

THE LONDON ELECTRIC TRAIN

16 – STANDARD EQUIPMENT?

by Piers Connor

DESIGN LIMITATIONS

On 23 September 1935, the last of the 1934 order for new motor cars for the Piccadilly Line entered service, marking the end of a long line of orders dating back to 1922, eventually reaching a total of 1,466 cars. On the way, six manufacturers were involved, three traction system suppliers, two air compressor suppliers and one brake system supplier but with two different systems. As I've pointed out before, even ignoring the varieties in body design, which we will look at in future articles, this variety of equipment hardly warranted the term "Standard" but that's what the fleet became called over the years, although individual batches were officially categorised by date.

Even though the multiple unit electric train had been around on the Underground for over 30 years by 1935, having first appeared in experimental form on the Central London Railway in 1901¹, the design had changed very little from its original layout. The motive power was provided at each end of the train (in the motor cars) and the passenger accommodation was provided in between. The two motor cars, each with one motor bogie, were actually the equivalent, power wise, of a single, 4-axle locomotive, split in half. As we have seen all through this series, LER motor cars were designed with their traction control equipment packed into a 'switch compartment' positioned over the motor bogie at the driving end of the car. Because of the continued use of big electric motors, the motor wheels were too large to fit within the same envelope as the smaller trailer wheels used in all the other locations under the train, so the floor of the switch compartment was raised to almost double the height of the passenger saloon floor (from 1ft 10ins to 3ft 6ins). The switch compartment space (roughly 11ft or 3,353mm) was lost to passengers twice in a six-car train – about 7.5% of the possible accommodation. This design limitation was continued throughout the Standard stock procurement cycle.

For some years during the early part of the 20th century, it was thought that it would not be desirable to have motor cars with switch compartments anywhere in the middle of the train. It was believed that the fire risk was sufficient to present a situation where a motor car positioned in the middle of the train could catch fire and separate the train into two parts, making the rescue of passengers from the tunnel much more difficult. However, after years of running with few serious incidents by the time the 1920 Watford Joint Stock (WJS) was designed, it was decided to allow a third motor car in the middle of the train. It was needed to allow more power for the higher speeds expected between the suburban stations north of Queen's Park. In this setup, the six 200hp motors on the WJS provided 1,200hp on the train compared with 800hp on previous designs but it came at a price. The extra space lost to passengers lifted the total from 7.5% to 11%.

TRACTION CONTROL

The supply of traction control equipment on the Standard Stock changed as the stock orders progressed. Up to 1920, British Thomson-Houston (BTH) had supplied 617 sets of traction control equipment to the Underground group and the Metropolitan Railway during the period of the main electrification schemes between 1905 and 1907. This virtual monopoly went on during the following 15 years during which time new stock for the Bakerloo, Central and District railways was all equipped by BTH. They also supplied the District with the equipment for its new F Stock fleet in 1920 and it seemed as if they had an unbreakable position. They were in for a shock.

William A. Agnew, the Underground's Chief Mechanical Engineer, had become disenchanted with BTH's price for the F Stock equipment, which he thought was too high, and with what he saw as developing BTH arrogance. He persuaded other electrical equipment suppliers to offer the same control equipment and traction motors as BTH but at a better price. Suppliers quickly rose to the challenge and the first batch of Standard Stock (1923) had equipment supplied by BTH's rival, Metropolitan-Vickers (MV). MV were formerly British Westinghouse, who had supplied equipment for much of the Metropolitan Railway's electric stock, and such was their keenness to replace BTH as the

¹ See my article "The Central London Electric Train" No.4, *Underground News* No.614, February 2013.

Underground's main supplier that they were prepared to abandon their usual electro-pneumatic system to provide electro-magnetic equipment to comply with the Underground's specification.

Another new supplier, GEC, equipped two of the 1923 batch of motor cars, possibly as a trial before a firm order. GEC (the General Electric Company) was a British company, nothing to do with General Electric in America. It was founded in 1886 and supplied lamps and switches. By the end of the First World War in 1918, they were well established in Britain but they were new to railway traction.

