INSULATORS – A POTTED HISTORY

by Antony Badsey-Ellis

Perhaps one of the more neglected items on the London Underground is the humble insulator, known colloquially as a 'pot'. These support the conductor rails and prevent the electricity from leaking to earth. The design of the four-rail system on the Underground is such that should either conductor rail be accidentally earthed, the voltage potential between the two conductor rails should remain the same, but nonetheless, the aim is to keep the electricity away from the earth.

This article is not intended to be definitive, but more a quick review of the different types of insulator used in the early days of the Underground. There might well be types that have been missed here, in which case details would be welcomed. Part of the problem is that in contemporary photographs, even those focusing on trackwork, the insulators are remarkably difficult to see. They tend to gather dirt very quickly, and so do not stand out against the background of ballast and sleepers.

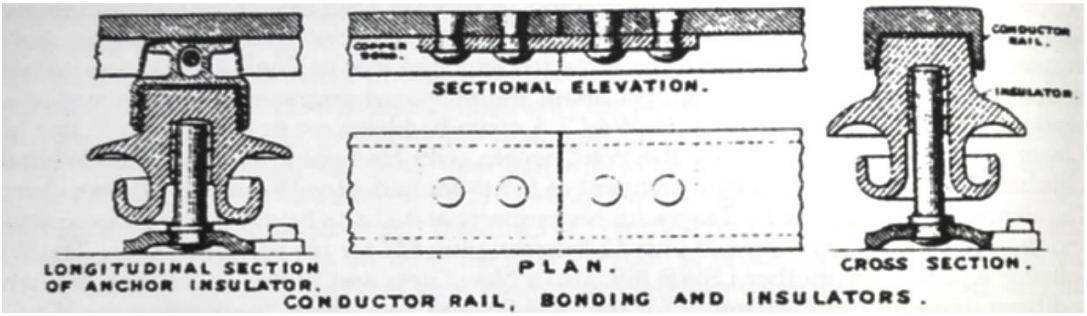
The insulators that people tend to think of today on the Underground are ceramic, mushroom-shaped objects. The shape serves to displace water and forces it to drip from the outer edge (known as the 'apron' or 'drip'), preventing the water from forming a continuous path for electricity to pass from the rail to earth. For railways that are entirely subterranean this is not a major factor, as the track should remain dry. However, the insulators in tube tunnels have tended to be the same shape, possibly because it reduces the number of insulators that need to be made and stored.

CITY & SOUTH LONDON RAILWAY

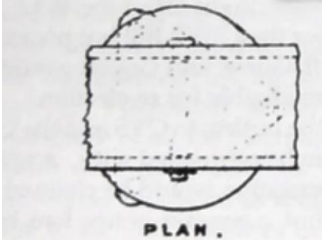
The first tube railway supported its single conductor rail on glass insulator blocks. The rail was not positioned centrally between the running rails, as this would have allowed the buffing gear to come into contact with it. Instead, it was 1 ft 2 ins from one of the rails, offset to the east (i.e., it would be to the right in the direction of travel when going northbound, and to the left southbound).[1] The conductor rail was of channel section steel of special low-resistance composition,[2] and the insulators cast from greenish glass *(Right).*

WATERLOO & CITY RAILWAY

The W&CR also used channel section rails, 4 inches wide and 2 inches high. These were supported on circular porcelain insulators about 4 inches both in height and diameter. These fitted onto short metal posts that were secured to the sleepers, spaced at 7 ft 6 in intervals *(Below).*



CONDUCTOR RAIL, BONDING AND INSULATORS.



CENTRAL LONDON RAILWAY

The conductor and insulator arrangements for the CLR were similar to those of the W&CR. Circular porcelain insulators positioned at at 7 ft 6 ins spacing supported a steel channel section rail weighing 85 lbs/yd.[3] From the published drawings, these appear to be mounted on metal posts screwed into and through the sleepers, secured by a nut on the underside (Overleaf, Top).

MR & MDR EXPERIMENTS

In 1900, the Metropolitan and Metropolitan District Railways teamed up to

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1 *Rails Through the Clay*, (2nd edition), p.30.

2 The silicon was removed, levels of carbon reduced, and increased manganese content.

3 *Tramway & Railway World*, 8 November 1900.

