THE METROPOLITAN RAILWAY ELECTRIC TRAIN

by Piers Connor

with Charles Horsey

4. THE WESTINGHOUSE LOCOMOTIVES

A TEAM APPROACH

You will see that, this month, I have added Charles Horsey to the author header. Charles was the author of the series published recently in this journal on the 'The Twenty Metropolitan-Vickers Locomotives One Hundred Years On – An Appendix to the Story'. When I started this series, I asked Charles if he could help with checking my texts to see if there were any gaps that he could fill as a result of his research into the Metropolitan Railway. It turned out that he has been able to provide a lot of new sources that have been a tremendous help. Between us, we have expanded the story of the Metropolitan's electric rolling stock with a lot of new information, thus It is only appropriate that Charles is added to the authorship.

GETTING RID OF STEAM

In the early 1900s, there was huge public and political pressure to get rid of steam in the tunnels of the Metropolitan Railway, not just on the Metropolitan's own trains but on all trains, like the Great Western Railway's through trains to the City stations from Windsor, Staines, West Drayton and Southall etc. and various freight trains. The ultimate goal was that all these were to be electrically worked so that steam was virtually eliminated. This aspiration required the acquisition of electric locomotives. It was decided also that the Met's own trains on the Extension line should be electrically worked south of Harrow so that steam was eliminated from the tunnels south of Finchley Road. To cover these needs, in December 1904, the Metropolitan ordered ten electric locomotives from the British Westinghouse Electrical & Manufacturing Company[1]. The first of them arrived at Neasden early in June 1905.

