THE CENTRAL LONDON ELECTRIC TRAIN

1 – THE ROUTE

by Piers Connor

INTRODUCTION

This is the first of a series of articles covering the story of the trains used by the Central London Railway between its opening in 1900 and the time of its conversion to the London Underground standard 4-rail traction supply system in 1938-39 when its own stock was replaced by Standard Tube stock. The story is in the style I have used for my series “The Underground Electric Train” and “The District Electric Train” except that there will be more specially selected photos, drawings and diagrams. The story will cover the original rolling stock and its subsequent conversions and additions.

THE PREMIER ROUTE

The casual observer of today’s London Underground map, be he a local commuter with a reasonable knowledge of the city or a tourist on his first visit, could hardly fail to notice the central position of the red line cutting across the diagram from west to east. This line, which we know so well as the Central Line, owes its location and its status to the fact that it runs under an old Roman road now called Oxford Street. The photograph *(Left)* of Oxford Street was taken circa 1892 and shows the view looking east towards Oxford Circus. By this time, the route of the Central London Railway, the Central Line’s original owning company, had been authorised and construction was starting.

Figure 1: View along Oxford Street circa 1892 looking east towards Oxford Circus. The second of the two gaps in the row of buildings on the left is where Oxford Circus is today. The Central London Railway was built under this street. If you were standing at this point today, you would see the London School of Fashion on the left. (Photo – LT Museum)

In the mid 19th Century Oxford Street began to develop as a shopping area and quickly became the premier street for retail commerce in London. It was natural therefore, that an enterprising Victorian company would soon be set up to build a railway under this street, once the tube tunnelling technique and electric traction had been proved by the City & South London Railway (C&SLR), which had been opened between Stockwell and the City of London at King William Street in 1890. This company, at first known as the “Exploration Company Ltd.”, quickly became the “Central London Railway” and obtained its Act of Parliament, authorising construction, in 1891[1].

Conveniently for the new railway, the Romans had a habit of building their roads in reasonably straight lines and this is reflected in the alignment of Oxford Street and its continuation in the roads on either side of it. Unfortunately, the railway had to spoil the straight route at each end because of the need to follow the line of the streets above to reach the City terminus at the Bank and the depot beyond the western terminus at Shepherd’s Bush. Both locations had severe curves, the one at

[1] Pamphlet published by the Central London Railway, 25 October 1892.

Bank (the present westbound platform) having a radius of 89 metres, while west of Shepherd's Bush, the single track from the station up into the depot on the surface at Wood Lane (today's westbound track) squeezes round a 60m radius curve[2].

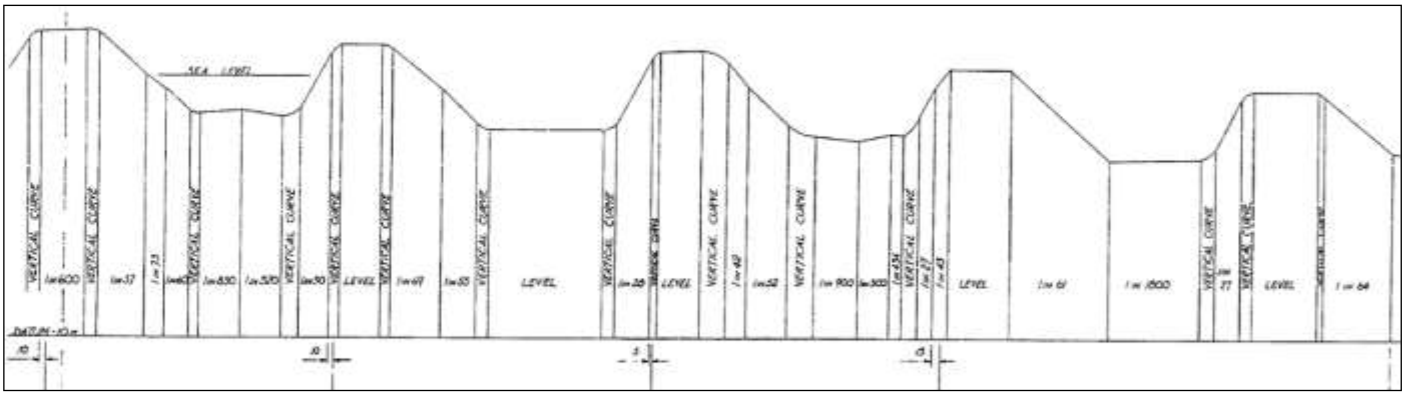

Figure 2: Section of gradient profile of westbound Central Line between British Museum (now closed) and Marble Arch showing the "sawtooth" profile with nominally 1 in 60 approach gradients and 1 in 30 exit gradients. The actual gradients were often steeper. Source: LT Chief Civil Engineer's drawing.

