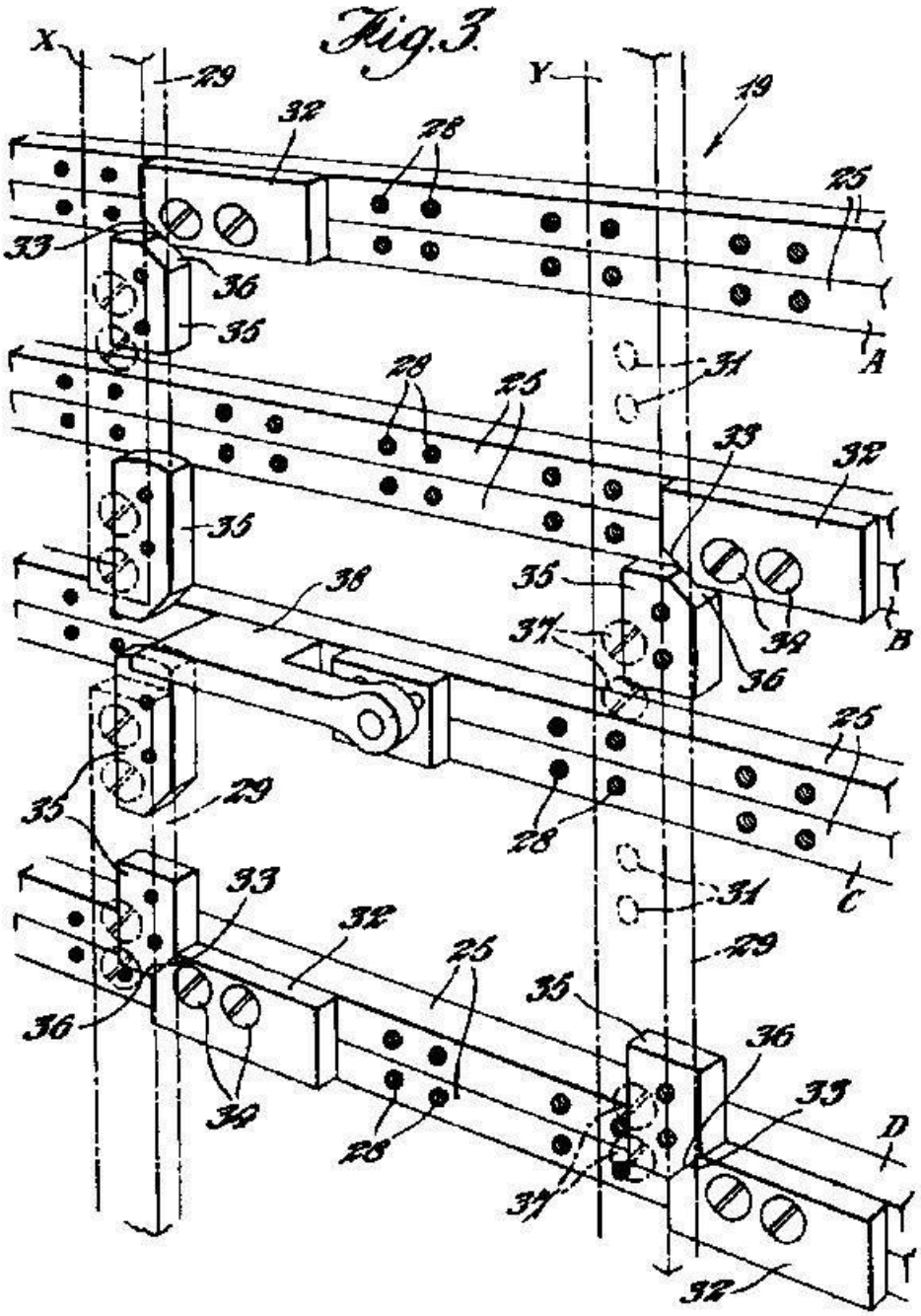
The "V" Style Interlocking Machine

and it's use by London Underground



John Tilly

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Cover Illustrations

Front Cover: One of the illustrations from Patent No 770187 showing the method of construction of the mechanical interlocking of a 'V' style interlocking machine (PO).

