THE METROPOLITAN RAILWAY ELECTRIC TRAIN

by Piers Connor

1. TRIAL & ERROR

TAKEOVER

When the London Passenger Transport Board (LPTB) was set up by the government in 1933 to run public transport in the greater London area, it took over all the London Underground railway operating organisations held by the company known as the Underground Electric Railways of London Limited and it absorbed the independent Metropolitan Railway.

The Metropolitan was a unique railway. It operated a number of urban railway services between central London and its suburbs and a few longer distance services as far north as Aylesbury and Verney Junction. A mix of steam and electric traction was used and the company also operated freight services. At the time of the takeover, the Metropolitan Railway's rolling stock fleet comprised a variety of passenger and goods vehicles, a range of steam locomotives and some electric locomotives. The story I intend to tell in this series will cover the electric multiple unit vehicles and relevant hauled passenger coaches and it will include something on the early electric locomotives complimentary to other histories like the works by the late Ken Benest and the recent series in this journal on the 1922 electric locomotives by Charles Horsey. The story will include the fleet of the Hammersmith & City railway, jointly owned by the Metropolitan and Great Western railways and the Great Northern & City Railway that was taken over by the Met. In 1913.

The Metropolitan's passenger fleet was, at the time of the takeover, a bit of a mess. It was a hotch-potch of original vehicles, conversions, modifications and rebuilds. Hardly any two vehicles were the same. Cars with the same basic body design could have different traction equipment, different motors, different braking systems or different wiring or a combination of any or all of them. Many of the older cars were in a deplorable state and were overdue for replacement. When the LPTB took over, a small team of engineers were sent from the Underground's overhaul works at Acton to the Metropolitan Railway's main works at Neasden to examine the condition of the fleet. The story is told that, as they watched a train starting in the yard, such was its slack mechanical condition that each car started in five stages. First the wheels, then the axleboxes, then the bogie frames, then the bolsters and, finally, the car body[1]. By 1933, a good proportion of the stock was over 30 years old, many with wooden-framed bodies built on steel underframes. Much of the fleet was due for replacement but, in its lifetime, it had had an interesting history which began back in the closing years of the 19th Century.

DRIVING OUT THE SMOKE

In 1882, an American electrical engineer, one Frank J. Sprague, visited London during his employment with the US navy and, while he was there, he travelled on the underground sections of the Metropolitan and District railways. In those days, the trains were steam hauled and had been for the almost 20 years since the opening of the first section in 1863. The tunnels were invariably cloudy with steam and smelly with the exhaust from the locomotives and the infrastructure was filthy from the soot generated by the trains. There was much talk about how the smoke nuisance might be reduced or eliminated but no progress was made towards it.

Sprague believed that electric traction, then in its infancy, could be applied to railways. He regarded the underground sections of London Metropolitan and District railways as ripe for its development. He wrote later that he became, "*so imbued with the possibilities of their operation by electricity that I thought of resigning from the navy and devoting myself to this project.*"[2] He didn't resign then but he later became recognised around the world as the inventor of the multiple-unit traction control system.

Nothing more was done until, in December 1894, a new idea appeared in the form of a preliminary application for a patent. The proposal seems to have been driven by the successful opening, in 1890, of the City & South London Railway (C&SLR) with electric traction. The patent contained a description of a locomotive fitted with electric motors and electric current collection shoes. The shoes were to collect

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1 Conversations with Cyril Birkbeck, former production controller at Acton Works, in 1979.

2 Sprague, F.J. (1932), 'Electric Traction in Space of Three Dimensions', The Journal of the Maryland Academy of Sciences, 1931-32.

current from a centrally positioned current rail. The locomotive proposed for this scheme was based on the Metropolitan's own 'A' Class 4-4-0 tank locomotive. The scheme proposed that the locomotive was to retain its original steam engine – boiler, firebox, cylinders etc. with the electrical equipment added along with two additional wheelsets, one at each end of the driving axles (Figure 1). The inventor of this scheme was John William Willans, a Civil Engineer from Kerry in Montgomeryshire. He must have been working on the idea for a while since he had drawings of both the locomotive type and of suitable electric motors. The motors turned out to be very similar to the Gramme-wound motors supplied for the original electric locomotives supplied for the C&SLR. The current collection shoes were also very similar to the C&SLR design.

