Horne-Payne and D Northall-Laurie, and its offices were in London. Its capital authorised was £600,000 and by 1924, £535,000 had been taken up.

On 31 August 1922 the Electricity Commissioners sanctioned the project on the basis of an ultimate capacity of 30 MW, and the West Gloucestershire Electricity Supply Special Order 1924 specified the area of supply as the Urban Districts of Awre, Coleford, Nailsworth, Newnham, and Westbury-on-Severn, and the Rural Districts of West Dean and East Dean, and the United Parishes of Wheatenhurst, Dursley and Stroud, together with parts of the Rural Districts of Thornbury and Lydney; a total of 300 square miles.

The system was to be 3 phase a c at 50 Hz, 6600 V. The overhead transmission lines were to operate at 33 kV, and the local distribution at 400V, 3 phase, and 230V single-phase. Two Belliss-Parsons turbo-alternators each of 5MW capacity were to be installed initially, working pressure 260 lbs/in.² The station was built, the lines constructed, and supply commenced generally by mid 1924.

Naturally this development greatly interested the Council at Stroud. Both the Urban and Rural District Councils considered the matter and after initial objections eventually agreed jointly to support the scheme and the entry of the Power Co into their areas. (34) The Stroud Electric Supply Co agreed to buy their electricity in bulk, and this decision necessitated the changeover of many fittings and equipment from d c to a c. There was a good deal of debate on this matter, but it eventually went ahead quite smoothly. Thus it was not until 1924 that Stroud got a satisfactory and adequate electricity supply. Even then the public lighting continued to use gas, in spite of the repeated complaints that are regularly reported in the Council's minutes and in the local newspapers over a period of 30 years or more!

Chapter 5

Tewkesbury

Early proposals and discussions

Although it was not until 22 years later that Tewkesbury got its electricity, there had been public discussion of the possibility of electric lighting as early as 1887, (35) owing to dissatisfaction with the gas supply. The Town Council started considering the matter early in 1892. (36) A committee was formed to look into the possibilities, and it is on record that an effort made to exclude the gas interest from it was unsuccessful! An editorial in The Electrical Engineer for 5 February 1892 took notice of the matter and suggested that it might be possible to use the water power of the rivers Avon or Severn for generating electricity at Tewkesbury. As the town is quite a small one (then well under 5000 people), the suggestion was sensible enough, but was apparently never followed up. Nor did anything come from the committee's deliberations.

The matter of electricity for Tewkesbury arose again in 1899, apparently on the initiative of Councillor Jackson and not because of some external stimulus. This time the Council considered it desirable to apply for a Provisional Order and appointed a committee to enquire into the cost of doing so and also into the cost of providing an electricity supply. (37) Messrs Christy Bros of Chelmsford were retained to report on a system of electricity supply for lighting in Tewkesbury. (38) By mid 1900 the Council were postponing their decision in applying for a PO 'to give the ratepayers a chance to discuss it', (39) and soon a company (the North British Electricity Supply Co) gave notice that they would apply for a P O. (40) It is believed that both they and Christy Bros made similar proposals (41) to the Council, specifying a low-voltage, d c system with storage batteries, incandescent lamps for street lighting and a total generating capacity equivalent to 4000 lamps of 8 c p. The recommended site was at the back of the Town Hall. The total cost was estimated at £6000. The Council did not give approval to the proposal from the N B E S Co, and decided also (on the grounds of expense) (42) not to proceed with its own scheme as proposed by Christy Bros. An interesting feature of the Council's discussions and decisions was the argument as to whether Councillors who were shareholders in the Gas Company should take part and vote. On one occasion a decision against electricity was determined by the casting vote of the Mayor who was a shareholder in the Gas Co, and protests about this were entered in the minutes. (43)

Electric Light Railway proposal 1902-3

An interesting proposal which was put forward in the Council during the interlude between the electricity proposals of 1900 and those which were to follow in 1903 was that for an electric tramway (technically described as a light railway for legal purposes) to link Tewkesbury to Gloucester. There was much dissatisfaction with the railway facilities at Tewkesbury, and it was thought by the supporters of the scheme that an electric tramway costing about £60,000 would be profitable as well as being of great benefit to the town. The Town Council on 15 December 1902 debated the matter and

referred to a Committee of the whole Council a proposition that the County Council be 'memorialized' to take such steps as might be necessary to provide the light railway.(44)

The Council undoubtedly met in Committee to discuss the matter,(45) but nothing further appears in the minutes, nor can any published report be found. The scheme was not proceeded with, but the reasons for its abandonment cannot be ascertained.

The Provisional Order, 1905

The question of electricity supply in Tewkesbury arose again in 1903, when notice was received from several companies of intention to apply for a P O to supply electricity in the town.

A summary of these cases follows:

- (1) National Provincial Electricity Corporation
- (2) Empire Electric Light and Power Co.

Both these companies gave notice to the council in July 1903 but were not supported.(46)

- (3) Southern District Electricity Corporation, a branch of Foote and Milne Ltd, of Westminster.

Notice to the Council, July 1903; the Council refused consent, December 1903; SDEC withdrew application, January 1904; New notice to the Council, July 1904; consent refused.(47)

- (4) Chepstow and Ross Electricity Co in the person of Mr Fourd Ely.

Notice to the Council, May 1904; advertised publicly, November 1904; refused by the Council, December 1904.(48)

- (5) Tewkesbury Gas Co.

Notice to the Council, August 1904; consent refused.(49)

It was these applications that stimulated the Council to debate whether it should itself apply for a P O. Several long discussions were held, and it was clear that if the Council decided to apply for a P O the objectives would be:

- (1) not to work an electricity undertaking itself, but to transfer the P O to some approved company on terms advantageous to the Council.
- (2) to get the price of gas reduced, and
- (3) should the Council decide to purchase the gasworks, to take them over on more advantageous terms than would be possible if the Gas Co had a monopoly of gas and electricity.(50)

Although those members of the Council who were shareholders in the Gas Co opposed the application by the Council for a P O, they did not on any occasion vote on the matter. It was either then, or a year or two later, established that it was illegal for them to speak or vote in connection with this sort of question.(51) It was finally decided in November 1904 to apply for a P O, and it was granted by the Board of

Trade in April 1905 and confirmed by Parliament on 4 August 1905. (52) The total expense of obtaining it had been £180. (53) The estimated cost of the electricity system proposed in the P O was about £6000.

There the matter rested for over two years. There is no further reference to electricity in the Council minutes until June 1907.

Transfer of the Order to a Company, 1908

Provisional Orders were issued with the provision that certain work specified in the order had to be done within two years of issue. The Town Clerk reminded the Council of this in June 1907, and the Board of Trade wrote to the Council on 3 July 1907 thus:

I am directed by the Board of Trade to enquire what steps the Undertakers have taken, or are proposing to take in the immediate future, to carry out their obligations under the Order.

At the same time, Messrs Foote and Milne Ltd, who had been the sponsors of the Southern District Electricity Corporation which had unsuccessfully tried to get a P O for Tewkesbury in 1905, noting that the Council's P O was about to expire, gave notice of their intention to apply for a P O.

The Town Clerk was instructed to reply to the Board of Trade that:

After proper inquiries had been made, it appeared very doubtful whether the works could at the present time be erected and conducted at a profit, and subsequently further inquiries were made. These various inquiries had occupied the time since the order was granted, and it was now felt that if an extension of the period for carrying out the works was made, it was very probable that in a short time arrangements would be entered into for the transfer of the order to a company. (54)

This was accepted by the Board of Trade and by December that year the Council had come to terms with Mr John Parker of Hereford and agreed to apply to the Board of Trade for an Order enabling them to transfer the P O to him. The terms of the agreement were that he was to pay the costs of the Order not exceeding £300; the Council was to have the option of purchasing the undertaking at the end of 14 or 21 years or any subsequent period of 7 years, or upon the liquidation of the company, at its fair market value; the maximum price for supply to public buildings and street lighting was not to exceed 4d per unit; a free wiring system was to be adopted, etc. These were rather harsh conditions. (55)

By November 1908, B O T and Parliamentary approval was obtained for transfer of the Order to the Tewkesbury Electric Light Co (the company having been formed by Mr Parker for this purpose). (56) The company proceeded rapidly to construct and instal its system.

The position of Mr Parker is interesting. He was City Surveyor and Waterworks Engineer to the Hereford City Council, and the Tewkesbury Council had to write to the Hereford Council to obtain permission for him to act for them, as he had already acted at Ludlow and other places. (57) He was apparently free to form companies and act as their Chairman.

Electricity in Tewkesbury, 1909

The company was leased a piece of land in St Mary's Lane, Tewkesbury for the purpose of erecting the generating station (see Fig 10). This land formed part of the Council's Yard, but was to be completely separated from the Council's operations by the erection of a high fence. The rent, to include a cottage and garden on the site, was £35 p a excluding rates and taxes. (58)

The proximity of the generating station to St Mary's Abbey gave rise to some concern lest the fumes and exhaust from the suction gas plant and gas engines which were to be used should damage the fabric of the abbey. The Council sought assurance from Professor Church and from the staff of some building journals and were informed there was little or no risk of damage. (59)

The electricity supply commenced in July 1909, and from early June the Cheltenham firm of Sanders and Co, electrical engineers, were regularly advertising in the local newspapers, offering specifications and estimates for electric wiring in Tewkesbury. (60)

Only private lighting was supplied. Public street lighting continued to be by gas, and the reasons for this are discussed later. The generating station contained a gas plant and a gas engine coupled to a 30 kW dynamo, together with a battery of 127 cells which could supply 36A for 10 hours. (61) Garcke's Manual said there was also a water turbine of 30 kW, but this is a puzzle. Although the station was very near the bank of the River Avon there was no weir nearby from which a water supply with a head of a few feet could have been obtained, nor is there any sign of a leat or headrace either on the Ordnance Survey map as revised in 1921 or on the ground now; nor is there any sign of a tailrace. Moreover, the company's prospectus, (62) which specifies the plant to be used, does not mention a turbine, and the plan of the site as discussed at Council meetings shows no leat. (63) It is difficult to see where a leat could have run. Unless more positive evidence of the use of water power can be found, we must view the existence of the water turbine with some scepticism.

The distribution was by d c mains at 230V, with cables in earthenware conduits, and some stretches of aerial conductors, as for example along the river bank from opposite the generating station to the Abbey Mills.

The company, whose authorised capital was £5000, had five directors: In addition to Mr Parker there were J Mitchell, A Johnson, J J Burton and J H Edwards. The last name is interesting. Edwards was ten years later to be the principal of Edwards and Armstrong Ltd of Stroud and of a large group of electricity companies with head office in Stroud, one of these companies being the Tewkesbury Electric Light Co.

By 1923 the station had a 57 kW Crompton dynamo driven by a crude-oil engine in addition to the gas engine set, and was generating about 130,000 units per annum. (64)

A nondescript brick building which was almost certainly the old generating station still stands beside the River Avon; from St Mary's Lane it is largely hidden by a very fine brick building of considerable antiquity. Both buildings now form part of the works of S & M Tools & Components Ltd.

Gas versus electricity for public lighting in Tewkesbury

In 1908, with the availability of electricity imminent, the Council had decided to terminate their contract with the Gas Co for the lighting of the streets of Tewkesbury. This left them free to consider whether in future the streets should be lit by gas or by electricity. Thus in February 1909 the Council called for tenders from both the Gas and Electricity Co's for lighting the town. (65)

The original contract with the Gas Co had been on an annual basis. In making a tender for continuing the gas lighting on the same financial basis as before, which worked out at £2-16s-10½d. or £2-19s-10d per lamp per year (according to type), the company insisted that any new contract must be for a minimum period of five years.

The Electricity Co tendered on the basis of £2-10s-0d for each lamp burning 4000 hours per annum, but (a) only in streets where their mains were laid, and (b) provided the Council would provide the lamp standards, costing about £7 to £9 each.

