LONDON UNDERGROUND SIGNALLING
A HISTORY
by Piers Connor
37. OPERATIONAL DEVELOPMENTS
CURRENT RAIL GAP INDICATORS

There are a number of features that have been added to the Underground's signalling system to provide the operator with indications, safeguards or recovery assistance when something goes wrong. In the category of additional indications provided by the signal engineer is the Rail Gap Indicator (RGI).

Figure 1: A superb photo of an illuminated Rail Gap Indicator at Hyde Park Corner. It is next to a standard disc type shunt signal. The RGI is illuminated because the traction current is switched off on the section ahead. The photo was taken during an inspection in non-traffic hours. Photo: Kim Rennie.

RGIs are provided at current rail section gaps to give the train driver a warning if traction current is discharged in the section ahead. It is important that a train does not enter a discharged section. The associated circuitry uses a 600 V 'current on line relay' connected to the traction current rails. Under normal circumstances, the indicator is unlit and the section ahead is live. Once the RGI is lit, it is treated in the same way as a red controlled signal – trains must not pass and they are not allowed to use the stop and proceed rule. The indicator is a signal with three 100 V lamps with red lenses in a triangular arrangement. A white front plate shows "RAIL GAP IND" in black letters. Repeaters may be provided where required for sighting reasons. These are the same signal but they use yellow lenses and are signed "RAIL GAP REP" on a yellow triangular plate (Figure 2).

The Underground's Traffic Notices for the time tell us that Rail Gap Indicators were first introduced in April 1917 on the Bakerloo Line. A year later they were commissioned on the Piccadilly Line and in August 1918 they appeared on the Hampstead Line. The Central London Line already had current on line indicators at substation gaps. When these were provided isn't clear but they would probably have been introduced quite soon after the line's opening in 1900. They were replaced by conventional Underground style RGIs in 1923.

Figure 2: A Rail Gap Repeater at Stockwell. When lit, it uses three yellow lights to show that the RGI ahead is lit. Repeaters are only provided where the sighting distance for the RGI itself is not sufficient to provide enough stopping distance. Photo: Kim Rennie.

In considering the design of the traction current feeding arrangements, substation gaps would usually be placed at stations so that a train wouldn't start from a station towards a dead section but if a substation current rail gap was located between stations, a co-acting indicator might be provided with the station starting signal in rear. Where a junction exists and only one route would involve a train crossing the current section gap, the indicator would have to be switched as required by the lie of the points. It is also important to remember that the positioning of running signals has to be considered so as to minimise the risk of the straddling of a gap by a stationary train standing at a signal.

ROUTE SECURE

A source of much irritation to railway passengers (and operators) is the "signal failure", stopping the train service. To get trains moving, someone, usually the station supervisor, has to trek along the line to the offending points and secure them by "scotch and clip"[1] so that train can pass over without the risk that they will suddenly move and cause a derailment. From the train driver's point of view, the cause of the signal remaining at red is unknown. Aside from a technical failure, there could be a train on the route ahead needing assistance. Whatever the reason, the result is a long delay to the train service.

Then, in the mid-1980s, "remote securing" of points appeared. This was originally an HMRI requirement for deep level OPO, so that it a Train Operator became incapacitated, a second train could quickly draw up behind and offer assistance. It was subsequently realised that it could also be used in the event of a partial failure of the signalling system, which is now its more common application.

The remote secure facility avoids the time-consuming job of scotching and clipping the points. It gives the driver an indication that the points are locked and detected. The signaller is provided with a push-button that operates special relays to introduce remote securing. The signaller has to set the route (causing the signal lever to be reversed, mechanically locking the point lever). Provided the signal lever is reversed, the points are detected and there is a train at the signal waiting to move, a white illuminated sign with the legend 'Route Secure' is displayed at the signal controlling the entrance to the route. The driver can then be instructed to pass the signal at danger and proceed at a slow speed. If remote securing can be applied to more than one route, more indicators will be provided.

The remote securing function can be set or cancelled either from the control centre or locally but it can only be cancelled until after the train has passed through the route. With remote secure in operation, the trainstop of the red signal does not lower. The train passing the red signal will be tripped and the driver will have to reset the tripcock to allow the train to proceed. However, if there is a "wrong road" trainstop in the route, it will be released normally.