Unfortunately, shortly after his application for a patent, Mr. Willans died and the application process was ceded to his wife as his executor. She progressed as far as getting the full description submitted on 14 October 1895 and it was accepted on 5 December of that year. The description of the locomotive says, "*The motive powers to be used and combined in this invention are steam and electricity, so that steam may be available for the open and electricity for the tunnels, with the main object of keeping the latter free from smoke and fumes*". This description is actually of a bi-mode locomotive, demonstrating to us today that there really is nothing new under the sun. Mr. Willans proposed a bi-mode locomotive over a century before it became "a thing".

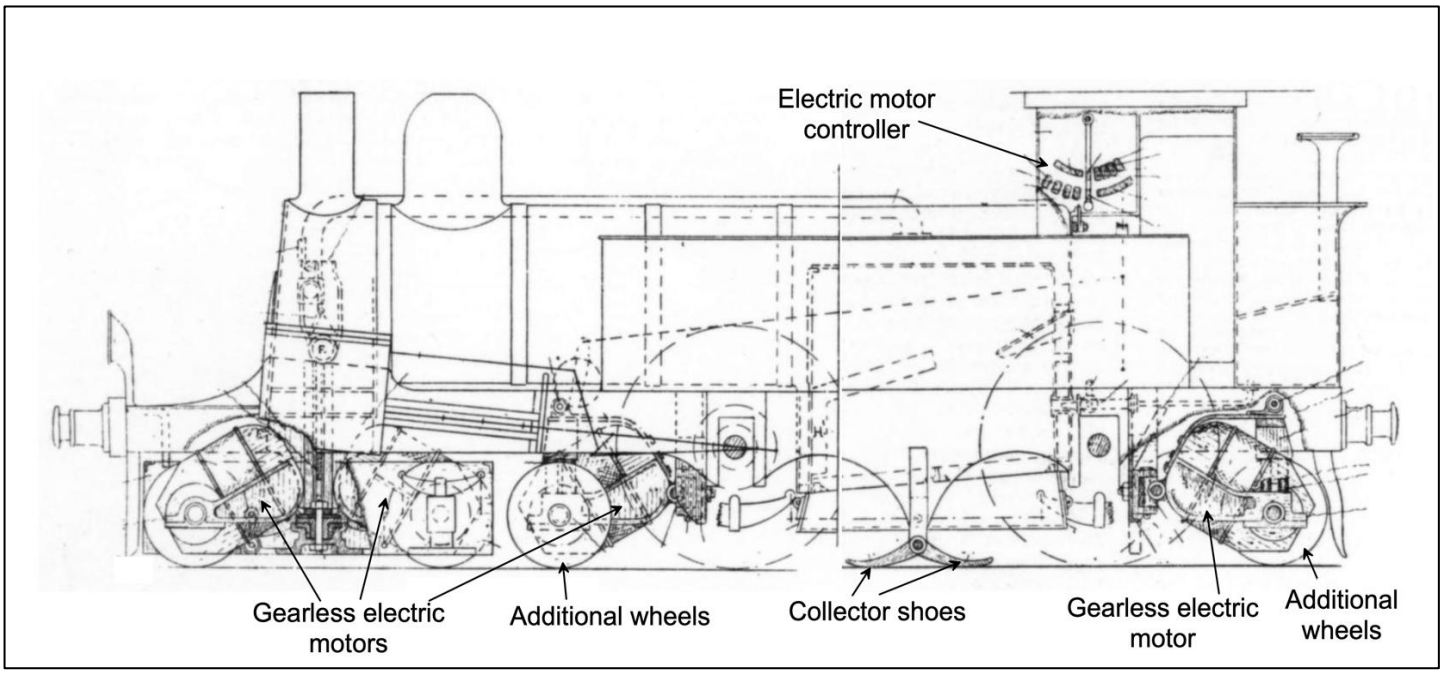

Figure 1: Reconstructed drawing of a bi-mode steam-electric locomotive proposed for the Metropolitan Railway in 1894. The locomotive retained all its steam equipment but had four traction motors and two additional wheelsets added. Two of the motors were to be mounted on the leading bogie while the other two were added to new axles, one to the front and one to the rear of the existing driving wheels. The power controller was located in the cab. Drawing from patent GB189424316A, modified by P. Connor.