Both tenders annoyed those members of the Council that were not associated with one or other company. The Council were not prepared to accept a commitment to gas lighting for five years since electric lighting was thought to be superior. On the other hand they objected to having to lay out capital on lamp standards without any guarantee that the Electricity Co would be able to continue to supply them. The arguments were protracted. Neither company would give way, and the Council's Surveyor had to prepare plans for lighting the town or part of it, without gas or electricity, using, for example, petrolite lamps. (66)

Eventually, in July 1909, with the electricity station just opening, the Gas Co gave in and agreed to continue the lighting on the old basis of an annual contract. (67)

In spite of the arguments that had taken place, the public lighting continued to be by gas for many years more than the five over which the council had argued so bitterly!

Cirencester

Early proposals for electric lighting

The first proposal for public electricity supply for lighting purposes in Cirencester appears to have been made in 1882, (68) and it was not until 30 years later that the town actually had electric light. However, 1882 was the year of the very beginning of public electricity supply in the world, and it was not to be expected that in a small town like Cirencester a public system would materialise as early as that. Nothing more was heard of such a proposal until 1890, when in July notice was received by the Cirencester Local Board of a proposed application for a Provisional Order by Messrs Latimer Clark, Muirhead & Co Ltd. (69) A few months later the company was asking the Board to arrange a special meeting to decide whether it could support the application. (70) The Streets Committee discussed the matter briefly in connection with their consideration of a rise in the price of gas, and recommended the Board to dissent from the company's proposal; (71) no action was necessary as the time had already passed by which the application had to be lodged.

In January 1897, Messrs Eastlakes Ltd asked the Urban District Council (as the Local Board had then become) whether they would support them in an application for a P O for providing electric light in Cirencester. (72) The General Purposes Committee considered the matter and on 30 September 1897 recommended that if electric lighting were to be established in Cirencester it should be in the hands of the Council and that the Council should not be prepared to grant facilities to the promoters of a private undertaking. (73)

The next proposal was in 1900, when the United Electric Light and Traction Co Ltd notified their intention of applying for a P O. (74) Nothing was done and the proposal lapsed. The next year the Lighting Committee of the U D C, bearing in mind the forceful steps the Gas Company was taking to obtain an increased price for gas lighting in the town, recommended the Council to give serious consideration to applying for a P O itself so that electric lighting would not get into the control of a private company. (75) However, the Council did nothing, and postponed discussion of the matter sine die. (76)

In July 1903, notices of intention to apply for a P O were received from the Southern District Electricity Corporation and the Empire Electric Light and Power Co Ltd (77) (which were both also making proposals at Tewkesbury at the same time) but the Council took no action in the matter until another letter from the S D E C caused them to decide not to consent to their application. (78) The Council received a renewed notice from the S D E C in July 1904, (79) but the Chairman said that when the intended application for a P O was actually made it would be time enough for the Council to deal with it. (80) The press report was sarcastically headed 'A Hardy Annual'.

In July 1905 and again in July 1906 similar notices were received from the Cirencester Electric Supply Co, and once again treated with lofty disdain by the Council, the term 'hardy annual' again being used. (81)

Electric lighting was then forgotten until July 1910, when a notice was received from Mr J H Edwards, then of Bristol; (82) the rural district area was also involved. This proposal was taken seriously, and led to the provision of electricity supply (but not electric street lighting) in Cirencester. The Council did not now raise the question of whether they should themselves obtain the P O but were content to let a private company obtain it.

Electricity supply in Cirencester

Edwards, the Council and its Streets Committee moved fast in this matter. On 22 August 1910 Edwards requested the Council's support, saying he would form a company as local as possible in character. (83) The Streets Committee interviewed him and ascertained that he had ample capital even without local financial help, that his company would have an initial capital of £6000, that he would start with 1 mile of supply mains. They then negotiated the terms of the draft P O which was to give the Council the option to purchase after 21 years or any succeeding 5 years (N B the normal period was 42 years and Edwards at first proposed this period; it was evidently beaten down to 21 years by the Committee). The streets initially to be supplied were agreed as Castle Street, Market Place, Cricklade Street, Dyer Street, Gosditch Street, and Dollar Street (see Fig 11). The maximum price per unit over 30 units was to be 7d.(84) All this was agreed by the Council on 26 January 1911,(85) the Board of Trade also acted rapidly, and the P O was granted in April 1911.(86)

The generating station was in Barton Lane, at grid ref SP 018024, as shown in Fig 11. Details of its plant have not yet been discovered, but an aged local informant, who remembers it being built when he lived in the same road as a boy, has stated that it was a crude building, largely in galvanised iron, and had a large external flywheel. It was burned down in the late 1920s or early 1930s. There is now a small metal-fittings factory on the site.

Supply commenced in November 1912, on the basis of d c at 230V (probably a 3 wire system with 460V across the outer wires; this was certainly the system 10 years later, when the total power was 284 KW).(87) Distribution in the main streets was by underground cable, and the Streets Committee had disputes with the company over the reinstatement of the roadways and footpaths.(88) The supply was later expanded by means of overhead wires.

J H Edwards transferred the P O to his company, the Cirencester Electric Supply Co, registered on 15 May 1912 as a private company; it later became a public company. The initial capital of £6000 had extended to over £10,000 by 1923, by which time the annual production was about 125,000 units.

Public street lighting in Cirencester continued by gas at least until after World War I.

Chapter 7

Introduction

It will be seen from Part 1 that the five towns in Gloucestershire for which we have examined the early history of electricity supply in some detail exhibit a very wide variation in this regard.

Reasonably detailed studies of a similar type are also available for four other towns which are very close to the borders of Gloucestershire, namely Worcester, (89) Bristol, (90) Monmouth (91) and Swindon. (92) Indeed, these are practically the only such histories available for Britain. It is useful that, with the five towns of Gloucestershire, they form a very convenient region (which we may call the 'Gloucestershire Region') of manageable size in which we may examine the electrical history and which may possibly prove to be a microcosm of the whole British provincial electrical scene.

The variety in the early electrical history of this enlarged Gloucestershire Region is shown very clearly in Tables 1 and 2, in which the history is presented in a highly-summarised form. From Table 1 we see, indeed, that no two of the nine towns had the same pattern of electrical development.

What we now propose to attempt is an examination of the varied history against the background of the national electrical scene, to determine whether the Gloucestershire Region is typical of the whole in regard to those aspects for which national information is available. It will appear that this is indeed very largely true, and it is therefore a reasonable argument that the more detailed history of the individual towns which we have set out in Part 1 may well be representative of the sort of processes which would appear in the electrical history of other towns and regions if they were to be studied in the same degree of detail. Thus we can claim that this study is of much more than local importance; it illuminates the whole British electrical scene.

Chapter 8

General Aspects

The growth of sales of electricity

The growth of the electricity supply industry over the years 1895-1913 is shown in Fig 12, where the plotted points have been obtained from Byatt.(93) It can be seen that while the power sales started slowly, by 1909 they had overtaken lighting sales and were soaring. Traction represented a more-or-less saturated market by 1913. Lighting sales, while generally increasing, showed a marked slowing down around 1905 to 1910. The only unexpected feature of these graphs is the last-mentioned, and Byatt suggests that this is probably due to the introduction of improved incandescent gas mantles, which for a time made gas lighting much more competitive vis-a-vis electricity.

For our Gloucestershire region, the total electricity sales (94) in the larger towns are compared in Fig 13, over the same period, with the national total sales obtained by adding together the three sets of figures in Fig 12. It will be seen that the general trends are all roughly the same, but that only Worcester and Bristol follow the national trend at all closely; the other three towns plotted show a marked slowing of growth from about 1906 onwards. Bristol and Worcester show only a small hesitation around 1909. The explanation of this difference of behaviour almost certainly lies in the different nature of the electricity load in Bristol and Worcester as compared with the other three towns.

In Bristol and Worcester there was a very substantial power load. In Worcester in 1909, the sales were approximately 674,000 kWh for private and public lighting and 557,000 kWh for power. In 1912 the former had risen only to 683,000, but the latter had risen to 780,000 kWh. Corresponding figures for Bristol have not yet been found, but it is known that the aggregate power system connections amounted to about 7500 kW in 1909, so that if each motor or heater were used, on average, only 600 hours per year, this would amount to a consumption of over half of the total sales of about 8.1m kWh. Thus, in these two towns, the sharply rising power sales prevented the failure of growth which showed in the other towns, where the sales were dominated by lighting. In Gloucester and Cheltenham in 1909, power sales were not more than 10% of the total sales. Nevertheless, in these towns, the failure of growth was more marked than in the national figures for lighting sales alone.

The large rises in sales at Cheltenham, Worcester, Gloucester and Swindon in 1901-2, 1903-4, 1904-5 and 1904-5 respectively represent the opening of the electric tramways in these towns.

The slowness of small towns in adopting electricity

By-and-large, it was the larger towns of Britain that first got electricity, and as we have seen in Gloucestershire, the small towns often lagged woefully behind them by ten, twenty or even more years. The reasons for this are not very clear.

Initially, in the 1890s, the economies of scale were not against the smaller towns. While generators had to be driven by relatively small reciprocating engines, even the biggest stations being made up of a multiplicity of small engine-generator units, there was no economic disadvantage for a small station using only one or two units. Later on, when steam turbines came to be adopted, it was possible for large stations to use very large power units and so achieve the 'economy of scale', but this, coming only towards 1910, was far too late to affect the decisions made by our towns in the 1890s and early 1900s. There was no economic reason why small towns should not have adopted electricity in the 1890s; many did, and we have seen (as summarised in Table 2) that there were plenty of companies anxious to set up electricity supply in the smaller towns of Gloucestershire. Why did these proposals not succeed?

There was no general satisfaction with gas lighting, either in private houses where it was regarded as smelly, hot and unsteady, nor in public lighting where it was regarded as inadequate and unreliable. There were repeated complaints about its quality and cost in Council meetings. There was a general understanding that electric lighting was far superior to gas, and it was obvious from the rapid progress of electric lighting in those towns which had already adopted it that people were willing to pay for it. It is true that it usually proved more expensive, (95) but the extra cost was slight, especially in view of the far superior quality of lighting.

In the small towns of Stroud, Tewkesbury, Cirencester and Monmouth discussions regarding the desirability of encouraging electricity schemes were begun as a result of threatened price increases for gas or by the initiative of companies giving notice of their intention to apply for a Provisional Order to enable them to supply electricity in the town. The Council's interest in the possibility of electric lighting was sometimes sufficient at that stage (as at Monmouth in 1890) to cause the gas company to withdraw its proposed increase in price. The gas companies were generally well represented on the local council by councillors who were also directors or shareholders of the company, and this was possibly a powerful influence in delaying the adoption of electric light. We have seen this aspect brought out vividly in the Tewkesbury Council minutes. Generally the Councils of the smaller towns were not pleased with the grip that a private company could get on such public affairs as street lighting, and were in consequence anxious that the same thing should not happen with electric lighting. Thus they generally tried to discourage companies who proposed electricity schemes, and frequently decided that they ought to apply for a Provisional Order themselves. Yet only Monmouth had the courage to go ahead with a scheme of their own.

Some smaller Councils held a belief that municipal electricity undertakings could not pay. In 1904, for instance, Cllr Jones at Tewkesbury, in proposing that the Council should apply for a P O, said that he did not think the Council would be wise to try to work the undertaking themselves for 'there was not one town... where lighting alone had been successful as a paying concern'. (96) His belief was completely erroneous, however, for in that year the municipal electrical undertakings of Britain (excluding tramways) had made a net profit of about £366,000, and only about one town in six which had had electricity for more than three years made a loss. (97) The position with the other towns of our Region which already had electricity was (98)

Bristol	:	£8207 surplus
Cheltenham	:	£1756 deficit
Gloucester	:	£480 deficit
Monmouth	:	£306 deficit
Worcester	:	£1694 surplus

So there was some room for doubt locally. However, Cheltenham's troubles were investigated by James Swinburne, a leading consultant, who found the system had been developed extravagantly, 'with a view to a rosy future rather than a matter-of-fact present', and that the tramway company was being supplied with electricity at a price too far below what it would cost them to generate it themselves. (99) Gloucester had been in operation only 3 years, and was expected to make a profit in the next year (1904-5). Monmouth's troubles were largely the result of mismanagement of capital expenditure.