The system was first commissioned on the Piccadilly Line at Heathrow T123 on 5 November 1985. This seems to have been a trial as other interlockings along the Piccadilly Line at Wood Green, Finsbury Park, King's Cross, Holborn, Down Street, Hyde Park Corner and Hatton Cross didn't get done until August-September 1987, almost two years later. The Bakerloo and Central lines were provided with RS upon resignalling (though RS on the Bakerloo slightly preceded resignalling in line with OPO). The Jubilee Line was equipped in readiness for OPO, with the Northern Line being the last to be equipped in 1999, again in readiness for OPO. It is still used from time to time.

ROUTE PROVING

Another technique developed in an effort to reduce delays due to signal failures was "Route Proving" (Figure 3 below). This was really another, cheaper, form of Route Secure as again, it involved ensuring trailing points were locked before giving permission for a train to pass a red signal and move over them but, in this procedure, it was restricted to points at either end of a crossover that were operated under the same controls. This meant that, if a signal was able to show a green aspect over one of the pair of points but the signal reading over the other set of points was showing a red and wouldn't clear, the green signal was sufficient evidence that both sets of points were locked. The circuitry already provided this guarantee and it provided another useful way to avoid scotching and clipping points. Route proving was first introduced on the Victoria Line around 2004 and it was then arranged for other lines where it was brought into operation during June and July 2009[2]. After the original introduction on the Victoria line, sites proposed for Route Proving became more complicated, often involving conditions, e.g., approaching Chalfont and Latimer a southbound train from Chesham could route prove for a southbound train from Amersham. In practice, the use of route proving results in delays to both trains involved in the procedure so it's preferable to use Remote Securing if it's available.

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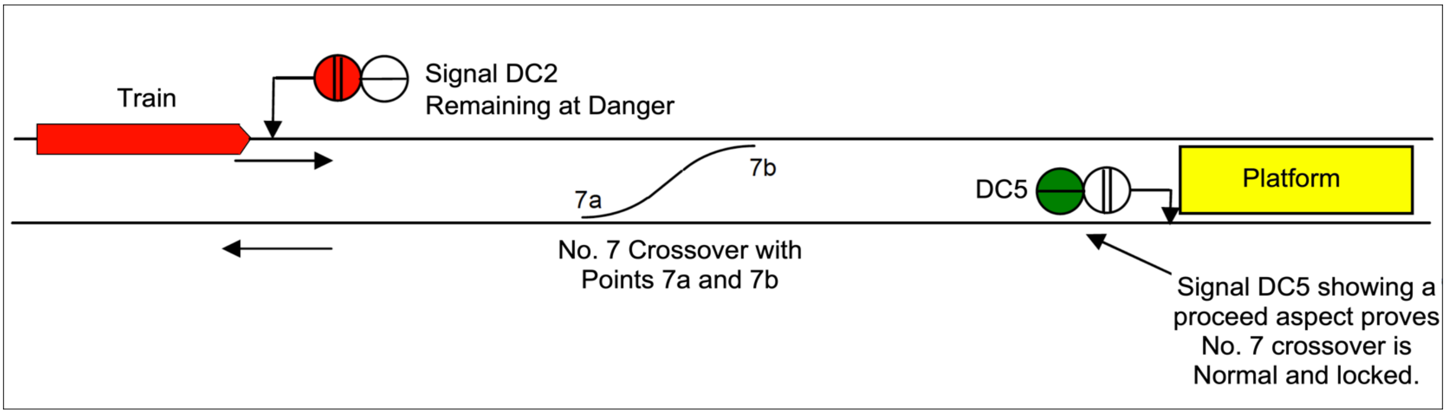
1 Originally it was always referred to as "Clipping and Scotching" but the procedure is safer if the scotch is inserted into the open switch first and then the clip added to the closed switch, thus it became "Scotching and Clipping" in the rule book.

2 London Underground Operational Standard Notices (various 2009).

Figure 3: Schematic showing the principles of Route Proving. A train is held at Signal DC2 that has failed. The crossover is proved to be in the Normal position by the ability of Signal DC5 to display a proceed aspect. The route is thus 'proved' and the train can be authorised to pass Signal DC2 without having to manually secure the points. Diagram from LU Internal Notice, modified by P. Connor.



