LONDON UNDERGROUND SIGNALLING
A HISTORY
by Piers Connor
10. THE DISTRICT'S NEW SIGNALLING

DOWN TO BUSINESS

With the installation of the prototype Westinghouse supplied signalling system on the Ealing & South Harrow Railway (E&SH) under way, eyes turned towards the resignalling of the District's main lines but surprisingly, the company did consider trying another supplier, the British Pneumatic Railway Signal Company. This company offered a low pressure automatic system using track circuits but operating signal arms and point machines almost entirely pneumatically. A single electro-magnetically operated valve operated an air supply network for each signal or set of points. They used a pressure of 15 pounds per sq. in. (psi) as opposed to the 65 psi used for the Westinghouse system. The low pressure system was installed on the London & South Western Railway (LSWR) main line between Andover and Grateley in the summer of 1901[1]. The LSWR liked it enough to go on to buy more of it for Salisbury, Staines and the main line between Woking and Basingstoke but it was not favoured by the American experts working for the District. The Westinghouse system worked well enough and they stuck with what they knew. They signed a contract with Westinghouse in February 1904.

SIGNAL DESIGN

The E&SH trials had used the existing semaphore signals but, for the main line installations, new semaphore signals were erected for the open sections. In the tunnel sections, a major requirement was to get signals that would fit inside the tunnels between stations. Semaphores were still used for many station starters but a new form of aspect changer was needed for places where clearances were tight. The solution turned out to be similar to the design used on the City & South London Railway (C&SLR) extensions, where a spectacle plate with two lenses was moved up and down in front of a lamp to change the signal aspect. The new design was very compact and could be mounted on a sleeper end in the six-foot between two tracks (Figure 1), with room left for the trainstop arm between the signal and the right hand running rail.

Tunnel signals were lit by gas lamps but they also used oil lamps in some locations. The old signals being replaced were apparently supplied from a gas main in the tunnel and this was used to supply the new signals. It is recorded that the oil lamps were only back-ups[2] but there wasn't room for two lamps in the design and some photos show what appears to be a gas pipe and burner (Figure 1). Another photo shows a new signal with an oil lamp, so there appears to have been a mix of both. In any case, with either type the lamps had a tendency to get blown out by the draughts from passing trains so they were all replaced by electric lamps within a few years.

