Sir William Preece (1834–1913)

by

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William Henry Preece (Fig. 1) was born on 15 February 1834 at Caernarvon, and died there on 6 November 1913. He achieved the position of Engineer-in-Chief to the Post Office in 1892 and retired from it in 1899 with a K.C.B. He was elected F.R.S in 1881. He was twice President of the Institution of Electrical Engineers (1880–1 and 1893–4) and President of the Institution of Civil Engineers in 1898–9. He was in his lifetime an extremely well-known and influential electrical engineer, dominating British Post Office engineering through the 1880s and 90s, and assisting the development of public electricity supply and lighting systems during the same period, but principally between 1890 and 94, by his private practice as a consulting engineer. He was less successful as a research engineer or scientist in spite of evidently seeing himself in this role. He was a man of immense energy and industry, and a prolific writer and lecturer.[1] But in spite of numerous reviews of his work published on his retirement, even more numerous and lengthy obituaries, and a book about him published quite recently,[2] there has never been a critical study of his work and personal relationships, and hardly even a mention of his consulting work for local authorities on electric lighting schemes in the early 1890s[3]—except in the author's own earlier articles,[4] and in a most interesting but very short article by his assistant H. R. Kempe, published in 1914.[5]

Kempe knew Preece well, for he had worked as his personal technical assistant from 1870 to 1899. A few extracts from Kempe's article will give a thumb-nail sketch of the great man:

Fig. 1

> 'Mr. Preece was perpetually and systematically at work. In the earlier part of his career he would take but four or five hours of sleep.'
>
> 'Fully appreciating the advantage of a mathematical knowledge, Mr. Preece was not an expert mathematician himself.'
>
> 'Any new electrical discovery, announced in any of the scientific papers, had to be verified, when possible, by a repetition of the experiments described.'
>
> 'The necessity of "self-assertiveness" was a thing which Mr. Preece was fully alive to, and it is certain that he deliberately (and most effectually) worked with this idea in mind; to say that he was ambitious of fame (using the word ambitious in its best sense) is only to state a fact, and he succeeded in obtaining it.'
>
> 'He had apparently no nerves, though he used to assure me that he was always in a state of trepidation before commencing to speak.'
>
> 'As an administrator at the Post Office, Mr. Preece was great, his strong personality overcoming numerous official obstacles.'

Preece married in 1864, and had four sons, two of whom became electrical engineers, and three daughters. His wife died in 1874 and thereafter, for many years, his sister kept house for him. He was a sociable man, lived in Wimbledon during most of his Post Office career, and took an interest in local affairs.

Preece made his early reputation in telegraph engineering, in which he was engaged from 1853. On 14 May that year he was appointed Engineer's Assistant in the Electric Telegraph Company at 30 shillings a week.[6] On 15 March 1856 he was promoted to Superintendent in the South-Western District of the company at £3 a week, with headquarters at Southampton.[7] In 1858 he was appointed engineer to the Channel Islands Telegraph Co., and held this post in parallel with his E.T.Co. post until 1862, getting good practical experience of cable work; e.g. in February 1860 he personally supervised from the steam tug *Resolute* the search for and raising of the damaged portion of the Channel Islands cable.[8] In 1860 he was additionally appointed to the London and South Western Railway Co., holding his post of Superintendent jointly between the railway and telegraph companies.[9] This appointment led him to work on railway signalling, as we discuss later. It was during this period that he started educational lecturing by setting up courses in telegraphy at the Hartley Institute, later to become the University of Southampton.[10] On the nationalisation of telegraphs in 1870, Preece was appointed to the Post Office as a Divisional Engineer, and promoted to Electrician to the Post Office in 1877. He was made Engineer-in-Chief in 1892 and retained this title until his retirement in 1899.

There is no doubt whatever that Preece was a remarkable man, distinguished by administrative ability and some scientific and technical insight, but above all by his immense industry, incredible activity, and remarkable breadth of interest. Throughout most of his working life he successfully conducted several professional careers simultaneously. In addition to various branches of electrical engineering, he took an interest in several other technical fields, e.g. sanitary engineering, on which subject—concentrating mainly on water supply and sewage disposal—he gave the Inaugural Address as President to the 1899 Congress of the Sanitary Institute.

Having said all these things in praise of Preece, it is only fair to state my own view, that in his writings, private and public, we see an almost arrogant self-confidence which led him into serious error on occasions. This comes out most strongly in his work on telephone transmission, where he pushed forward his own erroneous views in opposition to the work of Oliver Heaviside, which he could not understand; and where he made many errors of calculation when planning new trunk circuits. I dealt with this quite fully in my earlier Newcomen paper[11] and will only add a few new points later on. In spite of his theoretical errors however, he had vast practical experience and great engineering intuition which enabled him to achieve successful practical results notwithstanding. The highly-successful London-Paris telephone links of 1891, which formed the main topic of my earlier paper, are an outstanding example of this.

It is quite impossible to do justice to the work of so active and wide-ranging a man in one paper; consequently the discussion below will be confined to the following:

1. A brief note on Preece's work on telegraphy. He worked in this field for over 45 years and made such an impact in it that a separate paper would be needed to treat this aspect of his work properly; no serious attempt to cover it can be made here.

2. A brief note on his work in telephone transmission, merely adding a few points to my earlier paper. (*Transactions*, **47**, (1974–76), pp 117–132).
3. Preece and the telephone: a topic he had much to do with during a few years from 1877.
4. Preece and the Edison Effect: a piece of scientific investigation in 1885.
5. Preece and wireless communication: his own system, not involving radiation of electromagnetic waves, worked on during the 1880s and 90s.
6. Preece and railways.
7. A comparatively full account of Preece's work as a consulting engineer for electric lighting and generating projects in the formative years up to about 1894; this aspect of his work has been so overlooked by writers since 1900 that it has seemed desirable to devote a third of this paper to it.

As far as Preece's work after his retirement from the Post Office in 1899 is concerned, it will suffice here to say that he set up the firm of consulting engineers Preece & Cardew with offices in Westminster.[12] Major Cardew, Royal Engineers retired, had been electrical adviser to the Board of Trade for ten years. W. H. Preece's son, A. H. Preece, gave up his own consulting firm to join his father, and Llewellyn Preece, another son, also joined in. The firm endured long after its first principals died, and indeed is incorporated in the recently-formed Ewbank Preece Group of consultants.

1. PREECE AND THE TELEGRAPH

Preece had experience of cable telegraphy,[13] but his main work was with overhead open-line systems. He had shown an early interest in duplex working, whereby messages could be transmitted in both directions simultaneously over a wire. A system for doing this was invented by Gintl in 1853 and applied by the Siemens company to numerous lines in Europe and elsewhere by 1854–55.[14] So Preece was responding rapidly to a new situation in inventing his own system of duplex working and patenting it in 1855 at the age of 21.[15] It seems unlikely that duplex working was then introduced in Britain, because after the nationalisation of the telegraphs in 1870, and Preece's transfer to the Post Office, he began experimenting with duplex on Post Office lines in 1872,[16] inventing his own 'duplex relay' over which there was some internal controversy.[17] Preece's difficulties with Oliver Heaviside were already evident at this stage, for he wrote to his chief:[18]

> Oliver Heaviside has written a most pretentious and impudent paper in the Phil. Mag. for June . . .
> He claims to have done everything even Wheatstone automatic duplex! He must be met somehow . . ..

Duplex was widely adopted by the Post Office from 1873.

When Preece visited the United States in 1877 he was much impressed by the Edison quadruplex system of telegraphy, in which two messages could be simultaneously transmitted in each direction, the additional channel being distinguished by using changes of current-amplitude instead of reversals to indicate 'mark' or 'space'. He brought the system back to Britain and with characteristic enthusiasm introduced and improved it on Post Office lines.[19] From his visit to the U.S. in 1884 he brought back a multiplex system providing six channels which could be used independently in either direction, and which were at a later stage increased by his staff to eight.[20] This was the synchronous-sampling system (which we would now call a time-division-multiplex or TDM system) of P. B. Delany.[21] Trials on Post Office lines, under Delany's direction, late in 1885 confirmed the superiority of the system to duplex and quadruplex, especially in regard to its flexibility, even though the full six channels could only be obtained on circuits under 100 miles in length; and the system went into Post Office service for nearly 20 years.[22]

The systems so far discussed used hand-operated Morse keys. The Wheatstone automatic high-speed telegraph system, introduced in the 1860s, operated initially at about 70 words/min., but was by the early 1880s able to achieve 2–300 words/min., and by 1887 almost 600 words/min.[23] This was attractive on busy routes but was too inflexible for widespread use. Yet Preece used it as an excuse for not giving a proper trial to the system of simultaneous telephony and telegraphy on the same wire proposed by F.van Rysselberghe of Belgium in 1882 and widely adopted elsewhere in the world.[24] He said, correctly, that the provision of van Rysselberghe's equipment (effectively a low and high-pass filter pair) would slow down the Wheatstone system. But the van Rysselberghe system would have been valuable to provide a telephone service on numerous lines which did not use Wheatstone apparatus. It must be remembered that in Britain at that time the telephone system was largely in the hands of companies, although some of the trunk lines were provided by the Post Office; only the telegraph system was wholly operated by the Post Office; so Preece might have supported the official view that telephones were an undesirable competitor of the telegraphs. Yet it was uncharacteristic of Preece not to have tried out an important new invention, and the real reasons have not yet been discovered. Did he see van Rysselberghe in the same way that he saw Oliver Heaviside?