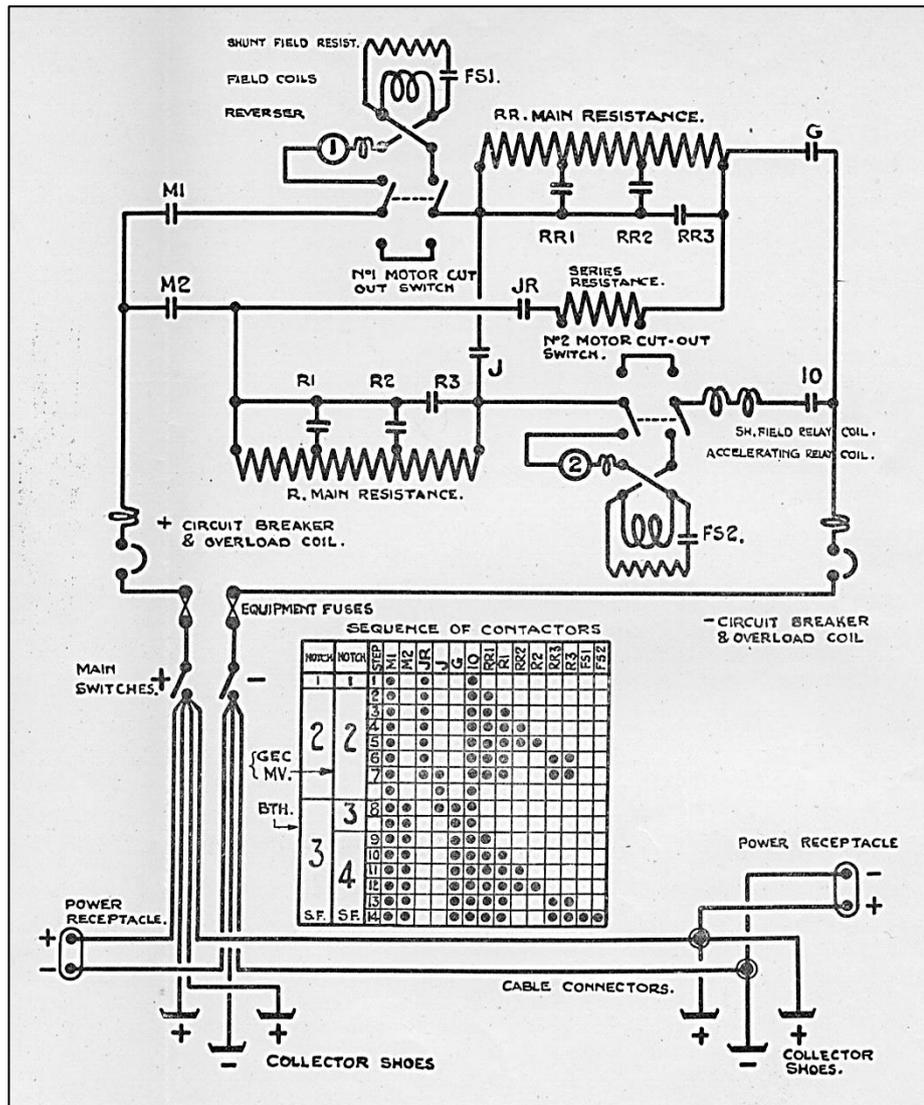


Figure 1: Power circuit diagram for 1923-27 Standard stock after modification with a shunted field resistance. Later stock was similar but had an additional field shunt circuits, activated by a cab mounted flag switch, added to give higher top speeds. Some of the earlier stock was modified to match. Each motor could be isolated if required. The MV and GEC cars had a 4-position master controller with a separate series-parallel transition position, whereas the BTH control went through transition to parallel in one movement. Note the provision of 'power receptacles' at both ends of the car. The trailing end ones were rarely used and were eventually removed. Diagram from 'Electric Trains' by W.A. Agnew (Vol. 1, Plate V).

the three systems were basically all the same since they had to be able to couple together and perform in a uniform fashion.

They did have an association with Oerlikon of Switzerland, developed back in the closing years of the 19th century in connection with 3-phase motors but it took another 20 years before they produced multiple unit traction equipment and motors to Oerlikon designs in the UK. It seems likely that the installation on the two Standard Stock cars in 1923 was the first in the UK under the GEC name, although similar equipment was supplied to the LNWR's Watford electric MU stock under the Oerlikon name.

Both MV and GEC supplied traction control equipment for the 1924 Standard Stock but this was MV's last order for the Underground group. GEC supplied the 1925, 1926 and part of the 1927 batches but BTH were called back into the field for the rest of the 1927 Stock and supplied all future stocks.