The financial responsibility of a municipal electrical undertaking in a small town was probably less of a deterrent to electrical development than the innate conservatism of small-town councils. The Board of Trade was well aware that councils would sometimes want to obtain P Os merely to prevent companies getting a foothold, without any serious intention of providing electricity themselves, and tried to make sure that applications from councils were genuine. It was generally thought that Stroud's decision to obtain a P O in 1900 was intended only to prevent electrical development, but as we have seen, another diversion prevented the matter being put to the test.

Bulk supply of electricity: The Power Companies

We have seen that Stroud's plans for electricity supply were greatly influenced by the setting up of the Gloucestershire Electric Power Company in 1902. By the time Stroud obtained its Provisional Order in 1903 there were several bulk-supply power companies in operation in Britain and there was probably good reason to suppose that bulk supply would come to Gloucestershire. The position in Britain was as set out in Table 3, where the later status of the companies is also indicated. Out of 20 companies sanctioned by Act of Parliament, no fewer than 9 were actually already in operation or nearly so. Prospects therefore would seem quite promising. Yet by 1910, the Gloucestershire Co was one of seven such companies that had made no progress since 1903. So our region was not particularly untypical in this respect. It will have to remain as a subject for later research to determine whether there was any significant correlation in other regions between failure to implement a bulk-supply scheme and backwardness in obtaining electric-light: a correlation which appeared to exist at Stroud, but which we cannot prove on a single case.

It is clear from Table 3 that the bulk supply schemes which got ahead were those in densely-industrial areas, while those which did not were those in the more rural areas. Here we find the main clue to the probable reason for lack of success in areas such as Gloucestershire. The power companies had to be bulk-suppliers, as we have seen from the terms of reference of the Gloucestershire Co. The municipal electrical supply undertakings generally preferred to remain independent and generate their own electricity. Thus the power companies were left only with industrial customers and the smaller towns. In Gloucestershire

the industrial customers were only around Stroud and in the Forest of Dean (hence the proposed generating stations in those two areas) and there were very few towns of any size, Stroud being the largest after Gloucester and Cheltenham, which were electrically independent. The need for electric power in the mills of Stroud and the iron and other works of the Forest was not pressing as there was water power available for the former and plenty of coal for the latter, and in any case the industries were not power-intensive. This is why the Gloucestershire Electric Power Co was interested in creating a customer in the shape of the Stroud District and Cheltenham Tramways Co. The region was not promising for bulk supply of electricity at that time, and it is not altogether surprising that bulk supply was so long in coming.

Tramway development vis-a-vis electricity supply

We have seen in this study many examples of the interaction of electricity supply systems and tramway developments. Most of the possible relationships are represented in our Gloucestershire Region, as set out in Table 1.

Abortive schemes at Tewkesbury and Stroud failed probably because in the first case there was no economic justification, and in the second case the scheme became dependent on the Gloucestershire Electric Power Co's bulk-supply scheme which also failed to materialise.

At Cheltenham, where the electric tramway was a new company venture, and at Worcester where the electric tramway was a company development of an old horse tramway system, a sensible arrangement was made whereby the municipal electricity undertaking sold electricity to the tramway company.

At Gloucester and Swindon the tramways as well as the electricity undertakings were owned and operated by the municipality, the latter place having the only example in the region of a tramway and electricity undertaking planned as a joint undertaking beforehand.

Bristol is left as the only example in the region of an electric tramway undertaking which operated entirely independently of the municipal electricity undertaking. This was not the choice of the Bristol Corporation; they were clear enough that whatever else happened, they wished to supply the electricity to the tramways. But the tramway company was too strong for them; the detailed story is told elsewhere,⁽¹⁰⁰⁾ but the corporation were soundly defeated in a battle of wits, and the company added insult to injury by building their own very handsome generating station immediately adjacent to the Corporation's more utilitarian station!

In a technical sense, the tramways influenced the electricity undertakings mainly by increasing their load, and by requiring a dc supply. This requirement led Worcester to build a new electricity station in 1903 in the central area of the town, because its original ac station was too far away at Powick. The other towns managed for a while with extensions of their original stations, even though at Cheltenham the distance over which new dc cables had to be laid was quite considerable.

Chapter 9

Technical Aspects

The 'Battle of the Systems': a c versus d c

During the later 1880s and the 1890s there was vigorous debate as to the relative merits of alternating and direct (or continuous) current. The arguments are well summarised by Parsons. (101) In general, at that time ac generators were less efficient than dc, and coal consumption per unit of electricity generated could be as much as doubled by using ac rather than dc. Moreover, ac systems could not use batteries in the way dc systems did, to store surplus power when available and thus reduce demand on the generators at times of peak loading or eliminate the need to run the generators when the load was very small. Ac generators could not at first be run in parallel, and so much flexibility was lost. On the other hand, ac permitted easy generation of high voltages (say 1000 - 2000 V) and efficient and reliable static transformation of voltage for distribution to consumers. Thus the longer cable (or overhead-wire) links could operate at high voltage with corresponding saving of copper and of power loss. At first ac was not suitable for industrial motors, and electric tramways always needed dc. So the case for choosing one or other system was often not very clear.

One point most writers make is that, 'alternating current found its field chiefly in places where the population was less dense, and the consumers were scattered over a larger area'. (102) In our study region, out of the stations operating by 1900, Cheltenham, Bristol, Worcester and Monmouth all adopted ac, while Gloucester used dc. One could hardly claim that the four towns which chose ac had markedly scattered populations, although Bristol did state (103) that its large area of supply was the reason for continuing with ac in 1902; and Worcester went over to dc in the centre of the city when it built a new generating station in 1903. (104) One wonders to what extent our region failed to conform to the normal pattern in this regard. So it seemed worth while to test the validity of the rule from which our region appeared to deviate in its early development but which it appeared to accept in developments after 1902.

The year 1900-01 is suitable for the test, because our five stations were all operational by then and the result of decisions regarding ac versus dc should be clearly apparent by that time. Obviously London was a non-typical region, and we shall confine our analysis to provincial towns. If we take our data from the Tables of Electricity Supply Works published by The Electrician for that year, we find that for most, but not all, the undertakings the area of the district specified in the Provisional Order is given. It was on the basis of this area of supply that the choice of system was made - if it was indeed related to area. If then we plot on a graph the installed capacity of each station against the area of supply, for those stations where the area is given, and make separate graphs for undertakings generating ac, dc, or both, we get the results shown in Figs 14, 15, and 16. The mixed systems are hard to deal with, and we cannot profitably examine them any further.

For the ac systems (Fig 14), there is naturally a great deal of scatter, but the general trend for installed capacity to increase with area is clear. We would indeed expect this trend. At a first guess we might expect the installed capacity to increase in proportion to area, but as population density is generally lower in the outlying parts of towns, we might also expect the curve to rise less rapidly as the area continues to increase. Our data is hardly consistent enough to enable us to examine this refinement, however. Merely drawing a straight line at 45° (necessary on the log - log scale to give a proportional relationship) as symmetrically through the points as possible gives the relation:

$$kW = 130 \times \text{area}$$

as shown on the graph. This is a reasonable indication of the general trend. What is particularly interesting is that our four ac stations in our study region lie very close to this line, showing that in this particular relationship, they are very 'normal'.

We should remember that the area of supply would, in some of the older undertakings, have increased somewhat by 1900, so that the true typical value of the ratio kW/area would be slightly decreased relative to that given by the line on the graph.

Turning now to the dc systems (Fig 15), we observe that the scatter is greater and any general trend is far less clear. Nevertheless, the straight line representing the simple law deduced above lies as symmetrically among the points as it did for the ac case. It may not now be a very convincing statement of the kW/area relationship, but its position does however show that there is no significant difference in the kW/area relationship between dc and ac. We must, on this evidence, discount the suggestion that ac was chosen for scattered areas where the kW/area ratio would be low, and that dc was chosen for compact areas where the ratio would be high. No doubt this basis was adopted in many individual cases (as at Gloucester, which had a particularly high kW/area ratio as we see from Fig 15), but it clearly was not a general rule.

A much more likely reason for adopting ac in many cases is that it was desired to site the generating stations some distance away from the centre of the town, and the cable costs would be much reduced by using high voltage ac. This circumstance applied at most hydro-electric stations (eg Worcester and Monmouth; also Keswick and Lynton which were opened in 1890,⁽¹⁰⁵⁾ and used ac at high voltage), and also at Cheltenham.

Another important factor in determining the choice might well have been the choice of consulting engineer. Bristol, Worcester and Cheltenham all involved W H Preece, and practically all the schemes he was associated with used ac. (Dewsbury was possibly the only exception). R Hammond who was involved at Gloucester, did not take sides; the schemes for which he was responsible were almost equally divided between dc and ac. But such well-known consulting engineers as A B W Kennedy, J N Shoolbred and J Hopkinson were almost 100% dc men. Data regarding these five engineers, extracted from the tables in The Electrician referred to above, are given in Table 4. In the face of this evidence we can have little belief that each scheme was considered on its merits!

Motive Power

In Britain as a whole the vast majority of electrical generating stations for public supply used steam engines as their motive power, and during the 1890s and early years of the 20th century these were mostly of the high-speed reciprocating type, operating at 350 rev/min or more. The high speed meant that they could be directly coupled to the generators without the very substantial loss of power and reliability involved in the rope or belt drives which were involved with low-speed steam engines.

It has been stated that about two-thirds of all engines in the 1890s were of high-speed type, and that over one half of these were Willans engines.⁽¹⁰⁶⁾ Willans was a particularly successful engine designer and manufacturer. Belliss and Morcom high-speed engines were also successful. The use of high-speed engines did rather restrict the maximum size of each generating unit, so that larger stations were composed of a large number of separate engine-generator sets.

The use of steam turbines, with their attendant advantages of freedom from vibration and noise and their availability in increasingly large sizes, after a slow beginning became more common in the early 1900s.

Smaller stations often used gas or oil engines, as these appeared to have some economic and operating advantages in small sizes, but they were never used in large stations.

The use of water power for generating electricity, while widespread in other countries, where numerous suitable rivers were available, was very limited in Britain. There were perhaps as many as one or two hundred small private hydro-electric plants for lighting mills, mansions, etc, and one or two large industrial plants, such as that of the British Aluminium Company at Foyers in Scotland; but in our period, ie from 1888 up to the early years of the 20th century, the hydro-electric stations used for public electricity supply could be numbered in single figures.⁽¹⁰⁷⁾

In these various respects, our Gloucestershire Region appears to have been quite typical.

At Cheltenham, Gloucester, Bristol and Swindon the motive power was high-speed reciprocating steam engines, with Willans engines well to the fore, being used at Cheltenham and Bristol. When Bristol built a new generating station at Avonbank in 1902 they equipped it with Willans engines,⁽¹⁰⁸⁾ and when Worcester built a new station at Hylton Road in 1903 it was equipped with Belliss engines⁽¹⁰⁹⁾ as were already in use at Gloucester.

Steam turbines were introduced in the Region during 1902-3 when both Cheltenham and Bristol installed them in extensions of their stations.⁽¹¹⁰⁾

The small generating stations at Tewkesbury and Cirencester, although coming very late on the scene, used the gas and oil-engines which were so common in such stations.

Perhaps the most interesting aspect of motive power in our region was the use of water power at both Worcester and Monmouth. The hydro-electric plant at Worcester, brought into use in 1894, was indeed the largest such

plant used for public supply in Britain during our period, having a water-generated capacity of about 400 kW. Both towns used the smaller rivers Teme and Monnow respectively, when much larger rivers such as the Severn and the Wye were available (and were at first considered). Consequently both towns suffered from inadequate water power for their stations and had to rely too much on the stand-by steam engines (low-speed type at Worcester to match the water turbines). It is clear that our region displays the whole range of motive power in a remarkable way.

Combined refuse destructors and electricity works

It will have been noticed that Cheltenham and Gloucester both planned their electricity generating stations on the basis of associated dust-destructors. The steam generated from the heat of burning refuse was used to drive the engines in the generating station, being supplemented by steam from coal-fired boilers when necessary. The dust-destroyer at Cheltenham supplied steam to the electricity works from the opening of the latter in 1895; that at Gloucester was brought into use in 1902, two years after the initial opening of the Gloucester electricity works. We have already remarked that the Cheltenham dust-destroyer scheme was found to be very effective, in reducing the cost of electricity generation. The question arises as to how usual or normal this practice was.