A SAWTOOTH

It took the rest of the 19th Century to complete construction of the Central London. Tunnelling was started in August 1896 (according to the Railway Magazine, March 1903) and completed by October 1898. Equipment of the route was advanced enough for the official opening of the line by the Prince of Wales (later King Edward VII) on 27 June 1900. After three weeks of running a full service without passengers, so that staff could get used to the new systems and to iron out the inevitable teething troubles, the line was opened to the public on 30 July.

The design of the Central London was advanced for its day. The line was arranged to what we might today call an "ecological profile". The stations were built on humps, so that trains ran uphill into the platforms to reduce the braking requirement and then downhill as they left to assist their acceleration. The profile resembled a sawtooth pattern (as shown in the sample gradient profile in Figure 2 above), a name that was later adopted to describe it. The gradient inbound was nominally 1 in 60 while the departure side was supposed to be 1 in 30. The actual grades varied and most approaches were graded at less than 1 in 60 while some of the exit ramps were as steep as 1 in 26. As far as I can see, the steepest gradient (probably the steepest over the longest distance on LU) is the 1 in 26 for about 80m on the eastbound exit from Chancery Lane.

Figure 3: Voltage and Ampere trace for a test train on the westbound Central London between Marble Arch and Lancaster Gate, showing the rises due to renewed motoring as the train approaches Lancaster Gate up the 1 in 60 ramp. Source: "Traction & Transmission" 1903.

The energy saved by this profile was reported to be about 19%, following a number of trial runs carried out in 1903 and described in that year in a series of supplements to the journal "Engineering" called "Traction and Transmission"[3]. However, the design of the profile was not without issues. Originally, the idea was to provide 1 in 30 on the approach as well as on the exit side but it was realised that, if a train was delayed at a station and the following train was held at the home signal on the approach, there could be difficulties in restarting on such a steep slope once the signal cleared. Whether this was actually

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2 The depot entrance road was built on a rising gradient partly at 1 in 37, making it steeper than the gradient to the east of Bow Road on the District Line (1 in 38). The current eastbound route into Shepherd's Bush is even steeper at 1 in 28. Sources: LT Chief Civil Engineer's drawings.

3 Written by H.F. Parshall, E. Parry and W. Casson.

true was never tested but it showed that there was some integrated thinking even in those early days of urban railway design. However, even with a 1 in 60 approach, trains often had to reapply power on the gradient as they ran into stations, as shown by the voltage and current trace of a test train in Figure 3 opposite. Of course, this negated some of the energy saving but it was largely a problem with the original locomotive performance, of which more in the next article.

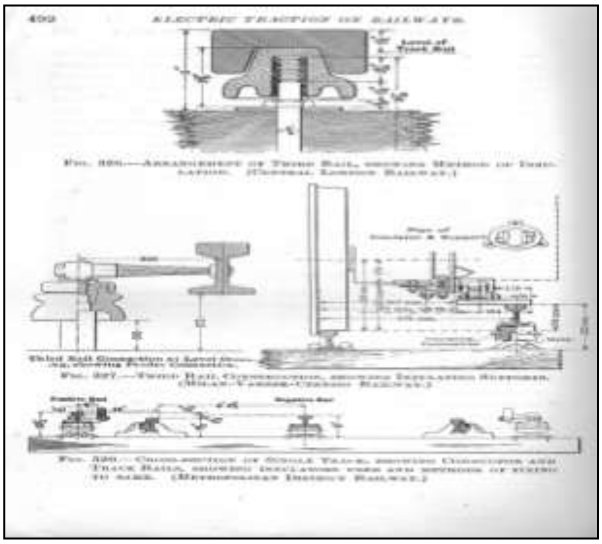

Figure 4: Original arrangement of current rail on CLR. The height of the top of the rail above the sleeper was 5 inches. The height above the running rail was 1½ inches, which provided a challenge at point and crossing work. Source: "Electric Traction on Railways", P. Dawson, 1909.