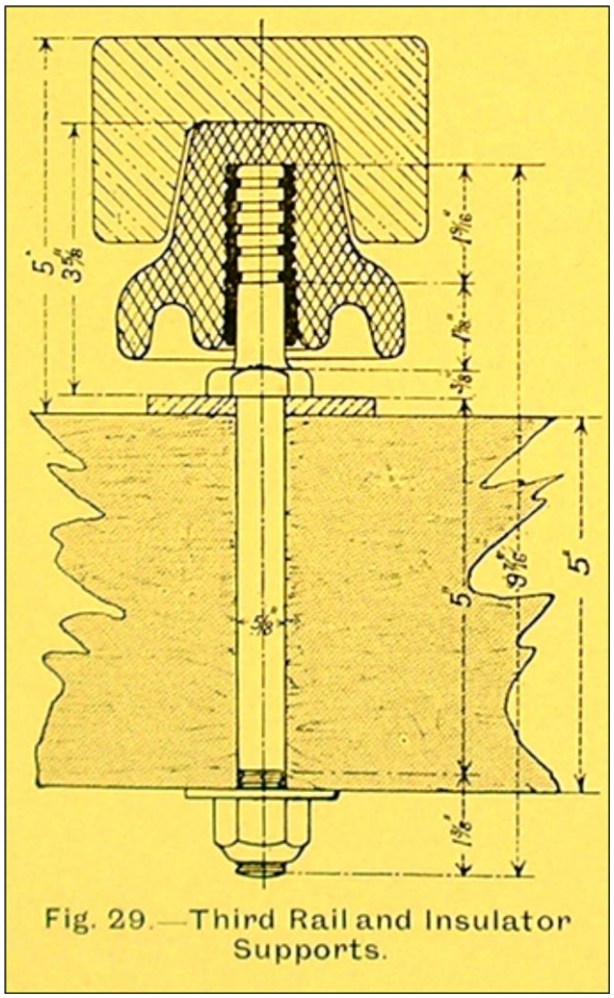
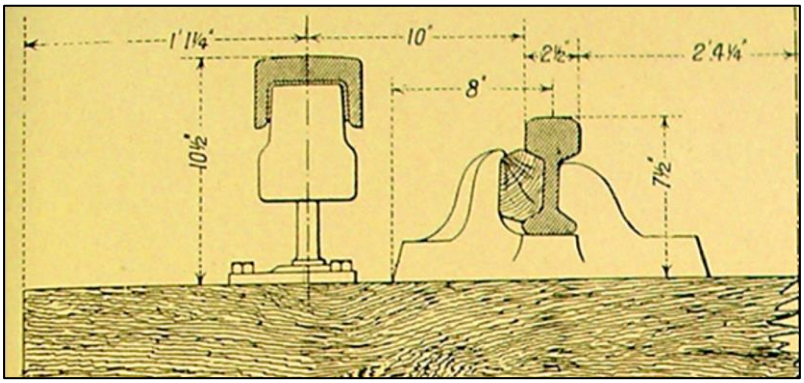


Fig. 29.—Third Rail and Insulator Supports.

create an experimental electric service between Earl's Court and High Street Kensington. Mild steel channel section conductor rails weighing 75 lbs/yd were used – unlike the aforementioned tube railways, two conductor rails were used to avoid the current being returned via the running rails. These were both located outside the running rails *(Below).* The conductors were supported by circular porcelain "Post Office pattern" insulators which were fitted with leather caps to prevent excessive vibration.[4]



METROPOLITAN RAILWAY

When the Metropolitan Railway began to electrify its lines in the early 1900s, it adopted a Vignole section conductor rail weighing 100 lbs/yd, and subsequently increased to 120 lbs/yd.[5] The insulators were made by Bullers of Tipton, and were "Chambers' patent third-rail insulator", made of highly vitrified porcelain mounted on a metal tripod. Different sized tripods were used for the side and centre conductor rails, which were placed at different heights.[6] Metal clamps bolted to the side of the insulators secured the rail. *(Below, Left).*