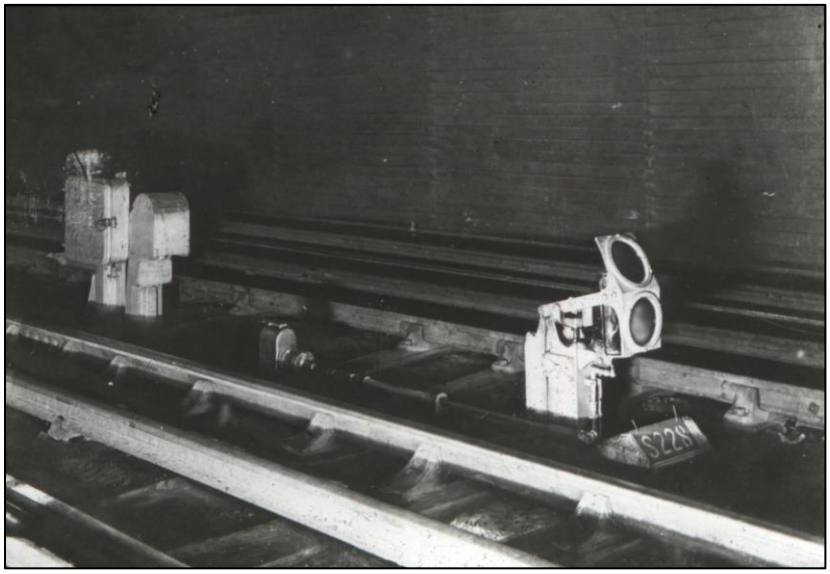

Figure 1: An automatic signal as originally installed in District Railway tunnel sections; this one is fitted with a gas lamp and is believed to be on the eastbound road near Mansion House. 'Auto' signals were numbered with an 'S' prefix until District signals were renumbered into the 'A' series in the 1930s. The numbers were also altered then so that even numbers were on the westbound road and odd numbers on the eastbound road. The signal is currently showing a green aspect. The spectacle plate will drop to show the red aspect. The relay box and air valves can be seen in advance of the signal. The trainstop operating valve and arm can just be seen next to the running rail. Photo: Courtesy Westinghouse Archive & Chippenham Museum.

1 Raynar Wilson, H. (1909), '*Power Railway Signalling',* Railway Engineer, London, p.239.
2 Horne, M.A.C. (2019), 'London's District Railway Vol. II', Capital Transport Publishing, London, UK, p.84.

It seems strange to me, looking at the colour light design available on the Waterloo & City Railway (W&C), courtesy of W.R. Sykes, that it wasn't adopted on the District. It was more compact than the Westinghouse arrangement and it was electrically operated and it used electric lamps[3]. However, it seems that, as it wasn't in the Westinghouse design range imported from Boston, it wasn't even considered. Within a few years, this was to change, as we will see in a future article.