TRACTION CURRENT

It was determined from the initial concept for the new railway in 1891, that it should be electrically powered. Direct current (DC) was chosen as the system for use by the trains since it was realised that the series wound DC motor was a simple machine in comparison with other types available and it had a power characteristic that suited the operation of an urban train service very well. It was a choice that was to remain largely unchallenged for almost a century.

Another decision that was heralded as new for the time was the choice of 3-phase alternating current (AC) at a frequency of 25Hz as the energy distribution medium between the power station and the feeder points along the line[4]. At each feeder point, a substation was built where the incoming AC was transformed down from 5,000 volts to 330 volts AC and then converted to 550 volts DC for connection to the third (conductor) rail. Although this is a common arrangement today (but at higher voltages), at the time it was quite novel. Both the previous underground lines in London, the C&SLR and the Waterloo and City Railway had DC transmission throughout but their routes were shorter than the Central London and it was known that DC doesn't transmit well over long distances. Alternating current transmission was therefore the obvious choice for the longer route. The three substations were provided at Notting Hill Gate, Marble Arch and Post Office (now called St. Paul's).

The current was transmitted to the trains by a third rail mounted on insulators fixed mid-way between the running rails – in the "four foot", as we call it. The arrangement was introduced largely because the tunnel linings were cast iron and were included in the return circuit by being bonded to the running rails at the substations. To have had the conductor rail outside the running rails would have placed it very close to the lining, increasing the possibility of a short circuit. The running rails were cross-bonded to each other as well as to the tunnel lining, presumably to try to reduce losses and corrosion.

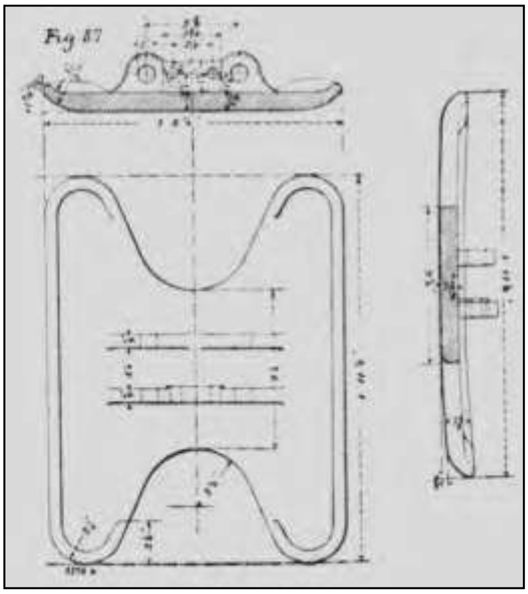

Figure 5: Drawing of original CLR locomotive collector shoe. It is almost 2 feet wide and just over 1ft 6in long. The bottom contact surface is slightly bowed to ease movement on and off the current rails. Later versions were smaller, measuring 1ft 9in by 10in. Source: "Traction & Transmission", 1903.

The current rail system was a direct copy of the Waterloo & City Railway system. The rail was of "bridge" section and the insulator "pots" were designed to allow the rail to rest on top under its own weight (Figure 4). The top of the rail was only 1½ inches above the level of the running rails, an arrangement that lead to an interesting design at points and crossings and to the adoption of a special current collector shoe (Figure 5).

4 The idea was described by Parshall et al in "Traction & Transmission" as "new" but it had already been installed for tramway systems in Dublin and Middlesborough.

At points and crossings, current rails were provided with wooden extensions so that the huge shoes could ride over the crossing rails without touching them. The width of the shoes allowed this (See photo, Figure 6).

The photo shows a set of points in the Central London Railway's Wood Lane depot. Where the current rails cross the running rails, wooden sections with a similar profile were added to the ends of the current rails and these were angled to run parallel to and on either side of the running rails so that the wide shoes would slide over them, clear of the running rails. I have added an outline of the collector shoe to the photo to show how it sits clear of the running rails.