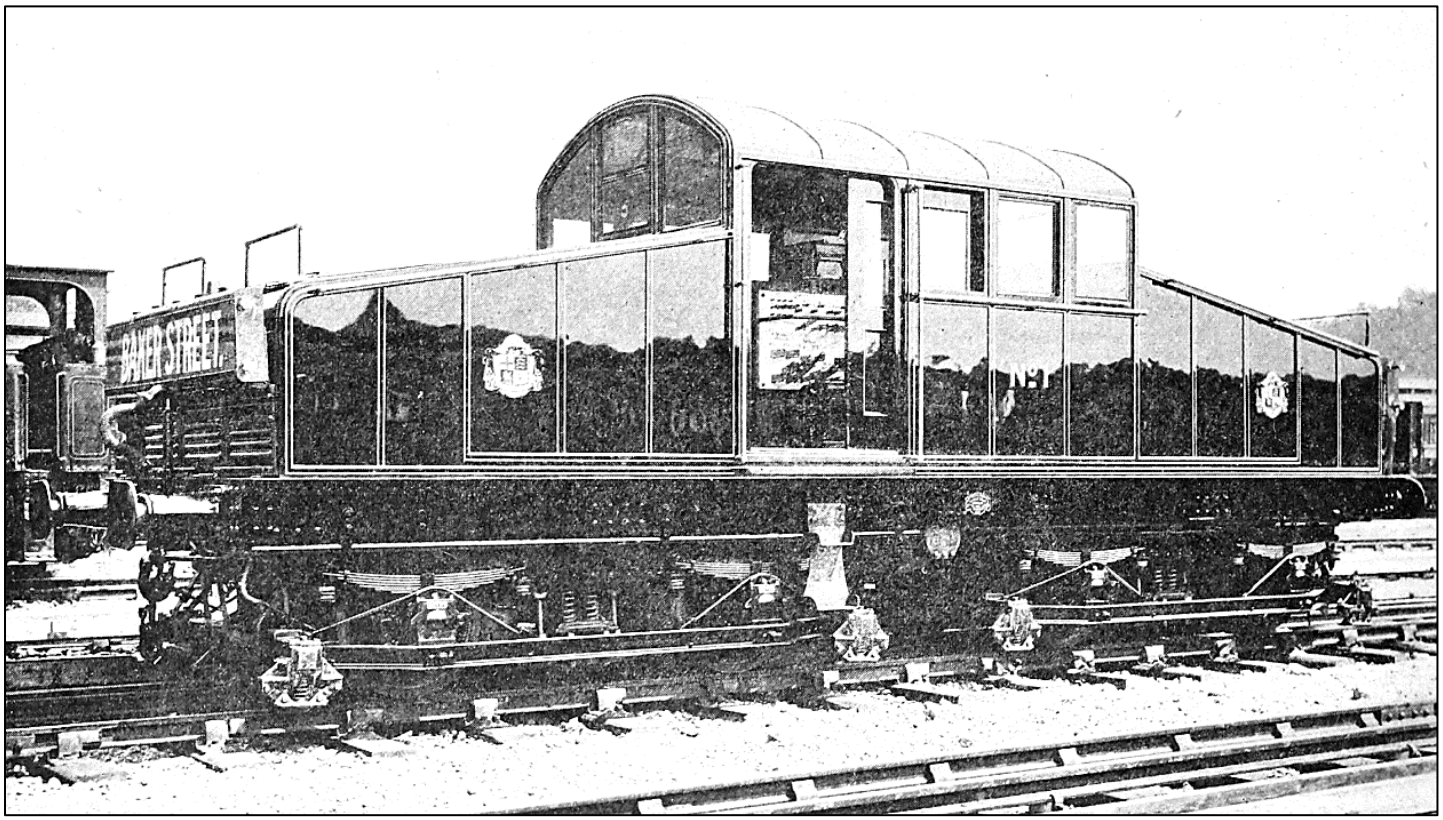

Figure 1: The Metropolitan's first electric locomotive design. British Westinghouse electric locomotive No.1 outside the workshops at Neasden. It has its original spring-loaded shoegear but it was not fitted with tripcocks. This locomotive was basically a prototype. The rest of the batch entered service with modifications. Photo: Street Railway Journal, April 1905.

[1] The late Ken Benest wrote a good history on the Metropolitan's electric locomotives, 'Metropolitan Electric Locomotives' first published by Lens of Sutton and LURS in 1963. An improved second edition was published by LURS in 1984.

THE LOCO BODY

The Metropolitan's new locomotives were in the 'camel back' format, having a large central cab with sloping bonnets on either side (Figure 1). The design was 'fashionable' at the time. It was based on various earlier designs of electric locomotive that had a central driving position between the bonnets where most of the equipment was fitted. The need for a single driving position was because the early designs had full line voltage controllers, where the motor current passed through the controller. Because of this, the controller had to be large to carry the pretty hefty motor current. Since there was no mechanism for the remote control of the motors, there could only be one controller in the loco. The camel back design was intended to allow the loco to be driven in either direction from the middle so as to avoid the need to turn the loco at each terminus. The driving position wasn't ideal but workable, it was thought. For the Metropolitan, this was to prove a mistake.

Once multiple unit control became available (from 1895 in the US and 1901 in the UK), the master controller could be miniaturised and the huge, centrally positioned controllers abandoned. It was also possible to control the motors remotely. This would allow the motors to be controlled from more than one driving position. A multiple unit train could be driven from either end. This meant that the central driving position on a locomotive was no longer essential. However, for the Metropolitan, this realisation came too late and the driver was positioned in the centre of his machine.

WHAT ABOUT THE DRIVER?

Trials with the first locomotive in June 1905 quickly demonstrated that the central driving position wasn't workable. The layout of the controls meant that the driver had to look to the left or right from his position in order to see where he was going (Figure 2). And, placing the controls in the middle of a large cab, some 16 feet away from the couplings, was just not sustainable for locomotive operations. Drivers couldn't see to be able to operate safety, particularly for shunting and coupling, essential to locomotive operations. The Metropolitan's technical consultant, Thomas Parker, had already raised the issue back in April 1905 but no one seems to have taken any notice so, when the trials showed the problems, requests were made to Westinghouse to change the layout. They were not too happy about it as they had already had the design approved but regardless, the remainder of the order was modified so that the driver's controls were duplicated on either side of the central cab on the nearside in the direction of running, next to the cab doorways. At the same time, the main switchboard seems to have been removed from its position in the centre of the cab and replaced with two, one at each end next to the driving position.

LOCOMOTIVE EQUIPMENT

The building of the locomotive bodies was subcontracted by British Westinghouse (BW) to our old friends the Metropolitan Amalgamated Railway Carriage & Wagon Company of Saltley, Birmingham. The work was split between their Old Park works and Saltley and, when the bodies and bogies were completed, the locos were sent down to Neasden where BW staff fitted them out with all the electrical equipment.