A very full paper published in 1904 by Adams (111) on the subject of associated dust-destructors and electricity works suggests that the very first case of steam from a dust-destroyer being used for electricity generation was at Oldham in March 1896. Since the Cheltenham works were opened in May 1895, ten months earlier, it is clear that Cheltenham may well have been the first example of the combined operation and even if it was not, it was at least established before there was any experience of such operation in this country. Before the end of 1904 there were at least 40 such combined works in operation, with another 20 under construction. Thus it is fair to say that Cheltenham was a real pioneer in this respect, and a successful one.

Although Adams completely ignores Cheltenham, he gives some details of the operation of the system at Gloucester. The way in which the electricity load was shared between refuse and coal is illustrated by the graph of Fig 17, which relates to the 24 hours of 18 February 1904. The load was in those days dominantly lighting, as can be seen from the size of the evening load relative to the rest of the day. Most of the day's electricity supply was obtained from refuse: 1172 kWh (units) as compared with only 218 kWh from coal. The amount of coal burnt was 17.5 cwt (0.875 ton), the amount of refuse burnt being 20 tons. The kWh per ton of fuel were about 250 for coal and 59 for refuse; the refuse was evidently surprisingly good as fuel, considering its nature.

We can see from the growth curves of Fig 13 that as the years went by, the proportion of the day's electricity output that could be contributed by the refuse-burning diminished very considerably, and, of course, the association of refuse destruction with electricity generation eventually ceased. When the last combined works was built has not yet been ascertained.

It is interesting that the idea has very recently been resurrected, and a generating station using refuse as fuel has been built at Edmonton (North London).

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Table One

Swindon
 Monmouth
 Bristol
 Worcester
 Cirencester
 Tewkesbury
 Stroud
 Cheltenham
 Gloucester

Electric Lighting by:

Company

Municipality

A.C.

D.C.

Electric Tramway:

Horse Tramway electrified and extended by Company

Horse Tramway electrified and extended by Municipality

New Electric Tramway built by Company

New Electric Tramway built by Municipality

New Electric Tramway proposed but never built

Electricity Supply for Tramway:

Generated by Tramway Co.

Bought from Municipality

Generated by Municipality for own Tramway

Joint Lighting/Tramway scheme at Initio

				○	○	●			
○	○	○	○				○	○	
	○	○	○				○		
○				○	○	●		○	
		○	○						
								○	
⊗					⊗	⊗	○		
○									
					○	○			
		○							
			○				○		
								○	
○									

● No electricity before 1914, but supply as indicated later.

Table Two

	Notice by Companies of intention to apply for Prov. Order	Prov. Order obtained	Supply Commenced
Gloucester	4 in 1889 2 in 1894 2 in 1895	1896 by Council	July 1900
Cheltenham	5 in 1889	1890 by Council	May 1895
Stroud	1 in 1890 1 in 1900 1 in 1902 1 in 1909 1 (others ?) in 1912	1903 by Council <i>revoked 1908</i> 1913 by Company	Temporary Supply 1914
Tewkes	1 in 1890 ² 1 in 1900 5 in 1903-4 1 in 1907	1905 by Council transferred to Company 1908	July 1909
Cirencester	1 in 1890 1 in 1897 1 in 1900 2 in 1903 1 in 1904 1 in 1905 1 in 1906 1 in 1910	1911 by Council Company	November 1912
Worcester	Several in 1889	1890 by Council	October 1894
Bristol		1883 by Council repeatedly extended	September 1893
Monmouth		1894 by Council	June 1899
Swindon	1 in 1889	1895 by Council	June 1903

Table Three

Bulk-Supply Power Companies in Britain Sanctioned before end of 1903

Status	Year of Act	Name	System	Installed Capacity in 1903
In operation in 1903	1898-1901	Midland Elect. Corp. for Power Distn.	7 500V, 2 phase, 50Hz	3.1MW
	1900-02	Newcastle upon Tyne Elect. Supply Co.	5 500V, 3 phase, 40Hz	17.5MW
	1900	South Wales Elect. Power Distn. Co.	11 000V, 3 phase, 25Hz (and others)	4.4MW
In partial operation or in progress in 1903	1900	County of Durham Elect. Power Supply Co.	DC at low voltage and AC at high voltage	3.5MW
	1900-03	North Metropolitan Elect. Power Supply Co.	DC at low voltage and AC at high voltage	?
	1900	Lancashire El. Pr. Co.	10 000V, 3 phase 50Hz	6MW
	1902	Yorkshire El. Pr. Co.	10 000V, 3 phase 50Hz	6MW
	1901	Cleveland and Durham County El. Pr. Co.	2 200V, 2 phase, 50Hz 2 200V, 3 phase 50Hz	1MW
	1901	Derbyshire and Nottinghamshire El. Pr. Co.	AC at high voltage	?
Operating by 1910	1901	Clyde Valley El. Pr. Co.		
	1903	Fife El. Pr. Co.		
	1902	Kent El. Pr. Co.		
	1903	Scottish Central El. Pr. Co.		
Not operating by 1910	1903	Carmarthenshire El Pr. Co.		
	1902	Cornwall El. Pr. Co.		
	1902	Gloucestershire El. Pr. Co.		
	1902	Leicestershire and Warwickshire El. Pr. Co.		
	1903	North Western Elect. and Power Gas Co.		
	1903	Shropshire and Worcestershire El. Pr. Co.		
1903	Somerset and District El. Pr. CO.			

(Data from tables published by 'The Electrician')

Table Four

Consulting Engineers and the Choice of AC or DC

Data based on 'The Electrician Table of Electricity Supply Works, 1900—1'

Engineer	Number of AC Schemes	Number of DC Schemes
W H Preece	5	1
R Hammond	7	9
A B W Kennedy	1	17
J N Shoolbred	0	5
J Hopkinson	0	4