2. PREECE AND TELEPHONE TRANSMISSION

Preece may have been responsible for advances in some other fields, but in long-distance telephone transmission he could be said to have retarded progress. This arose from his obstinate refusal to consider the proper effect of self-induction (or inductance) in transmission lines. His theory of telephone transmission, using his "KR" law, set out in my earlier paper, was based on inadequate experimental data and a misunderstanding of the basic theory.

Oliver Heaviside,[25] an eccentric genius, rather younger than Preece, saw clearly that the inductance and leakance of the line played dominant roles in telephone (and, for that matter, also in telegraph) transmission,[26] and that improvement could often be obtained by increasing them. Preece published his own calculations of inductance in lines, and argued that it was quite negligible, and that increasing it could only do harm;[27] but Heaviside showed him to be seriously in error and was extremely sarcastic.[28] Heaviside continued to despise Preece, and in 1900 wrote in a Preface[29] that the KR law 'became so ridiculously wrong (say 1000 per cent) that it was impossible to save appearances by any manipulation of figures' and that 'It is to be hoped and expected that the late important removals in the British Telegraph Department [i.e. Preece's retirement] will lead to much improvement in the quality of official science'. On the title page of his own copy of the book[30] he wrote that 'The book was all ready before the end of that year [1899], save the Preface. It was kept back, I was informed, to allow W. H. Preece to make sure of his knighthood'. Whether there was any truth in this would be hard to discover. Preece certainly stuck most obstinately to his KR law, and even in 1894, in response to a courteous letter from the American A. E. Kennelly sending a preprint of his calculation of telephone transmission, he wrote:[31]

> I think your result is obviously wrong . . . you have assumed . . . the existence of self-induction . . . I ignore the effect of self-induction. I cannot find the smallest trace of it on long copper lines . . . .

He would have nothing to do with the inductive loading of lines and cables until the success of Pupin from 1899 onwards forced him to change his ideas a little. He had the courage to give a paper[32] to the British Association in 1907 (8 years after he had retired) in which he admitted that inductive loading could be effective in increasing the distance over which telephony was possible, and gave his own explanations as to why this should be so; but he still maintained that 'The establishment of the telephone trunk system in Great Britain in 1896 [i.e. the nationalisation of the trunks] showed the practical value of the KR law in determining the construction of an aerial system'. In the discussion on this paper, Sir Oliver Lodge, S. G. Brown and Silvanus P. Thompson all stressed Heaviside's great contribution to the subject, but Preece 'did not agree with the other speakers as to the services rendered . . . by Oliver Heaviside'!

3. PREECE AND THE TELEPHONE

Although Preece was not really an inventor himself, he had a remarkable enthusiasm for new discoveries and inventions put forward by others, and gave public expression to this by demonstrations and lectures to many bodies, learned and otherwise, and by public support for the inventors. A very good example was the introduction of the telephone to Britain. This also involved some very puzzling private transactions.

Preece went to America, as we have already seen, in 1877, and although the visit was primarily concerned with seeing American developments in telegraph systems, he took the opportunity of seeing A. G. Bell[33] and of acquiring some sample telephones to bring back to Britain. Now these were not actually the first telephones to be brought to Britain; Sir William Thomson (later Lord Kelvin) had seen a demonstration by Bell at the Centennial Exhibition at Philadelphia the previous year (the year in which Bell's telephone patent was filed) and had brought back a sample and shown it at the British Association meeting in August 1876,[34] but without being able to operate it. Preece was able to demonstrate his samples convincingly at the B.A. meeting in 1877.[35] and even, a little later, managed to converse over the submarine cable from Dartmouth to the Channel Islands. Doubtless as a result of Preece's demonstrations, Bell was invited to address the Society of Telegraph Engineers at a special meeting on 31 October 1877 when he was in London.[36]

T. A. Edison, the great American inventor, now comes into the picture. He was, among other things, a consultant to the Western Union Telegraph Company. They, having turned down the chance of having Bell's telephone in 1876, and observing to their chagrin the commercial success Bell's company was having, commissioned Edison to develop a rival telephone apparatus. They had Elisha Gray's variable-resistance telephone patent, and Edison developed a new telephone transmitter on this principle, using the variation of resistance with sound pressure in a block of carbon between two contact plates.[37] This was an effective transmitter, because in modulating a strong current from a battery it enabled the electrical speech signal to have, in principle and possibly even then in practice, a greater power than the acoustical power of the voice.

Preece had evidently established friendly contact with Edison when he was in America, and had subsequently had correspondence with him. He had learnt about the carbon transmitter and described it briefly at the meeting of the B.A. in August 1877.[38] Edison had sent him, through agents, samples of his transmitter at various stages of development, the first in October 1877, the second in March 1878, and the third in April 1878. So there was no doubt that Preece was well-informed on this work.

Now during the early part of 1878 Preece became aware of work being done in London by D. E. Hughes on a very sensitive device for converting sound waves into electrical signals. Hughes later called this the 'microphone'. It had been demonstrated to the Submarine Telegraph Company as early as January 1878, but it is supposed that Preece did not see it until April. Certainly in surviving correspondence from Preece to Hughes,[39] the first letter dated 23 April 1878 shows only a formal acquaintance: 'My dear Professor'. But after one or two private meetings, they were friends: 'My dear Hughes', 'Yours ever'. Preece was most impressed by the microphone, which used loose contacts between carbon or metal rods as a variable-resistance device in a battery circuit.[40] The way in which the sound waves varied the resistance was not understood, and was explained by Hughes in terms of a supposed molecular action, which did not actually explain it at all. But the device was really most effective, and Preece staked his reputation by giving a lecture on it at the Society of Telegraph Engineers on 23 May 1878.[41] He had earlier arranged, at a few days' notice, for Hughes to present a paper to the Royal Society on 9 May 1878.[42] On 10 or 11 May, Hughes showed some journalists, in the course of some demonstrations, how loose carbon contacts in a quill formed a very sensitive heat detector owing to the large coefficient of expansion of the quill. This was reported with considerable emphasis.[43]

All this came to Edison's attention, of course; not only did he feel that he had anticipated the microphone, but he had also demonstrated the use of his carbon block as a heat detector. He evidently felt that Preece had told Hughes all about his carbon transmitter and was party to a disgraceful bit of plagiarism. He sent a telegram to Sir William Thomson on 27 May, and published letters accusing Preece and Hughes in numerous journals. The whole business was most unedifying and reverberated violently for many weeks. It is very fully reported in *Engineering*,[44] which took Preece's side. *The Engineer* was critical of Preece.[45] In France, the Comte du Moncel took the side of Preece and Hughes largely because of Edison's ill-natured attack.[46] Preece left it largely to Hughes to write letters of defence, but wrote one or two himself, thus establishing that he too dismissed Edison's charges as unfounded.

In all the circumstances it is very curious that the Preece letters which have recently become available[47] show that Preece wrote to Hughes on 15 May 1878 in these terms:

> Your wishes shall be strictly attended to—
> Edison and Bell
> may go to H---
> I will only use
> my old friend Hughes
> And d--- his eyes
> whoever tries
> to rob a poor man of his kudos.
> Have nothing to do with Bell. He is a skunk.

What had been going on? What were Hughes's wishes that involved such sentiments? It certainly looks as though Preece and Hughes were engaged in some sort of argument with both Edison and Bell *before* the publication of the papers and demonstrations in May 1878 could have reached America. There might have been exchanges of telegrams between 9 and 15 May, but there might also have been some negotiations following the demonstration to the Submarine Telegraph Co. in January 1878. Perhaps further records will come to light which will illuminate this matter.

At any rate, we see Preece in an aspect differing considerably from his 'public image'. And we are left wondering if Edison may have had some real grounds for ill-feeling against Preece and Hughes. Eventually Preece rationalised the relationship between the microphones of Edison and Hughes and later developments of practical telephone transmitters as being all based on the properties of loose carbon contacts.[48]

4. PREECE AND THE EDISON EFFECT

Whatever the feelings between Edison and Preece in 1878, friendly relations had evidently been restored by 1884, when Preece again visited America and was made welcome in Edison's laboratory. He was shown demonstrations of Edison's recent discovery that when a platinum plate was fixed within or near the loop of the filament of an incandescent filament lamp, and connected to one or other terminal of the filament through a galvanometer, then current would flow through the galvanometer when the plate was connected to the positive terminal but not appreciably when connected to the negative terminal. This 'Edison Effect', as it was called,[49] later on—much later—led to the invention of the thermionic diode valve by J. A. Fleming, but at the time nothing was known of thermionics or electrons. Preece, as usual, was fascinated by the new discovery, and persuaded Edison to make for him a number of samples of the special lamps which he could bring back to England for investigation.

In his own laboratories in the Post Office, Preece made a series of careful experiments to elucidate the nature of the effect, which he reported to the Royal Society.[50] He concluded that:

> It is very evident that this Edison effect is due to the formation of an arc between the carbon filament and the metal plate fixed in the vacuous bulb; that this arc is due to the projection of the carbon particles in right lines across the vacuous space; and that it makes its appearance earlier, and is more strongly marked, when the connections are as shown in Fig. 1 [our Fig. 2] than when they are reversed, because, as Mr. Crookes has pointed out, the projection proceeds from the negative to the positive pole, and it would commence at the point of least resistance.