Mr. Willans offered a number of variations on his theme. His patent documentation, although showing a series of detailed drawings of a 4-4-0T Metropolitan locomotive, also has a number of separate drawings of variations on the wheel arrangements, presumably for larger locomotives[3]. Despite all this detail, none of the ideas were never put into a practical application. Doubtless, Mrs Willans did not have the understanding or the desire to push the idea to either the Metropolitan or District railways and it seems that her husband's idea died soon after him.

Commenting on this invention some years later in an article for 'The Engineering Review' about unusual locomotive proposals, Charles Lake cynically wrote, "*The inventor must have been possessed of a very sanguine temperament if he really believed that his scheme would be taken up and applied to practical uses on railways, but then if optimism were not one of the principal traits in the average inventor's character, there would be little need for such an elaborate patent law system as that now existing, the administration of which provides employment for immense numbers of workers in all parts of the civilised*

[3] Willan, W. (1895), 'Improvements in Locomotive Engines, and the Application of Motive Power thereto and therefrom'. GB Patent GB189424316A.

world."[4] We might think from that the Mr. Lake had a dim view of inventors in general and of the patent system in particular and the army of bureaucrats needed to manage it.

ELECTRIFICATION

In 1890, the City & South London Railway opened to the public. This line ran from Stockwell to the City of London in tube tunnels and it used electric traction. It cost a lot of money to build and was never able to show much of a profit as a commercial enterprise but it did show that electric traction was a viable means of transport and that it worked in an underground environment. The poor return on the capital invested in it was to slow the development of other new underground schemes but two, the Waterloo & City Railway and the Central London Railway, did get enough backers and did get built. Their openings (1898 and 1900 respectively) encouraged other tube railway schemes across central London, three of which were to become the Bakerloo, Hampstead and Piccadilly lines.

The new and planned electric tube lines all cut into the central area ringed by the Circle Line. With the Circle being steam operated, people tried to avoid the tunnels as much as possible, especially in hot weather. The public and political pressure to "do something" led, in 1898, to an enquiry by the government's Board of Trade into air quality in the Circle's tunnels. It rather obviously came to the same solution, as Sprague had years earlier, that the best solution was electrification. Indeed, since the new tube lines offered the possibility of a vastly superior journey once they were opened, they were going to create a huge dent in the Metropolitan Railway's income. The Metropolitan's partner in the operation of the Circle, the Metropolitan District Railway, especially as it was already strapped for cash, couldn't take much of that sort of loss and survive.

Under these conditions, electrification was obviously the only way forward and, with their joint operation of the Circle, they had to choose the same system. They set up a joint committee to consider options. With the long-standing rivalry between the two companies, they must have struggled to get through the animosity to decide how to tackle the problem. Still, eventually they agreed, in May 1898, to try out an experimental installation of electric traction between High Street Kensington and Earl's Court. They each paid £10,000 towards the cost.

Sir John Wolfe-Barry and (later Sir) William Preece, who were engineer-in-chief and electrician to the Post Office respectively, were appointed as consultants. The work of building the generating equipment and supply system was awarded to Thomas Parker of Wolverhampton (as T. Parker & Co.) who had relevant experience after providing the electrical equipment for the Liverpool Overhead Railway back in 1893. The Metropolitan then decided to divert Parker off the job so that he could run a separate trial for the Metropolitan, so Siemens Bros. were asked to take over the job in his place[5].