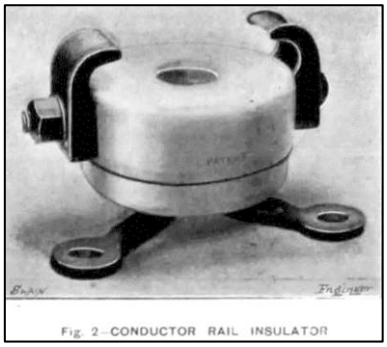


Fig. 2—CONDUCTOR RAIL INSULATOR

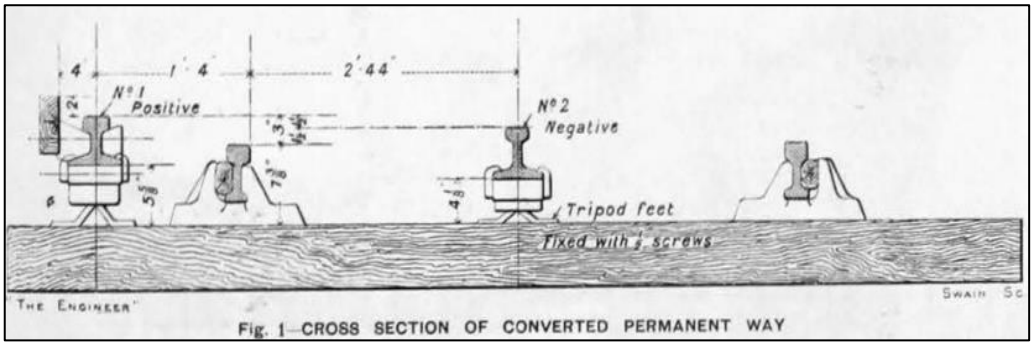


Fig. 1—CROSS SECTION OF CONVERTED PERMANENT WAY

By the time that electrification was being extended north to Rickmansworth in the 1920s, mushroom-shaped insulators were being used. Photographs of the track near Neasden in 1925 show these, but not sufficiently clearly to determine any more details. A broken example, missing its cast iron top, is shown in the photo *(Right).* It is stamped **M.R. NO.1**.

METROPOLITAN DISTRICT RAILWAY

It is probably unsurprising to find that although the MDR electrified their lines at the same time as the MR, and so that trains should be able to operate over both systems, they would choose a different style of conductor rail and insulator. Their insulators were made by Doulton, and came in two sizes for the higher outside rail and lower centre rail.

4 *The Engineer*, 18 May 1900.
5 *The Electrification of the Metropolitan Railway* (1923).
6 *Tramway & Railway World*, 14 July 1904.

They were made of cream enamelled vitrified stoneware, with cast iron caps and bases.[7] The latter were screwed to the sleepers. It was found that there was a high rate of breakages, with fractures occurring near to the metal cap. It was thought that this was due to vibration from the current rail, and especially the vertical motion of the rail as the conductor shoes passed along.[8]

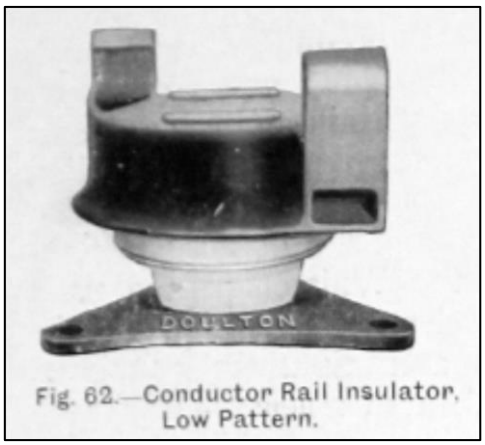


Fig. 62.—Conductor Rail Insulator, Low Pattern.

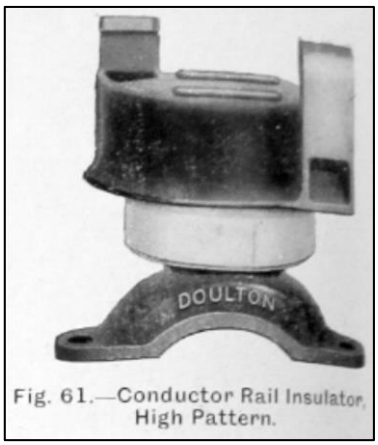


Fig. 61.—Conductor Rail Insulator, High Pattern.

Some insulators for outside use were made from a granite composition, and these were made without the cast iron caps. Instead lips were formed on the top surface to hold the current rail in position. They suffered fewer breakages, but provided reduced insulation.