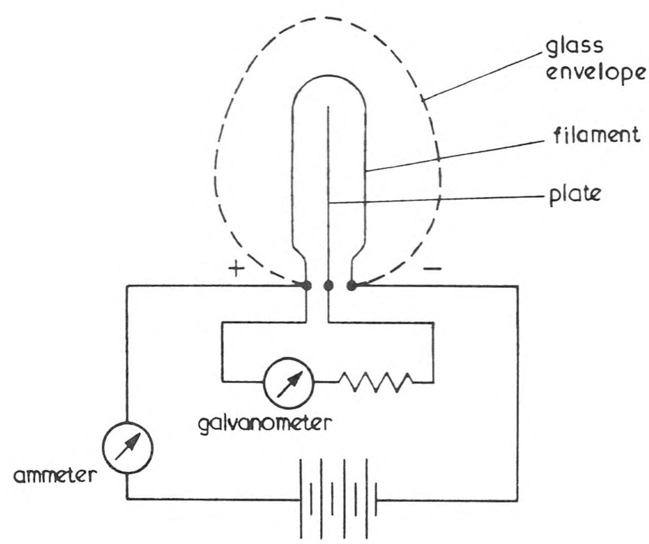

Fig. 2 Circuit for Preece's experiments on the Edison Effect. When the connections were as shown, the "arc" which Preece mentions was between the plate and the negative side of the filament.

Bearing in mind the state of knowledge in 1885, this was a reasonable conclusion from the experimental evidence and was probably at least partially correct. He may be excused for not discovering the electron.

5. PREECE AND WIRELESS COMMUNICATION

The main applications of Preece's system of wireless communication, which did not depend on the radiation of waves, came at the very end of his Post Office career, just as he was about to retire at the age of 65. The fact that he pushed them into practice at this period is not, however, evidence that he had rejuvenated his old taste for innovation, for (a) the early development (and even inventive) stage of the work had taken place in the early 1880s, and (b) the new stimulus was almost certainly Marconi's work on electromagnetic-wave wireless communication which Preece had been brought into contact with from 1896. His interest in the matter seems to have stemmed from his early observations of interference between telegraph and telephone circuits that were well separated in space. If isolated circuits could thus communicate, why not turn the effect to some useful purpose? An opportunity to test his ideas came in March 1882 when the cable to the Isle of Wight broke down. He attempted to communicate from Southampton to Newport (I.O.W.) by the following arrangement[51]:—

> Large metal plates were immersed in the sea at opposite ends of the Solent, namely at Portsmouth and Ryde, six miles apart, and at Hurst Castle and Sconce Point, one mile apart. The Portsmouth and Hurst Castle plates were connected by a wire passing through Southampton, and the Ryde and Sconce Point plates by a wire passing through Newport; the circuit was completed by the sea, and signals were passed easily so as to be read by the Morse system, but speech was not practical.

Preece recognised that this was a conductive system. He appreciated that electrostatic and magnetic systems were also possible, and set up experiments in 1885 near Newcastle-upon-Tyne, carried out by A. W. Heaviside, a Post Office engineer who was brother to the great Oliver Heaviside. Inductive transmission between loops of wire 440 yards square was proved up to separations of 1000 yards; and on a larger scale, using groups of telegraph wires many miles long and several miles apart, inductive transmission of a.c. signals at around 500 Hz was achieved over separations up to 10 miles, and with some reservations up to 40 miles.[52] Further experiments in other places established the technique,[53] culminating in a permanent installation in 1898 providing communication between Lavernock Point and Flatholm in the Bristol Channel. Preece was satisfied that in this case the system was inductive and not conductive.

This work was concerned with telegraphy. However, in 1894, John Gavey, one of Preece's staff and a future Engineer-in-Chief, conducted some experiments at Loch Ness in which he tried to transmit speech across the loch by Preece's method. With one wire running down each side of the loch for four miles, well earthed at each end, and at an average distance of one and a third miles apart, he found that speech transmission was satisfactory. In 1899 Preece took up the matter himself. He wrote in 1900:[54]

> The sensation created in 1897 by Mr. Marconi's application of Hertzian waves distracted attention from the more practical, simpler, and older method . . . In 1899 I conducted some careful experiments on the Menai Straits, which determined the fact that the maximum effects are produced when the parallel wires are terminated by earth plates in the sea itself . . . It became desirable to establish communication between . . . the Skerries and the mainland of Anglesey, and it was determined to do this by means of wireless telephony.

The distance was 2½–3 miles, and a permanent installation was made in Spring 1900 and was still functioning three years later.[55] A trial between Ballycastle and Rathlin Island (in Northern Ireland) 'demonstrated the possibility of transmitting articulate speech . . . over distances of 7 or 8 miles.' However, the permanent link was only telegraphic.[56]

This was the last fling of the Preece system. In March 1902 the new Engineer-in-Chief reported that it was now thought that the Hertzian system would in future provide a better system and that therefore there would be no further installations of the Preece system.[57]

It is interesting that Oliver Lodge had been interested in a magnetic wireless system. He wrote to Preece on 4 March 1898:[58]

> 'I have been working for six months or more at a method of magnetic telegraphy . . . with no propagation of waves worth noticing . . . It has developed into something not unlike your old plan.

He later (5 August 1898) made a specific proposal for a Guernsey-Sark link. But nothing seems to have come of this.

The connection between Preece and Marconi has in recent years received much publicity.[59] It is greatly to Preece's credit and quite typical that he encouraged the young Marconi in 1896, and collaborated with him in experimental work until the formation of the Marconi Company in July 1897. Yet by 1900 he thought Marconi's system had no future,[60] and was still rather pessimistic about its general value in 1905.[61] The Marconi Co. had little respect for him by then, for Hall, the managing director of the company, wrote to Marconi complaining of Preece's paper to the B.A. in 1905—'Either he is wilfully misleading the public or is so ignorant of the subject of his paper that it is presumption for him to have read it at all.'[62]

6 PREECE AND RAILWAYS

Preece maintained a professional connection with railway work throughout his career. This was mainly concerned with telegraphy, signalling and safety, but around 1900 he was associated with a project for high-speed electric traction. His first formal association with railway work appears to be when in 1860 he became Superintendent of Telegraphs to the London and South Western Railway, holding this post additionally to his other appointments until 1879, when he became Honorary Consulting Telegraph Engineer until 1884, then Consulting Engineer at a fee of 50 guineas (100 from 1899) until 1904, when he once again became honorary. His association with the L&SWR thus lasted almost half-a-century. His main innovatory contributions were (a) his campaigning[63] for the general introduction of the block system of signalling and his development of special apparatus for this, and (b) his support for the introduction of passenger-to-guard-and-driver communication and, again, his development of suitable apparatus.[64]

According to Preece's technical assistant over nearly 30 years, H. R. Kempe,[65] the stimulus for his first main contribution to block working was the problem of the Queen Street to St. David's incline at Exeter opened on 1 February 1862. Preece's invention was a 3-wire telegraph link which gave in the signal box at each end of the 'block' a miniature semaphore signal reproducing the state of the signal at the other end of the block.[66] He later developed a single-wire system in 1866, improved in 1872, which was the most highly-regarded of all available systems in the view of at least one contemporary expert.[67]

The problem of communication between passengers and the guard and/or driver was considered from about 1852 by railway authorities in various countries in the light of attacks made on passengers and various accidents in isolated compartments, especially on trains making a long non-stop journey. The matter was certainly taken seriously, for a committee of the House of Commons twice considered it, and similarly a committee comprising the general managers of major railway companies.[68] To meet the need, Preece developed an electrical system in 1864; in this a passenger, to give an alarm, had to break a glass panel, whereupon bells rang in the guard's van and on the locomotive, and small semaphore arms were raised on each side of the carriage concerned.[69] A review of the background, and a technical description of his system, was given by Preece in December 1866.[70]

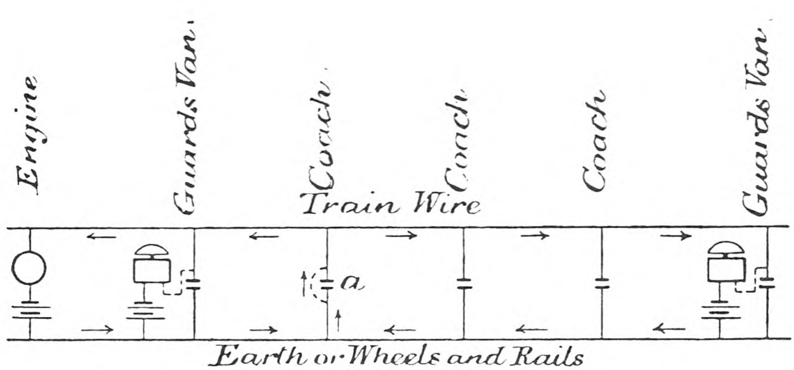

Fig. 3. Preece's balanced current system for railway carriage communication. From W. E. Langdon, *Railway Magazine* Vol. 3 (1898) p. 333.

The L&SWR took up the system early in 1865[71] and arranged for a train of six carriages and two guard's vans to be fitted with the apparatus, and worked for the ordinary traffic of the line. By August:—[72] 'The carriages of the Exeter express are now fitted with the apparatus, and plain directions for its use have been issued.' The use of the system grew at first, but eventually gave way to a non-communicating safety system in which 'pulling the cord' caused the application of the brakes. Fig. 3 shows Preece's system as described as current practice in 1898.