The Metropolitan's separate trial was planned to be conducted at Wembley Park. Parker's first proposal suggested that locomotives should be used but this idea was dropped after it was realised that the gearless motors on two driving axles would involve an unsprung dead weight of 14 tons per axle. Even with four axles it came out at eight tons for each axle. The next proposal was to use a bogie passenger vehicle with a driving cab so that, with two of these in a train and a total of eight smaller motors. the dead weight was reduced to about 3½ tons per axle.

The project progressed with the building of two new bogie coaches at the Metropolitan's Neasden Works, each provided with a driving cab and 33-inch diameter wheels. Parker had the patent rights of a design of traction motor designed by American engineer Rudolf E. Eykemeyer,[6] so he built them under licence but the dynamos were supplied by the Westinghouse Corporation of America, whose tender was accepted by the Board in April 1899, since their price was lower than Parker's. The strategy of going for Westinghouse, who often turned out to be the lowest bidder, was to cause the Metropolitan a great deal of trouble in future years.

The first completed motor was tested satisfactorily towards the end of July 1899. However, by then, Westinghouse were indicating that the dynamos, promised for early August, would not arrive until the October. When they didn't arrive in October, the Metropolitan, exasperated by the delay, cancelled the order. To save a possible delay of several months while the contract was rebid, Parker suggested that he could adapt some of the motors to become generators. According to Ken Benest, in his article for

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4 Lake, C. A. (1908) 'The Locomotive as a Field for the Inventor'. The Engineering Review, February 1908: Vol 18 Iss. 2.

5 Jackson, A.A. (1986), 'London's Metropolitan Railway', David & Charles, Newton Abbott.

6 Eykemeyer was a partner in Osterheld & Eickemeyer, of Yonkers, New York, who started, in 1889, to manufacture DC electric motors. The company was taken over by General Electric in 1892. Source: http://vintagemachinery.org.

'Underground' in November 1963, it is likely that the tests continued intermittently into the summer of 1900 and they were carried out "*with the use of one car only, as no replacement dynamos appear to have been obtained*."[7] Parker's adapted generators were belt-driven off an old Beyer-Peacock locomotive (No.1 built in 1864) that had been raised on blocks to act as a stationary engine.

The trials were conducted on a long siding, built around 1894 between Wembley Park station and the worksite of the ill-fated "Watkin Tower" on the Wembley Park estate. The line left the station goods yard in a westerly direction and made a wide sweep to terminate at the top of a mound where the original stadium was built many years later. It was about 1,200 yards long and had some gradients as steep as 1 in 25, well suited to the purposes of the experiment. A four-rail system was used, the conductor rails being of channel-iron mounted on insulators at eight-foot intervals.

Little literature seems to have survived regarding the course of the trials and, after they were abandoned, the two purpose-built motor coaches were placed in store. In 1908 they were resurrected for conversion into two motor coaches for one of the 6-coach Westinghouse-equipped trains which appeared in that year. They were given the numbers 417 and 418 and we will see more on these in a future article.

THE SIEMENS TRAIN

Meanwhile, the High Street to Earl's Court trials continued. The tests used a special train, ordered in May 1899 from Brown Marshall & Co. of Saltley, Birmingham (later absorbed into the group that eventually became Metro Cammell). It was delivered late in 1899 to the District's depot at Lillie Bridge. Trial running started early in December 1899 and continued spasmodically up to 21 May 1900, when public operation began. The fare was one shilling – 5p in decimal money but actually the equivalent of £4 today. Naturally, the train ran practically empty since the ordinary fare was about 20% of that and it only took a week for the special fare to be dropped. Even so, the train never did "pay its working expenses", as reported at the time – hardly surprising, since it was a high-tech experiment over a very short piece of line. We might wonder why anyone thought it would give a meaningful assessment of running costs in the first place.