BTH got back in because the GEC and MV equipment was not as reliable as expected and many modifications were carried out over the years to both types to try to get them to match the reliability of BTH. I wonder if BTH allowed themselves a moment to think, 'We told you so'.

Detailed descriptions of each of the control systems used on the Standard Stock are available in Agnew's 'Electric trains', published in 1937 by Virtue & Co. but the

MOTORS

Most of the traction motors for the Standard stock were supplied by GEC. Only the MV equipped cars had MV motors, known as the MV152 type. The GEC motors were known as type WT54. The WT referred to the factory in Witton, Birmingham where they were built. Both types were of a new design and both had a nominal power of 240hp (179kW). A 6-car train therefore had a total of 960hp (716kW) while a 7-car train with three motor cars had 1,440hp (1,074kW). The 7-car provision in terms of h.p. per ton is 8.47hp, which is interesting when compared with the 10.27hp/ton of a 7-car 1996 Tube Stock. (The weight of the 1996 Tube Stock has been converted to imperial tons to provide a sensible comparison).

The MV motor and its associated control equipment was only supplied for some 1923 and 1924 cars. The rest of the fleet was equipped with the WT54 and its variants. The range of variants was introduced with variations in wheel size and pinion/gear ratios as shown in Table 1 below.



Figure 2: The interior of Northfields Depot car shed in September 1937 showing an overhead lead being inserted into the receptacle box under the headstock of 1931 Stock motor car No.3213. Most of the Underground's car sheds did not have current rails so power to move cars or test equipment was provided by these leads. The leads were suspended from a small 4-wheeled trolley running on twin rails fixed alongside each road in the depot at roof level. Having the receptacle boxes on the front of trains was the traditional practice on electric railways as they were normally used to provide jumper connections to supply line voltage along the train. This practice was prohibited on the tube lines so the receptacle was only used in the sheds as shown here. Trailer cars did not have them. Stocks built after 1935 had the receptacle box fitted on the side of the car. Being fixed on the front left them vulnerable to water and dirt, despite having spring-loaded lids and, in 1958 and again in 1960, there were incidents on the Central Line where fusing in these boxes caused fire and smoke on service trains. A passenger died from the effects of smoke in the 1958 incident at Holland Park. Photo: LT Museum.

The same motor, classified WT54B, was also used on District stock built between 1923 and 1935. It was the de facto standard of the day. Each motor weighed 2.5 tons (2,548 Kg), compared with less than 400 Kg for a modern tube stock motor. Of course, the power of the modern motor is about 25% of the old one. The WT54 design survives to this day on the Underground's battery locomotives. The variations denoted in the 'A' suffix are related to the gear ratio and wheel diameter used with the motor as Table 1 shows. As we shall see in future articles, the bogie types were broadly similar but with variations for wheel size and some minor design improvements.

Stock	Motor	Gear ratio	Motor Bogie	Wheel base	Motor Wheel diameter	Trailer bogie	Wheel base	Trailer wheel diameter
1923-25	WT54	16/67	Y	6'-11"	3'-4"	V	6'-0"	2'-8"

1926	WT54A	17/63	Z	6'-6"	3'-0"	W	5'-7"	2'-8"
1927-29	WT54A	17/63	Z	6'-6"	3'-0"	W ²	5'-7"	2'-6"
1930 WRS	WT54	16/67	Y ²	6'-11"	3'-4"	W	5'-7"	2'-8"
1930 UCC	WT54A	17/63	Z	6'-6"	3'-0"	W ²	5'-7"	2'-6"
1931-34	WT54A	17/63	Z	6'-6"	3'-0"	V ²	5'-7"	2'-8"

Table 1: Motor and bogies provided on LER Standard stock 1923-34. Source: LPTB 1935 rolling stock data sheets.

EQUIPMENT

As was normal for the LER, each motor car had an air compressor to provide compressed air for door operation and brakes. The 1923-27 cars with MV or GEC traction equipment had Westinghouse CM38 compressors while the BTH cars had BTH CP30s. This latter type had been used on the District and was known to be reliable. It survived to be used on many of the 1936-38 surface stocks (O, P and Q types) and has since remained on a number of engineers' vehicles. As was usual, the compressor was mounted behind the driver's position on the left hand side of the switch compartment (Figure 3). Immediately behind that was the main reservoir except that on the 1931-34 Stock, the main reservoir was mounted on the underframe the car.

