# THE LONDON ELECTRIC TRAIN

## by Piers Connor

# 3 – MOTORS AND MORE

## MOTORS

The design of the London Electric Railway's (LER) 1906-07 gate stock was developed from the Central London Railway's first multiple unit train of 1901. The layout of the cars, the train formations and the electric traction system were all similar to the Central London's prototype and were really derivatives of it. In the case of the traction motors, the 125hp GE66 motors used on the Central London became 200hp GE69s on the LER (and, incidentally, the District Railway too). The GE initials referred to British Thomson-Houston's (BTH) parent company General Electric of America, who designed the motors and originally supplied them to BTH from the US. The same type was used on the GE equipped cars of the New York Subway when its first line was opened in 1904.

Each LER motor car had two motors mounted on the leading bogie. As we have seen a previous article, the size of the motors required the wheels to be large (3ft or 914mm in diameter) and the floor of the motor car to be raised over the bogie to accommodate them. A 6-car train had two motor cars, which provided a total of 800hp per train.

With the weight of a 6-car train given as 120 tons, this gave 6.66hp per ton of train (empty). By comparison, the Victoria Line's 2009 Tube Stock gets almost double that at 12.37hp per ton. Another big difference between the two stocks, apart from over a 100 years of development, was that the 1906 Stock had 16.7% of its axles with motors whereas the 2009 Stock has 75% motored axles.

## MOTOR RATING

Motor rating can be confusing. This is because most DC electric motors are recorded as being rated at two values. For example, the GE69 motor was described in technical literature as being rated at both 200hp and 240hp[1]. Both are correct but there are some variables that give the different figures.

To begin with, the voltage applied to the motor will affect the value and, in the early literature, the standard voltage used to determine the power was 500 volts DC. Most DC traction motors made by BTH were tested at this voltage. This provided a constant and didn't affect the two variables. The variables were based on the heat limits of the motor when running. Thus, there was a 1-hour rating (in our case 240hp) and a continuous rating, at 200hp. The difference between the two ratings was usually in the range of 1.2 to 1.4.

## CONTROL

As I mentioned briefly last month, all the original LER stocks had the standard BTH Type M electro-magnetic traction control system. It was based on the system tried on the Central London in 1901 – indeed it was almost identical, apart from the introduction of interlocks on each of the thirteen contactors. These were introduced to ensure that the sequence of their operation was in the correct order. There had, apparently, been some problems where they hadn't and it is likely that fuses had been blown as a result.

The Type M system became the system of choice for the Underground at the time of electrification in the early 1900s. It was used on the District Railway and on the later batches of saloon stock cars built for the Metropolitan and Hammersmith & City Railways as well as the LER. As shown in Figure 4 of last month's article, the LER version of the system was fed off the 600 volt lighting supply mains through a change-over switch. It was then passed through a set of control resistances to reduce the current to a level sufficient for the control circuits.

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[1] See, for example, Hobart, H.M., "Electric Trains", Harper Brothers, London, 1910.

There was a control switch in each cab to allow the driver to isolate the controls when the cab was not in use. The driver's "master controller" stood in the cab next to the brake controller below the left hand cab window (Figure 1). Left hand drive was adopted on the LER and District lines and remained the standard on the Underground until the appearance of right hand drive on the 2009 Tube Stock.

The control system provided manual acceleration. This was not the intention of the original designer, Frank J. Sprague, the American who developed the system for the Chicago South Side Elevated RR in 1897. His system had automatic acceleration but it wasn't robust enough for everyday service and it was abandoned by GE for their later systems. Manual acceleration meant that the driver had to accelerate the train in steps by rotating the controller handle through nine "notches" until full speed was reached. The success of this arrangement depended on the driver choosing each step at the correct moment to maximise the acceleration but without overloading the circuit. The risk of overload was mitigated by a circuit breaker in the cab that could be reset by the driver if he had tripped it by trying to accelerate too fast.