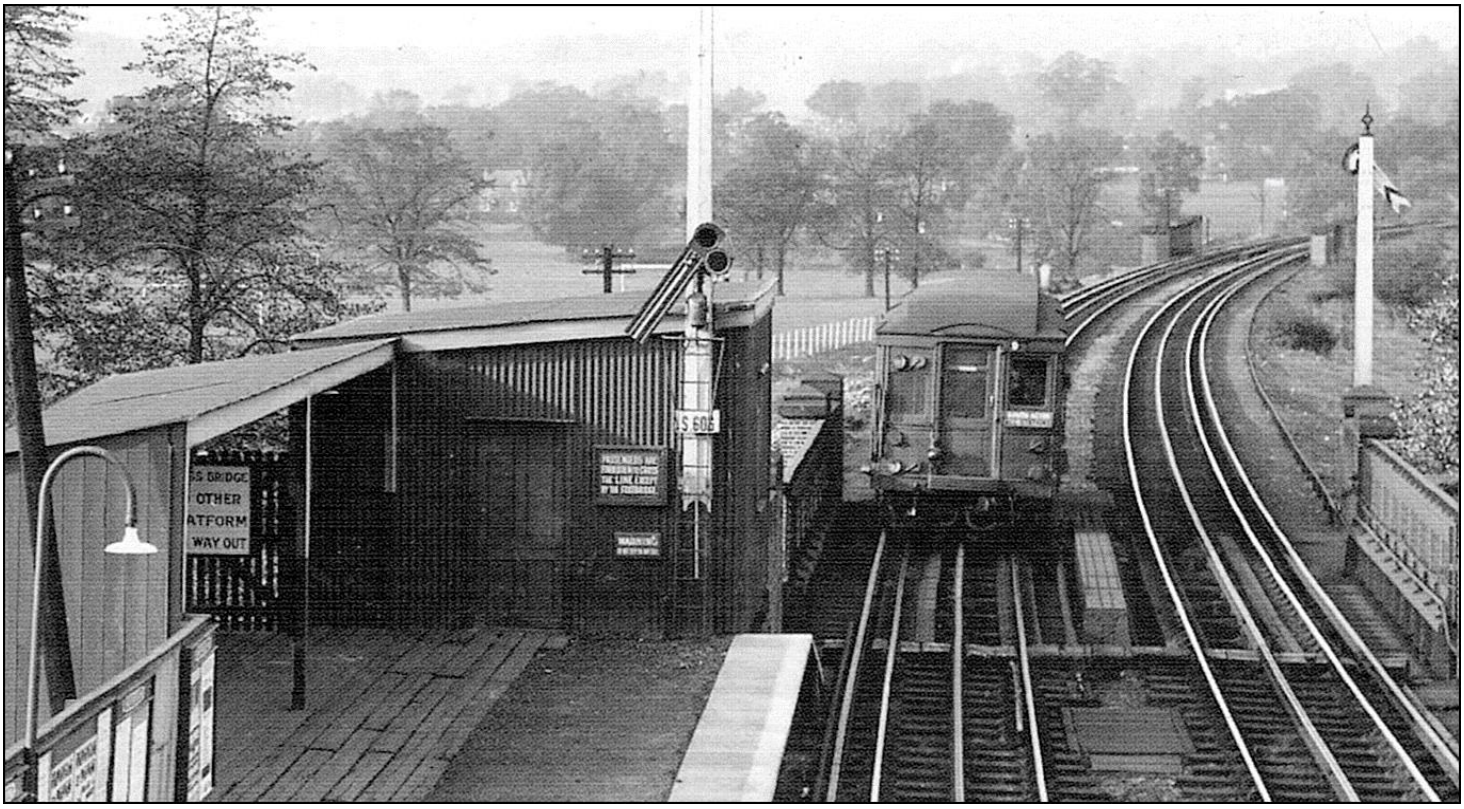

Figure 2: A single, middle motor car train of District 1905 Stock leaving Park Royal & Twyford Abbey, looking west towards South Harrow sometime in the 1920s. The original experimental signalling has been updated. The starting signal has a new semaphore arm and operating cylinder and it shows the white horizontal stripe provided on the arm to denote that it is an automatic signal. Although the train has passed the signal, it still displays a proceed indication because the train is still in the overlap. Modern Underground installations have additional track circuits that cause the signal to return to danger as soon as the front of the train passes it. Note the repeater signal on the other track automatically displaying that the staring signal is off. Photo: Author's collection.

The outdoor signal design was modified from that used on the E&SH. Instead of being near the base of the post, the air cylinder and operating valve were mounted near the top, close to the semaphore arm, so that the operating rod was shorter and less likely to expand or contract with changes in temperature. The arms were originally painted plain red on the automatic signals (Figure 3) but with the traditional white square added on the semi-automatic signals controlled from signal boxes. Soon after installation, the automatic signal arms were provided with a thin horizontal white stripe to denote that they were automatic (Figure 2). Automatic signals were numbered with an 'S' prefix, e.g. S606.

DISTANTS AND REPEATERS

The installation of the new automatic signalling presented some problems for the working of 'foreign' trains over the District and for the District working over foreign lines. In the latter case, the line between Richmond and Studland Road Junction, west of Hammersmith, was owned by the LSWR and the District had running powers over it to get to Richmond and onto their own branch from Turnham Green to Ealing. The same arrangement applied to the line between East Putney and Wimbledon. Neither of these sections was equipped with the District's automatic signalling nor trainstops and the trains operated under lock and block rules as they had done in steam days. Even without the automatic train protection of trainstops, they were allowed to operate without a second person in the cab to verify signal aspects. This soon became the norm for electric trains on main line railways.

The Midland Railway had a coal yard behind West Kensington station and their access to it was along the District from Studland Road Junction. The coal trains were heavy and not continuously braked, so their drivers needed early warning of the condition of signals ahead. To provide this, the signals along

[3] I described it in detail in Article 5 in this series (*Underground News, No. 704*, August 2020).

this section were provided with distants (Figure 3) that worked automatically in conjunction with the stop signal they repeated. These appear to have been the only distants provided for the original installation. In reality, they were automatic repeaters, rather than conventional, separately operated distant signals as used in mechanical block signalling.

More repeaters appeared from late in 1906 but these were in the tunnel sections. They were installed following the Board of Trade inspection of the signalling between Blackfriars and Minories Junction. The inspector, Major J.W. Pringle, discovered that motormen, when driving at normal speed, found that they needed to apply the emergency brake to avoid overrunning certain stop signals along the section and that to avoid this, they were driving at reduced speed.