Glass insulators were also tried on the MDR soon after electrification, but these were brittle and too many breakages occurred. A few years later another trial of some French-made annealed glass insulators was made, but these were also too brittle. Some insulators made of wood dipped in an hot insulating material were also trialled for the negative rail in tunnels only.[9]

GREAT NORTHERN & CITY RAILWAY

The conductor rails of the GN&CR were placed outside the running rails, like the experimental MR and MDR service of 1900. This was based on the original expectation that electric locomotives would be hauling GNR trains through the tunnels, and the locomotives would have had large axle-hung motors that would have fouled a central rail. Channel section rails of 80 lbs/yd weight were supported on Doulton '610' ceramic insulators *(Right).*

BS&WR, GNP&BR, CCE&HR

Perhaps the most unusual style of insulator was that used by the UERL for the three tube lines opened in 1906-07. Like the GN&CR, they used two conductor rails (one to the side and one centrally between the running rails), but with smaller tunnels they could not use a standard shape of insulator for the side rail. Instead they used an earthenware insulator that allowed the conductor rail to be offset from the insulator mounting, instead of carrying it directly above. These were rectangular in plan view, and incorporated four holes. The central conductor rail used a slightly tapered insulator and, being slightly lower, only had two holes. From the appearance of these insulators, it is possible that they were made by extruding the clay through a mould and chopping off pieces to form the insulator; if so, this probably reduced the cost.

They were manufactured by Doulton, and initially had two moulded side clips to hold the rail, which had a square cross-section and weighed 85 lbs/yd. Iron clips were secured to the sleepers, with a felt pad on top, to hold the insulators in place.[10]

These insulators were cheaper than the porcelain ones used on the MDR, but could not be used outside as they were too absorbent. An early problem for the tube railways was the breakage of several thousand of the insulators in the first few weeks of operation, largely due to the movement of sleeper

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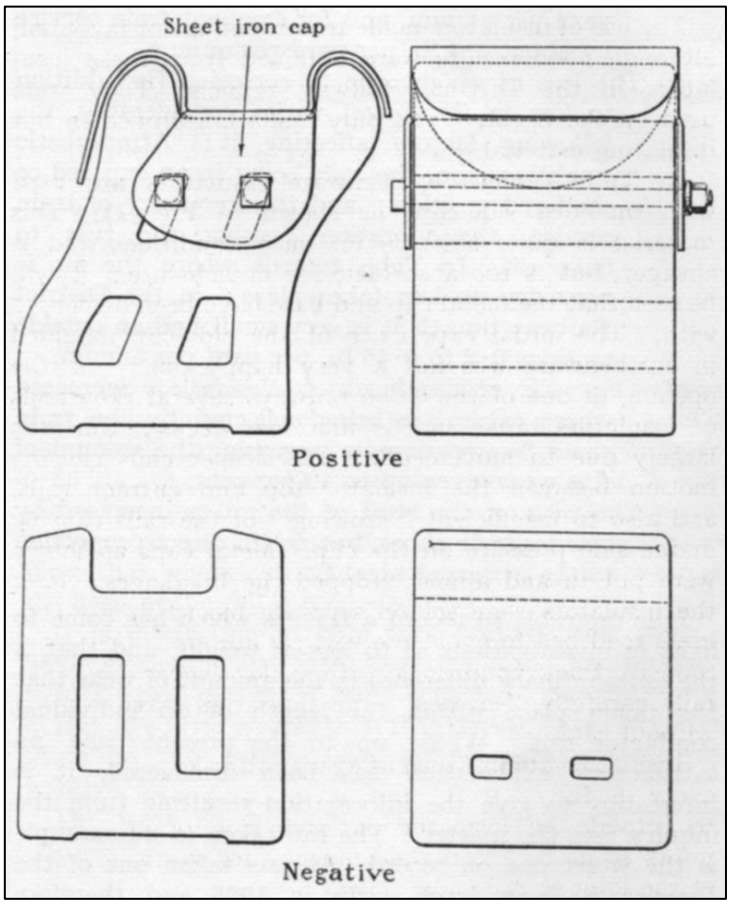
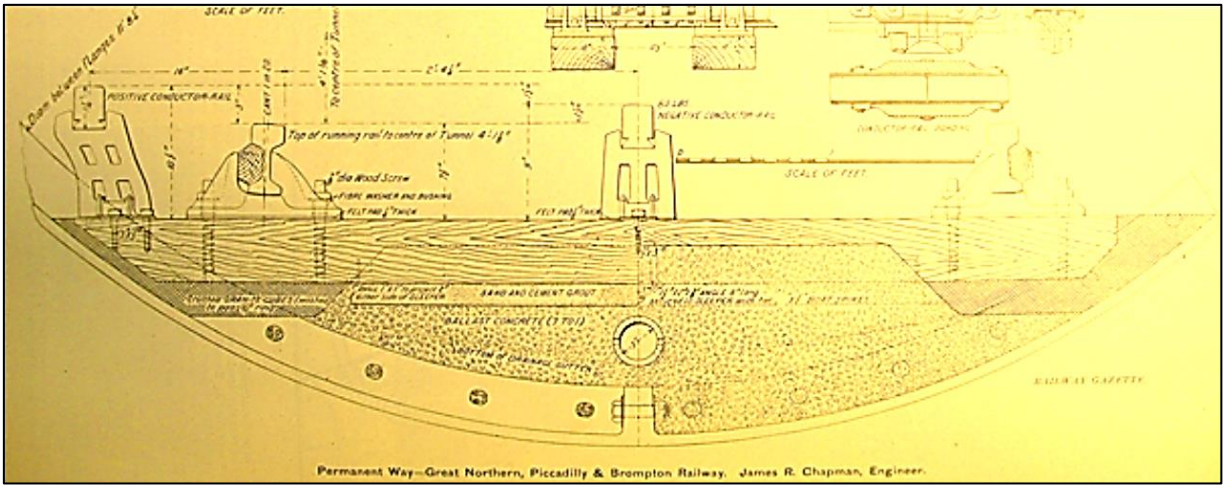
7 *The Tramway & Railway World*, 9 February 1905.
8 *The Electrical Equipment of Track on the Underground Railways of London*, Cooper, A.R., Journal of the IEE, April 1927.
9 *Ibid.*
10 *The Tramway & Railway World*, 8 March 1906.