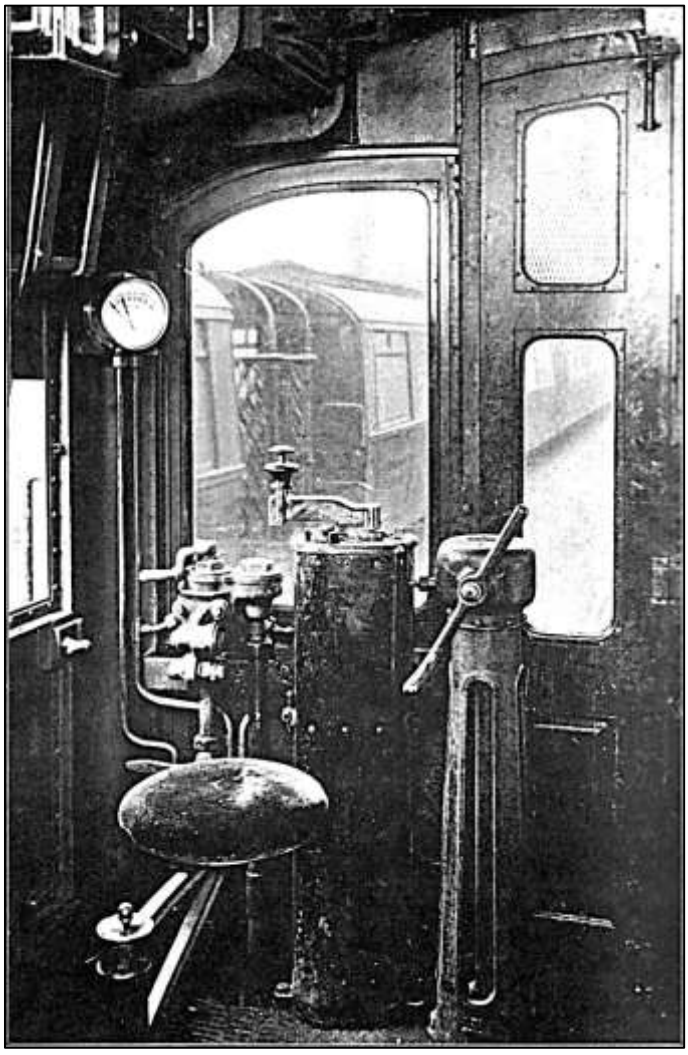


*Figure 1: The driving controls in a 1906 Piccadilly Line Gate Stock cab. From left to right, the Westinghouse No.4 brake valve, complete with its handle, the BTH master controller and, on the right, handbrake stand. The master controller has been left in the "full parallel" position with the deadman button released. The brake valve handle is in the "Lap" position. The duplex air gauge on the left hand side of the cab window is showing zero pressure for the train line and only about 30lbs in the main line pipe. The circular seat had to be swung out of the way to access the cab side door. The circuit breakers and other switches were fitted to a slate board behind the driver position and on the other side of the cab. Photo: From "Our Home Railways" Vol. II, W.J. Gordon, Frederick Warne, London 1910.*

In reality, drivers often adopted the "1-5-9" technique, where the controller was held in each of the three positions while the motors naturally accelerated to a level where the current levels dropped off and then moved on to the next position. It wasn't as efficient as hand notching but it was easier to use.

## BRAKES

The LER fleet was fitted with the Westinghouse automatic air brake. The "automatic" part referred to the operational safety built into the system so that the train would be automatically braked to a stop if the control pressure in the controlling brake pipe was lost. The deadman facility in the master controller handle (Figure 1) was connected to this pipe, as was the tripcock, mounted on the front offside of the car. Each car had a single brake cylinder operating single brake blocks on each wheel.

I've written about how these systems worked in various articles published previously in *Underground News*[2], so I won't repeat them here. Suffice to say that, as far as the LER gate stock fleet was concerned, they complied with the format of the day and they lasted pretty much unaltered until the stock was scrapped in the late 1920s.