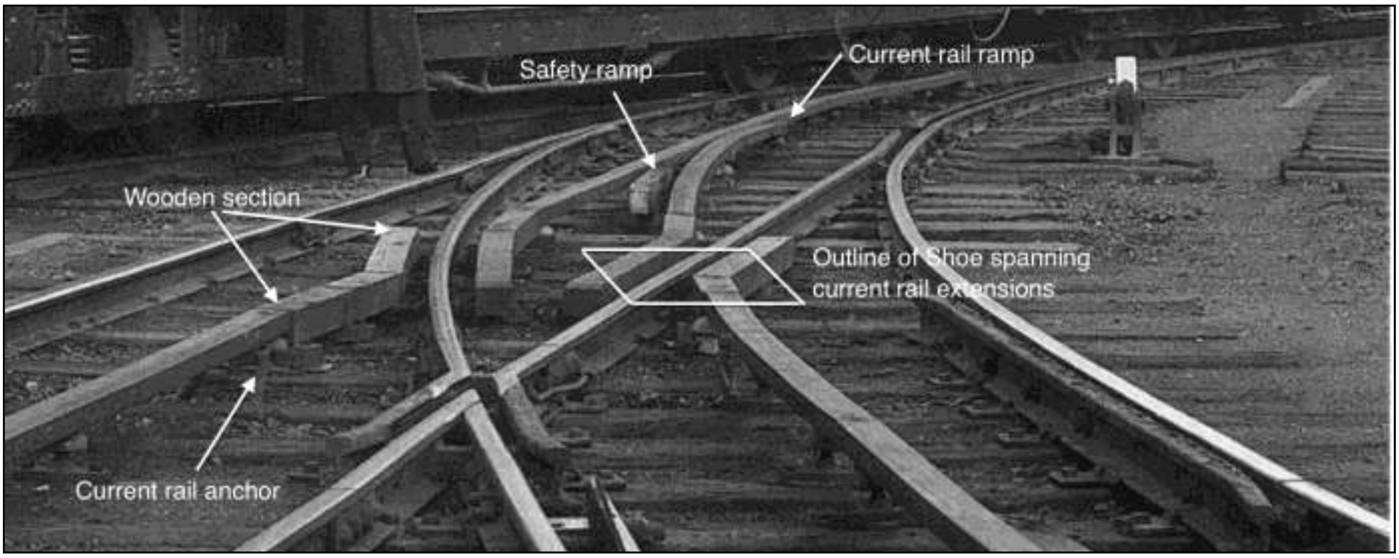

Figure 6: Detail from a photo showing a set of points in the CLR's Wood Lane Depot c.1925. The current rails have wooden sections added to the ends where rail cross their alignment. The wooden sections allowed the wide shoe to ride over the running rail without touching it. The outline of the shoe is added to demonstrate how it worked. Note also how the ends of the current rails are anchored to the sleepers to prevent them moving out of alignment. The photo also shows how the short curved section of current rail slopes down where it joins a straight section of rail. This is to prevent the shoe striking a blunt end of rail. The wooden safety ramp between the two joining sections of current rail performs a similar function. The final thing that this photo shows is that the depot uniquely used flat bottom rail, spiked directly to the sleepers in American style. On the main line, rails were bolted to sleepers. Photo: LT Museum.

LOCOMOTIVE OPERATION

The Central London Railway was to be operated using locomotive-hauled trains. This was for the simple reason that there was no other option. With the development of electric traction still in its infancy and with the operational thinking based on that of a main line railway, the use of locomotives was inevitable. The locomotive had to be at the head of the train, hauling a set of passenger coaches.

Aside from any technical issues, the main difficulty with locomotive operation occurs at the terminals. In order to change the direction of an arriving train, you need to place a locomotive at the other end of it. This can be a simple operation if you use a second locomotive, rather than providing expensive run-round facilities. The second locomotive is kept in a "loco siding" at the departure end of the terminal and, when a train arrives, the second loco follows it into the platform. You uncouple the arriving loco from the train while attaching the second loco at the departure end. Carry out a brake test and you are, as they say, "good to go". Once the train has departed, the arriving loco follows it out of the platform to the departure end siding and waits for the next train to arrive.