The air supply for the loco came from a Westinghouse 8G2 compressor hung in a cradle beneath the underframe and this supplied the air for the Westinghouse brake system as well as the electro-pneumatic control. The main and auxiliary reservoirs, together with two vacuum reservoirs for the vacuum brake were mounted inside the cab area. Both brake systems were needed because of the different brakes used on the old and new stocks. A single air brake and two vacuum cylinders were under the loco. With the compressor down there as well, there was little room for anything else.

For the vacuum brake, two Gresham and Craven electric exhauster pumps were fitted, one under each bonnet (Figure 2). One ran at full speed and one at half speed. The full speed one was switched in by the driver to get a rapid release of the brake after an application, while the second ran continuously to maintain the vacuum against small leakages in the vacuum brake pipe.

As built, these locomotives were designed to a Bo-Bo axle configuration with a Type 86M British Westinghouse motor on each axle. These motors were more powerful at a nominal 200 hp than the 150 hp Type 50M motors used on the BW motor cars of 1904-05 Stocks but, when it came to train operation, the 6-car saloon stock train was, with 1,200 hp, more powerful than the locomotive hauled train that had only 800 hp in total. This could have restricted the locomotives' capabilities so, for the original design, it

was decided to uprate the motor power by force cooling the motors with an air blower to reduce the temperature when the motor was being worked hard.