At the other end of his career, Preece became involved in a very different kind of project. In collaboration with F. B. Behr, he put forward in 1900 a detailed proposal for an electric high-speed railway between Manchester and Liverpool.[73] It was a remarkable proposal; train speeds of 110 miles/hr were proposed; 1600 hp were to be available to accelerate the 45-ton single coach to this speed in less than two minutes; but the most remarkable feature was that it was to be a monorail on the Lartigue system, previously used, *inter alia*, on the Listowel-to-Ballybunion railway in Ireland in a low-speed steam-hauled form.[74] It was a system with a single running rail supported on trestles, with the train straddling it symmetrically; there were steadying rails on each side of the trestles.

This project was quite outside any experience Preece had had. On the face of it, the idea of a train straddling a trestle track at 110 miles/hr does not seem promising; instability and excessive power losses due to air turbulence appear likely. But there was some practical experience to give Preece and Behr confidence. At the Brussels Exhibition of 1897 a three-mile demonstration electrified track[75] offered visitors a ride at which a speed of 75 miles/hr[76] was claimed around a curve of 1600 ft. radius. With much difficulty, Behr obtained an Act of Parliament authorising the Manchester-Liverpool line on his second attempt in 1901.[77] However, the project collapsed through being unable to raise the necessary capital.

It seems likely that Preece's retention as consulting engineer to this project was not really to have the benefit of his advice, but to have his eminent name in support of the financial and parliamentary negotiations.

7 PREECE AS CONSULTING ENGINEER FOR ELECTRIC LIGHTING SCHEMES

Preece had been taking an interest in the developments in electricity generation and in electric lighting in the 1870s and had started to take part in the discussions at meetings concerned with these topics at least as early as the end of 1878.[78] As with telecommunications, he was sometimes badly wrong in his opinions; for instance, in 1879 he stated that 'a subdivision of the electric light is an absolute *ignis fatuus*',[79] by which he meant that parallel operation of incandescent lamps was impracticable; yet it was precisely on the basis of parallel operation of incandescent lamps connected across distribution mains that electric lighting systems developed. Once Swan and Edison had shown that parallel operation was possible, Preece quickly adapted himself to the new position, and published his first paper on electric lighting in 1881,[80] having given a public lecture on the subject at the Albert Hall even earlier, in 1880.[81]

The exact beginning of public electricity supply using distribution mains is a matter of some controversy.[82] The celebration of the centenary of public electricity supply at Godalming in Surrey in September 1981 indicates that there is considerable support for the view that it began there in September 1881. Certainly public supply had begun in earnest by 1882 and led to the Electric Lighting Act of that year. This and other factors caused a lag in development in Britain, and an amending Act had to be passed in 1888. Preece summed up the situation very clearly and in terms which are still held valid, in a report dated 31 May 1889 to the Bristol Corporation (for whom he had been a consultant since 1884), thus:—[83]

> 'Since the last Report considerable progress has been made. The advance of Electric Lighting in the United Kingdom had been seriously checked by restrictive legislation, but by the Act of 1888, the principal cause of this restriction, viz. the compulsory purchase at the value of old material at the end of 21 years, has been removed, and now it can be fairly said that legislation no longer retards the enterprise of electric lighting firms. Advance was also seriously checked by the inordinate speculation of 1882. It has been found extremely difficult to induce capitalists to invest their money in electrical enterprises. But the success of electric lighting in America, in Germany, in Italy, at the Grosvenor Gallery in London, at Eastbourne and at Brighton has removed the want of confidence that existed, and now there is no difficulty whatever in raising capital for electrical enterprises. In fact, it can be said without any question whatever that electric lighting has now reached its practical stage.'

Preece was clearly in touch with contemporary attitudes and assessments, and he had given good advice to Bristol Corporation in his earlier reports of 4 December 1884, 16 October 1885 and 20 September 1887 in which he had recommended waiting until electric lighting systems were better developed and less experimental. But he now (i.e. in May 1889) advised that the time was ripe for the Corporation to go ahead:

> Apart altogether from the removal of restrictive legislation, and from the removal of want of faith, other causes are extant for the renewal of confidence. The cost of the requisite machinery has been diminished to about one third, while the output of the machinery itself has increased three times, so that the electrical apparatus of the present day is nine times more valuable commercially than it was in 1884.

He discussed at great length whether the Corporation should undertake the generation and supply of electricity themselves or arrange for it to be done by commercial enterprise. He pointed out that so far only one municipality (Bradford) had undertaken the task themselves, so that there was practically no experience to go on. While he avoided giving direct advice, he made a good case for a Corporation undertaking, and the Corporation certainly decided, after much discussion, to set up their own undertaking. Preece then became responsible for the preparation of plans and specifications and for supervising the contractors; he employed Gisbert Kapp,[84] an already eminent electric power engineer, as his assistant.[85] The station opened in Autumn 1893. The building still stands and Fig. 4 shows a view of it in 1972.

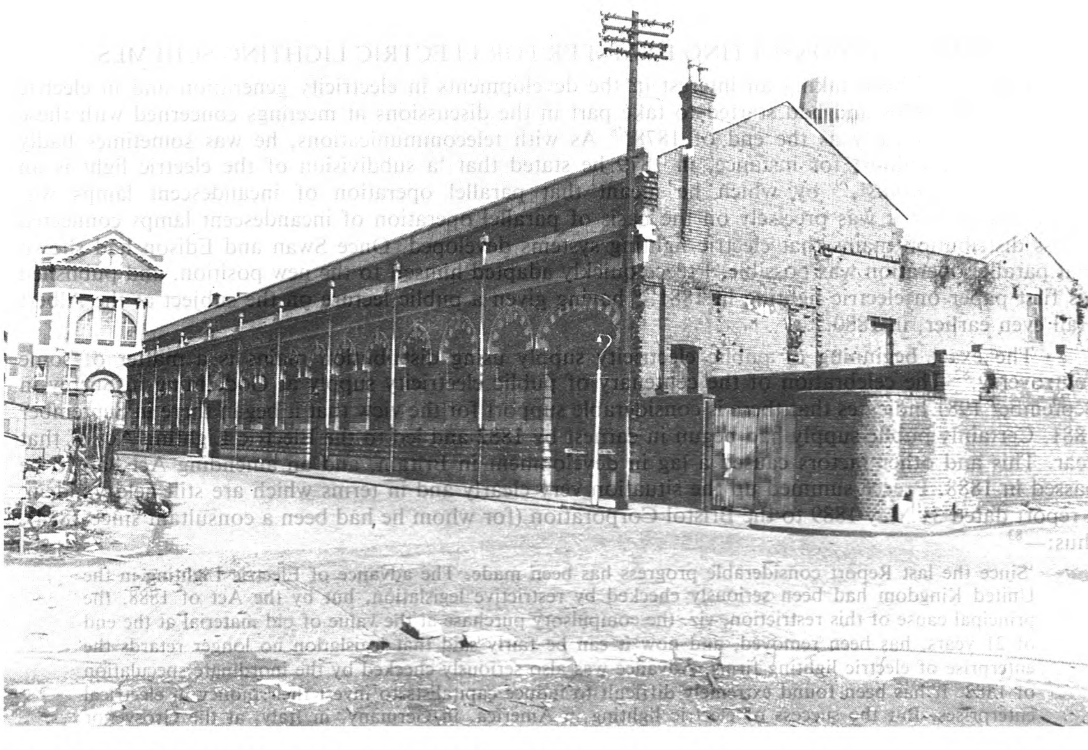

Fig. 4. Bristol Corporation's first electricity generating station at Temple Back, with the tramway company's generating station in the left background. *Author's photograph 1972.*

This connection with Bristol appears to have been Preece's first such consulting appointment, and it is interesting to speculate as to whether he had any practical experience of lighting and generating systems on which to base his advice. It is no doubt significant that he enlisted Kapp to do the detailed work, for by around 1890 Kapp was already very experienced. Before Bristol's undertaking was opened and could have given Preece some useful experience, he was already advising many other authorities, as discussed below. It seems that his main practical experience would have come from electric lighting at the G.P.O.,[86] for he included in his 1889 report the following statement:—

> Electric Lighting is perfectly practicable; it can compete on very fair terms with gas. It cannot be supplied as cheaply as gas. My experience in the Post Office is that a gas burner giving a light practically equivalent to 10 candles, and maintained alight during the average hours that work extends over here, costs 18/- [£0.9] per annum; while an electric lamp giving a similar amount of light can be maintained with greater uniformity, with greater comfort, with infinitely less heat at a cost of 22/- [£1.1] per annum. These two prices must be taken simply as the cost at the General Post Office, but I think the ratio between these two prices may very fairly represent the relative cost at the present day of the two lamps anywhere.

It is hard to find when Preece was first consulted by various other authorities, but it seems Swansea was probably his next—he was certainly reporting on tenders there in late 1890. He recommended acceptance of Crompton & Co.'s tender and his advice was acted upon. But it appears that he was not called upon to do anything further there.

His next consulting appointment, certainly his next major one, was that at Worcester, 1892–94.[87] Here he had to advise on the question of whether water power should be used at the proposed site at Powick on the river Teme. When the decision was made to go ahead with what was to be Britain's largest 19th-century hydro-electric generating station used for public supply, he had to supervise the construction and commissioning. The station was at least partially successful, and it endured many decades; but the hydraulic calculations had not been done very well, and it was often short of water for its 400 kW of water-generating capacity, and until the new steam-powered station was opened at Hylton Road, Worcester, early in 1903, had to rely heavily on its steam stand-by plant.