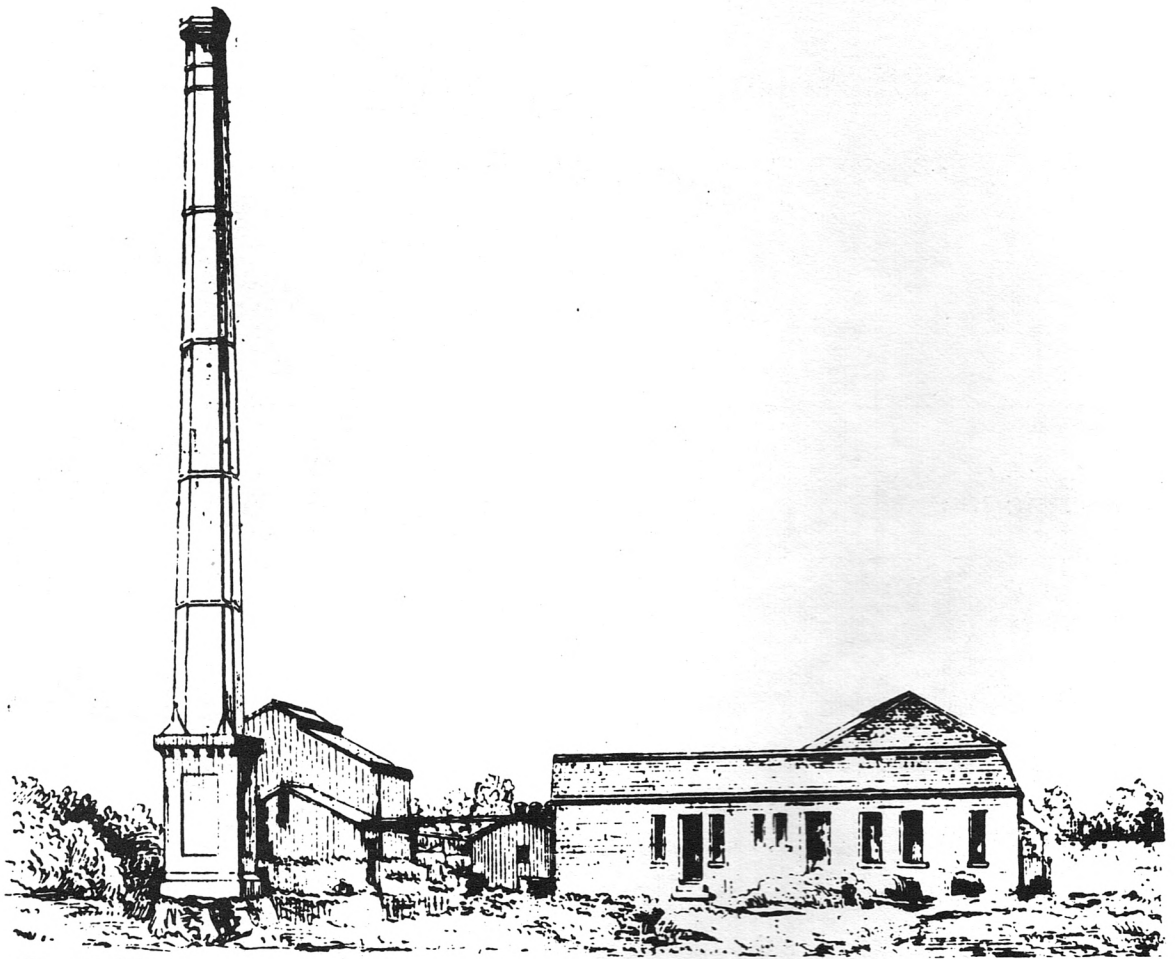


Fig. 1

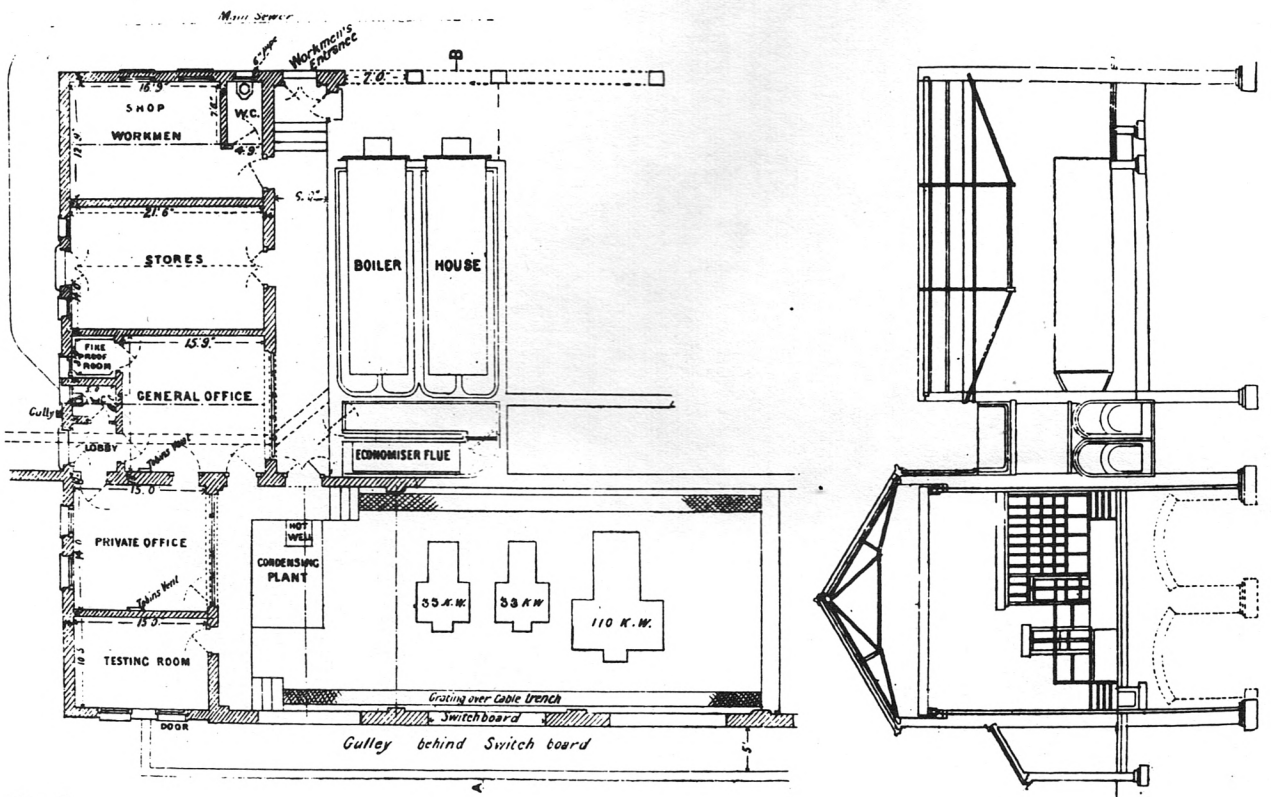


Fig. 2

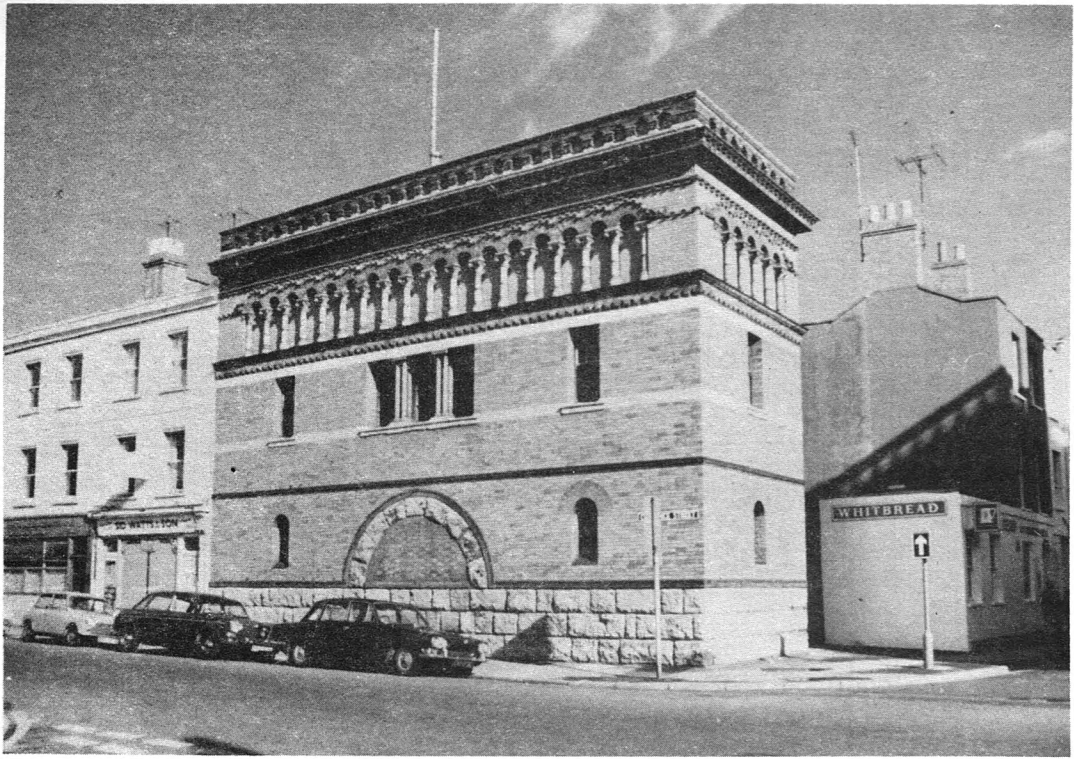


Fig. 3

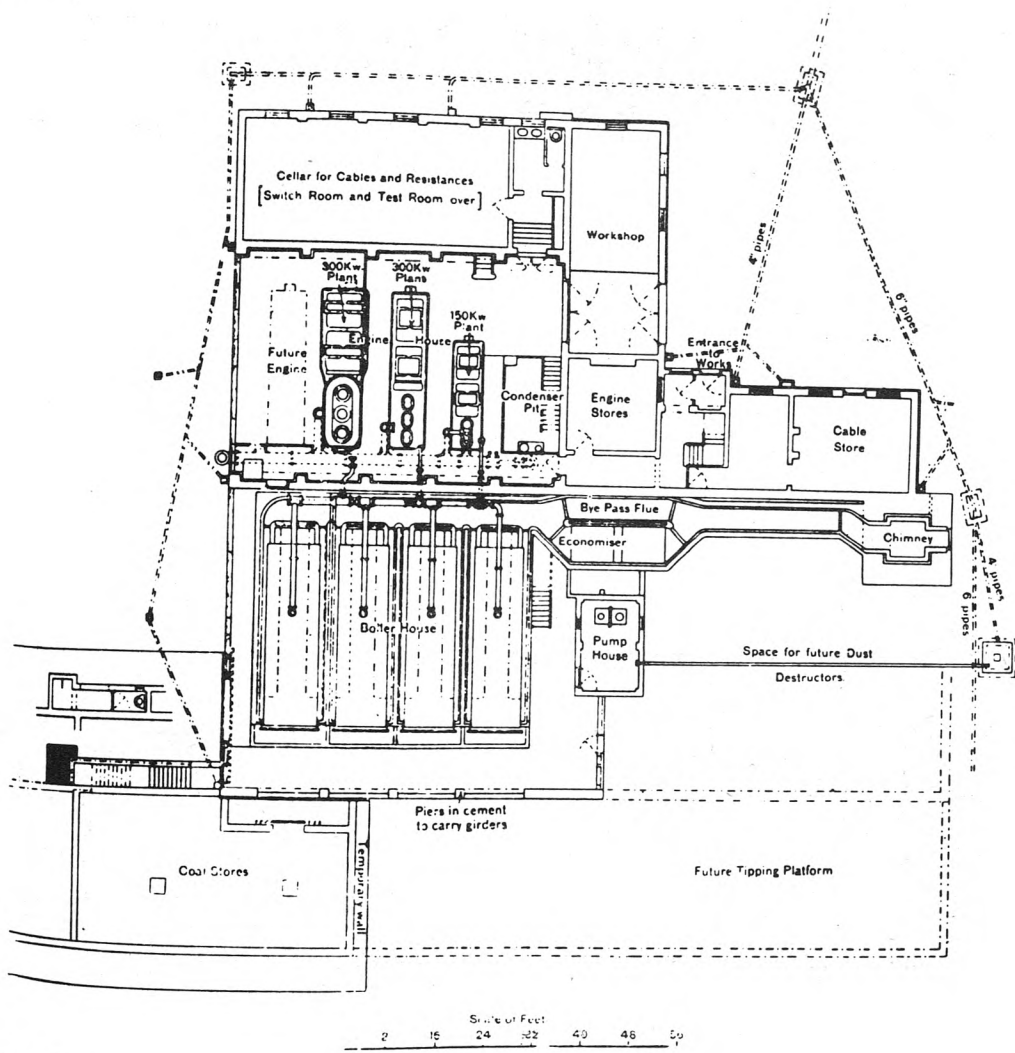


Fig. 4

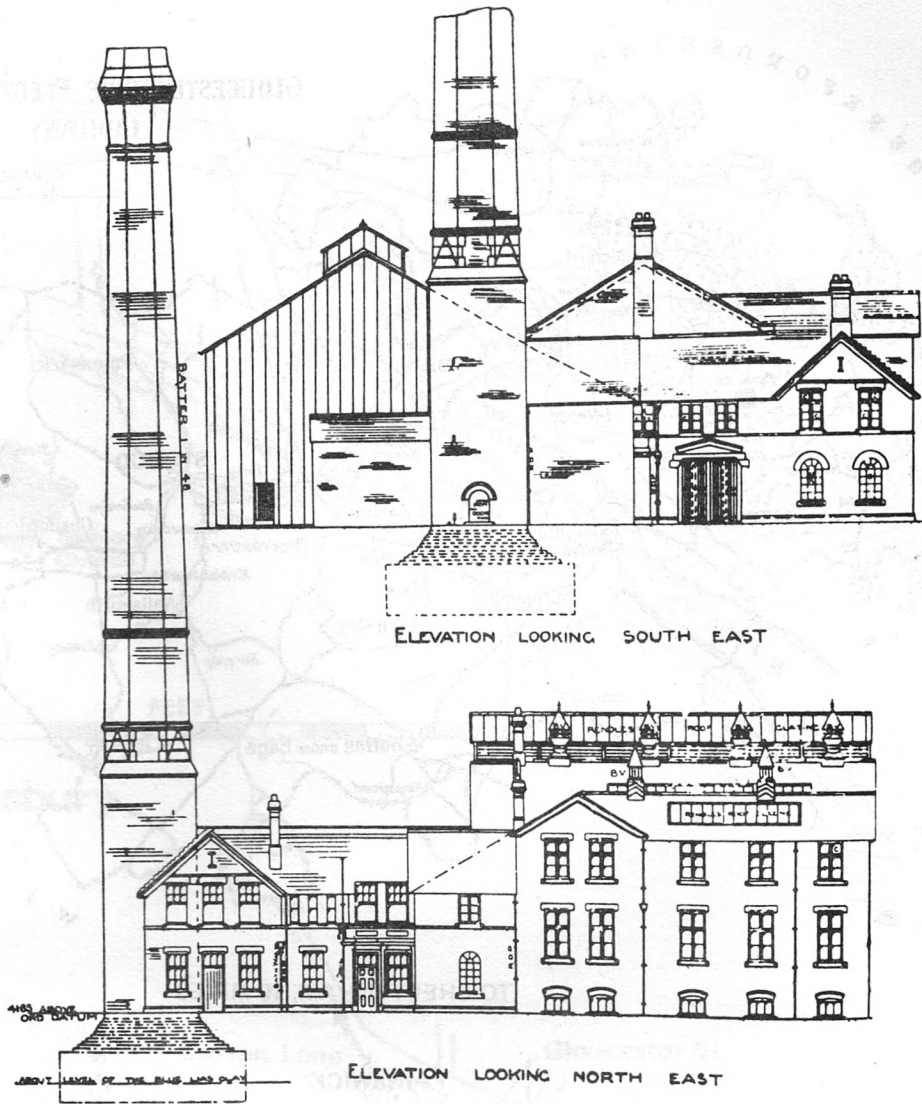