There must have been some discussion between the District and Pringle about introducing repeating signals to overcome this problem and allow trains to run at line speed because, in his report on his inspection, Pringle mentioned that, if the company wanted to introduce repeater signals, they would have to apply to the Board for approval[4]. They did want to and they did apply and they also decided to introduce the yellow aspect for such signals in place of the red used previously. Doubtless, the yellow was inspired by the Boston practice of using yellow repeaters. Repeaters were quickly installed where required in the District's tunnels and it was announced that this work was completed on 17 March 1907[5]. The yellow colour was applied later to the signal arms for those semaphore type repeaters provided on open sections of the District but it was to be another 20 years before it became the norm in Britain. The District was a pioneer in this respect.

Figure 3: A new automatic home signal with an automatic distant on the approach to Barons Court eastbound District road. Both signals were painted red, with the usual fishtail on the distant signal. Both signals showed red and green aspects at night, in accordance with the convention of the time. The trainstop for the stop signal can just be seen to the right of the track. The date of the photo is believed to be 1905. The Piccadilly Line tracks can be seen under construction on the left hand side. At the time, the District had the two southern tracks and the Piccadilly Line was to use the new tracks on the left to give them access to the existing terminal platforms at Hammersmith. In the background, the big wheel of the Earl's Court exhibition site can be seen. The use of a distant signal here was a special requirement because of the operation of Midland Railway freight trains to the coal yard at West Kensington. It was not required by District trains, which would normally stop at Barons Court but the heavy and largely unbraked coal trains required early indication of the starter because of their poor braking capability. The District did not use repeater signals until shortly after this signal was installed. Photo: Courtesy Westinghouse Archive & Chippenham Museum.

Small electric colour light repeaters were also installed on station platforms where sighting was poor to indicate the aspect of the starting signal to assist station and train staff during train dispatch. The idea came from the Great Northern & City Railway where they were introduced in 1904 (Article 7). They were provided with yellow and green aspects. Some of these little signals were very long-lived and a number of them are still to be seen around the Underground (Figure 4). The

[4] Westinghouse, (1955) 'The Jubilee of Automatic & Power Signalling on London Transport Lines', The Westinghouse Brake & Signal Co., London, p.11.

[5] ibid.

yellow aspect on the oldest examples actually looks rather orange and it seems that they were originally described as orange[6], something that would be considered almost a certifiable offence today

There was some criticism of the use of yellow for repeaters. In a paper to the Institution of Electrical Engineers in March 1915[7], W.C. Ackfield, Signal Superintendent of the Midland Railway, suggested that although yellow was a suitable colour for the low speed operation of the Underground "under the best conditions of atmosphere it is hardly an ideal signal colour. It is true that it can be seen farther than red or green, but it does not show the colour distinctly until comparatively near". Although some railways adopted yellow from around 1914, his attitude persisted on many main line railways until yellow was finally mandated by the Ministry of Transport in 1925.

Figure 4: A platform repeater of the 1906 design as seen on the District Line at Putney Bridge. This is a two-aspect repeater provided for the station and train staff to give them sight of the starter aspect before train dispatch. These became known as 'coffee pot' signals because of their design style. They offered two aspects, green, if the starter was off and yellow if the starter showed a stop aspect. Photo: B.R. Hardy.