Curiously, the Central London did not have loco sidings at its terminals. Right from the early planning stage, it was decided to equip each terminus only with scissors crossovers, "to get the trains shifted out of one tunnel and into the other" as a pamphlet issued by the company in 1892 described the operation[5]. At Bank, there was a crossover only at the east end of the station and this meant that all arriving trains used the eastbound platform and then had to be reversed in one of the two siding

[5] Central London Railway (1892),"The Central London Railway", London, 1892.

tunnels provided beyond the station (Figure 7)[6]. Departing trains used the westbound platform. The arrangement is replicated on the Piccadilly Line today at Heathrow Terminal 5 station, where one platform (the westbound) is used for arrivals and the other for departures.

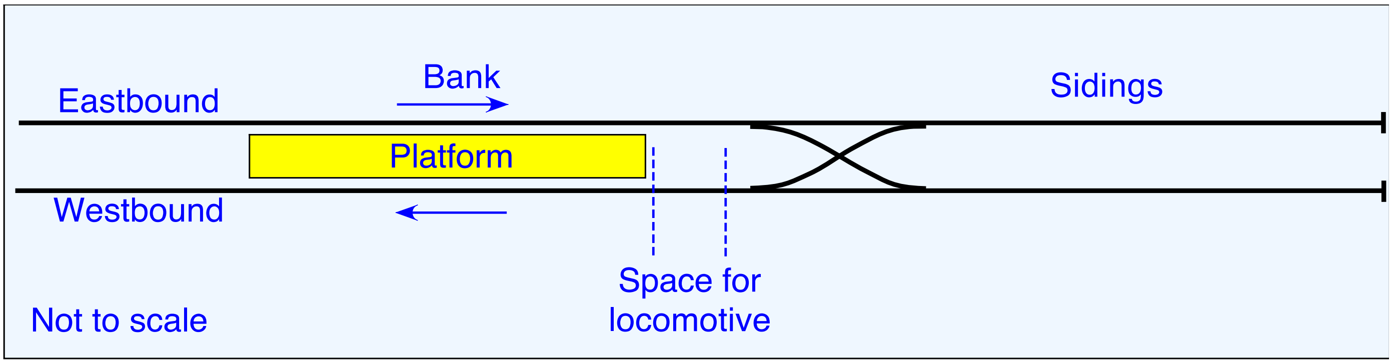

Figure 7: Schematic of the track layout at Bank, CLR, 1900, based on a signalling plan prepared as part of a bid by Westinghouse for the signalling of the line, dated 10 March 1899. The space to the east of the westbound platform allowed a locomotive to stand between the platform and the crossover. The original Westinghouse diagram shows a shunt signal was to be provided at the east end of this space to allow the locomotive access into the sidings to couple to a train therein. Diagram: Author.

This arrangement has a number of pros and cons. On the plus side, it makes the direction of passengers simple, since they are always directed to only one platform. You don't get the swapping of "Next Train" signs that often frustrates passengers at places like Elephant & Castle or Morden. It also makes for easy separation of passengers leaving and arriving. If you have large crowds to handle, this is a positive advantage. On the other hand, having to empty the train and then remove it to a siding beyond the station takes time and, if you have a locomotive to shunt as well, it will use up more time. This usually meant that you needed at least one extra train in service for each terminus – one arriving, one shunting and one leaving. As I show below, the Central London used two.