The train was formed of a 6-coach set with a motor coach at either end of a set of four trailer coaches, all the vehicles being based on traditional British compartment style coaches with "slam doors" (Figure 2). The motor coaches (Figure 3) were actually electric locomotives in their own right, the leading coach hauling the whole train without assistance from the other motor coach at the rear, which was consequently towed like a trailer. There was no through control and no power connections to the rear motors from the front but there was a pair of "bus lines[8]" connecting the collector shoes at each end of the train. This reduced the risk of the train getting "gapped", i.e. stalled at the breaks in the current rails necessary at points and crossings due to loss of contact between the shoes and the current rails[9]. Both positive and negative current rails were provided, one on the outside of each running rail.

It has been suggested[10] that one of the reasons for the adoption of the outside current rail arrangement was because of the size of the gearless motors. Being mounted directly on the axles meant that the clearance to the track below the motor was very tight and would not be sufficient to accommodate a current rail. This does not seem to have presented a problem on the Central London, nor the Waterloo & City, even though the clearances on both those lines were very tight. It may be that, with their experience on the W & C, the Siemens engineers thought the outside current rails offered more scope for larger motors.

They stuck to the idea of having four motors on each coach, one on each axle, giving a total individual axle weight, including the car body, of 13½ tons. The wheels were 47in. in diameter. Being gearless, the armatures of the motors were mounted directly on the axles. The motors were of Siemens type 4B 26/2, their iron case enclosed type. They were designed to develop 110 h.p. at normal rating with up to 200 h.p, maximum.

The power controller had twelve positions, with the motors at starting connected all in series, then, to increase power, two in series and two in parallel and, finally, all parallel. The controller was a large box

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7 Benest, K (1966) 'The Rolling Stock of the Metropolitan Railway', *Underground 23*, November 1963.

8 This can be defined as a "common user" electric conductor where fixed connections are added to supply various circuits or systems. From "omnibus", Latin for "all".

9 Contemporary accounts report that the gaps were up to 40ft long – longer than the span of collector shoes on one coach.

10 J. Graeme Bruce, Steam to Silver, 2nd edition, Capital Transport Publishing, 1983

in the middle of the cab with a control wheel on its left-hand side where the driver sat. The measuring instruments and gauges were mounted in front of the driver, just above his head. On his left-hand side was the brake valve for the Westinghouse brake. The Westinghouse brake was new to the Metropolitan as it used the vacuum brake on its steam trains. It was later to adopt the air brake on most of its electric trains[11]. Sand to assist with adhesion was provided on steam locomotives as standard equipment and some early electric trains had it too but it was eventually abandoned on the underground railways in London since it since it had the effect of occasionally isolating the trains from the track circuits and thus rendering the automatic signalling system useless. It also got into the point machines and into the grease used for lubricating them especially, which annoyed the P-way engineer no end.

An automatic cut-out, which activated if there was a short-circuit, was mounted behind the driver together with a small compressor for the brake, whistle, and sanding system. The main air reservoir was under the coach, together with the traction resistance frame. It would be safe to assume that, apart from the motor control, the whole electrical system was very similar to the W & C arrangements[12].

There was a guard's van behind the cab, with the remainder of the coach arranged as a third-class smoking compartment. The floor was slightly raised to provide sufficient clearance for the very large motors. The seating was longitudinal, arranged in open saloon style, apparently to allow access to the motors through the floor. The floors had glazed access doors over the motor commutators so it was possible for people to see the motors turning from inside the coach.