TRAINSTOPS

For the District's main line, the train stops were of a new design. The use of a balance weight to restore the trainstop to an upright position, as used on the E&SH (described in last month's article), was discarded in favour of a long spring. This seems to have been because there wasn't room for the movement of the balance weight in the tunnel and it was also too close to the shoegear of the train[8]. After the experimental left hand positioning on the E&SH, the trainstop was now positioned on the right hand side of the track. In the E&SH examples, the electromagnetic valve operating the train stop was mounted separately from the air cylinder but it was integrated with it for the production version (Figure 5). The cylinder, the operating rod and the trainstop arm itself, were normally mounted on the sleeper ends near the right-hand running rail. It was a neat design, being mounted on a steel plate that could quickly be bolted to the sleepers and then 'plumbed in'. It was soon described as a "Long Tom"[9]. I think the main disadvantage was that it was rather exposed to the weather and it could be prevented from operating correctly if any rubbish got in the way of the mechanism. And, being mounted over four sleepers, it was also vulnerable to twisting from sleeper movement generated by passing trains.

Figure 5: District Railway "Long Tom" trainstop as installed in 1905. It is mounted in the now standard right hand location. The trainstop arm is in the up position. The electro-magnetically operated pin valve is housed in the round topped box at the rear of the small operating cylinder. Next comes the push rod with the spring used to raise the arm to the up position when the signal is on. This type was fitted in both open and tunnel sections of the District.

Photo: Courtesy Westinghouse Archive & Chippenham Museum.

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6 Horne, ibid.

7 Acfield, W.C., 1915. Development of main-line signalling on railways. *Journal of the Institution of Electrical Engineers*, *53*(249), pp.763-784.

8 The 550 volt traction supply used on the experimental E&SH installation was raised to 600 volts for the District's main line electrification.

9 The nickname 'Long Tom' is said to have originated in the US military in the 1850s and was adopted for a number of types of large, long barrelled artillery pieces including some used in the Second Boer War (1899-1902) and both World Wars.

Main line electric train services began operations between Ealing and Whitechapel on 1 July 1905 and other services were electrified gradually over the next few months until District steam was eliminated on 4 December. Since the new signalling, which included the modernised version of Harold Gilbert-Brown's Boston polarised track relays, was installed in stages between March 1905 and May 1908, it meant that the new electric trains, with only one man in the cab, were being operated for some months in the tunnel sections under block telegraph regulations without trainstop protection, something which we would rather frown upon today.

The two-track section of line owned by the LSWR between Studland Road Junction, west of Hammersmith and Turnham Green became somewhat congested soon after electrification and it was eventually decided to build two separate tracks for the District on the south side of the existing line. These were equipped with the Underground's automatic signalling system and a new signal box was built for the District junction at Turnham Green. A new District station was also built at Stamford Brook.

After the formation of the London Passenger Transport Board in 1933, there was a concerted effort to regularise many of the operating and technical anomalies in a number of areas, including signalling. As a result, trainstops were installed at running signals on the Wimbledon and Richmond branches. They were brought into use on the Wimbledon branch on 11 August 1935 and between Acton Lane and Kew Gardens on 6 October 1935. Work at Richmond was completed on 19 September 1936.

SIGNALS AT JUNCTIONS

Signal boxes at all the major junctions on the District were to be equipped with new power signal frames. These were equipped with miniature levers that were connected to the points and signals by electric circuits operating magnet valves. The interlocking was still mechanical but the frame was above the floor instead of below, based on a Union Switch & Signal (US&S) design, which had first been imported into Britain in 1899 and installed in London at Granary Junction on the Great Eastern Railway[10]. This installation had small vertically rotating handles in place of levers (rather like a table top football game) and the locking frame was laid out horizontally on a table behind the levers.