Back Cover: A view of a King lever lock quadrant, part of Chief Signal Engineer's diagram No BS32914a (LUL)

This paper is dedicated to

John Talbot and Frank Tuite

without whose help it would not have materialised

and both of whom passed away before it was published.

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Illustrations are on a common linked page. Appendices mentioned to follow.

Historical Aspects

Railway signal interlocking has been well documented over the years and deteriled treatment is outside the scope of this paper. It is however useful to outline the main events leading up to the introduction of the "V" style interlocking machine.

Introduction

With the advent of railways in the 1820's there was very little control of methods used to signal trains. The earliest signals and points were controlled by mechanisms located at the signal. From the 1840's these mechanisms were gradually bought together, and put under cover, the Signal Box had arrived. In 1843 the first serious attempt at interlocking[1] was introduced at Bricklayers Arms Junction on the London, Brighton and South Coast Railway where the frame prevented conflicting moves but still allowed movement of points. In 1856 John Saxby invented and patented a frame, on which individual levers moved points and signals together, thus preventing conflicting moves. This was welcomed by the Railway Inspectorate, but ignored by all other railway companies!

In 1859, Colonel W. Yolland of the Railway Inspectorate refused to approve the Stevens Stirrup frame installed at Kentish Town Junction on the North London Railway and insisted on full interlocking between points and signals. The frame was adapted and patented to comply by the line's engineer. In 1860, Stevens and Saxby realising the significance of this, designed their own versions. In the following ten years many developments took place and tappet interlocking, patented by Stevens in 1870 gradually became the norm throughout the UK. Other manufacturers followed Stevens lead and produced their own brands of frame.

James T. Hambay

Miniaturisation arrived in the UK at the turn of the century with the "A" style frame developed by Westinghouse, from its American origins, to incorporate miniature levers. From then on a succession of miniature frames were produced with London Underground using many frames of styles "B", "K", "M", "N", "N2", "N2M" & "V".

Turning to the Underground system specifically, the events leading up to the "V style machine are important The railways that eventually became the London Underground system took railway signalling very seriously from the start. The 1874 Royal Commission on Railway Safety noted that the Metropolitan and District railways were the *only* railways in the country to fully employ block working and interlocking throughout their respective systems.

The next significant date was July 2nd, 1889, when James T. Hambay, of The Union Switch and Signal Company was granted Letters Patent No 406212 by the United States Patent Office for *"certain new and useful improvements in Switch and Signal Interlocking Apparatus".* In simple terms Hambay had invented a form of interlocking (Fig 1) that enabled miniature interlocking frames to become a practical proposition, Hambay's Patent is reproduced in full in Appendix A. The first miniature frames were imported from the United States and subsequently the Westinghouse Brake & Signal Company were licensed to manufacture such frames. London Underground's first miniature frame was a "B" style,
commissioned on 11th June 1905 at Mill Hill Park[2]. The following thirty years witnessed the rapid expansion of miniature frames throughout the system with "B" frames being joined by "K" frames in 1912 and "N" frames[3] in 1931.

Figure 1:

Two of the figures from Hambay's Patent, note the similarities in Dell's Patent. (US)

[1] Invented by Gregory and manufactured by Stevens, known as Stevens Stirrup frame. For the history of signal interlocking in greater deteril, see; *The Signal Box* published by OPC, and *A Guide to Mechanical Locking Frames,* published privately by the Signalling Study Group. The authors of both publications are the Signalling Study Group.
[2] Renamed Acton Town, 1.3.1910.
[3] "N" style frames were/are exclusive to the London Underground system. No other railway is known to have used them.

The Metropolitan railway installed the only "L" type, electrically interlocked frame at Wembley Park, commissioned in early 1932[4]. Traditionally, all of London Underground's miniature frames have been of Westinghouse manufacture.