BALANCED HEADWAY CONTROL

One of the responsibilities of the Underground signaller looking after a station was to check that trains didn't leave early and only departed at the time according to the timetable. This ensured that the interval between trains or 'headway' was even and trains would thus be evenly loaded. Trains that arrived early were 'regulated', in other words, held to time. With the introduction of programme machines, this was supposed to be done automatically, with the time sequence machine ensuring that trains departed on time but the collapse in train service reliability that started during the late 1960s due

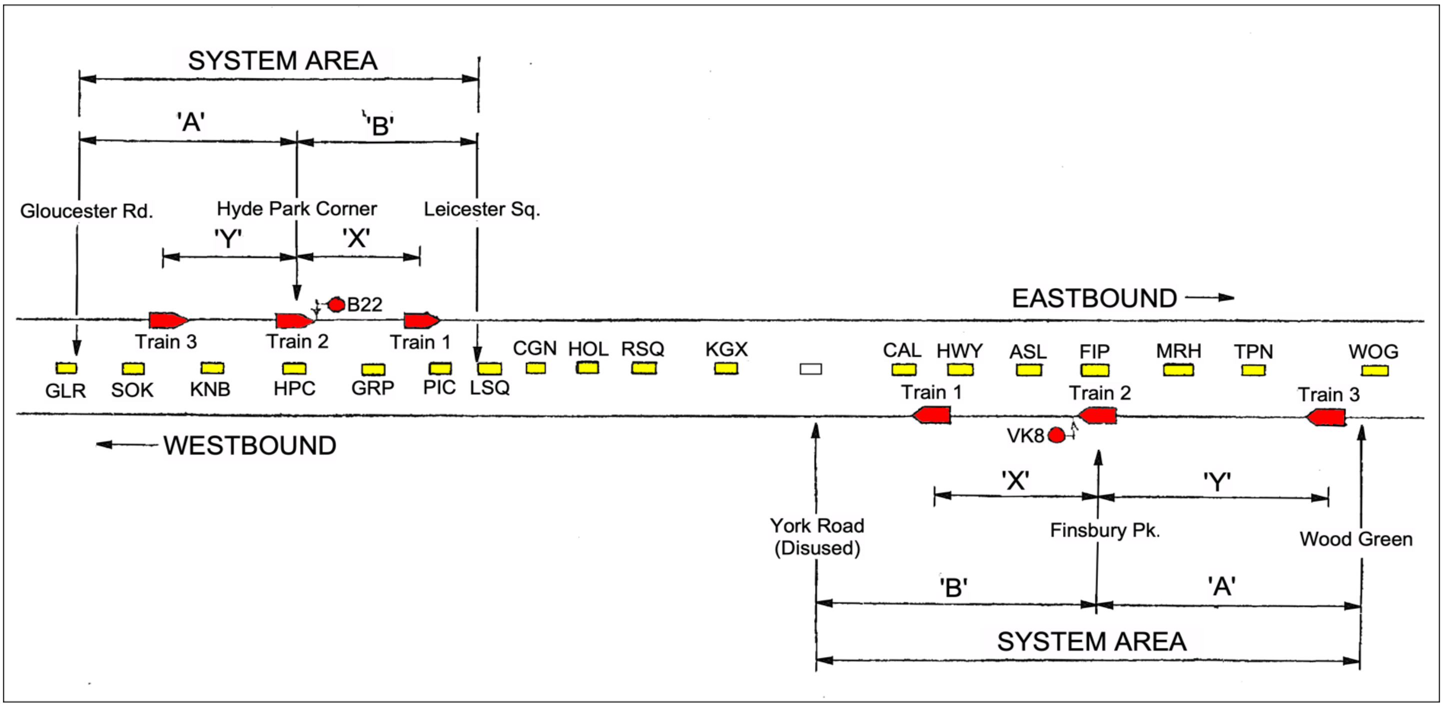


Figure 4: A schematic of the 'Balanced headway Control' system as installed on the Piccadilly Line in 1970. Looking at the EB control, the starter at Hyde Park Corner (HPC), Signal B22 was controlled so that when Train 2 arrived, B22 would not clear until the time between Train 1 and Train 2 ('X' on the diagram) matched the time between Train 2 and Train 3 ('Y' on the diagram). If there were no other trains in either section 'A' or 'B', Signal B22 would clear anyway. The 'System Area' began at Gloucester Road (GLR) and ended at Leicester Square (LSQ). It was designed to operate with a maximum 6-minute headway for each of sections 'A' and 'B'. The same principles were applied at Finsbury Park (FIP) using starting signal VK8 for the WB service. This plan was taken from the Traffic Circular issued at the time (No.46, December 1970) and modified by P. Connor. The commentary that accompanied this diagram referred to the letters 'A' and 'B' but ignored the letters 'X' and 'Y', leaving the reader to deduce their meaning. The drawing itself was hand drawn and was rather scruffy when seen in print.

to staff shortages and train maintenance strikes, meant that trying to keep all trains to the timetable didn't mean that you would get an even interval service if trains were regularly being cancelled. Services became very 'lumpy', to use a phrase common at the time. Eventually, a scheme was devised to try to provide even headways automatically. It was known as 'Balanced Headway Control' (Figure 4).