One thing worth mentioning here is that the brake blocks (sometimes referred to as brake shoes), were originally made of cast iron but the frequent braking of the trains on the LER meant that they were used up quite rapidly and they were expensive and difficult to replace. Originally, cars had to be examined every three days in order to replace brake

[2] I described the Westinghouse Brake in "The Underground Electric Train", Article 6, *Underground News* No.528, December 2005, the deadman and tripcock in Article 18, *Underground News* No.540, December 2006, amongst other places.

blocks and adjust the rigging[3]. The cast iron also produced a fine ferrous dust that tended to settle everywhere and which was surprisingly combustible. It caused trouble with electrical insulation, signal circuits and it sometimes created fires. The Underground sought a suitable substitute non-metallic composite material for many years, most not being any better. There were some concoctions that worked fine as long as they were dry but they were less successful when cars ventured into the open during wet weather. They were still trying out new materials when I joined the service in the early 1960s.

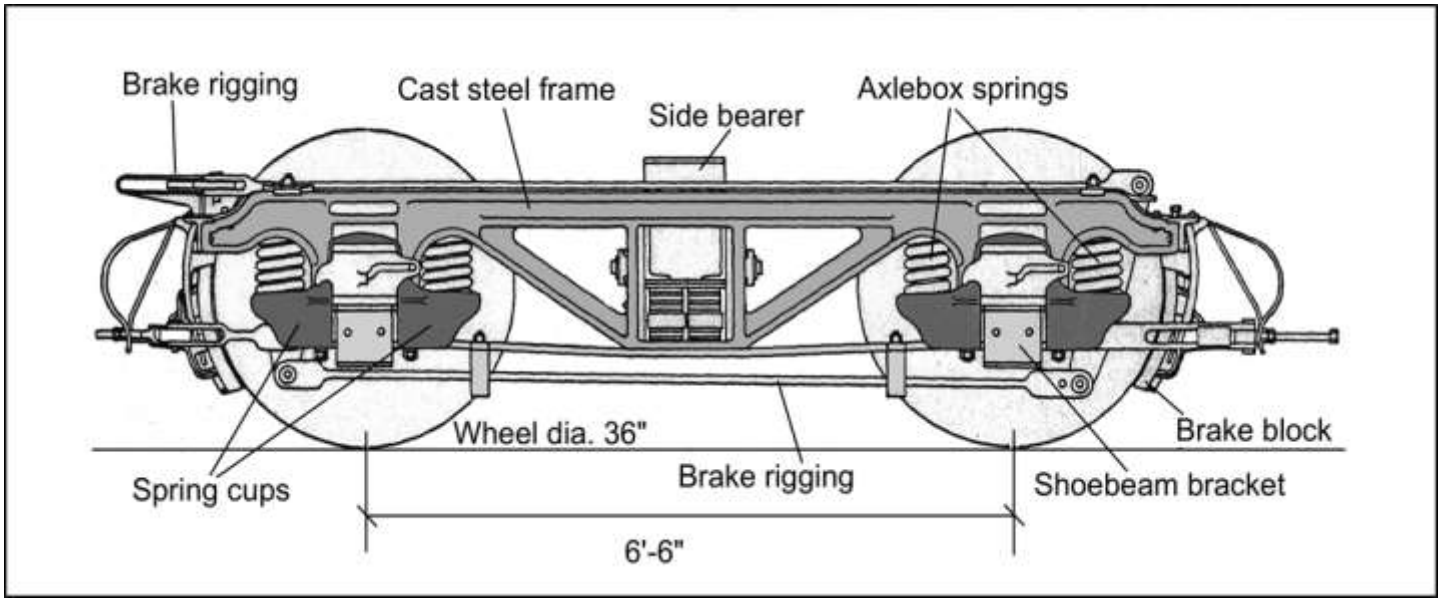



*Figure 2: The Hedley motor bogie used for the LER gate stock. It had 3ft 0in diameter wheels. It was later known as the Type A bogie. The frame was cast steel, then fashionable in the US but not in the UK. In terms of the duty it was required to perform, the design looks rather flimsy and it didn't perform well on the District's poorly laid track and many there were replaced by more substantial designs. It survived on the LER lines with little alteration, despite the extensive utilisation. The drawing was adapted by the author from an original by the late Stuart Harris.*