Centralised Traffic Control

Towards the end of the 1920's signal engineers were beginning to consider the prospect of concentrating signalling equipment and to control the equipment from central points. The first example on London Underground was between Wembley Park and Stanmore when Major R. Falshaw-Morkhill, the Metropolitan Railway's Signal Engineer[5] supervised the installation of Westinghouse 3 wire CTC[6] equipment controlling the new Stanmore terminus from the signal box at Wembley Park, commissioned on 10.12.32 with the opening of the line. At the time this was the first CTC installation outside North America and held the record within the British Isles of controlling a site the greatest distance from the signal box - a princely 4.5 miles!

On 19.9.32 the Piccadilly line was extended northwards from Finsbury Park. At Wood Green, the site with its reversing siding was signalled with a train describer controlled relay interlocking, which could be locally controlled by a signalman switching out the train describer controls and manually operating the "N" style frame. This was the first relay interlocking installed on the system. However, there was no remote control of the site until later years. When in train describer control mode, the Arnos Grove signalman[7] had to set up southbound descriptions for the siding but had no other control over the site.

Every & Dell

Of far more importance, were William Every and his assistant Robert Dell and their ideas of centralising control. Their first successful attempt was the partial control of West Kensington West signal box from West Kensington East (Fig 2) signal box commissioned on 1.7.34. This scheme retained the "B" style frame in the West box and control of most of the District signals were by route lever from the East box. Four of the lesser used District routes required a signalman in the West box as did the Piccadilly tine signals, when out of King lever control. To utilise the remote control, certain levers in the West box were reversed, a control lever put to the mid position, followed by point levers to the mid position, and then control lever reversed. The signalman in East box then reversed his control lever giving him control of the West box by push/pull route levers. The signalling was a form of route relay interlocking commonly known as "Deterflex" signalling. This remained in use until 14.4.62 when new Interlocking Machine Rooms with "V style machines were bought into use at West Kensington West and Barons Court

Figure 2:
Two illustrations from Traffic Circular No. 25 of 1934 relating to the West Kensington installation, showing typical routes. (LUL)

One of the most important aspects of the West Kensington scheme was the use of a normally de-energised rail (track) circuit. During the preliminary approval process, Lt. Colonel E. Woodhouse of the Railway Inspectorate queried its purpose. He was advised by the Board's Secretary that *"it was to prevent mis-operation of No 4a signal's approach locking circuitry which might arise from dirty rails in the L.M.S. yard[8]".* The Secretary also indicated that *"this type of track circuit has been in use for other special conditions and found satisfactory".* The scheme was inspected and approved by Colonel A. C. H. Trench[9]. The use of such

[4] Converted to air worked (nominally "N" style) 25.9.54. (See notes 14/19.)
[5] Morkhill was appointed by the Metropolitan Railway in 1925, and continued as joint Signal Engineer with Dell under the L.P.T.B. reaching retirement age in June 1941. He was retained by L.P.T.B. due to the war and finally retired from L.P.T.B. on 31.12.41, Dell becoming Signal Engineer from 1.1.42. (L.P.T.B. Board minutes 2718,2872).
[6] Centralised Traffic Control. Stanmore resignalled with an 'N' style frame, 29.5.38.
[7] Converted to push button operation from Arnos Grove signal box, 25.3.57.
[8] The goods yard at West Kensington was L.M.S. property and thus "dirty" rails were outside of L.P.T.B.'s control.

[9] PRO MT 6 3383. See Bibliography for details of reference source and location of HM Railway Inspectorate reports.

track circuits was to play a prominent role in future air worked installations, *but was initially overlooked.*

Every and Dell were obviously convinced at the time that this was the way forward. Following the destruction in 1934 of the old mechanical signal box by runaway wagons, the Deterflex system[10] was installed at Rayners Lane, controlling the Metropolitan and Piccadilly junction (19.10.35), and a short while later (16.11.35) control was extended to include Harrow Gas Works sidings[11]. This was followed by Cromwell Road, the first and only large installation controlling Earls Court, Cromwell Road, Gloucester Road and High Street Kensington triangle (1936[12]), Finchley Road (25.7.37), then Finsbury Park (11.3.39)[13] and finally Elephant & Castle (2.11.41). These installations proved that route signalling was a practical idea, reducing the signalman's physical workload and reducing the number of signalmen required. However, from 1937 onwards other sites were re-signalled and this system was ignored and conventional electro-pneumatic signalling was installed.