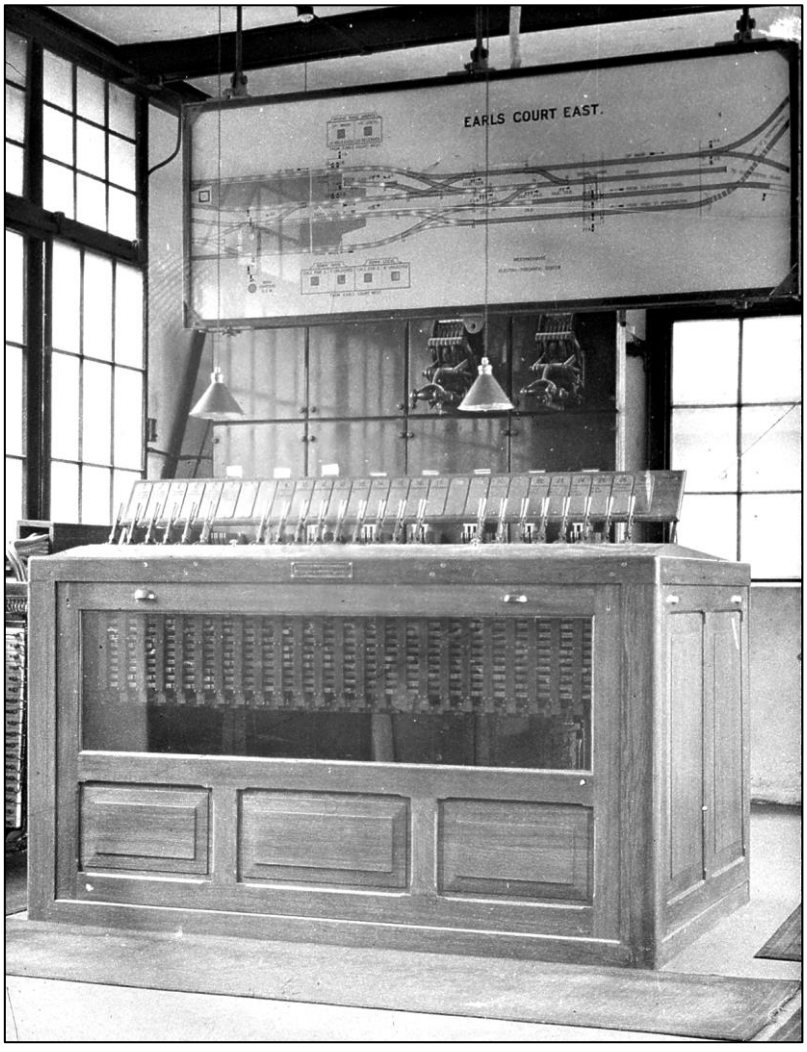

Figure 6: The interior of the new signal box at Earl's Court East before it was fully equipped in November 1905. The train describer system is not yet installed and there is no sign of a telephone. The box was erected on a gantry structure over the tracks at the east end of the station. The lever frame is an early version known as Style B in the Westinghouse catalogue. The miniature levers can be seen above the locking frame, which is visible through the glazed front panel. There were 27 levers and the frame was recorded in the Westinghouse list as No.45. The diagram of the layout is suspended from the ceiling and was arranged to repeat the switching of the track circuits on and off to show the passage of trains. Track circuits would be illuminated if unoccupied and would go dark if occupied. The inclusion of signal aspects on the diagram was a later addition. The track layout has been altered since this time. Photo: Courtesy Westinghouse Archive & Chippenham Museum.

The Granary Junction locking frame was based on a design first patented in America in 1889 by James T. Hambay on behalf of US&S. British operators didn't like the rotating handles so the frame was redesigned with miniature levers by Walter Allan Pearce of Westinghouse. It proved to be a neat and successful modification that

[10] Nock, O.S. (2006), 'A Hundred Years of Speed with Safety', Hobnob Press, Salisbury, UK.

was adopted for large numbers of signal frames installed across Britain over the next 40 or so years. Pearce also redesigned the locking frame so that it operated vertically instead of horizontally. This was done to reduce the space required by the frame (Figure 6).