## BOGIES

Two types of bogies were provided for the original gate stock, a motor bogie and a trailer bogie. The motor bogie was identical to the Type A bogie used on the District Railway (Figure 2). It was based on a design by the American engineer Frank Hedley and was originally supplied to the Chicago North Western Elevated in 1898 as a trailer bogie. In London it appeared with a pair of motors, one driving each axle in the time-honoured nose-suspended arrangement.

The Type A bogie was not a success on the District, largely because its track was badly constructed and poorly maintained and the cast steel design was too inflexible to cope with it but it remained in use under the LER fleet until the trains were scrapped in the late 1920s. Surprisingly, the last examples of them to survive were those under two former District Railway electric locomotives used to transfer wheels to and from Acton Works. They were scrapped in 1969.

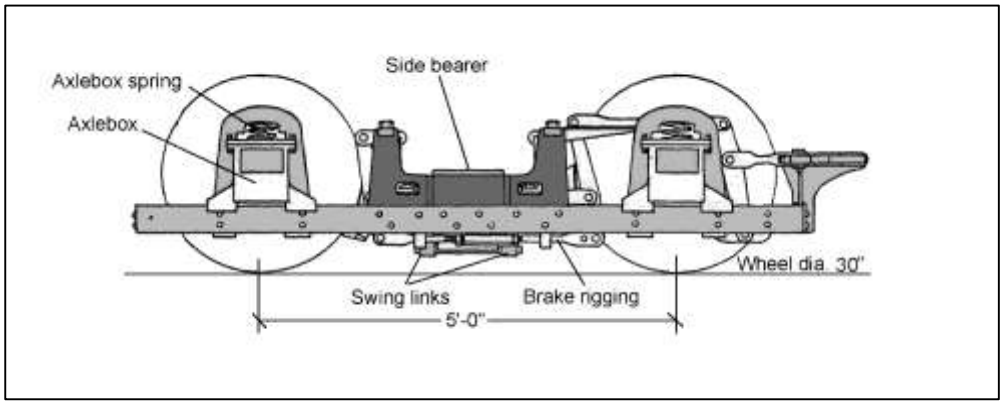



*Figure 3: The LER gate stock trailer bogies were known as Type O. This tiny lightweight bogie survived for the life of the stock but it does not appear to have been provided with any secondary suspension. The drawing was adapted by the author from one by the late Stuart Harris.*

[3] By comparison, the latest trains on the Underground will go for 28 days between examinations.

The trailer bogies were very lightweight. They seem to have been made up of steel straps welded together. They certainly weren't cast steel. They were seemingly smaller than the Central London's trailer bogies and they hardly looked adequate for the job. They were eventually designated Type O