Figure 3:

Track Layout at Shoreditch 1943. Shoreditch is the station to the left, and Whitechapel to the right (RG)

The reasons for the abandonment of the Deterflex system were summed up by Dell[14] in two papers to professional Institutions. Of particular concern to Every and Dell was the cost of the additional safety signalling cables; the belief that relay interlocking did not offer the same safeguards as mechanical interlocking; and most importantly the possibility of false operation of circuits by technicians, using test lamps while testing. Due to the complexity of circuit design, fault finding during signal failures became more difficult, leading to greater delays to traffic, which was obviously unacceptable with the densely operated services in the central area. In his paper to the I.E.E. Dell also referred to the more involved testing and careful workmanship that was required following track or signalling alterations.

Route Signalling with Miniature Frames

Every and Dell were now convinced that route signalling was a necessity for future signalling installations, but that some means had to be found to allow the retention of conventional frames with mechanical interlocking and simpler circuits. In addition two serious fires occurred highlighting the dangers that could affect large installations and the lack of fireproof materials being used to construct signal boxes and equipment. In both cases traction current was the cause of the fires; at Colindale (5.8.35) following a aeroplane crashing on to the track; at Camden Town as a result of stray fault currents coming together at a point where two cable runs entered the relay room.

Figure 4:

"N" style frame lever motor arrangement. (1RSE)

Every and Dell came to the conclusion that small frames were the best proposition, taking into account the smaller quantities of cable required, and the minimum disruption that would be caused by a serious fire or failure of the equipment. They decided to motorise the operation of the levers such that if disruption did occur, local control could be established quickly. As compressed air and electro-pneumatic valves were freely available on the system they considered this the best option. By the late thirties they had provisionally designed a system based on the "N" style frame which was submitted as a Patent

[10] Deterflex signalling was basically similar at all locations, although "variations on a theme" were known; for instance the installation at Elephant & Castle did not have point levers, where as Rayners Lane did. Some sites had remote frames (High Street Kensington); some relay rooms without frames (Gas Works Sidings).

[11] Coal sidings for Harrow Gas Works, midway between South Harrow & Rayners Lane. Locally known as South Harrow Gas Works.

[12] Commissioned in 4 stages: Cromwell Rd, 21.6.36; Earls Court E, 9.8.36; High St Kensington, 6.9.36; Earls Court W, 20.9.36.

[13] Finsbury Park (Northern City Line). Controlled from Drayton Park (LT) high level signal box, telephone type keys until 6.12.41 when control transferred to conventional miniature push/pull levers on main frame. The signalling at *Drayton Park* was controlled from the low level mechanical signal box (Ex NC) until transferred to high level box on 14.3.53.

[14] In his 1944 paper to the Institute of Electrical Engineers and 1969 paper to the London Transport Signal Department Technical Society.

application on 13.10.39. Every passed away on 12.4.40 before the full Patent specification No 536609 was granted, (on 21.5.41) to Every, Dell and the L.P.T.B: As it is historically relevant, the Patent is reproduced in full in Appendix A. Every and Dell referred to their system as the Power Worked Lever Remote Control Signalling System. Contemporary accounts[15] suggest that the Central line extensions were to be fitted with the new system but undoubtedly the Second World war interfered with plans to introduce the system widely.

Shoreditch

On 8.9.43 the first air[16] powered frame (Figs 3 & 4) came into use at Shoreditch on the East London line. The frame was a converted "N" style controlled from the frame at Whitechapel (ELL) signal box[17]. Each lever at Shoreditch was operated remotely from a corresponding lever at Whitechapel. Route signalling was not used. Post Office type 3000 telephone relays in cans were (Fig 5) used for the control circuits. The frame at Shoreditch is the only frame bearing a striking resemblance similar to the patent. It will be noted the patent drawing shows catch handles on the levers.