The auxiliary electrical supply for lighting, battery charging and, on later batches of cars, heating, was based on the original LER system, used on all the previous batches of trains, where a separate supply was provided from each motor car to supply half the train in order to ensure that there was never a connection between the two motor cars on a train so as to comply with the Board of Trade regulations². However, the addition of requirement for door control and later for heaters saw the introduction of "auxiliary buslines" where the supply to lighting was fed through separate circuits instead of the main circuits as previously. The original 4-wire jumper seen on the 1906-07 Stock became a 10-wire jumper. This made for complex wiring arrangements.

One of the oddities of the wiring was that the control trailer cabs had a cab light that was switched on by diverting the feed to one of the marker light lamps. The assumption was that the driver would not normally drive with the cab light switched on. Most normally don't, even today, but I did.

Heaters were not provided on the 1923-27 cars as built, so if you lived at Edgware and went to work early on a winter's morning, you needed to wrap up well. They didn't get heaters until the 1935-40 New Works Programme when they went through an upgrade programme in preparation for the Central Line extensions. Many of them went through the programme, only to be stored when the extensions were put on hold after the start of World War II in 1939. Heaters were fitted from new to trains supplied to the Piccadilly Line, starting with the 1928 UCC Stock. There were also provided on the 1930 Watford Replacement Stock on the Bakerloo.

BRAKES

All LER trains were fitted with the Westinghouse air brake and the Standard Stock was no exception. Operation of the brake was pneumatic and accurate stopping was entirely due to the skill of the driver in manipulating the control air pressure in the correct way to allow the train to stop in the right place. Some drivers were better at it than others. After a series of experiments on the District Railway, the first of which is recorded in a Traffic Notice as starting in 1916, it was decided in 1928 on a strategy of fleetwide fitting of electro-pneumatic (e.p.) braking. The first new stock to get it was the 1929 UCC stock ordered for the Piccadilly Line. All subsequent orders had it and older trains were fitted from 1930 onwards.

Conversion to e.p. brakes involved the installation of new wiring along the train with an additional control jumper between cars and a set of valves mounted under each car. The new system was

² A description of the original system appears in Article 2 of this series, *Underground News* No.647, November 2015.

mounted on top of the existing Westinghouse brake, which was retained to provide a back up and to perform the safety functions required by the passenger alarm, deadman's handle and tripcock.

A new e.p. brake controller was provided in most driving cabs. I say 'most' because there is evidence to suggest that they were not provided in all control trailer cabs. Agnew, in his "Electric Trains" Vol II, says that e.p. brake batteries were provided in control trailer cars so, logically, one could assume that e.p. brake controllers were installed too. However, a photo in the LTM collection (Figure 4) dated September 1937, shows a control trailer cab with a 'pure' Westinghouse brake valve undergoing maintenance in Northfields Depot. By this time, all the Piccadilly Line fleet was recorded as having e.p. brakes, so there does seem an apparent anomaly here.

In considering this though, it is not impossible to operate control trailers without e.p. brake controllers as long as they had the necessary electro-pneumatic valves to operate the brakes under the car. E.P. brake controllers for control trailers weren't really necessary. The purpose of the e.p. brake was to get accurate stopping, quickly and efficiently, to improve station stopping in peak hours. Control trailers were only used in off-peak hours and then only on certain trains made up of three cars or less. The stopping accuracy wasn't needed. Another thought, too, is that, by 1937, control trailers on the Piccadilly Line were only used during coupling or uncoupling to move the 3-car 'uncoupled set'. The off-peak trains were made up of 4-car M-T-T-M sets. Control trailers were not normally used for driving on Piccadilly Line service trains after May 1936.