The line chosen for the experiment was the Piccadilly Line. By this time, the scheme was also being referred to as 'Headway/Hindway Control'. The idea was that trains should be held at a particular station until the time since the previous train had left matched the time the next train was expected. The system worked by using the detection of the next train at a particular location as the start of the countdown. This had to be far enough back along the line to allow for a sensible range of times that you might expect for the headway. The longest headway was settled on at 6 minutes, the Sunday headway at the time.

Two sites were chosen, Hyde Park Corner on the eastbound and Finsbury Park on the westbound. This was so that the balanced headway would be presented through the central area of the line. The system was commissioned on 10 December 1970, with control on the eastbound starter at Hyde Park Corner and the westbound starter at Finsbury Park[3] (Figure 4 above). Note that, in my version of this diagram, I have used the current three letter codes for station names to save space.

HOW IT WORKED

As a driver on the line at the time of its introduction, I was convinced that Balanced Headway Control would be operated using the train describers so that, as a train dropped the berth track at the trigger station in the rear, the timer at HPC would start and would match another time triggered by a suitable berth track at the trigger station ahead. However, it turns out it was a whole lot more complicated than that. It worked on a resistance balancing system. It compared the amount of resistance in two different circuits, one either side of the regulation point. Each circuit contained six resistances, each one operated by a selected signal (Figure 5). As the signals cleared, they cut out their resistance from the circuit and, if the resistances were equal at the control point, it meant the time was equal either side of the regulation point and the starter would clear.[4] The complexity of the scheme seems to have been an attempt to monitor the progress of the trains once they had entered the system, particularly in case a train got held up once the circuit was triggered.