It has not been possible to establish conclusively why Shoreditch became the first air-worked site. There are a number of possibilities, the most obvious of which is connected with the war. The East London line suffered a number of "hits" during the war, and also saw heavy cross Thames traffic as the result of troop and supply trains. The site was controlled from Whitechapel using typical "Met" signalling including electric point machines and cabling via telegraph poles. The electric point machines were prone to failure in damp conditions, which are notorious on the East London line! Dell is known to have had a disliking for "Met" signalling and it may well be the case that a combination of war damage and failures led to the resulting air worked frame. The third possibility is one of political practicalities in respect of trade unions. The new frame was initially controlled from the same frame at Whitechapel and thus there was no loss of signalman's positions with the introduction of the new frame. Lastly, Shoreditch had a very light passenger service and passenger delays would not have been a major concern at this site.

Figure 5:
Post Office type 3000relay "can". (IRSE)

Harrow on the Hill

Following the cessation of hostilities, Dell ordered several style "N2" frames from Westinghouse[18]. The first was commissioned at North Acton on 23.6.47 controlling the two western branches of the Central line. Control was by push/pull telephone type keys from Wood Lane signal box until 3.7.48 when the new White City signal box opened. Push/pull route levers were used in the new box (for North Acton)[19].

In Dell's 1942 paper to the Institute of Railway Signal Engineers he expounded the virtues of the system, and the possibilities of controlling far larger sites. Included in the paper was a track diagram showing the layout at Harrow on the Hill with three signal boxes shown being controlled from a single control panel. Dell emphasised the need to consider carefully the numbering of signals and points so as to avoid duplication of numbering.

The layout at Harrow shown in Dell's paper was re-signalled as suggested taking into account the numbering

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[15] Railway Gazette, Issue of Oct 29th 1943, p436.

[16] The patent refers to other possible methods of control.

[17] Control of Shoreditch and Whitechapel (ELL) transferred to Whitechapel (District) signal box 18.10.59.

[18] Number not accurately known. Westinghouse records show two orders for N2 frames - Harrow North and South. North Acton frame is described as an "electro-pnuematically controlled N" and close inspection of Grange Hill and Ruislip Gardens suggest that they are probably N2. It is known that specific orders were often re-directed by London Transport. (See notes 3/19)

[19] The air working was restricted to the junction signals only. A signalman wag required for other routes until 8.4.73 when the whole frame was converted to air operation.

of signal and points, with the north junction being commissioned[20] on 17.4.48 and the south junction and main box on 1.5.48. Once again control was by push/pull route levers located in the main box and on the same frame as the air worked levers for the station area. Apart from some track rationalisation and the Metropolitan line's four tracking scheme in the early sixties the signalling[21] today is similar to the original track diagram in Dell's paper. Following Harrow were Grange Hill[22] (29.10.48) controlled from Hainault and Ruislip Gardens (21.11.48) controlled from West Ruislip.

Dell's theories were put to the test at Harrow on 9.8.89 when a serious fire under a cable run caused extensive damage to cabling in the station area. As Dell had suggested back in the thirties, disruption was localised and near normal services were running very soon after the initial incident

Figure 6:
The troublesome mechanical toggle - Left - shown "holding" lever. Right- shown "broken" by electric lock. (PO)

Locked Up!

As would be expected the new system developed teething troubles which came to the fore at Harrow on the Hill with its heavy passenger and freight traffic. The circuitry design was such that air was allowed on to the normal lever motor as the train passed the signal concerned. The toggle linkage (Fig 6) was designed to perform a mechanical lock checking function to prevent the lever moving until the lock was energised. It required adjustment to very fine limits. An error of+0.001" in the adjustment of the lock stem would allow the toggle to break early causing the lock slide to jam solid on the locking face of the stem. Conversely with an error of -0.001" the toggle would fail to break maintaining the lever in the reverse position. Many failures and delays were experienced.