Fig. 5

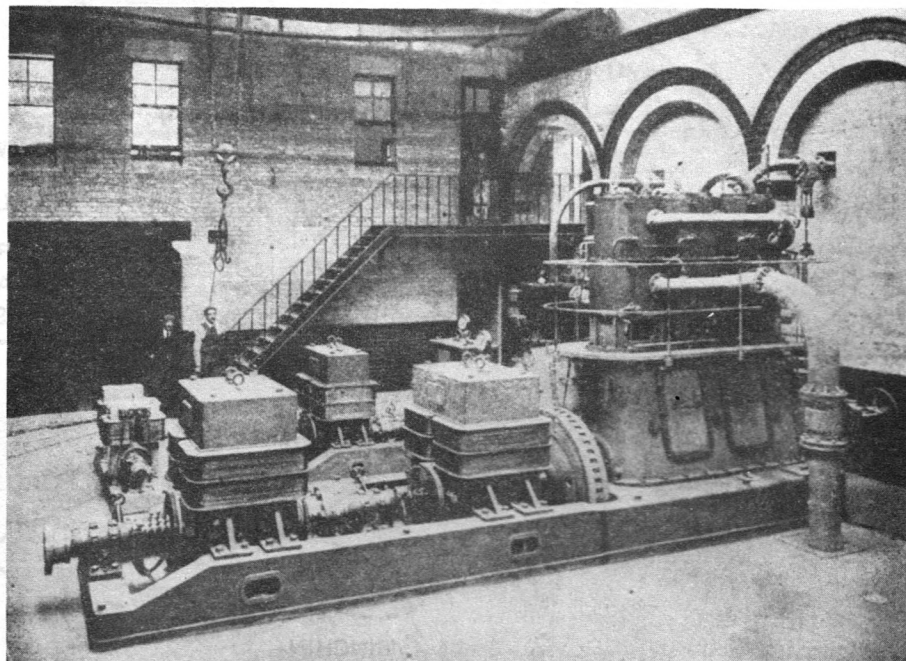


Fig. 6

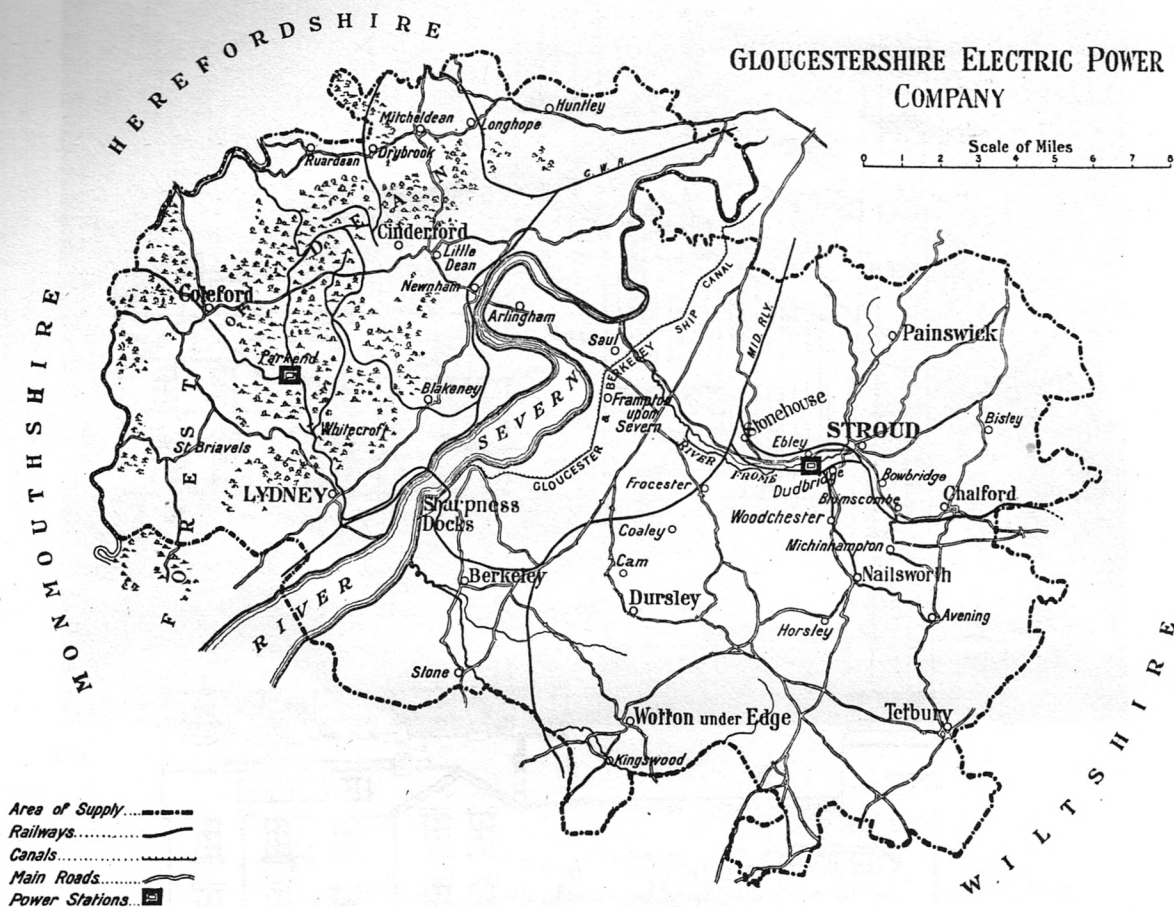


Fig. 8

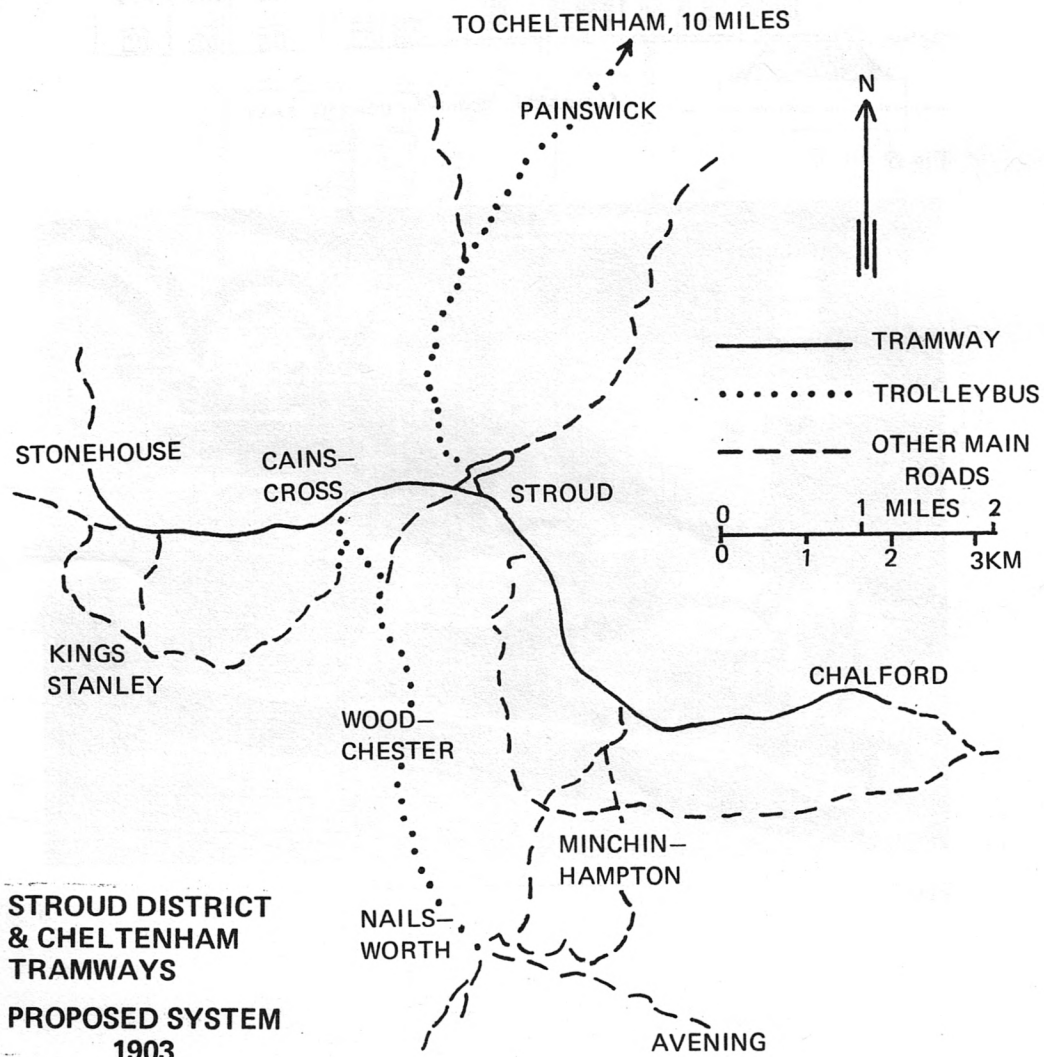
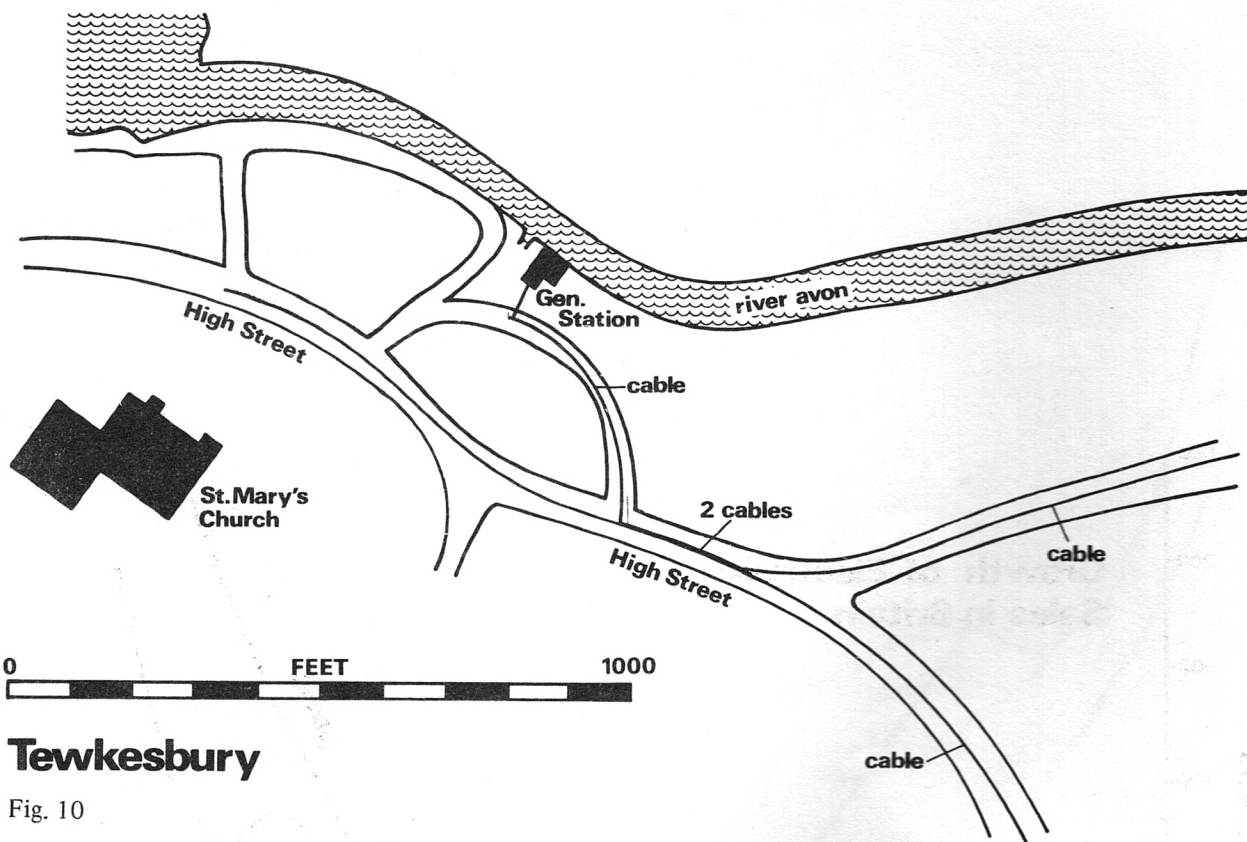
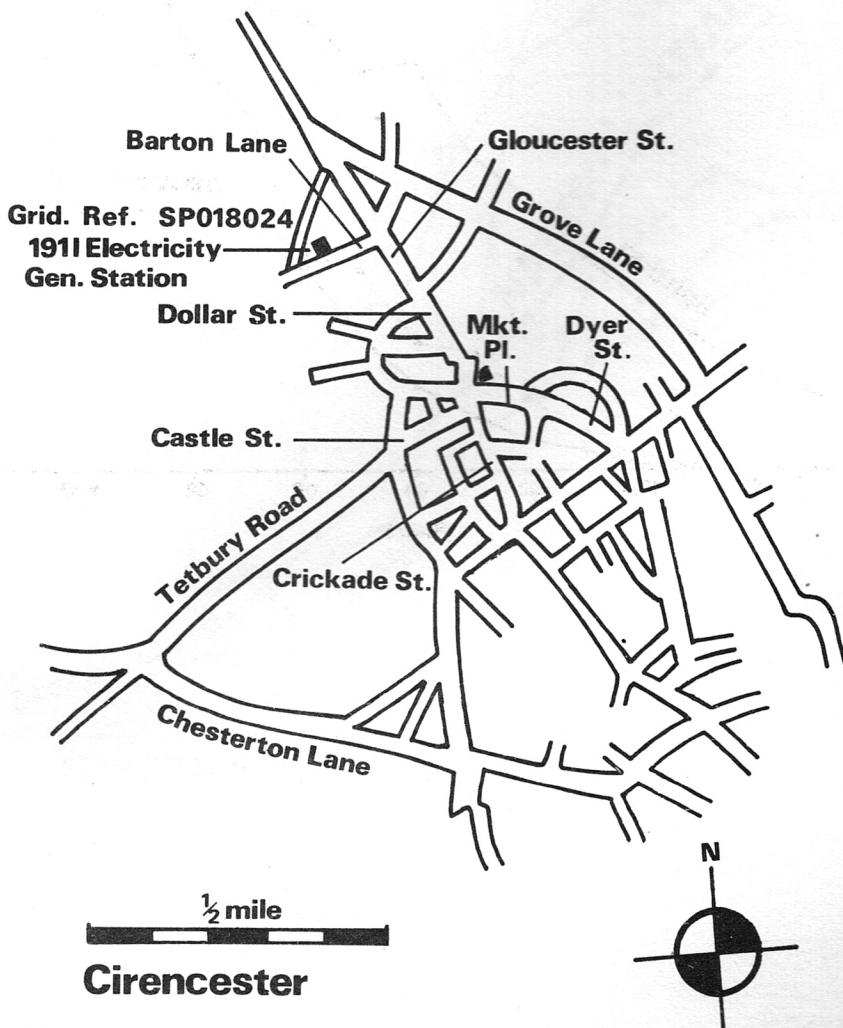