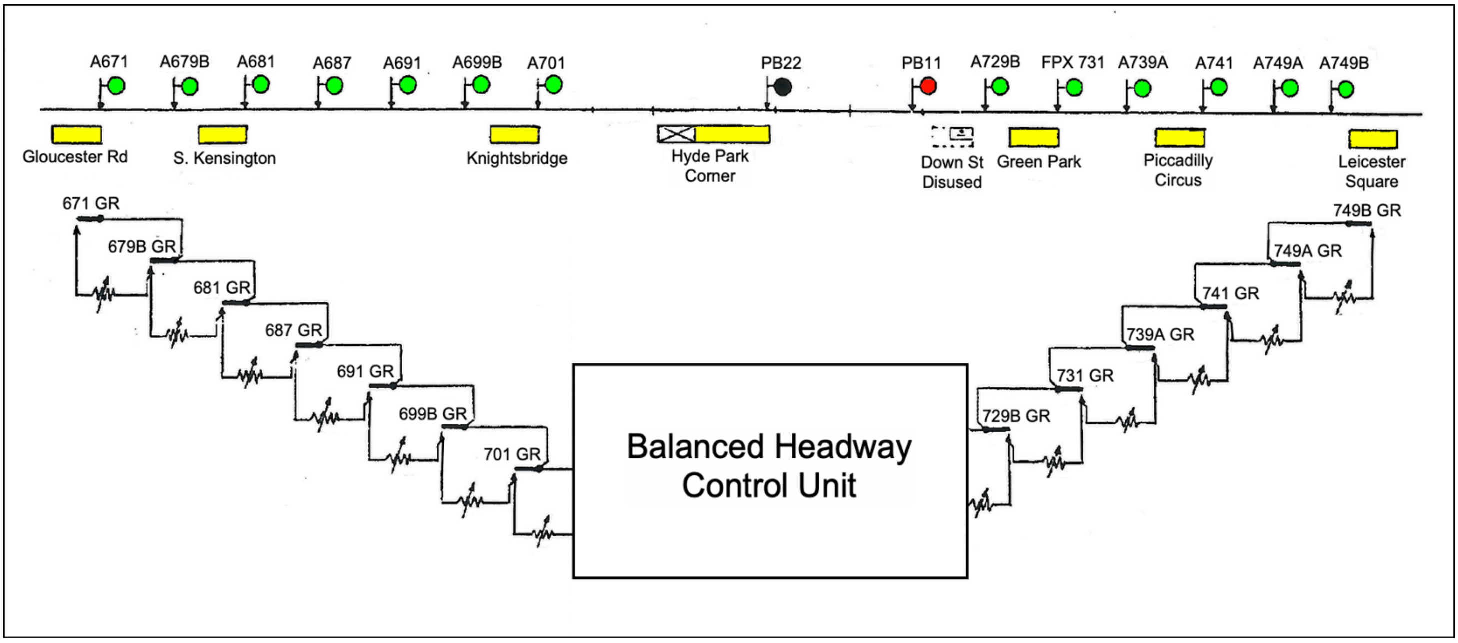


Figure 5: A schematic of the resistance control system used to drive the Piccadilly Line's eastbound Balanced Headway Control system. Each of the selected signals has an additional variable resistance that is switched in as the signal relay (GR) is de-energised by the dropping of the track circuit. The total value of the resistances is monitored by the control unit and, when the resistance of the section behind the control point matches that of the section ahead, the Hyde Park Corner starter can clear. This schematic was taken from part of the LU Signal Engineer's drawing No.CS49425P dated 3-9-80, some 10 years after the system had been in use and had already had several modifications. By this time, some resignalling work had been carried out and the signal cabin at HPC replaced by an IMR (Code

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3 LT Traffic Circular No. 46, 1970.

4 I am grateful for assistance with various operational and technical details from Tom Crame, Colin Weller, Pete Atkins and Steve Owen.

PB) at Down Street disused station. A similar arrangement was provided for the westbound between Wood Green and York Road. Drawing modified by P. Connor.

VARIABLE DWELL TIME INDICATORS

Another scheme to refine the Piccadilly Line service, which went beyond the scope of the Balanced Headway system, appeared in 2011 and was put into operation from early in January 2012. It consisted of a system of countdown clocks installed at stations between Wood Green and Kings Cross (westbound only) to advise drivers to wait until the time shown counted down to zero before closing the doors and continuing on to the next station. There were also platform repeaters for the use of station staff. The system was known as 'Variable Dwell Time Indicators' (VDTI). It was activated from the Earl's Court Regulating Room.

Figure 6 Top: A photo of the blank dwell time indicator screen at Finsbury Park WB on the Piccadilly Line next to the platform OPO monitors. The system was tried for a time in 2012 but quickly fell into disuse. Photo: LURS Collection.

Lower: A photo of a platform repeater for the VDTI system installed on the Piccadilly Line in 2012. Photo: Donald McGarr.

The clock counted down from a maximum of 60 seconds the number of seconds before a train should leave. The displays were designed to indicate that a train should hold, even if the signal was green. The display could also display 'No Regulation', for when the system was switched off.

The use of VDTI was separate from the Balanced Headway system and it was considered necessary to switch off the Balanced Headway when the VDTI was switched in. Apparently, it was designed to stop bunching up of trains on approach to King's Cross particularly in the morning peak so it was never intended to install the system on the eastbound road.

It isn't clear now why the system didn't last very long. It survived on and off for a few months early in 2012 but there seems to have been some technical defects and it has never been revived. Perhaps the benefits were marginal.

SECTIONAL ROUTE RELEASE

A signalling facility provided to give rapid clearance of routes through junctions and crossovers that is commonly used on main line railways is 'Sectional Route Release'. It was also later known as 'Train Operated Route Release' (TORR). Normally, a route is set up by the signaller or computer and is locked throughout until the train has cleared the fouling point of the last turnout at the end of the route. However, this can take a while, particularly if trains are long and the route is complex and low speed, like the fan of a large terminus. To speed up operations, sectional route release was designed to allow individual sets of point to be released as soon as the end of the train was clear and this enabled a new route to be selected and set up before the old route was fully released. On the Underground, TORR is now standard except at manual cabins.

The first known example of sectional release was in 1929, introduced for the resignalling of Manchester Victoria and Exchange stations[5]. It subsequently became quite common on main line railways but it was not common on the Underground. This was largely due to the fact that long complex routes were not often seen on the Underground, although it has been provided on some sites, usually to gain a headway advantage without providing an additional signal. A good example of this existed at Stanmore, prior to the introduction of ATO.