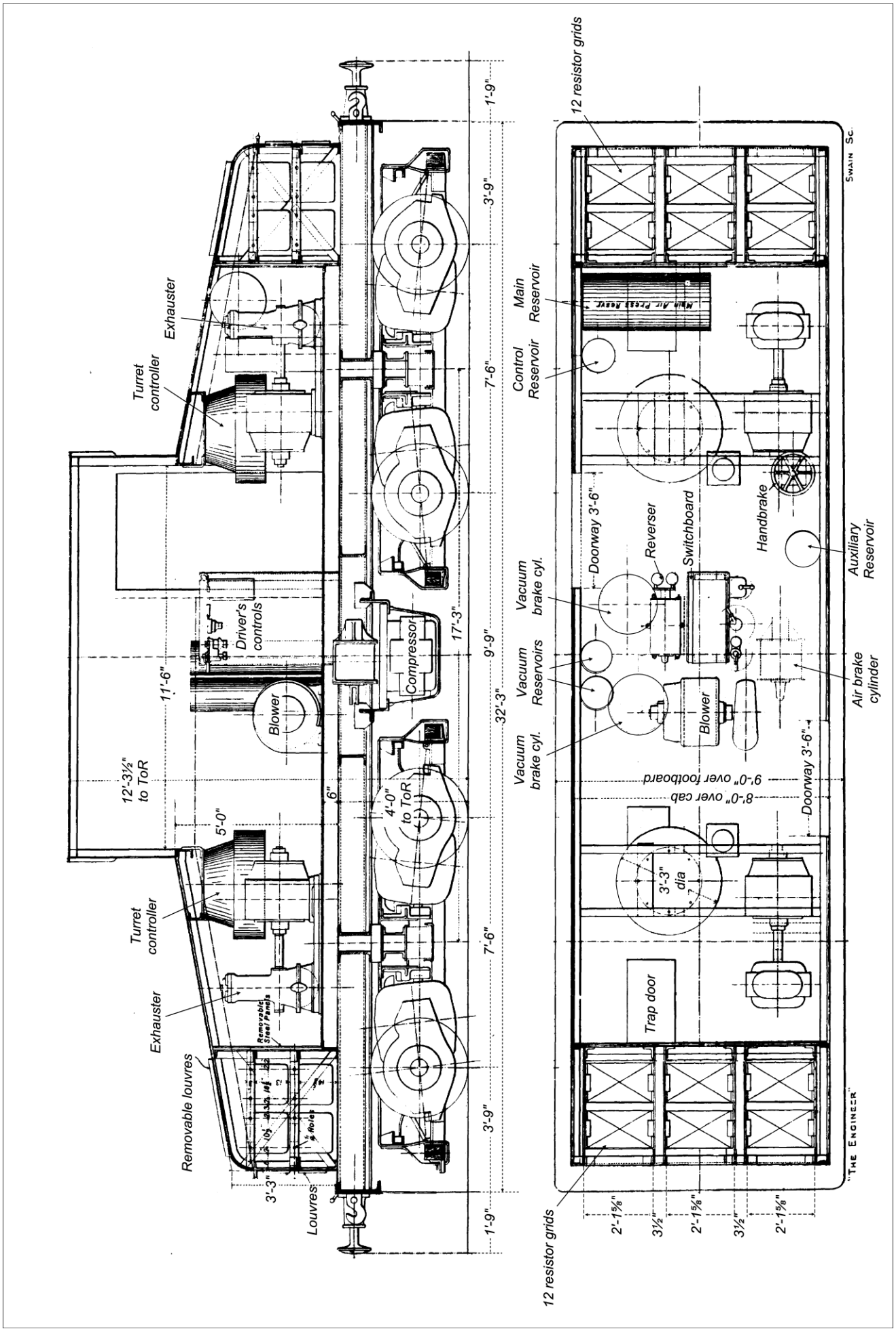

Figure 2: A drawing of the original layout of the Metropolitan' s BW locomotive No. 1. It was equipped with two sets of traction kit but only one set of driver' s controls in the middle of the locomotive cab. This was soon altered to two sets, one at each end. Drawing: Originally from ' The Engineer' , September 22, 1905, p. 282 and modified by P. Connor.

POWER PROBLEMS & BAKER STREET

Interestingly, the shortfall in the power of the locomotive was due to a perceived problem with the Metropolitan's infrastructure. The original design was for a 6-axle machine that would have offered equal power with the saloon stock. The design envisaged 2 x 3-axle bogies (a Co-Co arrangement), allowing six motors. However, Benest, in his book on the locomotives, tells us that the wheelbase for this machine would have been too long to fit on the sector table in use in the bay roads at Baker Street station at the time of the design (Figure 3).

Looking at the sector table, it is worth recalling here the methods used to turn round trains with locomotives at terminals, especially since it is rarely seen nowadays except on heritage railways. Baker Street is a good example since it had a difficult layout in a cramped space and they used two methods there. Baker Street originally had two stations, one on the original alignment of the present-day Circle Line under the Marylebone Road and one for the St John's Wood line, known as Baker Street East.

The 'East' part of the name was misleading as it was actually north of the original station. It was dropped after the station was rebuilt in 1912-13. A quick look at the layout of the old station demonstrates how awkward it was to operate a frequent service with locomotive haulage (Figure 3).