George Kent, the then maintenance assistant, came to the rescue with an electrical lock checking circuit (LCC). The motor normalising circuit was redesigned so that the passage of the train cancelling the route (or the signalman) bought the lever towards the mid position, its passage being stopped by a "RE" lever band breaking, thus removing the air from motor. To fully normalise the lever the circuit employed a lock indicating relay (LKR) which energised at the same time as the lock, giving the lever a second puff of air to bring it to normal position[23]. The circuit was christened the "KENT" circuit by the drawing office! Subsequently the lock checking circuit was redesigned again using an electrical contact operated by the lock stem in much the same manner as the toggle mechanism. Nowadays an electronic version is used replacing the electrical contact and is found on the more recently installed machines.

The Kent circuit was in use at Harrow and other sites by 1951, possibly earlier. Dell's next move was the introduction of Push Buttons controlling similar frames. Ealing Broadway was the first site to be re-signalled[24] using a converted "N" style frame[25] controlled by push buttons from a specially designed console located in the signal cabin above the interlocking machine room.

Until this time all the air worked frames had been located outside of tube tunnel areas where space was not a factor that needed consideration. Dell's **Power Worked Lever Remote Control Signalling System** was a success, even more so with the introduction of push buttons at Ealing Broadway in 1952 and Wembley Park in 1954. It is rumoured that following the success at Ealing Broadway, Dell was visiting the signal box at Camden Town when he was involved in a stand up argument with the signalman on duty.

The signalman apparently told Dell that no one on the Northern line would operate his push buttons. The

[20] As far as it is known, controlled from "Main" box.
[21] Closure of goods facilities and reduction in BR traffic following closure of G.C. route to Nottingham and the North.
[22] Apart from Shoreditch, Grange Hill *is* the only site controlled on a lever to lever basis as opposed to push/pull route levers. Shoreditch was converted to "route" signalling with the commissioning of WWtechapel (ELL) machine.
[23] Later changed to LPR - Lock Proving Relay.
[24] Commissioned 30.11.52.
[25] An in-house version of Style "N2", LUL refers to converted N frames as N2. (See notes3/14)

"rumour" suggests that this was the one thing that spurred Dell on! Whilst the rumour may be grossly exaggerated it is interesting to note that Camden Town became the site of the first tube based "V" style frames, controlled by train describers and supervised by local push buttons initially. Dell obviously won the argument!

Aldersgate[26], however became the first site to be resignalled with a "V" style machine, following serious safety concerns after a locking irregularity discovered on 30.9.52 when a signalman was demonstrating to a trainee the actions of the electric interlocking on the old equipment.

Simplyfying

As the Underground's Signal Engineer, Dell had always aimed to simplify the signalling both from the point of operation and maintenance reasons. With the intention of simplifying the frame and the need to consider the space factor Dell set about designing what was to become the "V" style interlocking machine. In a specially produced souvenir booklet issued in 1956[27] it states that *"arising from the experience of the Ealing Broadway installation, a new design of interlocking machine was introduced".* It was not possible to speak with Robert Dell prior to writing this paper, however John Talbot of the Signalling Record Society did have several discussions with Robert Dell during 1990. During the course of these Dell said that he alone was responsible for the design[28].

Dell's idea was simple. In a conventional miniature frame, the locking till and contact shafts are already in the vertical plane why not stack them on top of each other, add a suitable handle (for manual control), and in effect "unfold" the frame and thus save space. There were two principle advantages; Firstly a considerable saving of space - a one section (11.5 lever) "N" style frame takes up a floor area of 36" x 51", and requires access from underneath, compared with 36" x 17" for a 12 lever "V" style interlocking machine. Secondly the design enabled the removal of all the bevel gears connecting the lever with, and driving the contact shafts, lock slide and locking thus simplifying the mechanical and maintenance aspects of the machine.

Dell also had two further ideas which were put into practice; the first was that all parts of the machine, and in particular the interlocking bars and dogs had to be standardised and interchangeable between machines and secondly the machine was to be supplied in a kit based form similar to a Meccano set Dell's view was that such a kit would not need locking fitters and could be put together by lower graded mechanical fitters[29].