Another innovation was the use of illuminated track diagrams, showing the occupation of track circuits as trains passed through the area of control. This was the idea of the Underground group's signal engineer C.E. Strange and a prototype was designed for him by Bernard Hartley Peter, the District's signal engineer for the new installation[11]. The early production examples were made up of small illuminated strip lamps fitted behind the track display diagram, creating a mottled appearance[12]. The displays were made with glass screens where, at first, they had to paint the diagram on the back in reverse but this was very time consuming and soon the design was modified to make it easier. The modified diagram was made up with a paper plan fitted between two glass sheets. The parts showing the track circuits were cut out, leaving clear sections illuminated by small lamps wired in parallel and mounted at the rear. A problem with this design was the reflection in the glass from lights in the signal box or from bright outdoor light. Some relief from this was introduced in the 1930s by using a lightly acid washed glass for the front glazing[13].

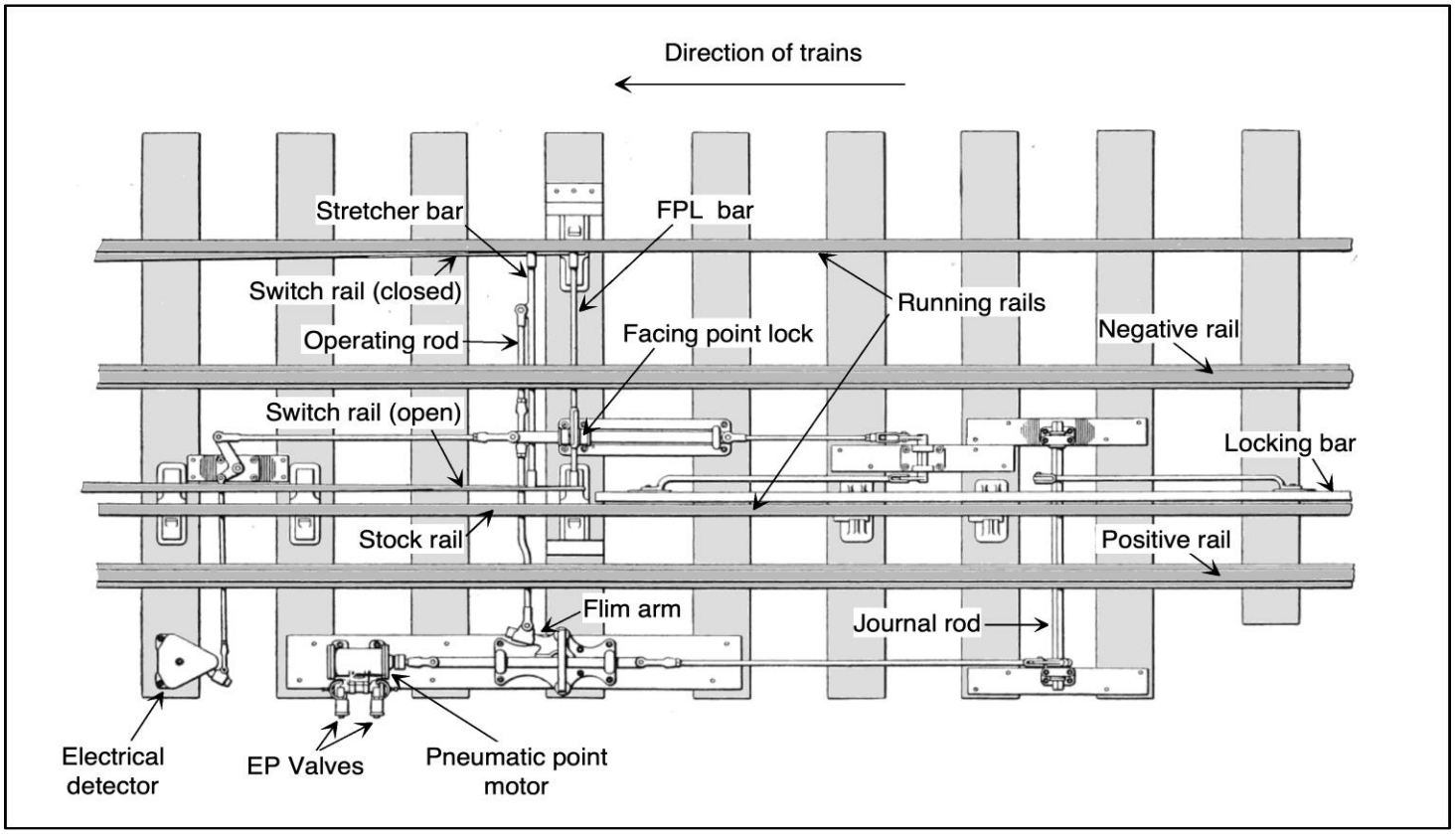

Figure 7: A drawing of a set of District Railway facing points of 1905 with a pneumatically operated drive supplied by Westinghouse mounted on a Sykes type locking arrangement. The air operating cylinder had two EP valves mounted on the outside of the cylinder, one for normal and one for reverse. This design is now very rare. The crank connecting the point engine to the operating rod is a modified version of the McKenzie & Holland 'butterfly' design. The position of the points was detected electrically by a detector of the Sykes type. The facing point lock (FPL) was of the standard Sykes design locked by the locking bar but driven off the point machine. Drawing from The Street Railway Journal, March 4, 1905, p. 415, modified by P. Connor.

Many years later, Peter told the story that, when the first new box was opened at Mill Hill Park in June 1905 with his new illuminated diagram, he had to work the frame himself to demonstrate to the overawed signalmen that the diagram really was showing the trains passing through the track circuits. At that time, this was the first semi-automatic signal installation on the District and the first time that the signalmen had to work with track circuits. Initially, signal status indications weren't provided on the diagrams nor point indications behind the levers but they were added later for new installations and upgrades.