ends. The problem was resolved by fitting the top of the insulators with malleable iron clips made from a piece of sheet iron fitted over the top of the insulator.[11]

The curved style of insulator for the side rail was also used in situations where there were not clearance problems, such as crossovers. Tunnels for junctions on these lines did not use the 'step-plate' formation, but were instead just short lengths of enlarged tunnel around 25 ft in diameter.

These two types of insulator did not require aprons, as they were used in tunnel sections. Photos of London Road Depot, on the Bakerloo Tube, in the early days show the conductor rails supported by a different shape of insulator. This had a channel at the top in which the rail rested, and sloping shoulders either side, presumably to drain off water. These appear to be unique to this location, as photographic evidence suggests that the MDR style of insulator was used for the other open sections of track from Barons Court tunnel portal to Hammersmith (Piccadilly Tube) and at Golders Green (Hampstead Tube). It seems reasonable to assume that these were also used in Lillie Bridge and Golders Green depots too. The UERL continued to use these insulators for many years. Photographs show them fitted to the C&SLR after its reconstruction in the early 1920s, and also on the extension of that line to Morden, opened in 1926. A few of these insulators are still *in situ* on the long-disused platform at Aldwych, which was closed in the early 1900s and which remains without an anti-suicide pit.

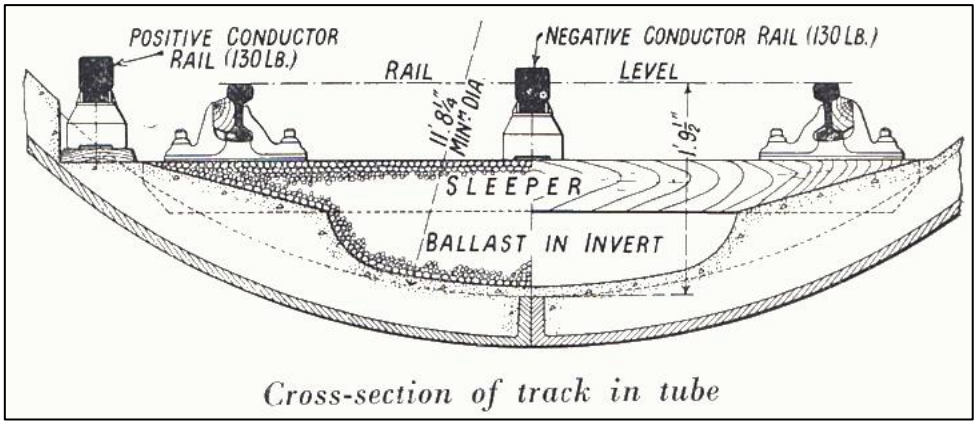




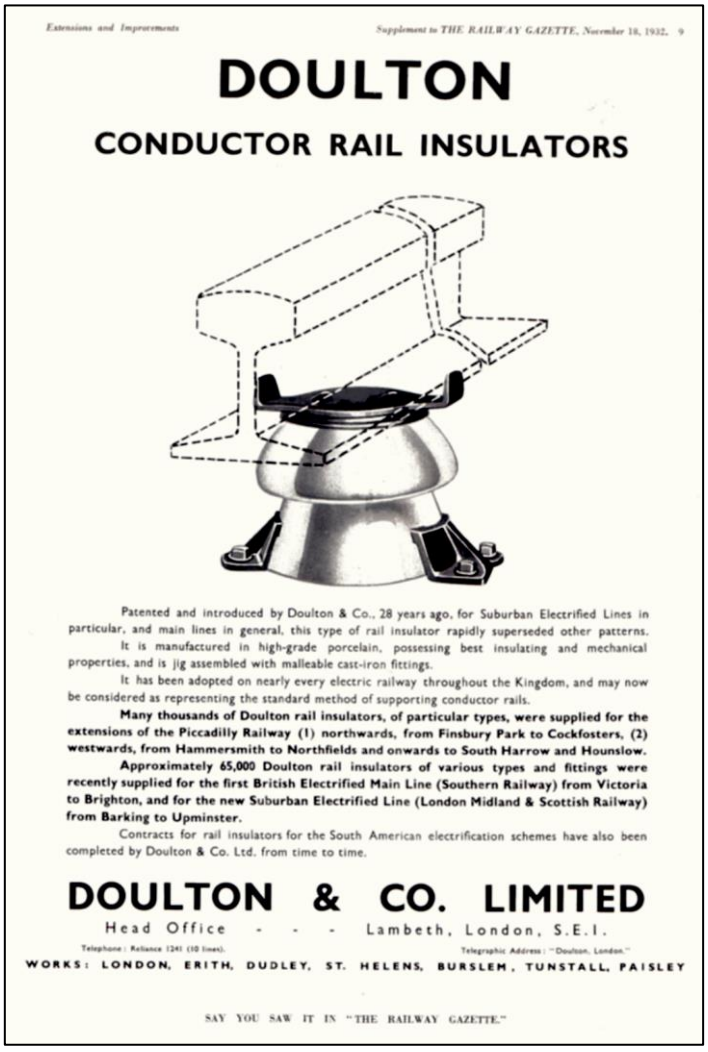
[11] Cooper, April 1927.

1930s EXTENSIONS – PICCADILLY LINE AND NEW WORKS PROGRAMME