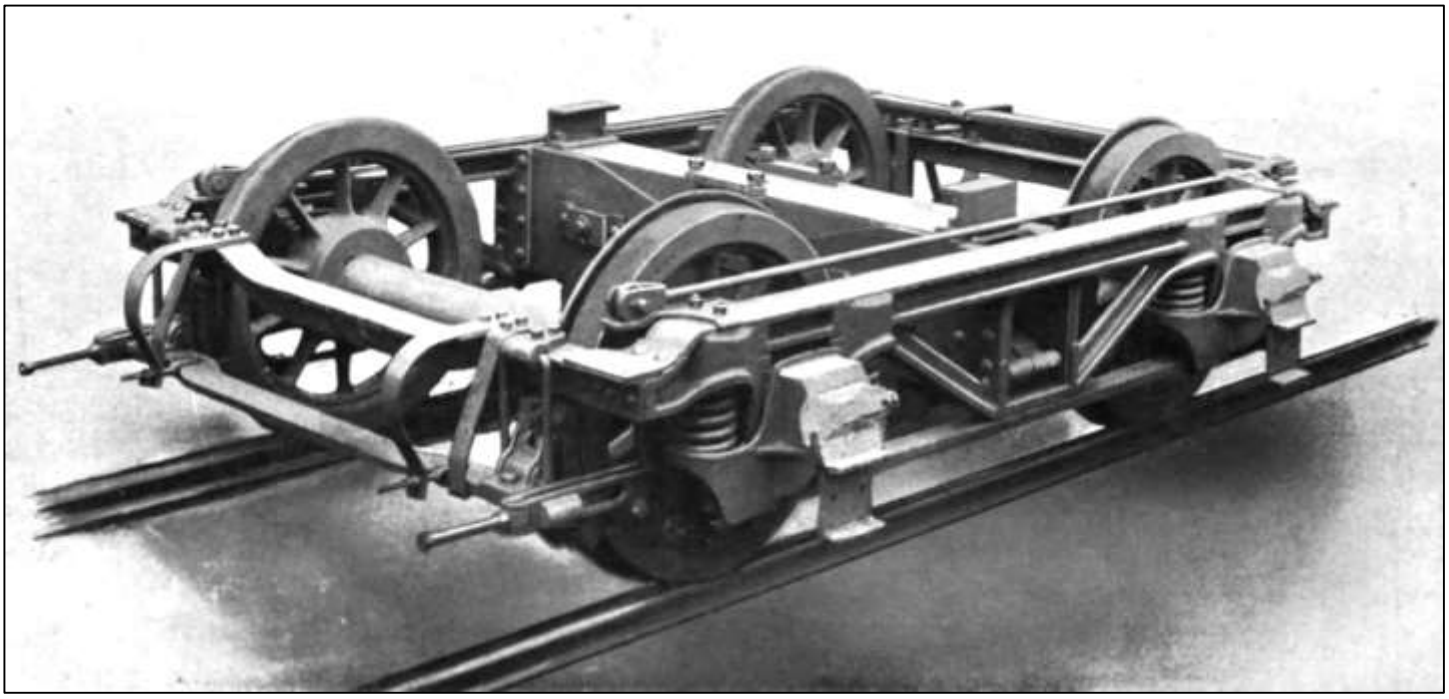


*Figure 4: A recently discovered photograph in reasonable condition of the cast steel motor bogie design used on the London Electric and District Railways. The bogie originated in Chicago, being designed by the engineer Frank Hedley. Here it is shown in new condition without its motors and shoegear. This design was troublesome on the District and the bogies used on that railway suffered from cracked frames and many of them had to be replaced. However, it worked well on the LER lines, perhaps because the track was in much better shape and, being embedded in concrete, was more stable. Photo from Tramway & Railway World, 9 February 1905.*

by the Underground. They were specially designed to fit under the low tube car floor and, to look at, they were minimalist in the extreme. Looking at the drawing (Figure 3) and others of this design, it can be seen that no form of secondary suspension was provided. There wasn't room for it. Even if there was, the space is so tight, it can hardly have provided any relief from the hard ride. There was not much movement in the tiny primary suspension springs sitting on the axleboxes either. There was a swinging bolster but no springs were fitted to it. Despite its apparent shortcomings, the design seems to have survived for the life of the stock with little alteration.

## CONTROL TRAILERS

The three LER lines were all provided with control trailer cars. These were simply trailer cars with driving controls mounted on one or other of the end platforms. This allowed trains to be divided into short units for off peak traffic, usually in the form Motor-Trailer-Control Trailer (Figure 5). The driving controls were basic. Just the master controller and brake valve, plus an isolating cock and control switch, were all that was needed. The driving position had a simple steel screen with a small window at head height. There was no seat and the driver had to stand in order to see forward. It was all very primitive (Figure 5). A pair of lights was provided on the offside front, similar to those on the motor cars. One was a headlight, known as a "marker light" on the Underground because that's what they were called in the US – the other was a red tail light.