Fig. 9



Tewkesbury

Fig. 10



Cirencester

Fig. 11

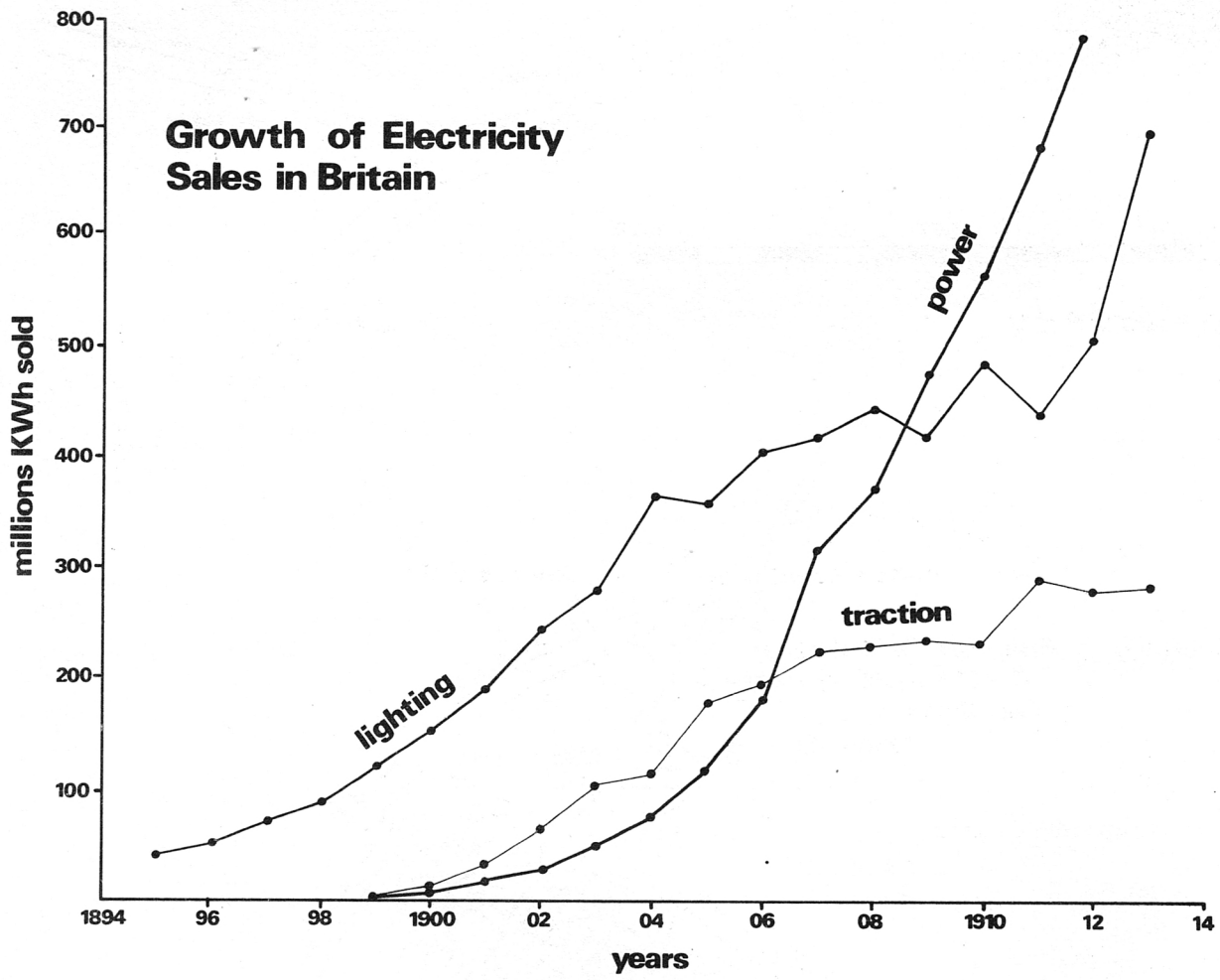


Fig. 12

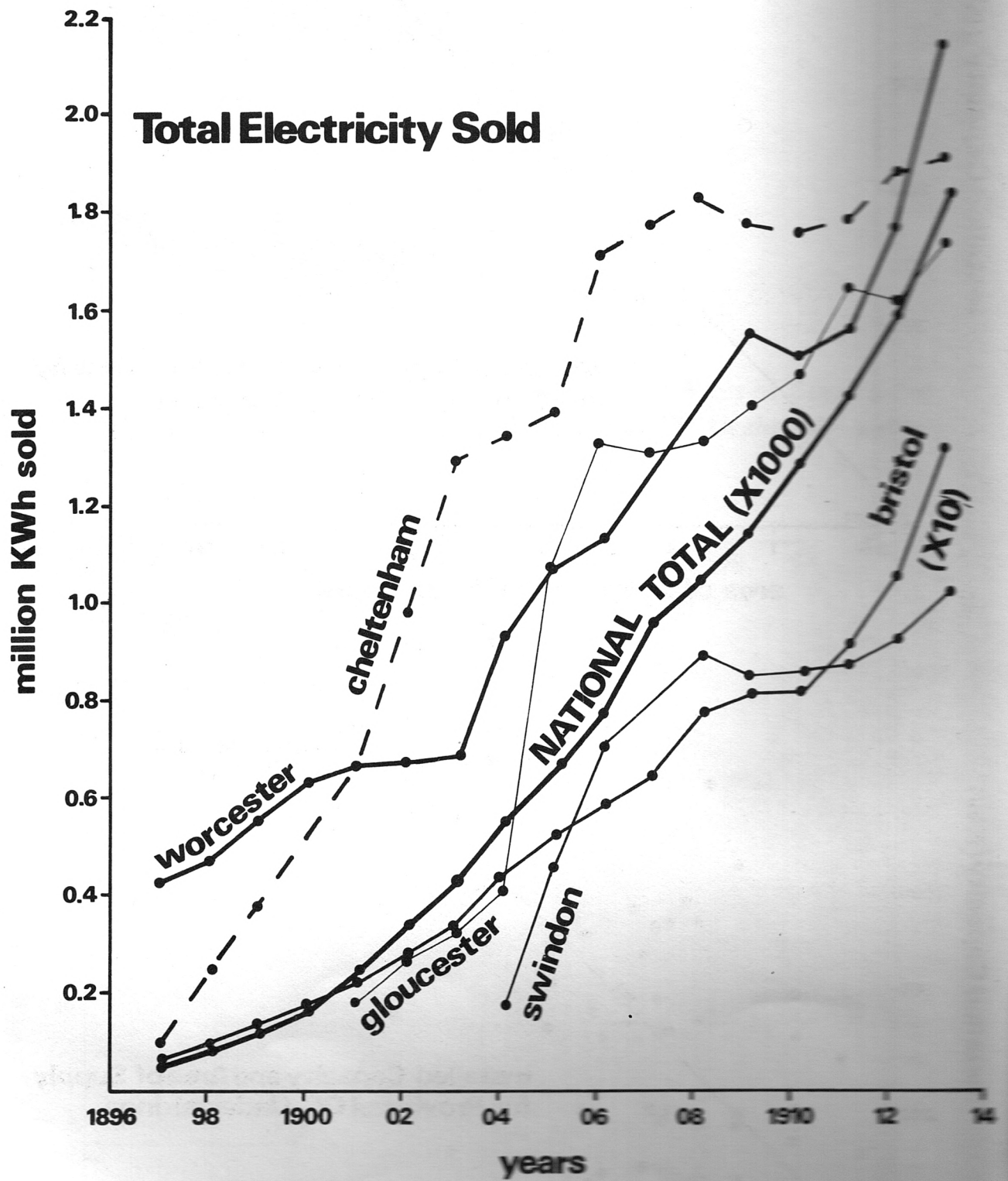
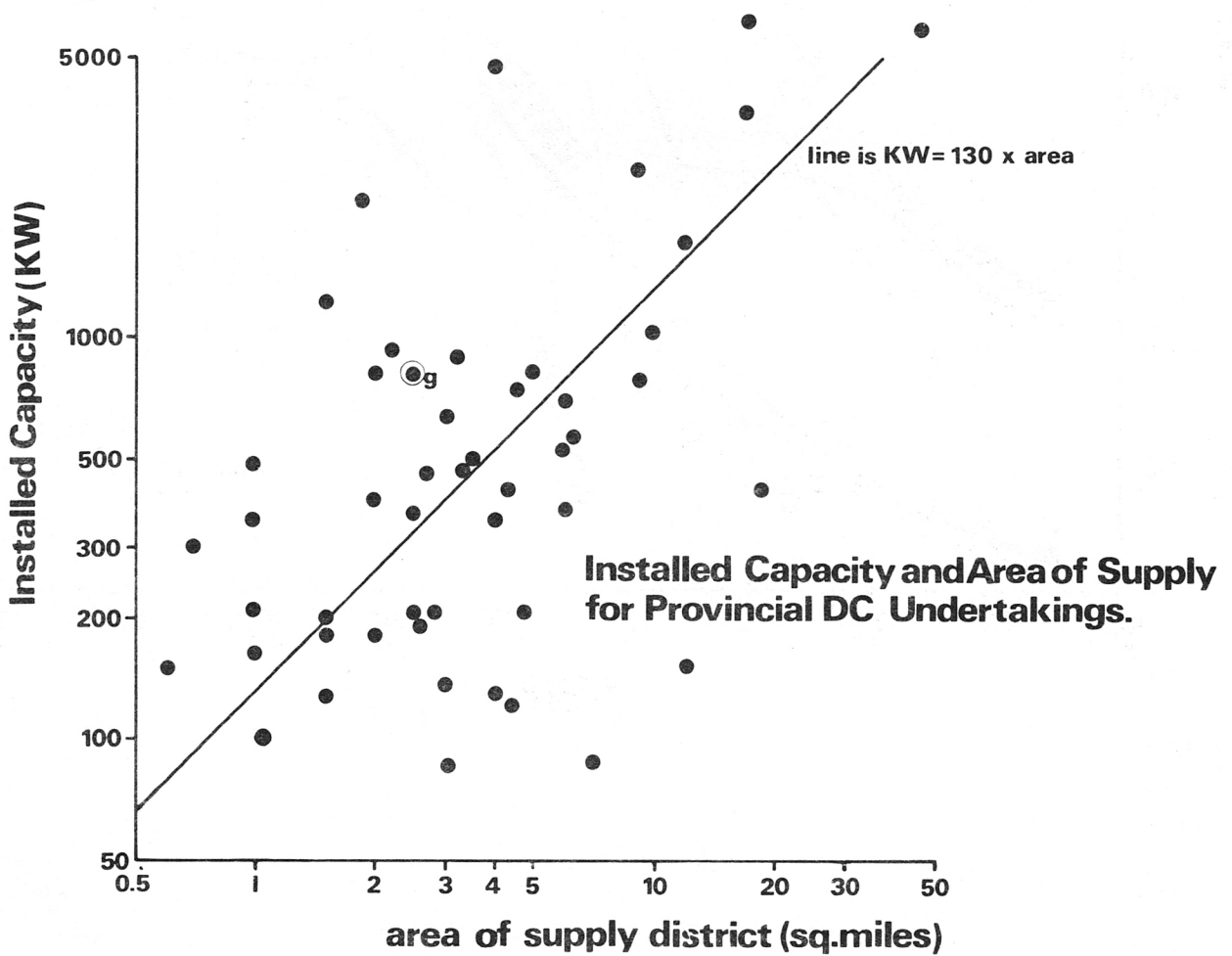
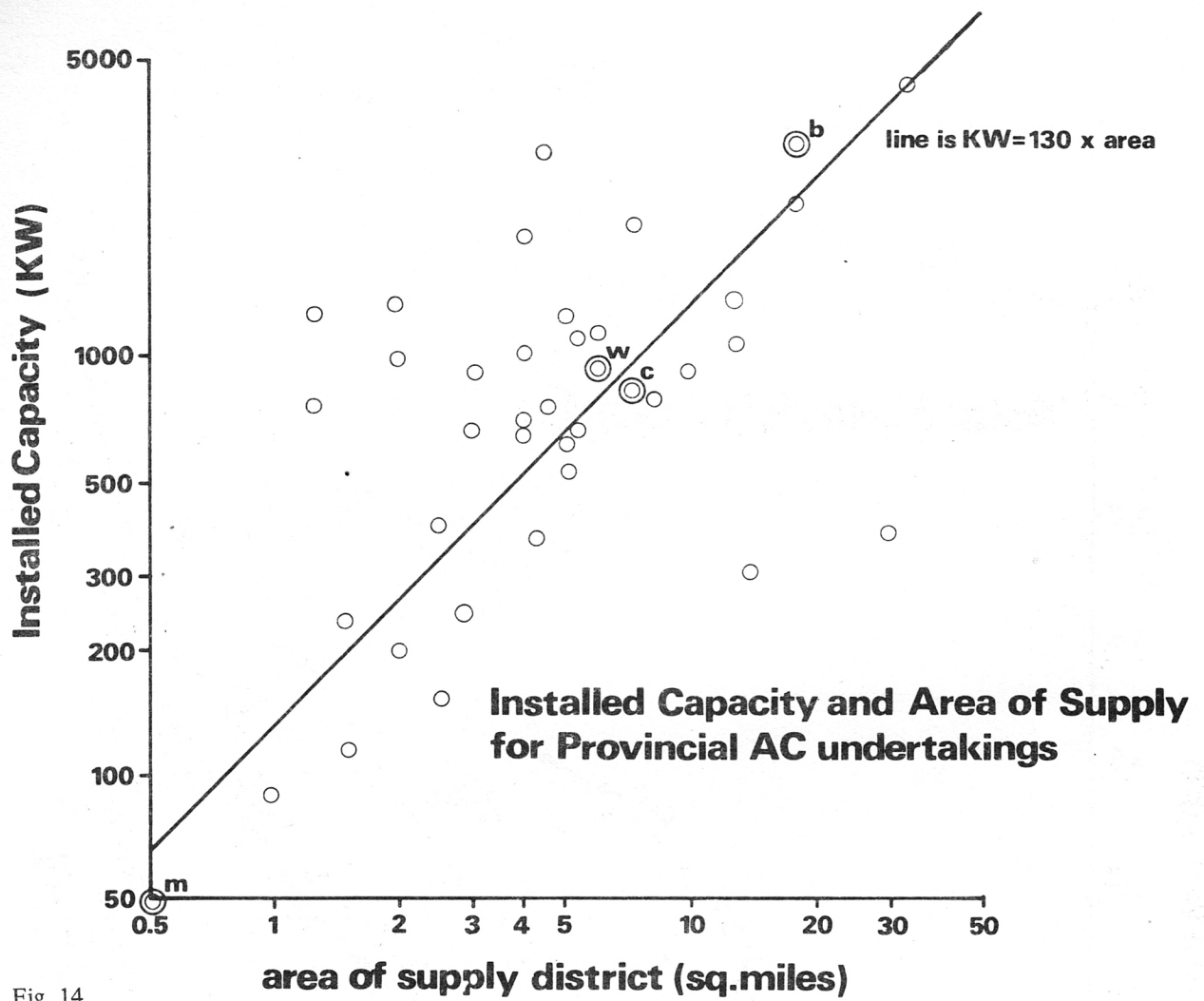