Figure 7:

"New" method of engaging electric lock. (3-dimensional view)(LUL)

The only aspect of the machine that required a totally new approach was the method of engaging the electric locks. The lock slide was dispensed with and in its place a lock quadrant was designed to attach to the shaft. The lock stem engages the locking face of the quadrant by a semi-circular horizontal action (Fig 7) as opposed to the longitudinal action of a "N" style frame.

Robert Dell, Walter Owen and the British Transport Commission filed a provisional Patent specification for the "V style machine on 26.4.54, followed by the complete specification 23.5.55 and were granted Patent No 770187 on 20.3.57. This is reproduced in full in Appendix B.

The Board of the London Transport Executive[30] gave Dell authority to include Aldersgate resignalling in the

[26] Renamed Barbican, 1.12.68.

[27] Visit to Camden Town by Minister of Transport, 27.2.56. (See later text) Two booklets were issued; One with the Minister's name on was of a more historical nature.

[28] Dell's recollections (made to John Talbot) have to be challenged, quite simply because Walter Owen's name appears on the Patent Specification. Owen was one of Dell's subordinates and held a position within the Design office. It is believed that Owen was involved in some aspect the electrical side of the design, possibly contact arrangements.

[29] In practice however, Locking Fitters still construct and maintain these machines. Dell's idea never came to fruition.

[30] L.T.E. Board minute No 2284, 6.5.54.

1954 modernisation programme. Expenditure of £60,000 was authorised in 1954 and further costs of £80,080 at a later date were included in the submission to the Board. The initial costs were quantified as being £200 for removal of old assets; £5,500 for "like for like" replacements; £54,300 for "betterments".

Dell's submission also included a financial saving of £1,600 per annum in respect of signalman's wages, as Farringdon signal box was to become the controlling point[31]. No major alterations were made to the signalling layout although mechanically operated points were converted to power operation and shunt signals converted to externally illuminated discs. A push button control unit was installed at Farringdon to control the Aldersgate area, using push buttons of the type previously installed at Ealing Broadway and Wembley Park.

Colonel W. P. Reed of the Railway Inspectorate inspected the resignalling work at Aldersgate (Fig 8) and Farringdon on the 8th of December 1954 and recommended that the new work be approved. In his report[32] he noted that; *"This novel design of interlocking frame appears simple and specially apt for electro-pneumatic operation, and the workmanship of all parts of the system is of the highest order."* The "V style interlocking machine at Aldersgate (and the signalling in the area) was commissioned on 18.12.54 and controlled the Circle and City Widened lines including the Smithfield goods depot[33] and Circle line layby sidings.

Figure 8:
The Traffic Circular diagram showing the layout commissioned at Aldersgate on 18.12.54. (The outer extremities at Farringdon and Moorgate are excluded for the sake of clarity.) (LUL)

London Transport's official description of the signalling at Aldersgate and Colonel Reed's inspection report are reproduced in Appendix C.

Camden Town

Dell was given authority by the Board to re-signal Camden Town in the 1954/5 modernisation programmes. He did so at a cost of £63300, installing three "V" style machines to control what was then the busiest railway junction on the Underground system with a daily total of 1204 train movements and a peak of 107 trains per hour. Dell also overcame the problem of signalmen by installing a control system utilising the train describers which, at facing junctions routed trains according to destination, and at converging junctions in order of arrival. The scheme was entirely automatic and allowed the signalman to intervene by taking appropriate areas out of train describer mode and into push button mode and overcome incorrect descriptions or hold the service for operational reasons. The signalman[34] was thus reduced to a supervisory role!