During 1892 and 1893 Preece became involved with numerous other electricity supply projects, four of which were in the same category as Bristol and Worcester, that is they involved the initial reports on the proposal, then the detailed plans and specifications, and then the superintending of the construction and commissioning of the generating station and supply system. The four were Great Yarmouth, Tunbridge Wells, Dewsbury, and Hampstead. In all of these except possibly Tunbridge Wells, Preece employed his son Arthur Henry Preece (later Sir Arthur, but then only about 25 years old) as assistant.In addition to these four very large involvements, Preece made initial inspections and reports, usually including estimates, for the following places:—

Arundel Castle, Croydon, Lambeth (separate involvements with the Corporation and Board of Guardians), Chester, Poplar, and Nottingham. And at Kingston-on-Thames and Cheltenham he was asked to report or comment on the reports of other consulting electrical engineers.

Further information and references relating to these 15 consultancies and the projects they were concerned with are given in Appendix 1. I have not been able to find copies of all the reports that Preece wrote in connection with these various projects, but in those I have examined there is, not surprisingly, something of a pattern. General remarks recur with only the slightest modifications of wording. Examples are:—

> 'Nothing can prevent it from being the light of the future.' (i.e. electric light)
>
> 'In some places it is found to pay for itself by the value of the extra work obtained from the staff through the diminution in the number of days of absence due to sickness.'
>
> 'Gas, paraffin, and tallow vitiate the air of ill-ventilated and over-crowded rooms. Electricity prevents this pollution.'
>
> 'I consider that it is the duty of a corporation to assume the supply of pure light.'

(This actual wording comes from the report to the Great Yarmouth Corporation.)

In spite of the high reputation which Preece evidently enjoyed as a consulting electrical engineer, his reports were sometimes subjected to adverse criticism. Naturally his recommendations would not be expected to be received favourably by councillors opposed to the introduction of electric light; but criticisms by two councillors at Croydon were especially interesting.[88] Expressions used to describe his second report were 'loose report', 'careless estimate', and 'irritatingly patronising'. His reports were certainly very long and verbose, and his estimates of cost were not detailed, but these were normal features of such reports. Perhaps there was more substance in the charge of being patronising; the last example of general remarks quoted above ('it is the duty of a corporation to assume the supply of pure light') might be a case in point.

Some idea of the fees Preece obtained for these consultancies might be of interest. For preparing an initial report on a proposal, with estimates of cost, the fee varied from £30 at Lambeth (Board of Guardians), through 50 guineas at Yarmouth and Poplar, to 100 guineas at Tunbridge Wells. For superintending the construction and commissioning of a generating station and system the fee was a percentage of the contract cost of the project: $2\frac{1}{2}$ percent at Worcester, but 5 percent at Yarmouth and Hampstead. The cost of buildings might be excluded from the contract costs for this purpose. The total fee received for each of these projects would have been of the order of £1000.

How did Preece's consulting activity compare with that of other consulting electrical engineers of the period? My researches into the practice of consultancy in electrical engineering are very far from complete, but I have notes of about 50 consulting electrical engineers in the years 1890–94. Of these, only four had more than about eight consultancies during these years in relation to electric lighting projects of the type we are considering; these were Robert Hammond (at least 14 projects), Prof. A. B. W. Kennedy (at least 16), E. Manville (about 10), and J. N. Shoolbred (about 9). Clearly, Preece was in the top class in this respect.

* * *

Some more general thoughts about the growth of consultancy work in electrical engineering and Preece's part in it seem appropriate at this point. The idea of engineering consultancy was, of course, quite old at this time. River navigations, port authorities, and canal companies had been engaging consulting engineers to prepare recommendations, plans and estimates, and to oversee the construction, for well over a century; railways for half-a-century, telegraph companies for 40 years or more. Think of Smeaton, Telford, the Stephensons, and Lord Kelvin among the more famous consultants. The telephone had not involved such a large amount of consultancy, perhaps because the business quickly became organised into large monopolies with their own professional staff. Although Preece undertook much lecturing and publishing in telephony, there seems no record of his doing any consultancy in this field. Perhaps it would have been unethical in his position, for he would virtually have been helping the Post Office's competitors. However, when public electricity supply began the situation changed. There was an immediate need for consulting electrical engineers. There was no supply of ready-trained electrical engineers other than telegraph engineers, and even the companies which were specially formed to set up electricity supply undertakings had often to retain consultants; much more so the manufacturing companies which were so often already-established engineering manufacturers who extended into electrical engineering when the demand came. An example of the latter was W. H. Allen & Company who for some years, from 1884 to at least 1890, had their new electrical department directed by Gisbert Kapp on a consulting basis.[89]

It was, however, the growth of interest on the part of local authorities in the idea of municipal electricity undertakings which really stimulated the demand for consulting electrical engineers. This growth of interest occurred from around 1890, up to which date all electricity supply had been by companies; but by 1894 about one-quarter of the hundred or so undertakings in operation were municipal, and about 18 percent of the capital had been obtained by municipalities.[90] This meant that numerous local authorities which had no electrical engineer on their staff had to consider whether to set up a municipal electrical undertaking. Some borough surveyors and municipal engineers were able to work out schemes in detail and some (such as Joseph Hall at Cheltenham, mentioned in Appendix) produced schemes which were later approved by leading consultants. But generally this was not the case and the local authority approached a consulting electrical engineer at a very early stage. Preece's appointment as consultant to Bristol Corporation at least as early as 1884 was, of course, exceptional; as we have said, the main demand was from 1890.

Preece would probably not have considered such consulting work unethical, for it was in a field of electrical engineering different from that in which he was primarily employed by the Post Office, and not competitive with any Post Office enterprise. At first it would not have taken much of his time; for the years up to 1890 very few municipalities were taking any serious interest in the possibility of having their own electricity undertaking; and in any case Preece's advice was to await developments, so that he had no actual planning, specification or supervision to do. So he was able still to devote his energies to innovations in communications. As we have seen, the early and middle 1880s were his most productive period in this field. However, by 1892 he was beginning to be involved, not only with an increasing number of electric lighting projects, but also in their planning, specification and supervision. He avoided much of the detailed work, for which he was not well-qualified, by employing an assistant, notably Kapp at Bristol and then his son A. H. Preece at other places. But the work must nevertheless have been very time-consuming with reports to write, visits of inspection to make, numerous meetings to attend in distant places. During the early 1890s he could have had little time for anything more than his most basic duties in the Post Office. No wonder that eyebrows were raised, and questions asked in Parliament[91] as to how a full-time civil servant could be allowed to do this private work, which was against the rules. The official answer was 'that the case of Mr. Preece is exceptional' and no action was to be taken to hinder him. Probably they could not have stopped him; his consultancy earnings must have greatly exceeded his Post Office salary.

At this stage Preece was in his late 50s, his desire for innovation may well have gone, and the busy life of advising in fairly routine electricity supply systems was probably attractive to him. His advice was sound and it was generally highly regarded—but there was no spark of originality in it. Yet his ability to give this advice was the result of his intense interest in new ideas during the previous decade. Without the grasp of electric lighting and supply engineering which this caused him to acquire, he would not have been able to hold such an eminent position as consulting electrical engineer.

It was noticeable that during the 1890s there were few technical advances in Post Office communication engineering; the big task of extending and improving the trunk telephone system when it was nationalised in 1895–6 involved only well-established engineering and was probably done mainly under the supervision of Preece's assistants.

* * *

It should be emphasised that all the above discussion about the development of public electricity supply and more particularly the role of the consulting electrical engineer, applies specifically to Britain. The situation was quite different in some other countries, notably the U.S.A., where the consultant played a much less significant role.[92]

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Appendix

W. H. PREECE'S CONSULTANCIES IN RESPECT OF ELECTRIC LIGHTING SCHEMES, 1892–93

A. Consultancy involving initial report(s) and full superintendence of work

Bristol. W.H.P. concerned from 1884, station opened 1893 (see pp 127 – 129).

Worcester. Basic proposals for scheme (including recommendation to use water power of R. Severn) made by consulting electrical engineer G. E. B. Pritchett, Nov. 1890. Tenders invited Nov. 1891, received Mar. 1892, and at this stage W.H.P. engaged as consulting electrical engineer. He approved proposals and Brush Co.'s tender was accepted. Brush did detailed design. Site had to be changed to Powick, and R. Teme used for power. W.H.P. supervised work, which commenced late 1893; station opened Oct. 1894; total cost:— Brush Co. about £23,000; buildings £15,000.

Ref. D. G. Tucker, 'Hydro-electricity for public supply in Britain 1881 – 1894', *Ind. Archaeol. Rev.*, **1**, 1977, pp. 126 – 163.

Great Yarmouth. Tenders for proposals for electric lighting invited by Council, June 1892. W.H.P. appointed to examine tenders and specifications and advise on best scheme. Report Oct. 1892, recommending Council to start modestly with £10,000 scheme, and expand as necessary by 'the multiplication of the plant', and to introduce electric street lighting as experience gained. P. prepared specification, gave evidence in respect of loan applications, supervised further tendering and the construction and commissioning of the works. A. H. Preece probably did most of the detailed work. Station opened Oct. 1894.

Refs. *Yarmouth & Gorleston Times,* 16 July, 13 Aug., 12 Nov., 17 Dec. 1892; 14 Jan., 18 Mar. 1893. *Elect. Engr.,* **10**, 1892, pp. 527 – 8.