Fig. 13



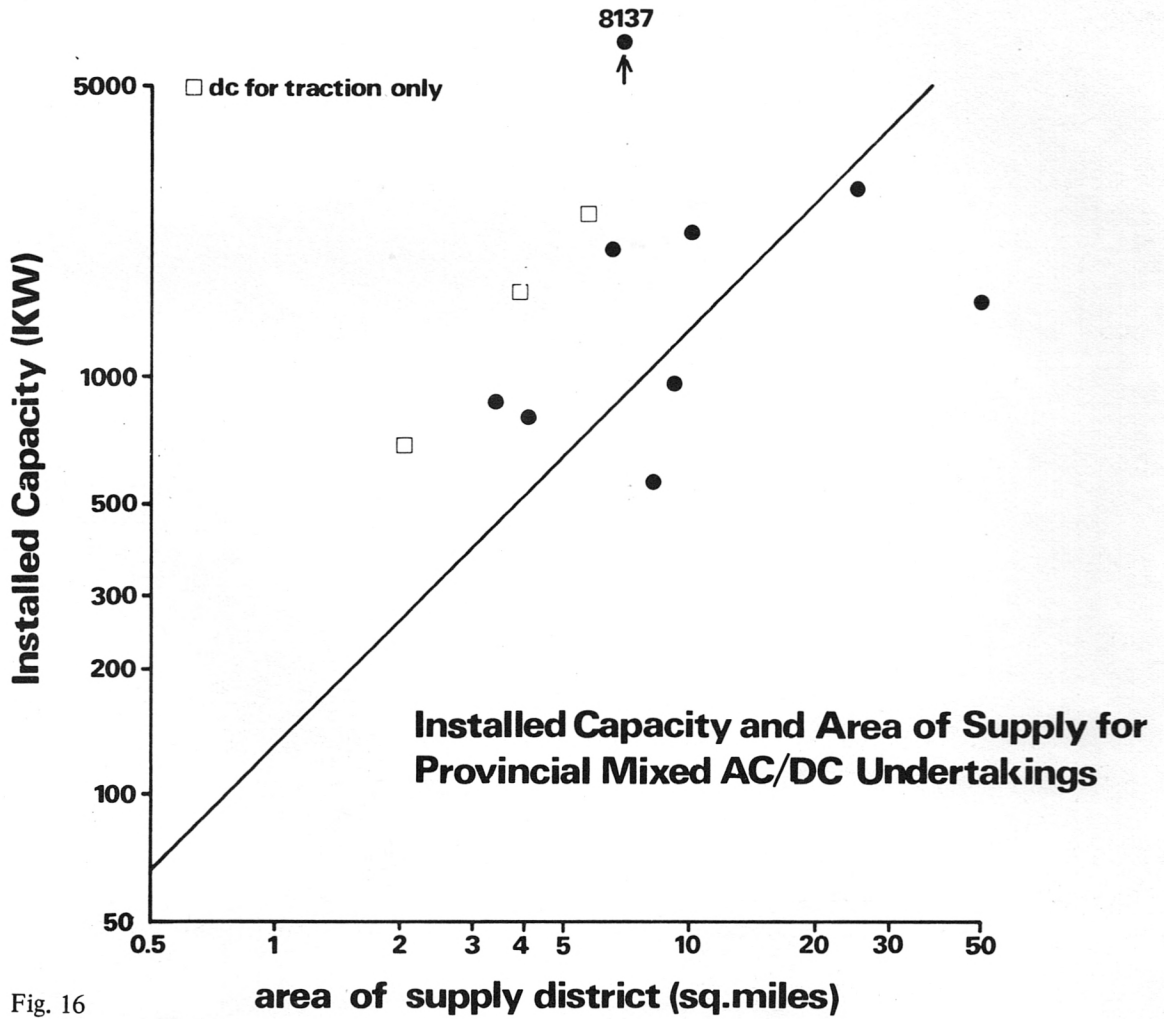


Fig. 16

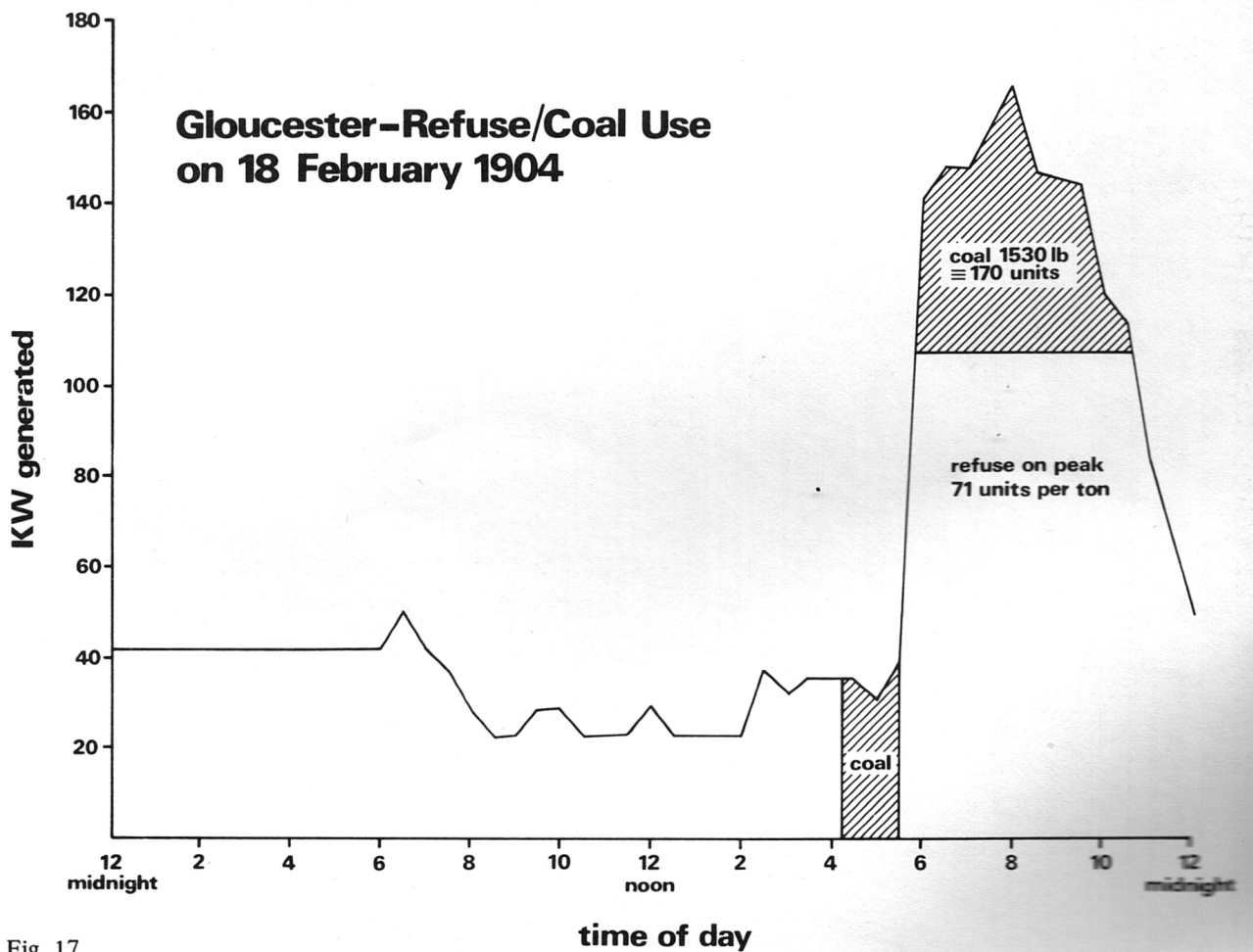


Fig. 17