Some time after the trains went into service, an additional tail light was added to the motor car cab fronts on the driver's side. It was certainly before 1918, when the inspecting officer reporting on the Warwick Avenue accident of 25 February of that year described the two tail lights on the rear of a train "burning". In the language of the day he meant they were working. The additional lamp was added in conjunction with the fitting of emergency lighting, which was done in 1914-16. It was intended that a tail light should remain on when power was off, so adding one to the battery fed emergency lighting circuit was eminently sensible.

## PICCADILLY COMMISSIONING

The Piccadilly's French fleet went into service over the last two months of 1906 but the Hungarian fleet was commissioned much more gradually. The motor cars entered service over a period of several

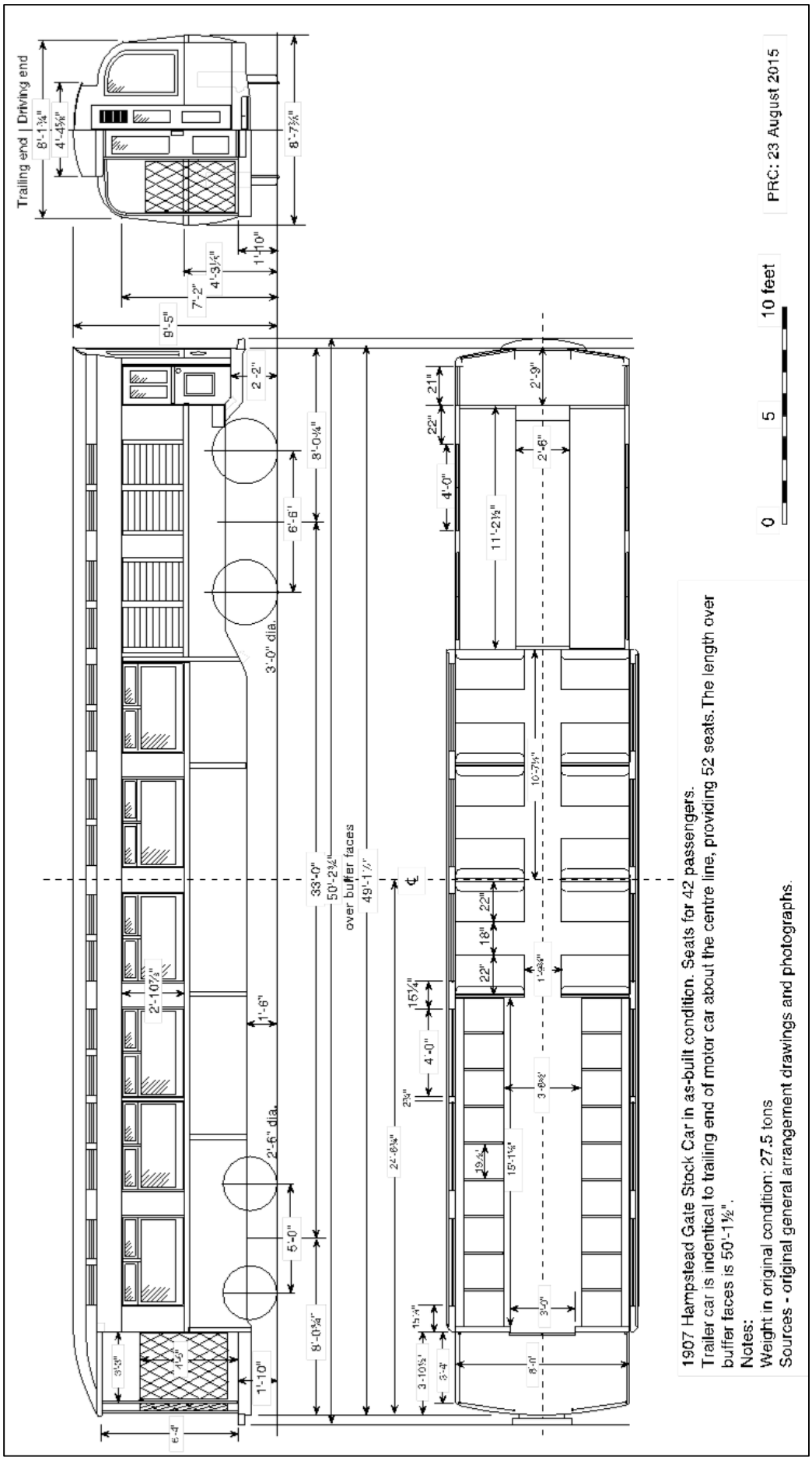
years, six of them not entering service until 1909 and four remaining idle until 1911. The trailer cars went into service a little more quickly, the last of them in November 1908.