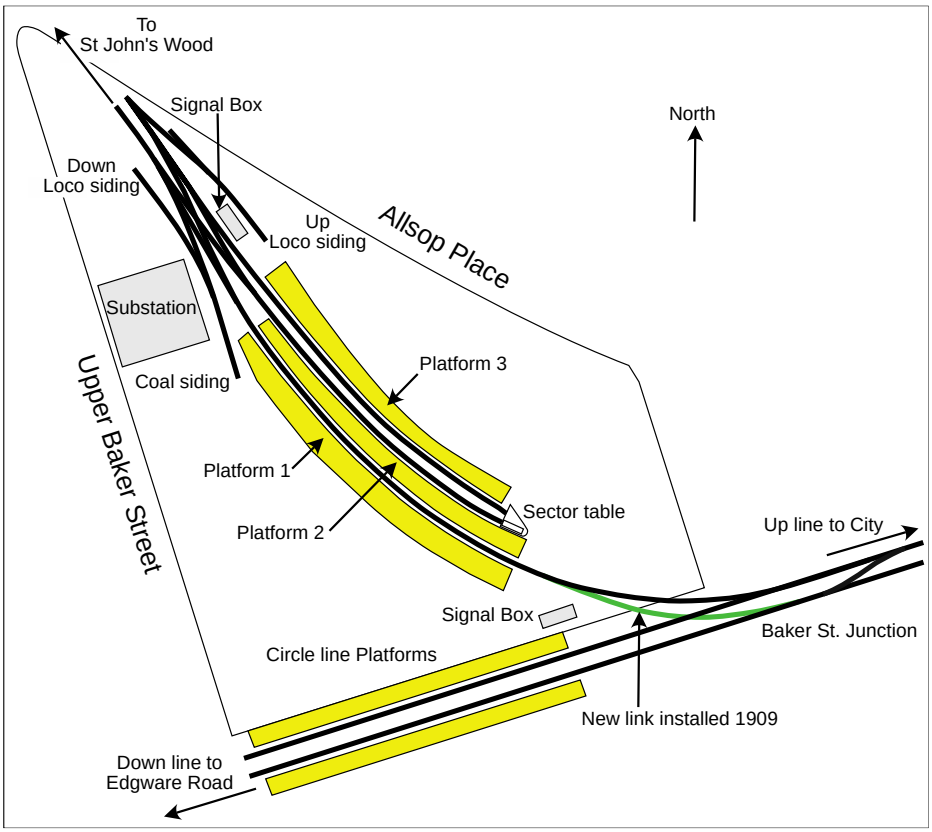

Figure 3: Map of the layout at Baker Street station, Metropolitan Railway in 1909. The sector table can be seen at the end of the tracks between Platforms 2 and 3. The single through track was connected only to the Up line until 1909 when the connection from the Down line (shown in green) was added. Drawing: P. Connor.

A transfer, or 'sector' table was provided at the ends of the bay platform tracks (Nos. 2 & 3) to allow locomotives to change ends on arriving trains. The table allowed a locomotive to be uncoupled from its train, then moved onto the sector table, which was then turned to an angle to align with the adjacent track so that the locomotive could be run up the adjacent track to the other end of the platform to reach the crossover and then back onto the train.

The sector table was one way of turning trains. The other was the one-track solution, requiring two locomotives. This solution would have the arriving train uncouple its locomotive when it arrived, after which another locomotive would attach to the other end of the train.

When it was time to leave, the second locomotive would haul the train away, leaving the arriving locomotive free to move to one of the loco sidings and wait for the next train to arrive. It would then repeat the role of the second locomotive. The problem at Baker Street was that the location of the loco sidings required double or even triple shunt moves. These effectively shut down the exits from the terminus while the moves were being made.

Some of the timetabled turnrounds for locomotive hauled trains were very tight, as low as 4 minutes during peak hour operations[2]. When electric multiple units began entering service in 1905, reversing became so much simpler; the crew just had to change ends. They were allowed 3 minutes. With the reduction in locomotive operations, it allowed an improved frequency of trains on the Extension line.

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[2] A.C. Ellis, the Metropolitan's then General Manager, once suggested publicly in a fit of excessive enthusiasm that, with steam, a train could be turned round at Baker Street in 2 minutes and, with an electric loco, in 1 minute. Source: *The Electrician*, August 23, 1907. Vol 60, p.758. In the words of a famous tennis player, "You cannot be serious".

Up until 1907, the direct connection between Baker Street East and the 'Main' line to the City was only to the Up line. It was used for empty stock and light engine movements. Stock requiring to get to Edgware Road and other places west had to shunt over the trailing crossover east of Baker Street Junction. For a short time from 1907, a few passenger trains were worked through to the City but the return trips required a back shunt from the Down 'Main' line over the crossover and this move was just too time consuming to make the timings viable. A direct connection to the Down line, as shown in green in Figure 3, was put in in 1909 to facilitate through traffic. This allowed a peak period through service to the City of roughly five trains per hour.

The restriction of the sector table length at Baker Street forced the final design to be limited to four axles so that the total wheelbase was kept down to 24ft 9ins. The locos had two Fox's bogies with pressed steel frames reinforced with steel plates, angles and gussets on a 7ft 6in wheelbase. This was six inches longer than the standard 7ft 0in wheelbase of the Saloon Stock bogies. Wheels were 38 inches in diameter, as opposed to the 36-inch wheels of the Saloon Stock.

One might be forgiven for thinking that the restriction of the locomotive length caused by the sector table at Baker Street was the tail wagging the dog. Logically, the single track, two-loco turnround operation was much the better option and a simple review of the process at terminals would have led to the idea that the sector table could have been abandoned and that a 6-axle locomotive specified. On the other hand, a 6-axle locomotive would be more expensive and, with the variety of sharp curves on the Metropolitan system, a bogie with three axles would certainly cause more rail wear than a 4-axle design. With all these considerations, force cooling was, perhaps, the most cost-effective solution.