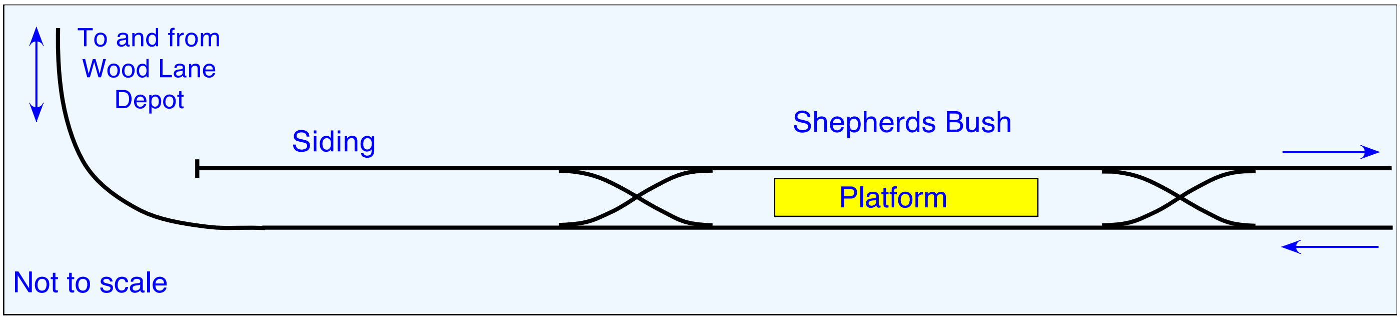

Figure 8: Schematic of the track layout at Shepherd's Bush, 1900. The station has a crossover at each end of the platforms. One of the tracks is extended beyond the siding to become the access track for the depot at Wood Lane. Diagram: Author.

At both terminals, the signalling was arranged to allow locomotives to be shunted over the crossover behind a train standing in the westbound platform. There was sufficient space between the rear of the train and the crossover to allow a locomotive to stand there while the departing train was being dispatched from the westbound platform.

Although I have seen little firm evidence on how it was done, I offer a sequence of a train reversing as follows. The train (locomotive and carriages) stops in the arrival platform, disposes of its passengers and then moves to one of the sidings. Next, a locomotive, waiting in the space at the rear of the departure platform, moves into the same siding to couple to the train while the arriving loco is uncoupled from the other end. Following (I hope) a brake test, the train is then hauled out of the siding into the departure platform by the second locomotive to form the next service. It is immediately followed out of the siding by its arriving locomotive but only as far as the loco space, where it waits for the next train to go into the sidings, when the changeover process is repeated. At Shepherd's Bush, they went about reversing trains in the same way but a second crossover was provided at the departure end of the station. I'm not sure this was really much use. As at Bank, both

[6] The lack of a loco siding at Bank is understandable, since the original intention was to build to Liverpool Street and the two sidings were actually the intended running tunnels.

platform tracks extended westwards beyond the station but only one of them ended as a siding. The other became the depot access track (Figure 8 above). I suspect most of the trains were reversed via the siding.

SERVICE PERFORMANCE

The terminal operation had to be slick. Although the original plan (CLR, 1892) was to operate trains at 3-minute intervals (20 trains per hour), it was soon increased to 24 trains per hour or every 2½ minutes. The time allowed between Shepherd's Bush and Bank was 26.7 minutes each way (Parshall at al, 1903). For those who might ask, today it's 20 minutes. With a recorded 62.4 minute round trip time, this meant that each train had 4½ minutes at each terminus. The minimum time allowed for shunting at the terminals was 2¼ minutes but this was not normally required. With a 2½ minute service interval, both sidings would be in use at both terminals and this also allowed for some recovery time from minor delays. The following table shows how it could have worked.

Time: mm.ss	Operations in Arrival Platform	Operations in Siding 1	Operations in Siding 2	Operations in Departure Platform
00.00	Train 3 stops in arrival platform.			
00.10				Train 1 clears platform berth.
00.20			Route set for Train 2 to move from siding to departure platform with its loco following.	
01.00				Train 2 arrives in departure platform.
01.10				Loco off Train 2 arrives in space behind Train 2.
01.20	Train 3 departs for Siding.			
02.00			Train 3 berths in siding.	Train 2 starts from platform.
02.20			Loco (ex-Train 2) arrives in siding and starts couple process to Train 3.	
02.30	Train 4 stops in arrival platform.			
02.40				Train 2 clears platform berth.
02.50			Route set for Train 3 to move from siding to departure platform with its loco following.	
03.30				Train 3 arrives in departure platform.
03.40				Loco off Train 3 arrives in space behind Train 3.
03.50	Train 4 departs for Siding.			

Table 1: Probable Timings for Central London Railway Terminal Operation with Locomotive Hauled Trains.

Assuming we start the clock running upon a train's restart from the arriving platform to go into the siding, we should calculate for a maximum 15km/h during the movement. The distance is about 170m from the platform to the end of the siding, so we will need 40 seconds to take the train clear of the crossover. I have allowed 10 seconds for the setting up of routes and another 40 seconds for the train to move from siding to platform. The time available for coupling the loco and doing the brake test was about 30s – tight but do-able with practice.