Of the 72 control trailers ordered for the Piccadilly line, only 47 actually entered service as planned. The remaining 25 (all Hungarian) were stored, five of them at the Piccadilly Line's depot at Lillie Bridge, the other 20 at the Hampstead depot at Golders Green. Those at Golders Green never even got their numbers, let alone their control equipment. They remained there for a number of years until a use was eventually found for them, as we shall see in a future article. In the meantime, the train service managed quite well with the remaining cars. Most peak hour trains were of 3- or 5-car formation.

## PICCADILLY STORAGE

*Figure 5: LER gate stock control trailer shown in a specially posed photo at the Hampstead crossover about 1907 when the whole system was new. The driving position has a simple steel screen with a small window that forced the driver to stand whilst driving. The driver's hand is on the master controller. The platform could be used by passengers if the car was in a train where the control position was not being used. Photo: LT Museum.*

*Figure 6: A photo of the Piccadilly Line train shed at Lillie Bridge with new stock being prepared for service. This shed was built on the site of the District Railway's main works that had become available when they decamped to Ealing Common depot in 1905 for that railway's electrification. The new Lillie Bridge shed had six roads, each capable of accommodating 4 x 6-car trains. It was long but it was too small. It could take only two thirds of the originally ordered fleet and meant that the rest had to go elsewhere. In a reversal of history, the Piccadilly shed, or what's left of it since half of it was demolished to make way for Earls Court Two (the exhibition building), is now used for stabling District trains. Photo: Collection B.R. Hardy.*




The storage of a number of the Piccadilly Line's Hungarian control trailers highlights the problem that the line had with stabling space. The line's main depot was at Lillie Bridge. The site was originally the District Railway's locomotive and carriage works. It was vacated when the District built a new depot at Ealing Common for its electric rolling stock and a new, long train shed was built on the site for the Piccadilly Line's new stock. The trouble was it could only take 4x6-car trains on each road – 144 cars or only two-thirds of the Piccadilly fleet – and this left little room for full maintenance facilities. Trains were sent to Ealing Common for some of the maintenance work. The equivalent of 12x6-cars trains had to be found homes outside the Lillie Bridge shed. With 20 cars that were sent to Golders Green for storage, the number of cars left to find space for was 52. Fifteen of these were stored around the yard at Lillie Bridge, leaving 37. There was a siding between West Kensington and Barons Court on the north side of the Piccadilly Line tracks leading down into the tunnel towards Earl's Court and another one just east of Hammersmith station. These two sidings could squeeze in another 20

cars mostly acting as storage for un-coupled sets during off- peak periods.

*Figure 7: Scale drawing of Hampstead 1907 Gate Stock Motor car. Drawing: Author.*

Cars were also stabled in the tunnels beyond Finsbury Park during the “slack hours”. With a few cars at Ealing for maintenance and overnight stabling in the platforms at Finsbury Park, there was just enough room for everything but it was always very tight.

**To be continued ……**