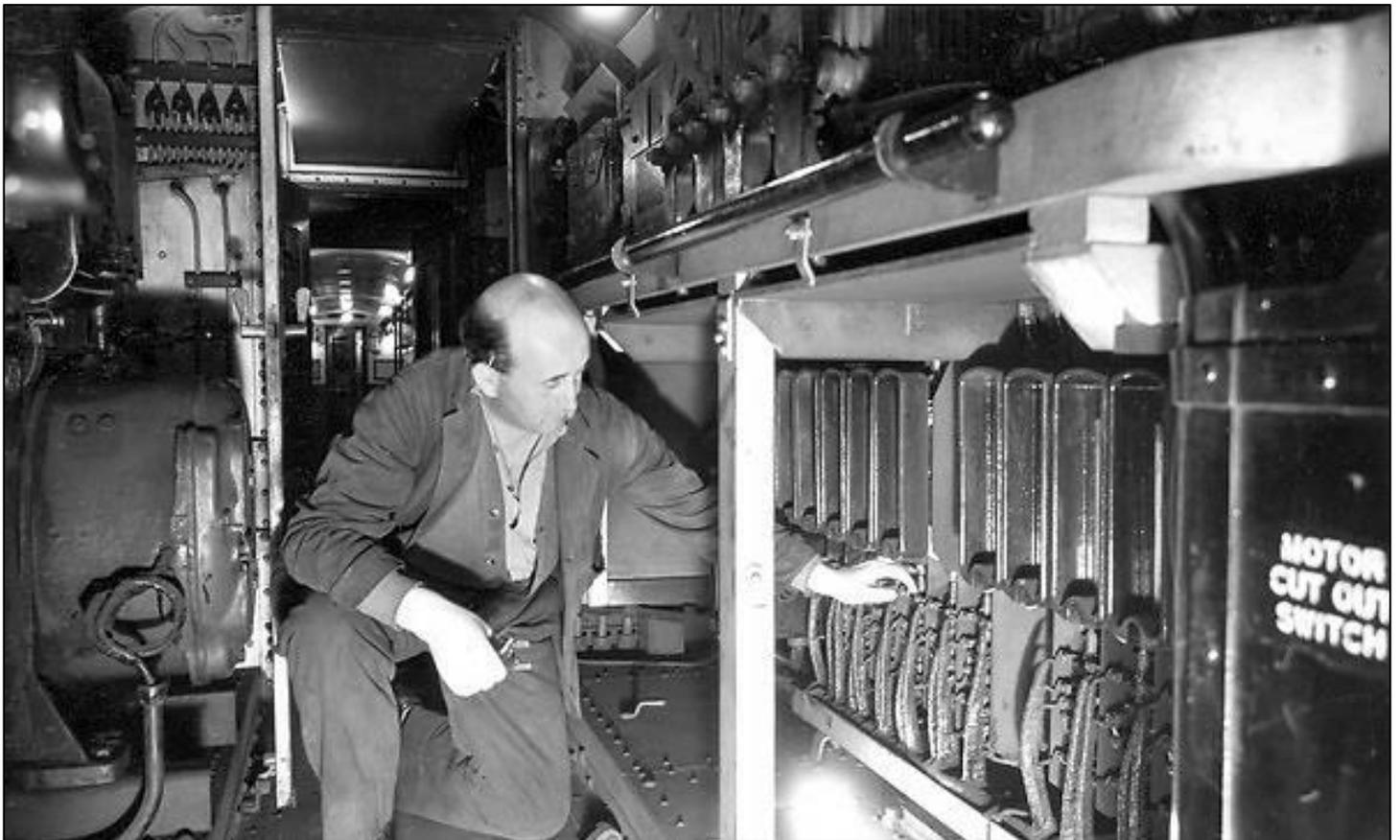


Figure 3: The interior of the switch compartment of a Standard Stock motor car with a fitter resting his hand on the back of one of the contactors used for switching the power circuit resistors. Above the contactors is the rack carrying the resistors and reverser. The motor bogie is under the floor. Floor plates were removable to provide access to motor brushes. The fitter is kneeling in the aisle connecting the passenger saloon of the motor car (behind the camera) with the driver's cab behind the fitter. On the left side of the aisle, the motor end of the compressor can be seen. Beyond it is the screen separating it from the driving position. The car in this photo is a middle motor car. The next car is probably a control trailer. Photo: LT Museum.

CONVERSIONS

It is known that the 1929 UCC and 1930 WRS orders did have e.p. brake controllers fitted to their control trailers but the 1930 WRS was the last order for control trailers on any of the Underground's lines. All earlier trains were converted to e.p. brakes. The work was done in stages.

The first line to be converted was the Piccadilly. Work started on the line's 1927-28 BTH stock in late 1930 and ran in parallel with the delivery of the e.p. equipped 1929 UCC stock.

A second wave of conversions was started on the Bakerloo following the delivery of the WRS in 1931. Work began on converting 7 x 6-car trains to allow them to run to Watford if required. Although the original WRS order had larger wheels than the other Bakerloo cars and special high-speed gearing, no other cars were modified to match. This didn't stop them making up some trains of mixed WRS and other e.p. fitted cars.