One thing that is clear from this is that the signalmen had a "full on" job. Everything was manual. They were working a form of "Lock and Block", where trains were offered and accepted manually between signal boxes. Points and signals were all manually operated too. With trains passing at 150s intervals in each direction, there was hardly time to scratch your nose, let alone make tea. The system worked largely unaltered until 1912, when a signalling replacement programme was started. The line was fitted with AC track circuits, impedance bonds and automatic signalling. The work was completed in November 1913[7].

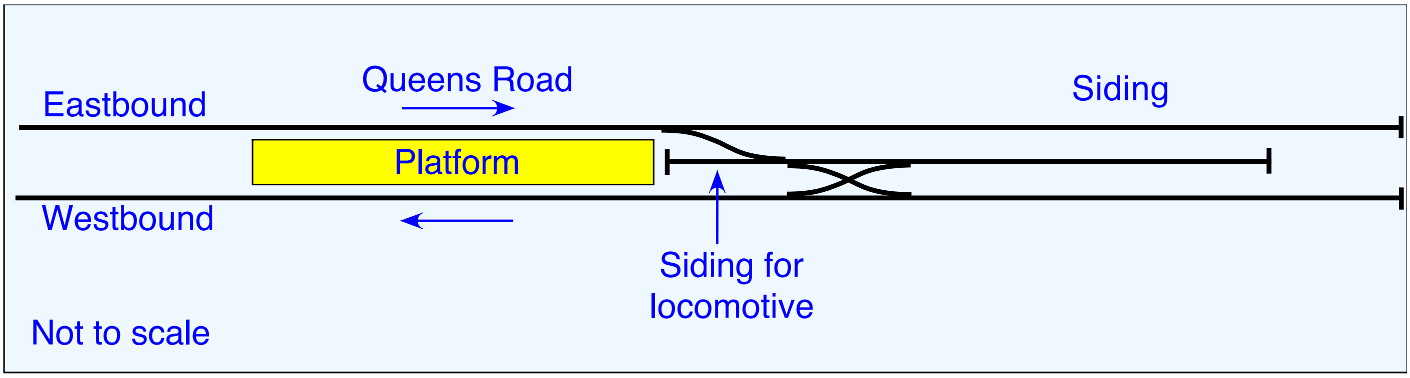

Figure 10: Schematic of a Central London Railway reversing siding as built at Queens Road (now Queensway). The arrangement was repeated at British Museum and Marble Arch. Unlike the terminals, a dedicated locomotive siding was provided. The sidings at Marble Arch and British Museum survive today but the one at Queens Road was taken out of commission on 12 July 1982. Diagram: Author.

INTERMEDIATE REVERSING

An odd feature of the Central London was the provision of intermediate reversing sidings (Figure 10). Not that these were unusual in themselves but in that, for a line that was only six miles long, it had three full blown reversing sidings built in their own tunnels between the running tunnels, complete with loco sidings and connecting crossovers. They were provided at Queensway (then called Queens Road), Marble Arch and at British Museum (now closed), between Tottenham Court Road and Chancery Lane. Figure 9 below shows the arrangement at Queens Road.

Perhaps what we might consider surprising is that the reversing arrangements were designed so that shuttle services could be provided between Shepherd's Bush and Queens Road, and between either Marble Arch or British Museum and Bank. These facilities were rarely used but Marble Arch accommodated a spare locomotive that was used for rescues from time to time – a Central London "Thunderbird", if you like.

The reversing facilities at these places were actually better suited for train reversal than the arrangements at Bank and Shepherd's Bush. The provision of a loco siding was much more efficient than using the running line, simply because a loco could be stored without interfering with other train movements. The facilities were also used as a model by later tube lines (without the loco siding, of course) and has been extensively adopted elsewhere. Whilst writing this, I wondered if the idea was a first for the Central London but I am unable to find any evidence.

The siding at Queensway was taken out of use in 1982 after some incidents with 1962 Tube Stock cars fouling each other as they passed through the crossover. A new facing crossover was installed in 1994, without the siding.

To be continued …..

[7] According to the Board of Trade enquiry into an accident at Shepherd's Bush on 30 September 1913.