In the 1930s a new type of insulator appeared in tube tunnels. It had a square base (6 in square) and flat sides to half its height of 5½ inches, above which it tapered to a flat circular top on which was cemented an iron cap with two flanges to keep the conductor rail from moving sideways. These were made of porcelain by Doulton, and supported rectangular cross-section rail weighing 130 lbs/yd. Each side had a pair of holes into which the iron sleeper brackets fitted.



Cross-section of track in tube



Extensions and Improvements — *Supplement to THE RAILWAY GAZETTE, November 18, 1932.* 9

DOULTON

CONDUCTOR RAIL INSULATORS

Patented and introduced by Doulton & Co., 28 years ago, for Suburban Electrified Lines in particular, and main lines in general, this type of rail insulator rapidly superseded other patterns.

It is manufactured in high-grade porcelain, possessing best insulating and mechanical properties, and is jig assembled with malleable cast-iron fittings.

It has been adopted on nearly every electric railway throughout the Kingdom, and may now be considered as representing the standard method of supporting conductor rails.

Many thousands of Doulton rail insulators, of particular types, were supplied for the extensions of the Piccadilly Railway (1) northwards, from Finsbury Park to Cockfosters, (2) westwards, from Hammersmith to Northfields and onwards to South Harrow and Hounslow.

Approximately 65,000 Doulton rail insulators of various types and fittings were recently supplied for the first British Electrified Main Line (Southern Railway) from Victoria to Brighton, and for the new Suburban Electrified Line (London Midland & Scottish Railway) from Barking to Upminster.

Contracts for rail insulators for the South American electrification schemes have also been completed by Doulton & Co. Ltd. from time to time.

DOULTON & CO. LIMITED

Head Office - - - Lambeth, London, S.E.1.

Telephone: Reliance 1241 (10 lines). Telegraphic Address: "Doulton, London."