BLOWERS

The force cooling for the motors was, in the original design, supposed to obtained with a single blower mounted in the main cab of the locomotive. This was connected by 3-inch flexible trunking to each motor, passing through the locomotive floor[3] into ducting arranged between the structural members of the locomotive underframe. The air pressure was only 4 ounces per sq. inch. The blower motor was fitted with a resistance which could be switched into a shunt connection with its field coils, so that its speed could be increased by 25% and the pressure of the air increased to 6 oz. per inch[4]. This arrangement was supposed to be used when the motors were working hardest.

One could suppose that the engineers who designed this arrangement were confident that the drivers would know when to shunt the blower motor to get it up to the higher speed but this was never going to happen unless some automatic system was applied and we have no evidence that it was.

Benest, in his book on the locomotives[5], reports that a blower was only fitted to No.1 of the order and that the rest of the fleet weren't fitted with them. Curiously, the Metropolitan's Appendix to the Working Timetable dated August 1921 shows that control switches for blowers were fitted to some of the later versions of BW equipment in use at the time but not to the first ten BW locomotives.

The same document has a sketch of the equipment layout of the locomotives but it doesn't show the location of the blowers, neither does it show them on the other BW equipped vehicles that had them. From the currently available evidence, we could deduce that Loco No.1 had a motor blower but that the design modifications to the remainder of the batch during manufacture excluded them.

TRACTION SYSTEM

The new locomotives were all fitted with Westinghouse turret controllers like those in the BW Saloon Stock but, unlike the Saloon Stock, each pair of motors had its own turret controller and resistances, so they were effectively 'double-equipped'. The equipments were both controlled from one master controller. The arrangement also differed from that of the saloon stock in that automatic acceleration wasn't provided so trains had to be 'notched up' by hand.

There is no evidence of what was done in the way of alterations to the master controller nor of the additional positions that were added to the controller handle (if any). According to contemporary descriptions, the alteration was required because the locos were often used on slow moving shunting operations requiring moderated speed control.

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3 Drawings of this arrangement were published in 'The Engineer,' 22 September 1905, p.295.