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[11] B.H. Peter joined the District Railway in 1903 at the age of 17 years. He was entrusted with the management of the installation of the new signalling in the following year and in 1907 he became the Underground's signal engineer when Strange left to join Westinghouse. He followed Strange to Westinghouse in 1911 and later became Managing Director.

[12] Westinghouse, (1955) ibid, p.9.

[13] Dell, R., 1944. 'Developments in railway signalling on London Transport'. *Journal of the Institution of Electrical Engineers-Part II: Power Engineering*, *91*(23), pp.400-415.

POINTS

New, electro-pneumatic point machines, using air engines developed from those used in the U.S., were installed to power most of the main line points on the District (Figures 7 and 8). Many of the existing mechanical parts of the points were retained but the rods and mechanical connections to the signal boxes were removed and replaced by the new point machines with air valves to operate them and electrical connections wired back to the signal boxes to control them. As shown in Figures 7 & 8, the valves were mounted on the side of the motor but later versions had the valves mounted separately on a rack or on the tunnel wall and connected to the motor by hoses. The original type are now very rare – Northfields is a known location where one remains, though with the valves mounted separately and connected by hoses.

Figure 8: A set of District Railway facing points in 1905 with the pneumatic drive supplied by Westinghouse on the right of the track. All the parts shown in the drawing above can be seen here. Note the iron straps fixed over the locking in the four-foot. These supported wooden boards fitted over the top of the locking to protect it from equipment that might drop from trains. Note also the current rails are cut away and fitted with wooden fillets to allow clearance for the stretcher bars. Photo: Courtesy Westinghouse Archive & Chippenham Museum.

In all, the District's resignalling project involved the installation of 488 new signals, 410 track circuits and 14 new power signal frames. Some five emergency boxes were provided and another 11 boxes kept their original mechanical lever frames and mechanically operated points but the signals were converted to e. p. operation[14]. Original track circuit lengths were between 700 and 900 feet (213m – 274m) long. Overlaps were nominally set at 400 feet (122m) where possible.

To be continued …

[14] Horne, M.A.C. (2019), 'London's District Railway Vol. II', Capital Transport Publishing, London, UK, p.87.