WORKS: LONDON, ERITH, DUDLEY, ST. HELENS, BURSLEM, TUNSTALL, PAISLEY

SAY YOU SAW IT IN "THE RAILWAY GAZETTE."

The more familiar mushroom-shaped insulators *(Above, Right)* were also in use on the Underground at this time, in different sizes to support the positive and negative rails.

These were manufactured by Doulton, who made reference to this in their advertising at the time. The adverts clearly showed how the insulators were clamped to the sleepers using a pair of iron brackets. The LT Museum has a type P89 in its collection, which comes from Down Street. This was a tube tunnel positive rail insulator.

POST-WWII

Following the Second World War, LT introduced new standards and mushroom-shaped insulators became widely adopted. Different types of insulators were used in different situations. Some of the main types in use are as follows:[12]

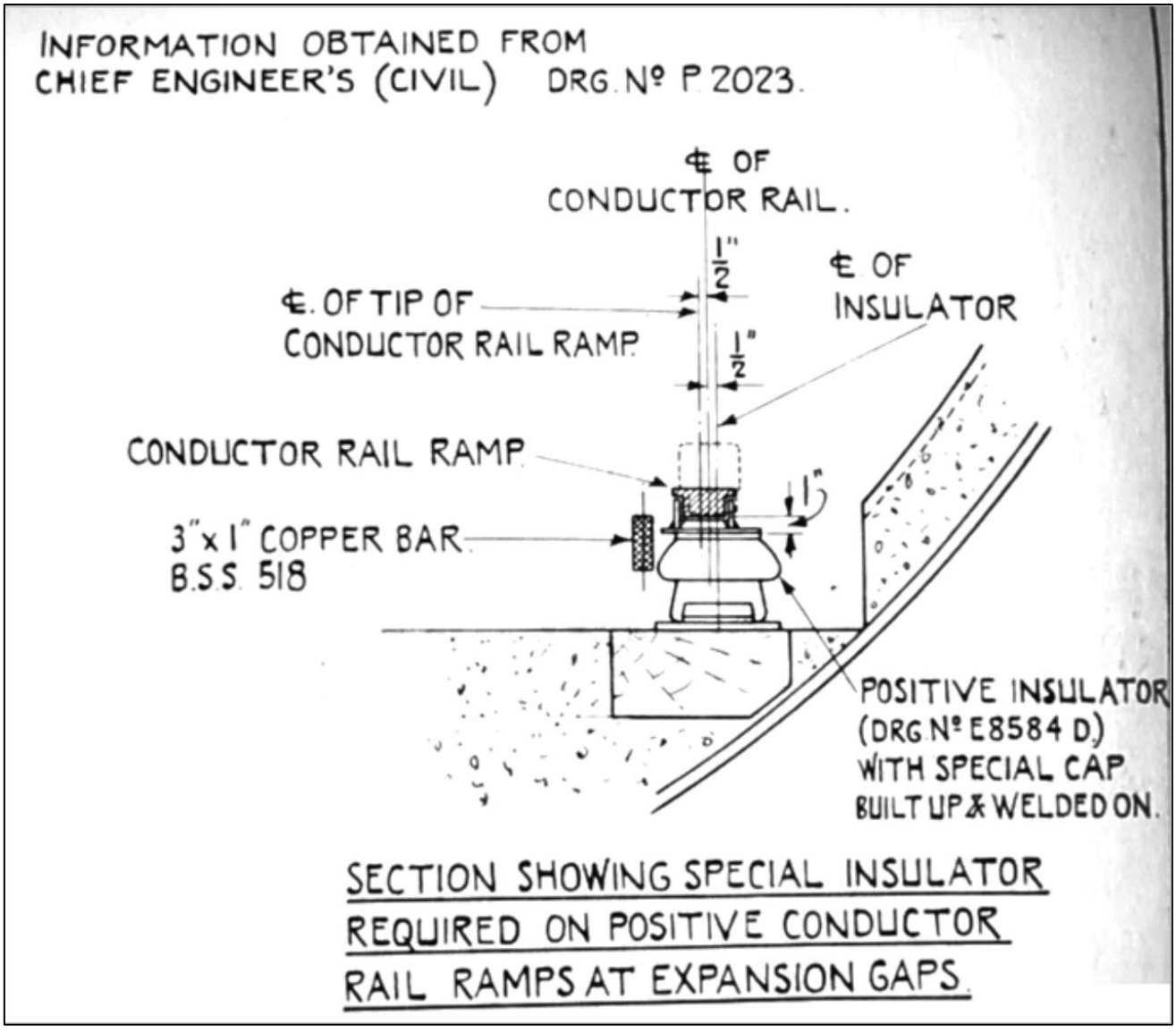
1. P18 – outside, positive rail, 110 lbs/yd rail.
2. P19 – outside, negative rail, 110 lbs/yd rail.
3. P20 – outside, positive rail, 150 lbs/yd rail.
4. P21 – outside, negative rail, 150 lbs/yd rail.
5. P29 – tube tunnel rails.