Tunbridge Wells W.H.P. appointed to make proposals in Aug. 1892, and in Dec. 1892 was asked to prepare complete plans and specifications by the Electric Lighting Committee. Council, however, deferred matter until Dec. 1893, when W.H.P. went ahead. He supervised tenders, construction and commissioning. Capital cost £25,000. Station opened Oct. 1895.

Refs. *Tunbridge Wells Advertiser*, 6 Jan., 3 Mar., 7 July, 8 Dec. 1893. *Elect. Engr.* **16**, 1895, pp. 385 – 93 and 396 – 400.

Dewsbury. W.H.P. appointed at end of 1892 to report and prepare specifications and detailed plans. In Mar. 1893 he was appointed to superintend the works. A.H.P. assisted. Station opened Dec. 1894, cost about £25,000.

Refs. *Dewsbury Reporter*, 11 Feb., 11 Mar., 11 Nov. 1893. *Elect. Engr.,* **11**, 1893, p. 291; **12**, 1893, p. 214; **14**, 1894, p. 726.

Hampstead. W.H.P. appointed Jan. 1893 to prepare plans and specifications, to supervise tenders and to superintend the works. Specifications, received by Council May 1893, tenders invited by Sept. 1893, and work completed and public supply inaugurated Oct. 1894. Total cost about £28,000. A.H.P. assisted.

Refs. *Hampstead Record*, 28 Jan., 6 May, 16 Sept., 21 Oct., 18 Nov., 16 Dec. 1893; 6 Oct. 1894. *Elect. Engr.*, **14**, 1894, pp. 384 – 391 and 566 – 9.

B. Consultancy involving only initial reports and estimates

Arundel Castle. W.H.P. appointed consulting electrical engineer to Duke of Norfolk for installation of electric lighting plant Nov. 1892; G. Kapp also appointed, and must have done the detail work and superintendence, for only he was mentioned in accounts of opening in Aug. 1894. It is presumed that W.H.P. made initial recommendations and estimates.

Refs. *Elect. Engr.*, **10**, 1892, pp. 526 – 7; **14**, 1894, pp. 176 – 8 and 206 – 8.

Croydon. An interesting case in which W.H.P. was criticised and replaced by another consultant. W.H.P. appointed to make initial report June 1892; he recommended Corporation to delay decision re setting up a municipal undertaking, but Committee recommended going ahead and asked W.H.P.

for new report and revised estimates, which were considered in July 1893. After criticism of W.H.P. by councillors, Council decided in Feb. 1894 not to proceed; but reversed this in Nov. that year and appointed A.B.W. Kennedy as consulting electrical engineer. Station opened late 1896.

Refs. *Croydon Times*, 27 July, 28 Sept. 1892; 12 July 1893; 28 Feb. 1894. *Elect. Engr.*, **18**, 1896, pp. 517 – 27.

Lambeth Vestry (forerunner of the Corporation). W.H.P. appointed Jan. 1893 to make proposals. Report recommending £75,000 scheme considered Feb. 1893, still being argued about in 1895 and project eventually shelved.

Refs. *South London Mail*, 25 Feb. 1893. *Elect. Engr.*, **11**, 1893, pp. 243 – 4; **16**, 1895, pp. 307 – 8.

Lambeth Board of Guardians. W.H.P. appointed June 1893 to give estimates for electric lighting system and generating plant for Workhouse and Infirmary. Reported in Aug. 1893 recommending scheme costing £6900. Board decided in Sept. 1893 to postpone decision for a month, and then dropped the scheme altogether.

Refs. *South London Mail*, 2 and 30 Sept. 1893. *Elect. Engr.*, **12**, 1893, pp. 235 – 6 and 333.

Chester. W.H.P. appointed May or June 1893 to make initial proposals. His report discussed various sites for the generating station and the penalty of having long high-voltage mains if a remote site was chosen; he recommended low-voltage d.c. for inner city area and a small high voltage a.c. plant for outlying areas. He also recommended John Hopkinson as 'the best electrician in Europe to undertake the work'. He then dropped out, and Hopkinson became consultant.

Refs. *Chester Chronicle*, 22 July, 14 Oct. 1893; 16 June 1894.

Poplar. W.H.P. appointed Nov. 1893 to make recommendations and estimates. His scheme, costing initially £30,000, was considered by the District Board in May 1894 and recommended to Bow Vestry (the superior authority). Project deferred, and eventually taken up again under a different engineer; opened 1900.

Refs. *East London Advertiser*, 18 Nov. 1893, 5 May 1894. *Elect. Engr.*, **14**, 1894, p. 466. *Electrician Tables*, Jan. 1901.

Nottingham. W.H.P. appointed with J. Hopkinson to make recommendations, Nov. 1891; Council approved £25 – 30,000 scheme. W.H.P. then dropped out. Station opened 1894 under Hopkinson's superintendence.

Refs. *Electrician*, **28**, 1891, p. 107. *Elect. Engr.*, **13**, 1894, pp. 218, 250.

C. Consultancy involving comment on reports of other consultants.

Kingston-on-Thames. 'The committee [of the Town Council] had an able report from Mr. Shoolbred, but they were rather anxious to hear some further information from a second person . . .' and in Nov. 1892 requested W.H.P. to give them a report. He declined, but agreed to attend a meeting of the committee on 19 Dec., at which he generally supported Shoolbred's advice to go ahead with a £15,000 scheme. The Council eventually agreed.

Refs. *Kingston & Surbiton News*, 26 Nov. 1892, 7 Jan. 1893. *Elect. Engr.*, **10**, 1892, p. 573; **11**, 1893, p. 52.

Cheltenham. Here the original report and estimates were made by the Borough Surveyor, J. Hall, and W. E. Ayrton was appointed consultant to report on Hall's report in June and Dec. 1892. W.H.P. was then appointed to report on the previous reports in July 1893. He supported Hall and Ayrton and the £16,000 scheme went ahead, opening in May 1895. As far as is known this was the only scheme with which W.H.P. was associated which involved using the heat from a refuse destructor to reduce the cost of electricity generation; W.H.P. offered his own calculations on the saving.

Ref. D. G. Tucker, *How Towns got Electric Light and Tramways*, Science Museum Paper, 1978, pp. 8 – 9.

NOTES AND REFERENCES

1. Mary Lane and Joyce Bartle, *Bibliography of Published Work by W. H. Preece*, Dept. of Electronic & Electrical Eng., University of Birmingham, 1974, unpublished, but copy in Archives of Inst. Elect. Engrs. This bibliography, which does not claim to be complete, shows about 136 *different* papers. There were hundreds more actual publications, for many papers were published in several journals and there were numerous minor contributions, all listed. A large proportion of the principal publications are listed in *Royal Society Catalogue of Scientific Papers,* Vol. **5** (1800-1863), Vol. **8** (1864-1873), Vol. **11** (1874-1883) and Vol. **17** (1884-1900).
2. E. C. Baker, *Sir William Preece, F.R.S., Victorian Engineer Extraordinary,* Hutchinson, London, 1976. A review by the present author appeared in *Radio & Electronic Engr.*, **46**, 1976, p. 572.
3. However, there was usually a mention of his advisory work for the lighting of the British Museum and the Houses of Parliament, and for lighting in Gibraltar and Malta, although these were comparatively small commitments. See Baker, op.cit. (2), pp. 219 – 221; *Elect. Engr.*, **9**, 1892, p. 145. *The Engineer,* **83**, 1897, pp. 337 and 342 – 4.
4. D. G. Tucker, 'The beginnings of electricity supply in Bristol 1889 – 1902', *Bristol Ind. Archaeol Soc. J.*, **5**, 1972, pp. 11 – 18; 'The first cross-channel telephone cable; the London-Paris telephone links of 1891', *Trans. Newc. Soc.*, **47**, 1974 – 76, pp. 117 – 132; and a conference paper of limited circulation, 'W. H. Preece; 19th century telegraph, telephone and power station engineer', *Paper presented at the 2nd weekend meeting on the History of Electrical Engineering*, Inst. Elect. Engrs., 1974.
5. H. R. Kempe, 'Some personal reminiscences of Sir William Henry Preece, K.C.B.', *Post Office Elect. Engrs. J.*, **6**, 1913 – 14, pp. 401 – 5.
6. Company's memoranda preserved in Post Office Records Office (PORO hereafter).
7. PORO, memo dated 9 Feb. 1856 in Preece Collection; wrongly stated by Baker (see ref. 2) to have been the Southern District.
8. *Jersey Independent,* 2 Feb. 1860.
9. *Daily Telegraph*, 16 Feb. 1899.
10. A. T. Patterson, *The University of Southampton*, Southampton, 1962, p. 33.
11. See ref. 4.
12. *Elect. Engr.*, **23**, 1899, p. 393.
13. Indeed, he was awarded the Telford Premium for his paper on 'The maintenance and durability of submarine cables in shallow waters', *Proc. Inst. Civil Engrs.,* **20**, 1860 – 1, p. 26.
14. I.E.E. Archives, NAEST Box 20, item 20/46.
15. Brit. Pat. No. 2608 of 1855.
16. I.E.E. Archives, NAEST Box 20, items 20/32 – 33 and 20/80 – 90. The Post Office used J. B. Stearn's patent, discussed in E. A. Marland, *'Early Electrical Communication',* Abelard-Schuman, London, 1964, pp. 146 – 7.
17. I.E.E. Archives, NAEST Box 20, items 20/29 – 31, 20/51 – 52.
18. Ibid. 20/51 – 2. Note, however, that during the period 1874 – 1880 Preece tried, according to Baker (op.cit. (2), pp. 208 – 9), to help Heaviside materially by offers of employment which were rejected.
19. Preece's own account is quoted in *The Daily Telegraph*, 16 Feb. 1899.
20. Ibid.
21. Technical description in *Electrician*, **13**, 1884, pp. 410 – 11; **16**, 1886, pp. 518 – 21.
22. Full reports of the trials and of the financial negotiations leading to an annual payment by the P.O. to Delany's company of £2000 for the duration of the patent, are to be found in PORO, POST 30/485, file E3600/1886.
23. W. H. Preece, 'Fast-speed telegraphy', *Electrician*, **19**, 1887, pp. 423 – 6.
24. D. G. Tucker, 'Francois van Rysselberghe: pioneer of long-distance telephony', *Technology & Culture,* **19**, 1978, pp. 650 – 674.
25. Sir George Lee, 'Oliver Heaviside—the man', Heaviside Centenary Vol., I.E.E., 1950, pp. 10 – 17.
26. See, e.g., O. Heaviside, *'Electrical Papers'*, Macmillan, London, 1892, vol. 2, pp. 323 – 354. This section was written in Feb. 1887.
27. W. H. Preece, 'On the coefficient of self-induction of iron and copper telegraph wires,' *Electrician*, **19**, 1887, p. 400.
28. O. Heaviside, as ref. 26, pp. 160 – 5, written in Sept. 1887.
29. To his new book, *Electromagnetic Theory*, Vol. **2**, London, 1900.
30. In the I.E.E. library.