4 Street Railway Journal, Vol XXVI, No.9, 6 August 1905, p.314.

5 Benest K., (1984) 'Metropolitan Electric Locomotives' LURS 1984, p.11.

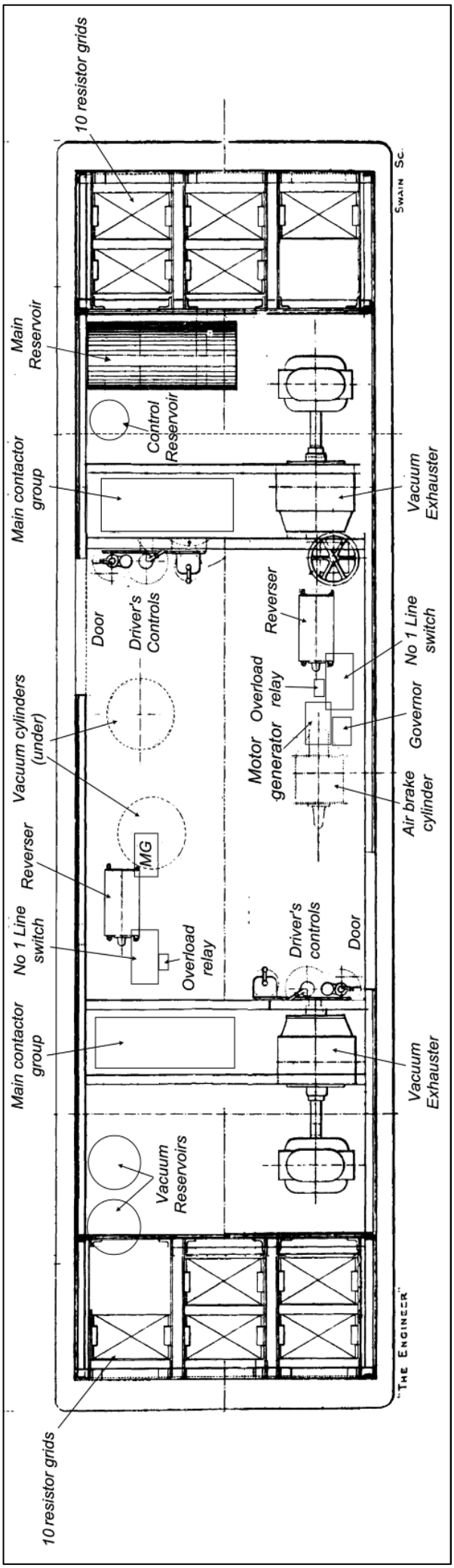


Figure 4 (left): The rearranged layout of a BW locomotive interior is shown here, using the original drawing (Figure 2) with alterations added as sketched out in the Metropolitan Railway's 1921 Appendix to the Working Timetable and some attempted corrections by me. We know that a number of changes were made compared with the original design of 1905. The driving controls were duplicated and positioned as shown here on all locomotives built after No.1 was delivered. The original switchboard was moved and replaced by two, probably one to the right of each driving position. The two turret controllers were replaced by conventional contactor groups in 1911. At the same time, the vacuum reservoirs seem to have been moved towards the resistor grids at one end of the loco, even though there was still room for them in their original location. The resistor grids are shown to have been reduced from 12 to 10 per set of traction equipment. The motor generators were added in 1908 to replace the batteries originally used for the control system. The location of the auxiliary reservoir is not defined. It is obvious that the 1921 sketch is not that accurate so it is difficult to confirm locations of equipment now but it looks as if some alterations took place during the 1911 replacement programme and that this was reflected in the new arrangements. The 1921 Appendix refers to locomotives being 'rewired', so we can assume there were some electrical alterations. We might also consider that the original drawing provided in 'The Engineer' journal was not accurate in terms of what was actually built. Drawing modified by P. Connor.

In reality, it was perfectly possible to manually accelerate a train that had automatic acceleration controls. It required some dextrous manipulation of the controller handle but it was soon learned with practice and, in my driving days, I often used it if rail adhesion was bad.

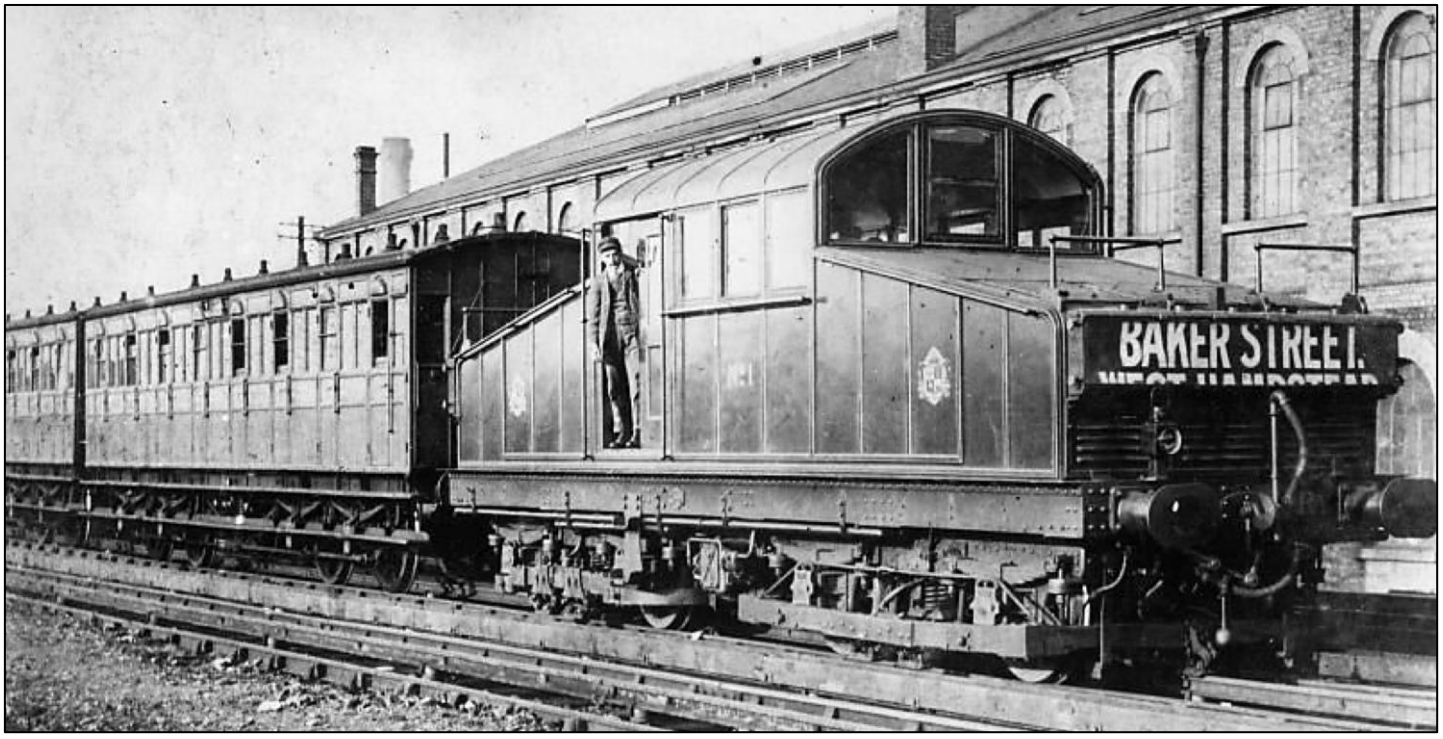
The driving controls consisted of the master controller, valves and gauges for the operation of the two braking systems and, according to Ken Benest, controls for the sanding gear. The drawing doesn't show any sanding gear and it's not visible on any photos either but it was fitted to the later BTH locomotives the Metropolitan acquired and it is reasonable to assume these locos had it too. It is also likely that there was an ammeter to indicate the motor current to the driver.