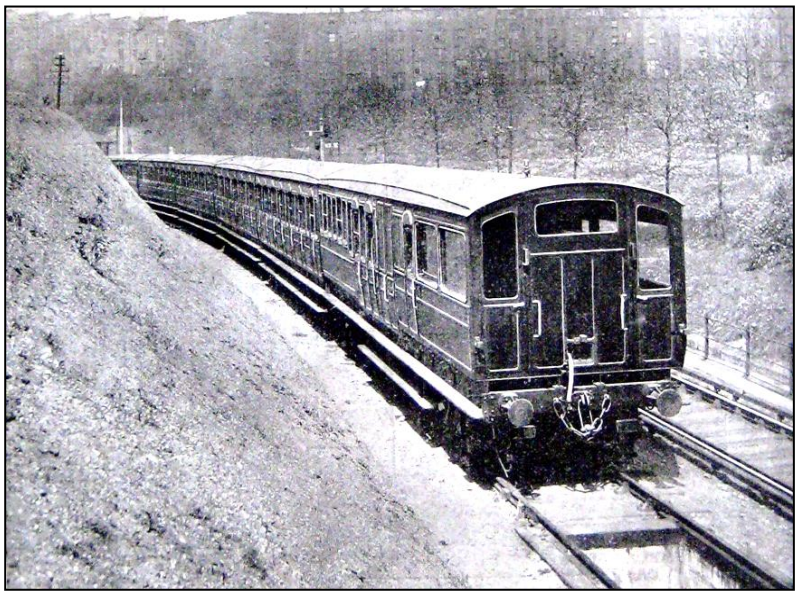

Figure 2: The 1900 experimental train stabled in a siding next to the eastbound track between Earls Court and High Street. This is the Earl's Court end of the train. The westbound track is lower and out of sight as it drops down towards the flyunder. This whole area is now underground. The train is stabled where a row of pillars now stands supporting the development above. The camera is standing on the site of the present 37 road in Triangle sidings.

The coaches were typical of British compartment stock and were similar to the Metropolitan Railway's "Ashbury" coaches of 1898 – of which more in a future article. The whole train had seats for 312 passengers including accommodation for 1st, 2nd and 3rd class arranged as 3rdM – 3rdT – 3rd/1stT – 1stT – 2ndT – 2ndM, and accommodated 136 3rd, 80 1st and 96 2nd class passengers. The first and composite trailers each had six compartments, the other trailers seven each. The trailers were generally similar to the Metropolitan's 1898 stock but had a body width of 8ft 6ins against as opposed to 8ft 3ins. They weighed 18 tons apiece. They were electrically lit by incandescent lamps, fed from the traction supply. Only a few years later, second class was dropped nationally so that only first and third classes were available. Both the Metropolitan and the District provided first and third classes up to the early part of the Second World War.

NEXT STEPS

The experimental service went on through the summer of 1900, finally being wrapped up on 6 November, after which the train was withdrawn and stored in the District's depot at Lillie Bridge pending a decision on its future[13]. Half the train was owned by the District and the other half by the Met. Various interested parties had been to have a look at it while it was in service, including Thomas Parker, who

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[11] For details of Westinghouse brake operation, see Article 6 of "The Underground Electric Train", *Underground News* No.528, December 2005.

[12] I describe the W & C equipment in Article 3 of my series "The Underground Electric Train", *Underground News* No.525, September 2005. There is much more detail in John Gillam's book "The Waterloo & City Railway", Oakwood Press, 2001. Also, "The Electrician" magazine of the period reported that the equipment was very similar to the W & C arrangements.

[13] The coaches of the experimental train were not given numbers. The three Metropolitan coaches were moved to Neasden on 27 March 1903, according to a District Railway Traffic Notice of that week and were drawn into its own stock, while the District's were sold to the Colne Valley Light Railway.

had abandoned his electric traction company completely and was now working for the Metropolitan Railway as a consultant. He, rather uncharitably, reported unfavourably on the equipment, even though the Metropolitan had paid for half of it and had gone along with the whole scheme. The District responded wryly by suggesting that the trial electric section should be extended to Putney Bridge. Unfortunately, the power plant at Warwick Road was not considered up to the job and the joint committee were not minded to stump up the cash to pay for more equipment. The three coaches allocated to the Metropolitan Railway were finally removed by steam locomotive on 27 March 1903 and were taken to High Street Kensington where they were picked up by a Metropolitan locomotive and taken to Neasden.

Even while the experiment was still going on, the joint committee running it asked for a report into "the whole question" of electrification. They were soon told they should electrify "the whole system" and that they would need "two or more" new trains on the "multiple unit" system for the Inner Circle and some electric locomotives to haul the existing coaches on the branches. In referring to the "multiple unit" system of electric traction control, the report was referring to what was then a new idea being developed in America at the time. It was untried in the UK but it was soon to arrive here and it quickly became the bedrock of electric traction across the world.