31. I.E.E. Archives, NAEST 39/1.
32. 'On the Pupin mode of working trunk telephone lines', *Elect. Engr.*, **40**, 1907, pp. 237 – 8 and 260 – 6.
33. On 18 and 19 May for a few hours only: see Preece's diary, reproduced in Baker, op.cit. (2), p. 162.
34. Sir Wm. Thomson, reported in W. H. Preece and A. J. Stubbs, *Manual of Telephony*; Whittaker, London, 1893, pp. 3 – 4.
35. Reported in *J. Soc. Teleg. Engrs.*, **5**, 1877, pp. 525 – 30.
36. A. G. Bell, 'Researches in electric telephony', ibid, **6**, 1877, pp. 385 – 421.
37. Description and diagram in *Engineering*, **25**, 1878, pp. 496 – 9.
38. As ref. 35.
39. D. M. Smith Collection, Mundelin, Illinois: copied on microfilm in 'The Letters and Papers of David Edward Hughes (1831 – 1900)—Part 1', edited and introduced by J. O. Marsh and R. G. Roberts, *Microfilm Archive for Victorian Technology,* No. 1, U.M.I.S.T. and N.W. Museum of Sci. & Ind., 1980;
40. J. O. Marsh and R. G. Roberts, 'David Edward Hughes: inventor, engineer, and scientist', *Proc. I.E.E.*, **126**, 1979, pp. 929 – 935. See also *Engineering*, **25**, 1878 (10 May), pp. 369 – 371.
41. W. H. Preece, 'The connection between sound and electricity', *J. Soc. Teleg, Engrs.*, **7**, 1878, pp. 270 – 81; discussion pp. 281 – 92.
42. D. E. Hughes, 'On the action of sonorous vibrations in varying the force of an electric current', re-printed in *Engineering*, **25**, 1878, pp. 384 – 5.
43. *The Engineer*, **45**, 1878 (17 May), pp. 343 – 4.
44. *Engineering*, **25**, 1878, pp. 518 – 9; **26**, 1878, pp. 13 – 15, 44, 45, 49 – 50, 116 – 7.
45. *The Engineer*, **46**, pp. 30 and 53.
46. Comte du Moncel, 'Une querelle à propos du microphone' *La Nature*, 20 July 1878; translation in *Engineering*, **26**, 1878, p. 44.
47. See ref. 39.
48. W. H. Preece, 'Recent progress in telephony', B.A. meeting 1882, reprinted in *Electrician*, **9**, 1882, pp. 389 – 93.
49. 'A phenomenon of the Edison lamp', *Engineering*, **38**, 1884, p. 553.
50. W. H. Preece, 'On a peculiar behaviour of glow-lamps when raised to high incandescence', *Proc. Roy. Soc.,* **38**, 1885, pp. 219 – 230.
51. W. H. Preece, 'Recent progress in telephony', *Electrician*, **9**, 1882, pp. 389 – 93.
52. W. H. Preece, 'Electric induction between wire and wire', ibid, **17**, 1886, pp. 410 – 2.
53. J. J. Fahie, *A History of Wireless Telegraphy*, Blackwood, Edinburgh and London, 1899, pp. 136 – 161.
54. W. H. Preece, 'Wireless telephony', *Elect. Engr.,* **26**, 1900, pp. 380 – 1.
55. PORO, Engineer-in-Chief's reports March 1900, 1901, 1902, 1903 (POST 76/15).
56. Ibid, March 1900.
57. Ibid, March 1902.
58. I.E.E. Archives, NAEST Box 21, item 21/38.
59. W. P. Jolly, *Marconi*, London, 1973; Sir Eric Eastwood, 'Marconi, pioneer of wireless telegraphy', *Elect. & Power*, 1974, pp. 308 – 311.
60. Letter to W. W. Cobb in Marconi Co.'s archives.
61. W. H. Preece, 'Wireless telegraphy', *Electrician*, **55**, 1905, pp. 787 – 9.
62. Letter in Marconi Co.'s archives.
63. W. H. Preece, 'On the block system of working on railways', *J. Soc. Teleg. Engrs.*, **2**, 1873, pp. 231 – 7.
64. For the chronology of this paragraph I am indebted to Chapter 11 of E. C. Baker, see ref. 2.
65. H. R. Kempe, see ref. 5.
66. 'Preece's electric railway signals', *The Engineer*, **24**, 1862, p. 108; also Brit. Pat. No. 77 of 1862. See also W. H. Preece, 'Railway telegraphs and the application of electricity to the signalling and working of trains', *Proc. Inst. Civil Engrs.*, **22**, 1862 – 3, pp. 167 – 193; discussion pp. 193 – 239.
67. Capt. Mallock, 'On the block system of working on railways', *J. Soc. Teleg. Engr.*, **2**, 1873, pp. 238 – 251.
68. Various reports are reproduced, with editorial discussion, in *The Engineer*, **18**,, 1864, p. 41; **19**, 1865, p. 257; **20**,, 1865, pp. 1 – 3 and 10 – 11.
69. There is a whole file on this, with patent specifications, in PORO, Preece Collection.
70. W. H. Preece, 'On the best means of communicating between the passengers, guards, and drivers of trains in motion', *Proc. Inst. Civil Engrs.*, **26**,, 1866 – 7, pp. 80 – 89 plus Plate 7.

71. *The Engineer*, **19**, 1865, p. 34.

72. Ibid, **20**, 1865, p. 125.

73. W. H. Preece, 'The Manchester and Liverpool Express Railway', *Elect. Engr.*, **26**, 1900, pp. 381 – 2; F. B. Behr, 'Manchester and Liverpool Railway: Brakes and signals', ibid, p. 381; joint discussion at B.A. meeting, ibid, pp. 381 – 2.

74. Lartigue's system was invented in 1882; the L&BR opened in 1888, see *The Engineer*, **65**,, 1888, pp. 174 – 5. But there had been a demonstration of the system operating in Westminster, England, in 1886 (*The Engineer*, **62**, 1886, pp. 223 and 225) and the report indicated quite extensive use of the system with horse-, steam-, and electric-powered traction in other parts of the world.

75. *Engineering*, **64**, 1897, pp. 40 – 41 for details and diagrams of the electrical system; *Elect. Engr.*, **20**, 1897, pp. 263 – 4 for more general details. The car was made in Gloucester and exhibited there in April 1897; see *Elect. Engr.*, **19**, 1897, p. 443.

76. *Elect. Engr.*, **20**, 1897, p. 257.

77. *J. House of Commons*, **156**, 1901, 17 Aug.; *Electrician*, **45**, 1900, pp. 146 – 7, 189 – 90, 792; **46**, 1900 – 01, pp. 331, 521; **47**, 1901, pp. 145 – 7, 185, 418, 455 – 7, 492 – 3, 534 – 5, 567 – 8.

78. E.g. *Proc. Inst. Civil Engrs.*, **57**, 1878 – 9, Part 3, pp. 152 – 5.

79. The phrase quoted was from a lecture given by Preece and reported in *Telegraphic J.*, **7** 1879, p. 60 and subsequently given prominence by H. C. Passer, 'Electrical science and the early development of the electrical manufacturing industry in the United States', *Annals of Science*, **7**, 1951, pp. 382 – 392 and *The Electrical Manufacturers 1875 – 1900*, Harvard, 1953, p. 83. Passer discusses at some length the background of the misconception. It is interesting that in an earlier comment (*J. Soc. Arts*, **27**, 1878 – 9, p. 35), Preece had been more careful: '. . . the subdivision . . . seemed to him a kind of *ignis fatuus* . . . for this simple reason, that the experiments he had examined showed that when you divided the light, the intensity diminished as the square'.

80. 'Recent advances in electric lighting', *J. Soc. Arts*, **29**, 1880 – 1, pp. 430 – 5.