THE CAMMELL LAIRD STOCK

Until 1931, the 1920 Cammell Laird stock worked on the Piccadilly Line with the converted 1906 French motor cars in a fleet of 10 x 6-car trains. The impending opening of the Piccadilly Line's extensions to Cockfosters, Hounslow and Uxbridge and the influx of new cars needed to work the new services showed that the Cammell Laird fleet was outclassed. They were not up to the standard of the Standard Stock.

The 1906 motor cars were due for retirement anyway and the 1928 UCC order was specially to replace them but the 1920 trailers and control trailers were only 10 years old, so it was decided to upgrade the stock to modern standards and to allow them to work with their Standard stock motor cars.



The 20 new motor cars, numbered 205-224, were delivered as planned but the actual cars which replaced the 1906 French cars were in fact some built by MCW in 1927 and some of the first batch of the 1928 UCC type. The last of the converted 1906 motor cars ran in service in January 1930.

The technical conversion of the Cammell Laird cars consisted of making the cars, in control trailer – trailer pairs, compatible with their Standard Stock motor cars. The couplings and connections between the trailers and control trailers were unchanged but the outer end centre buffers and couplings were altered to suit the Ward coupler and sprung buffer on Standard Stock. The jumper sockets were removed from their cant rail position to the standard position at waist level. The master controllers and control wiring were changed to match Standard stock automatic control and the door controls were modified. The guard's control position in the control trailer cars was removed. The sliding doors separating the control trailer driving cabs from the passenger saloon were replaced by a panel containing, with a slightly smaller doorway opening, a swing door. As a result, the cab area

Figure 4: A fitter at Northfields Depot in September 1937 cleaning the equalising valve piston of a Westinghouse No. 4 brake valve in a control trailer cab. We can see it is a control trailer by the shape of the cab door and by the position the control switch next to the brake valve piping. The evidence of this photo suggests that not all Piccadilly line control trailers had e.p. brake controllers, even though the cars were fitted with e.p. brake operating valves. Photo: LT Museum.

was isolated from passenger use.

The work also included removing the double sliding doors on the car ends, in favour of hinged cab and communicating doors. Door closing plunger switches (as used on Standard Stock control trailers) were added to the control trailer cab exteriors. The one modern addition that this stock didn't get was the conversion to electro-pneumatic brakes. The stock was obviously not considered suitable for this upgrade, perhaps because of its non-standard configuration or because of its age. Either way, it meant that the new motor cars working with it didn't get converted and, as a result, the 10 trains were confined to the Bakerloo 'local' service between Queen's Park and Elephant & Castle.

An interior refurbishment of the Cammell Laird stock was undertaken between 1926 and 1930. It consisted of replacing the bay of longitudinal seating in the centre section of each car with transverse seating (increasing the capacity from 44 to 48), and the addition of armrests to the remaining longitudinal seats, together with an improvement to the lighting. This was done by removing alternate ceiling fittings and putting frosted bulbs and standard LER frosted bowl shades on the remainder, and adding goose-neck lighting fittings of LER pattern to the eaves and draught screen frames, much as on the 1923-25 stock. Grooved maple wood flooring was laid in place of the original composite flooring.

The time taken to do this work (four years) seems excessive and, although the work was authorised in 1926, the application of the work order was slow and there were delays because of the need to lend two trains of the stock to the Central London Railway during 1926-27. The decision to replace the 1906 motor cars added more delay while some redesign was required as a result of the new interfaces with the new motor cars. The 1920 cars were transferred from the Piccadilly to the Bakerloo Line (via the conversion carried out at Acton Works) between January and October 1932, and were replaced by a reverse transfer of Standard Stock trailers and control trailers.

HAMPSTEAD CONVERSION

Finally, beginning in 1934, the whole Hampstead fleet was put through an improvement programme, including conversion to e.p. brakes. In an instruction issued in March 1934, the fleet was said to comprise 325 motor cars, 145 control trailers and 278 trailers of 1923 to 1927 Stock. They were all to get e.p. brakes, an upgraded door control circuit and shunted field control on the traction motors. This last idea was to give the cars a higher top speed and had already been applied to the newer cars being supplied to the Piccadilly Line and the Bakerloo's WRS. The Hampstead conversion programme was completed in 1936.

One note of interest to come out of records from the early 1930s that I have seen is that a total of 35 control trailers working on the Hampstead line were actually only used as trailers although all control trailer cabs were noted in records as being equipped with e.p. brake controllers. Perhaps, despite the records, some weren't actually done. We have already seen that some weren't done on the Piccadilly Line.