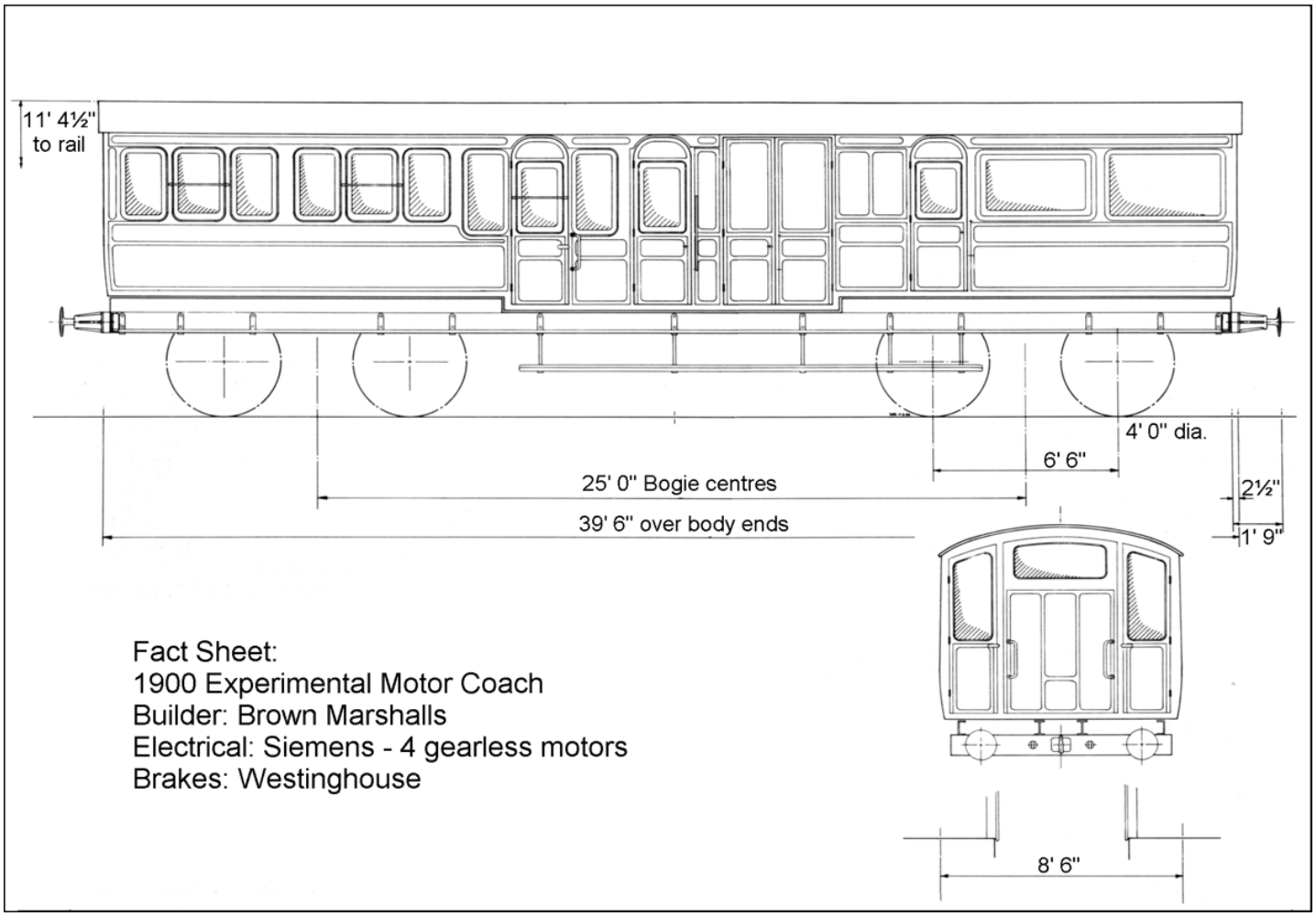

Figure 3: Scale drawing of the 1900 experimental electric motor coach used between Earl's Court and High Street Kensington. The drawing shows the two doors in the front end, apparently arranged to allow space between them for the massive, centrally positioned traction power controller. Drawing by Jim Snowdon, "Metropolitan Railway Rolling Stock", Swan Publications, 2001.