All of the examples of these show the initials of the company (LPTB, LTB, LTE), followed by 317, a slash, and then the insulator type.

[12] *Underground News*, 10 February 1978.

The photographs here (Far Left and Left) are of a P20 insulator, made by Allied Insulators (their logo is shown in the right hand photograph). AI was formed in 1959 by Bullers of Tipton, who supplied the Metropolitan Railway, and another company. Over the next 50 years, a series of mergers, acquisitions, and demergers resulted in the insulator division of Doulton joining AI, and in 2011 AI becoming a separate company in its own right.[13] The LTB initials suggest that this insulator dates from between 1963 and 1969, when the London Transport Board was running the Underground.

These insulators are secured to sleepers using a pair of iron baseclamps. These are secured to the sleeper using coachscrews and fit around the base of the insulator; it would appear that before WWII these had six screws, and with the new post-War standards this was changed to four.[14] With concrete sleepers, the holes are moulded into the concrete and fitted with plastic inserts into which the coachscrews grip. The drawing here, taken from the 1946 LPTB civil engineering standards document, shows that there was also a special design of insulator used at positive conductor rail ramps.



[13] http://www.alliedinsulators.com/company/history/
[14] http://www.clag.org.uk/3rd-4th.html

***Above**: This photo shows the relative sizes of the P19 and P20 insulators; the P19 is 9 cm high (to the base of rail level) whereas the P20 is 11·5 cm high. Note also the 'Doulton' lettering in the cast iron of the P19.*

***Above**: (Right) An earlier example of a P20 insulator, which is very easy to date from its stamp.*

***Right**: One final example of the ceramic insulators. This has sustained some damage, and annoyingly is missing the last digit of its type. It is stamped LPTB 317 / P2x. It is different in shape to the P19 and P20 insulators; perhaps this is a P29?*

RAIL ANCHORS

Conductor rails are not secured to the insulators, and over time have a tendency to creep in direction that trains are travelling due to the friction imparted from the conductor shoes rubbing along them. To prevent this from happening, rail anchors are installed near to the mid-point of the rails. These are diagonal bracings that link a metal plate welded to the underside of the rail to a bracket secured to a nearby sleeper. To prevent the current flowing along the bracing, it has a small insulator at its mid-point. Multiple anchors are often found together; the photo below, at Chalfont & Latimer, is in the southbound platform. Two anchors are provided to resist movement southbound (pointing left in the photo), whilst a single anchor works in the opposite direction.

SAFETY BLOCKS

Cast concrete safety blocks are used towards the end of conductor rails to prevent lateral movement. They do not provide any support to the rails. The photo *(Overleaf)* is at Watford North Junction, showing safety blocks on all of the conductor rails around the points (the clearest example is at bottom right).

MODERN INSULATORS FOR COMPOSITE CONDUCTOR RAIL

Since the 1990s, composite conductor rail has been introduced on the Underground. This is made of aluminium, which has a lower resistance and so less current is wasted through the heating of the rails. However, aluminium is soft, and so a wearing surface of stainless steel is provided. This is made from two J-sections which are welded together, securing them tightly onto the aluminium. One problem with these rails is that they are lighter than their steel predecessors, and it was found that they could 'bounce' off the insulators. To prevent this, a new style of insulator *(Left)* is used which not only supports the rail, but secures it into position as well by having sections that fit over the base of the rail.

These insulators are made of cast resin or thermoplastic. Metal fittings screwed to the sleepers have a thick metal 'spike' (known as a spigot) on which the insulators sit. The spigots are square in cross-section, to prevent the insulators from turning as this would unlatch the rail and allow it to move. The example shown in the photograph is of the type used on the Waterloo & City line in 1996, and made by Brecknell-Willis from plastic.