Beyond the starting signals at Stanmore (Figure 7), there was no headway requirement for another signal until the approach to Canons Park, well beyond the last set of points at the far end of the sidings. However, this long section brought a problem. The signalling principles required the lever for the starting signal to remain locked until a departing train was clear of the last set of points in the route but this meant that it would prevent a northbound train from accessing the (recently vacated) platform. To get around this, another lever was introduced known as a 'route lever'. This behaved like a phantom signal (JL3) just beyond the crossover, as it mechanically locked the point levers for the turnouts to the sidings in the route beyond, but there was no physical signal outside.

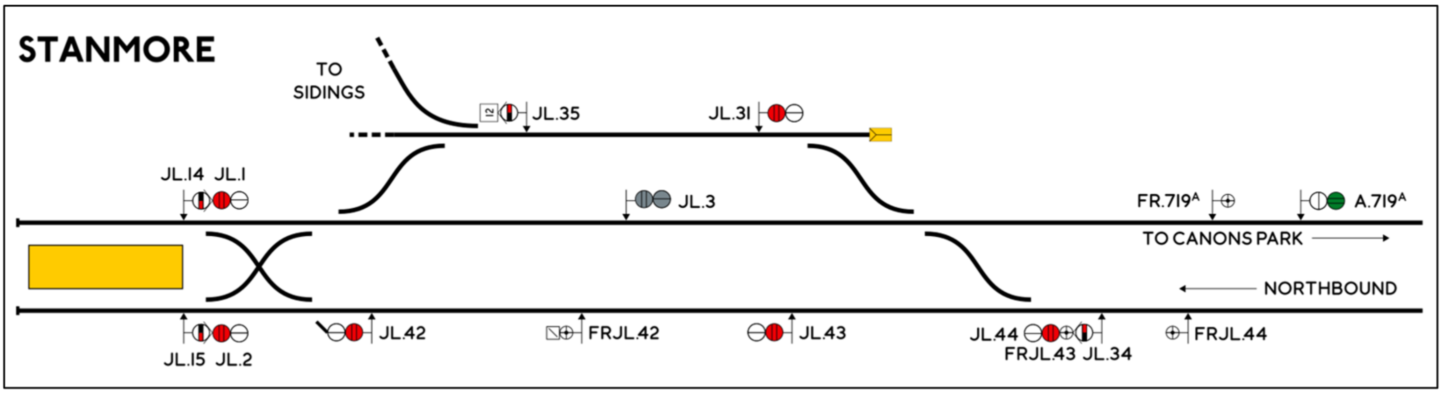

Figure 7: A schematic of the layout at Stanmore before the introduction of TBTC and the building of the third platform. It shows the purpose of the route lever acting as the 'phantom signal' JL3 (in grey) on the southbound track that, when reversed, locked the levers for the points leading into the sidings beyond. Drawing by T. Crame.

This arrangement meant that, before the starting signal could clear, the route lever had to be reversed, locking the points to the sidings. Then, reversing the starting signal lever would lock this route lever in the reverse position. When the departing southbound train had cleared the crossover just outside the station, the starting signal's lever would be unlocked, allowing the crossover to move for an incoming northbound train, but the route lever would remain locked until the southbound train was past the end of the sidings.[6]

When King's Cross (Met.) was resignalled in 2015, a similar arrangement was used for trains reversing Outer Rail to Inner Rail in the Inner Rail platform – No.23 lever was used as a phantom signal on the King's Cross side of the crossover. It was required to be reversed to clear OJ13. When a reversing train was clear of the crossover, lever 13 was able to normalise, freeing up the crossover for a second train, before the first train had fully berthed in the inner rail platform. Route levers were also used at more complex sites like Aldgate, Baker Street and Queen's Park, but these are often used to simplify the mechanical locking arrangements instead of providing a sectional route release facility.

Sectional route release as used by BR only arrived at West Ruislip when it was resignalled for the start of the conversion to automatic operation in 1991 but was removed when the site was converted from relay operation to Westrace in 1998. However, by that time, the Underground had inherited the Waterloo and City Line which uses a similar arrangement to BR based on the common heritage[7].

Apologies for this numbered issue being published out of sequence.

To be continued …

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5 Moore, H.W. (1929), 'Specification, Installation and Maintenance of Power Signalling Systems', Proc. IRSE 1929, Part 2, Pp.163-183.

6 E-mail from Tom Crame, 3 January 2023.

7 Information from Tom Crame e-mail 22 August 2022.