81. *Electrician*, **5**, 1880, p. 78.

82. P. Strange, 'Early electricity supply in Britain: Chesterfield and Godalming', *Proc. I.E.E.*, **126**, 1979, pp. 863 – 8.

83. All the reports mentioned are in the Bristol Archives Office, the one quoted being ref. 17845(1).

84. D. G. Tucker, *Gisbert Kapp*, Univ. of Birmingham, 1973.

85. D. G. Tucker, 'The beginnings of electricity supply in Bristol 1889 – 1902', *Bristol Ind. Archaeol. Soc. J.*, **5** 1973, pp. 11 – 18.

86. It had been on Preece's advice that the Post Office had had electric lighting installed on 'the Edison system' at the G.P.O. in St. Martins-le-Grand in 1882, using electricity supplied from the recently-opened Holborn Viaduct central station. By Spring 1883 there were over 1500 lamps in use. The P.O. had no generating station of its own at this time, but did have one by 1891. (*Electrician*, **9**, 1882, pp. 338 – 9; **10**,, 1883, p. 433; **26**,, 1891, p. 398.) Preece also had a private electric light installation, complete with generating plant, at his home in Wimbledon (H. R. Kempe, see ref. 5). He had no doubt also obtained some limited practical experience from experiments made in the streets of Wimbledon in the Spring of 1884 using a 8-h.p. engine and dynamo and a distribution system involving 3 miles of wire and various kinds of lamp. He included a report on these experiments in a long report (*Electrician*, **14**, 1885, pp. 480 – 3, 497 – 9, 519 – 20) to the Streets Committee of the Commissioners of Sewers for the City of London (the body responsible for the lighting of the City) in April 1885; he also included much other valuable information about the design of street lighting. He had previously given advice to the Committee in Nov. 1882. It is believed, however, that he was never a consultant to the committee for the planning and execution of an actual installation.

87. D. G. Tucker, 'Hydro-electricity for public supply in Britain 1881 – 1894', *Ind. Archaeol. Rev.*, **1**, 1977, pp. 126 – 163.

88. *Croydon Times*, 12 July 1893.

89. As ref. 84.

90. R. Hammond's report to Wakefield Corporation, *Elect. Engr.*, **13**, 1894, pp. 53 – 7.

91. Parliamentary Debates, 20 May 1892, p. 1442.

92. I. C. R. Byatt, '*The British Electrical Industry 1875 – 1914*', Oxford, 1979, p. 193.

DISCUSSION

Mr. K. Geddes said that the author's comments on the difference between Preece's private and public images could be borne out by an example from about 1886, when Preece's guard was down at an I.E.E. meeting. Owing to an injured eye he had to present his paper without being able to read it, and the report in the *Electrical Review* a day or two later showed that he rather let himself go and was very nasty; the official I.E.E. transcript some time later covered it up. Professor Tucker said that he believed that Preece spoke 'off the cuff' a good deal at such meetings as he often hadn't the time or couldn't be bothered to prepare his papers properly.

Mr. D. H. W. Hayton asked what power would have been used for the conductive telegraph system tried by Preece between the mainland and the Isle of Wight in 1882. Professor Tucker thought that Preece used not more than 100 volts and several milliamperes. Mr. Geddes asked if the system were not based on a.c. rather than d.c., and Professor Tucker replied that the system was effectively a.c. since an interrupted direct current was transmitted and a telephone receiver used to detect it, this method giving great sensitivity. In answer to a question as to whether any amplification was used, he said it was well before the time when any method of amplification was available.

Dr. R. J. M. Carr referred to Preece's association with a monorail project and said that monorails had tended to be the failing of many progressive thinkers since the earliest days of railways. There was a very interesting paper read before the Institution of Locomotive Engineers some 15 years ago, which identified over 125 monorail projects, finishing with the Tokio system, and pointing out that only one had even been commercially successful—that was the one at Wuppertal, where the conditions were most unusual; and practically all the others had been disastrous, like the Listowel and Ballybunion line, or would have been had they ever been built. Professor Tucker said that there had been a real rash of monorail proposals in the 1960s and it was probably that which had stimulated Barton to write the paper Dr. Carr had mentioned. He asked if Dr. Carr held the view that the Manchester to Liverpool monorail would have been a failure if it had been built, and Dr. Carr said 'Yes'. He thought that level crossings would not be practicable. Professor Tucker replied that none were intended; the line would be at sufficient height, and it would be fairly straight, with no intermediate stations. There was a good deal more discussion on monorails in general and the Wuppertal system in particular, in which **Mr. B. Earl, Mr. D. Adler, Mr. N. D. New** and **Mr. I. McNeil** took part.

Dr. Carr asked about Preece's system for passengers to be able to communicate with the driver and guard of a train in an emergency, which had been introduced on the L.S.W.R. in 1865. Presumably the coaches had to be connected by wires; did this lead to any operating problems in marshalling trains? Professor Tucker replied that the G.E.R. in about 1895 developed a system in which the wires were incorporated in the brake-pipe coupling, so that there was no extra complication in coupling-up trains. He agreed that if a wire broke the alarm system would not work; it was not a 'fail-safe' system. He thought that the concept of 'fail-safe' was probably of 20th century origin.

The discussion then turned to electricity generation, and to the generating station at Temple Back, Bristol, for which Preece had been the chief consultant. **Mr. R. Cox**, referring to the slide which the author had shown of one of the alternators, asked about some peripheral bolts for which there seemed no obvious purpose, and after a good deal of discussion **Dr. B. P. Bowers'** conclusion, that they held on the protective band which guarded the periphery of the rotor disc, was accepted. Referring to the slide of the Temple Back generating station, Page 128, the President pointed out that the building was in the typical long, low British style, whereas the building in the background, which was the tramway power station, was a tall colonnaded building in the American style, with the boilers above the engines.

Mr. Hayton commented that many of the companies had styled themselves Electric Light Companies; was there at that time any intention of providing motive power? Professor Tucker replied that around 1890 there was negligible use of electricity for power. There were just a few specialised applications, such as the electroplating industry in Birmingham, but they generated their own power. The first big use of electric power was by the tramways; there was only a very small development of the use of electricity for domestic heating and cooking. **Cdr. R. C. R. Brooke** said that he had seen the original records of some of the early London supply companies, and it was clear that no use other than lighting was contemplated. Mr. Hayton, referring to the availability of hydraulic power, said that the London Hydraulic Power Co. did actually sell little water turbine generator sets so that people could light their houses using L.H.P. pressurised water. In reply to discussion about the size of generating plants, Professor Tucker said that the typical station—municipal or commercial—in the

1890s would have had a capacity of about 0.5 MW. There was then much discussion on the cost of electric lighting in comparison with gas, and **Dr. Carr** and the **President** said that even as late as 1934 experimental flats built at Kensal Green had been fitted with gas lighting, but the President thought that the gas company, whose works were adjacent, had been responsible for this building development, and doubted whether gas was actually cheaper than electric lighting by that date. Professor Tucker said that Preece had emphasised the health benefits of changing from gas to electric lighting; sick leave in the Post Office had been much reduced when electric lighting was introduced. Dr. Carr thought that lighting companies could have combined with tramway undertakings to even out the load; Professor Tucker said that this was recognised as a good idea and was often done; in the case of Bristol, the corporation had been strongly advised by Preece to insist on supplying the tramways, as they became electrified, from the municipal generating station; but the tramway company insisted on generating their own electricity, and won the battle.

Much discussion followed on various aspects of early electric supply, ranging from the need for extensive underground distribution of power in the North Wales slate quarries, and the different problem of smelting aluminium where the ore could be brought to the source of power, to the question of whether early electricity supplies had been available continuously throughout the day and night (Professor Tucker thought that in most instances they had been, often with the use of secondary batteries during the periods of low demand).

The President referred to the paper on A. B. W. Kennedy by Professor Bishop. (*Transactions*, Vol. **47** pp. 1 – 8) and asked if Preece and Kennedy would have been acquainted before the period of electric lighting consultancy, Kennedy having been in the academic world at University College. Professor Tucker was sure they would have known one another through meetings of the scientific and engineering institutions; the engineering world was then comparatively small, and institution meetings played a very big part in it.

Dr. B. P. Bowers proposed a vote of thanks of Professor Tucker, saying that he had given them a fascinating account of a remarkable and versatile man; the proposal was passed by acclamation.

CORRESPONDENCE

Dr. R. J. M. Carr later wrote: "It appears that the Kensal Green flats were not, in fact, experimental. The all-gas Kensal House (two blocks) was opened as late as March 1937, tenants were chosen by the local Council and several similar schemes had been opened shortly before. In the mid 1930s blocks of flats equipped with gas lighting had been erected in Peckham, Bermondsey, Brixton, Charlton, Kensington and the old Kent Road, largely because gas lighting was then cheaper than electric; an important consideration for low income families. At the AGM of the Gas Light and Coke Company in 1934 it was stated that only 50% of the domestic lighting load in London had been lost. It seems that gas lighting was commonplace rather than exceptional in would-be utopian flats for the artisan in the blocks erected in the programmes of slum clearance around the Metropolis in the mid 1930s. (Refs: *Gas Journal* 14 Feb. 1934, 5 Dec. 1934, pp 754-5, 12 Dec. 1934, p. 819, 30 Dec. 1936, p. 899, 24 Mar. 1937, pp. 771–2 and 780–782). I am greatly indebted to Mr. Brian Sturt for information."