By 3 August 1900, the experimental train had only been running for three months but there was sufficient confidence in the operation to issue, on that date, invitations to nine different firms to tender for the electrification of the Circle. It is interesting to note that the tenders were due to be returned by 1 December *in the same year,* bearing in mind that our modern procurement processes seem to demand six months just to pre-qualify let alone tender. Interestingly also, the costs of both the Earl's Court and Wembley Park experiments overran their budgets by about 30%. From this, we can see that it seems that today, despite a century of experience, we are repeating the same project cost errors that our ancestors made over a century ago.

Two suppliers for the electrification project became what we would call today 'preferred bidders' – British Thomson-Houston (BTH), the UK arm of the US General Electric company and Ganz & Co. of Hungary. BTH proposed the DC 3rd rail system to become familiar across the world in many urban railway systems, with earlier versions already in place in America and on the C&SLR and Central London Railway in London, while Ganz offered a 3000-volt, 3 phase AC system requiring three conductors – twin overhead wires for two phases and the running rails for the third phase. The electrification committee came down in favour of Ganz, without a doubt because it was the cheapest offer but almost certainly against the advice of any sane electrical engineer of the time. Regardless of it being untried and untested, just the clearances required for the twin overhead lines in the tunnels of the Circle should have disqualified it.

In the event, the whole question of the choice of electrical system was turned on its head by the inability of the District Railway to raise capital in London and by their turning to the US for it, where a certain Charles Tyson Yerkes and his banker friends were persuaded to finance both the District's electrification and the building of several tube lines[14]. Yerkes brought a technical advisor to the UK, one James Russell Chapman, who had considerable experience of setting up electric railways in the US, notably in Chicago.

Chapman quickly realised the weaknesses of the Ganz system and set his mind in favour of something akin to the BTH proposal, already tried and tested in the US and, as we have seen, adopted by the current tube lines in London. This was in direct opposition to the joint committee's choice of Ganz and it set in motion months of argument between the District and Metropolitan and ended up with them being forced to go to arbitration. The arbitrator's decision, which was in favour of the District's DC system, was made in December 1901 and the Metropolitan was obliged to comply with it. Work on the conversion started quite soon afterwards but it was to be another four years before electric traction replaced steam in the Metropolitan's tunnels.

FINALLY

There was much public criticism in London concerning the delay in getting electric traction to replace steam on the Circle. There was quite a bit of vitriol, particularly in the technical press, and the following paragraph from The Electrical Review of 24 August 1900[15], right in the middle of the Earl's Court to High Street trial running, provides a typical view of the period.

"There is no topic of public interest to Londoners which comes more frequently under the condemnation of the "man-in-the-street" than the persistent iniquity of the District and Metropolitan Railway Companies in failing to convert instanter [sic] their lines from steam to electric traction. He produces, or his recognised representatives produce for him in the daily and technical press, numberless reasons satisfactory to himself why such a conversion should have been accomplished at any time within the past 10 years.

For is it not a fact, well known to him, that all similar railway services in America are operated electrically to the great comfort of his confréres [sic] in that delightful country, and to the profit of the stock holders? And is it not a fact also at home, right under his eyes, that the City & South London, the Waterloo & City, and now the Central London railways, are all operated by electric traction? What possible cause therefore, he asks himself, except innate perversity can there be for the refusal of the plutocratic proprietors of our underground railways to convey to him the unnumbered blessings attendant upon the use of electricity?".

The Metropolitan and District railways must have considered themselves 'suitably addressed'.

To be continued …

[14] The whole story of the electrification of the Circle and its associated financial and technical goings-on could not be detailed here but they are documented in various books and papers and probably warrant a story in their own right.

[15] The Electrical Review 1900-08-24: Vol 47 p.1187.