Like the 1904-05 motor cars, the locos had brake rigging of the inside type, with one block per wheel, but described as being of a more robust design in case operation was needed by both power brakes simultaneously. Collector shoes, with springs, were arranged more logically than on the motor cars. A positive shoe was hung at each end of a transverse wooden shoebeam, plus a negative shoe in the centre, with one beam at each end of each bogie.

As with the saloon stock, problems arose with the shoegear and the turret controllers. Both were eventually replaced. The shoegear was done first, in 1906, after the saloon stock but the turret controllers followed rather later in 1911. The shoegear went through a number of iterations before they got to a sensible design. Figure 5 shows two versions and later, after a means of mounting the negative shoes on the bogie frame was evolved, the short beam for

the positive shoes extending only between the axle-boxes was standardised. A feature of the shoegear on the locomotives was that the positive shoes were duplicated on each side of each bogie.

Figure 5: Metropolitan BW locomotive No.1 at Neasden Depot with two different types on shoegear. The leading end bogie has the first modified version that was applied to most, if not all the locomotives from 1906. The rear bogie has a later version that had wooden beams with curved extensions added so that the negative shoes could remain in the correct position underneath. A third iteration had what we would regard and conventional arrangement with wooden beams hung from the axleboxes with separate wooden beams on the bogie for the negative shoes. The train behind the locomotive is of the old 'rigid' stock. The photo was taken before mid-1907 since there is no evidence of tripcocks on the leading bogie. Photo: LT Museum.



More alterations seem to have been made, probably when the turret controllers were replaced with conventional contactor racks. There is some doubt about exactly how things were arranged but the sketch provided for staff in the 1921 edition of the Appendix to the Working Timetable gives some impression of a number of changes. What we have been able to deduce is shown in Figure 4 but the layout shown in the Metropolitan's sketch creates some unanswered questions. The sketch was not well done and showed some obvious errors. Apart from leaving out the location of the motor blowers, it swapped the position of the main reservoir and the exhauster at one end. The rearrangement I have prepared can only represent the most obvious layout, given the information currently available.

CORRECTION

My apologies, there was an error in Article 2 of this series (see *Underground News* No.746, February 2024). Near the end of page 121, I included a list of train formations for the 1904-5 fleets. The 3rd & 4th lines of this list should read:

1 x 6-car trains of 1905 Stock with vestibuled ends and including 2 x 1904 3rd trailers.

13 x 6-car trains of 1905 Stock with vestibuled ends.

To be continued …