Colonel D. McMullen was the Inspecting Officer and approved the installation noting in his report the following[35] - *"The whole arrangement is most ingenious and I am informed that it is the first completely automatic scheme of its kind on any railway in the world"* He continued - *"The equipment has been constructed to the usual very high standards of the London Transport Executive and all those concerned in its inception and construction deserve much congratulation".*

Colonel McMullen was very impressed and subsequently suggested[36] to his superiors that the Minister of Transport and Civil Aviation should inspect the installation. This was arranged and during the evening rush hour on the 27th of February 1956., the Minister, The Rt. Hon. Harold Watkinson M.P. accompanied by Lt. Colonel G, R. S. Wilson, (Chief Inspecting Officer) Colonel

[31] It is not clear from L.T.E. Board minutes what this figure refers to; the most likely explanation is that it relates to further modernisation work on the Circle line as opposed to Aldersgate specifically. Further submissions for Circle line work were made later believed to be in respect of schemes at Farringdon, Moorgate and Liverpool Street as well as City Widened Line improvements.
[32] PRO MT 29 99 p77.
[33] Smithlield Goods depot was opened by the Great Western Railway and remained a BR Western region depot after nationalisation in 1948.
[34] Such signalmen became known as Regulators.
[35] PRO MT 29 99 p134.
[36] PRO MT 114 113.

McMullen, Sir John Elliot, (Chairman, L.T.E.) and Robert Dell watched the progress of the peak service. The L.T. Staff News reported the visit in its March 2nd issue and referred to the party *"inspecting one of the interlocking machines - L. T. 's new signalling device replacing the normal power signal frame".*

Teething problems arose with the new machines as would be expected with any newly designed item. The first, frustrating[37] but safe problem was a re-occurrence of levers jamming on the electric locks. This was caused by the air pressure being too high resulting in the levers being driven fast enough to gain enough momentum to overcome the "KENT" circuit and hit the lock. Invariably when this happens, the Release lever is in-effective as the failing lever is mechanically jammed solid. Westinghouse were asked to re-design the bore of the inlet dowel so as to further reduce the air flow[38]. At a number of sites air pressure reduction valves were fitted to lower the air pressure to acceptable levels. It is likely that the lack of bevel gears on the new machines resulted in an increase in lever operation speed which was sufficient to cause the problem.

The second and potentially fatal problem was one of dirty or rusty rails, resulting in the false operation of track circuits[39], and affecting *any* type of air-worked installation. At 0652hrs on the 24th of January 1955[40] the signalman at Farringdon signalled a stabled train from one of Aldersgate's Circle line layby sidings to the main and then pre-selected the following move with his newly installed push button panel. As the stabled train started to move the track circuits bobbed as result of dirty rails, releasing the locking and causing the train to become de-railed over the outlet points. The Circle line[41] inner rail service was disrupted until 1515hrs the same day whilst the damage was repaired. Alterations to the layby sidings were commissioned on 4.2.55 to overcome the problem. (Fig 9) This problem was obviously appreciated by Dell as special measures had been taken at West Kensington 20 years previously. In addition special arrangements were taken a few yards across the City Widened lines in Smithfield goods depot, where shunters had to release the locking when freight trains were clear of the depot inlet. It will never be known why the layby sidings were overlooked. By the time Camden Town was commissioned a new circuit had been introduced to prevent this happening and was subsequently installed at all air worked sites.

Figure 9:
Traffic Circular diagram showing minor track alterations at Aldersgate following the mishap on 24.1.55. (LUL)

The circuit was known as a *"Route checking lock relay"* (UCLR). The circuit was designed so that the electric lock became *"dead"* until the passage of train had been detected to be the longest train length plus 40' clear of the last set of points in the route. Delta rail circuits[42] were used to detect the position of the train.

Following the Aldersgate and Camden Town installations, London Underground's post war resignalling and modernisation work proceeded rapidly with "V" style machines being used at the majority of locations[43]. A survey of commissioning dates reveals that 1960 was the peak year with eleven "V" style machines being bought into use, followed by 1958 and 1968 with eight machines apiece. From 1970 on, machines have been installed less rapidly with 1984 having four installed including the system's largest, at Wembley Park[44] (60 shafts)[45].

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[37] Frustrating due to the delays caused to passengers etc.

[38] A Westinghouse design report of 21.4.55 refers to further communication with Dell on this subject.

[39] A signal engineers "nightmare".

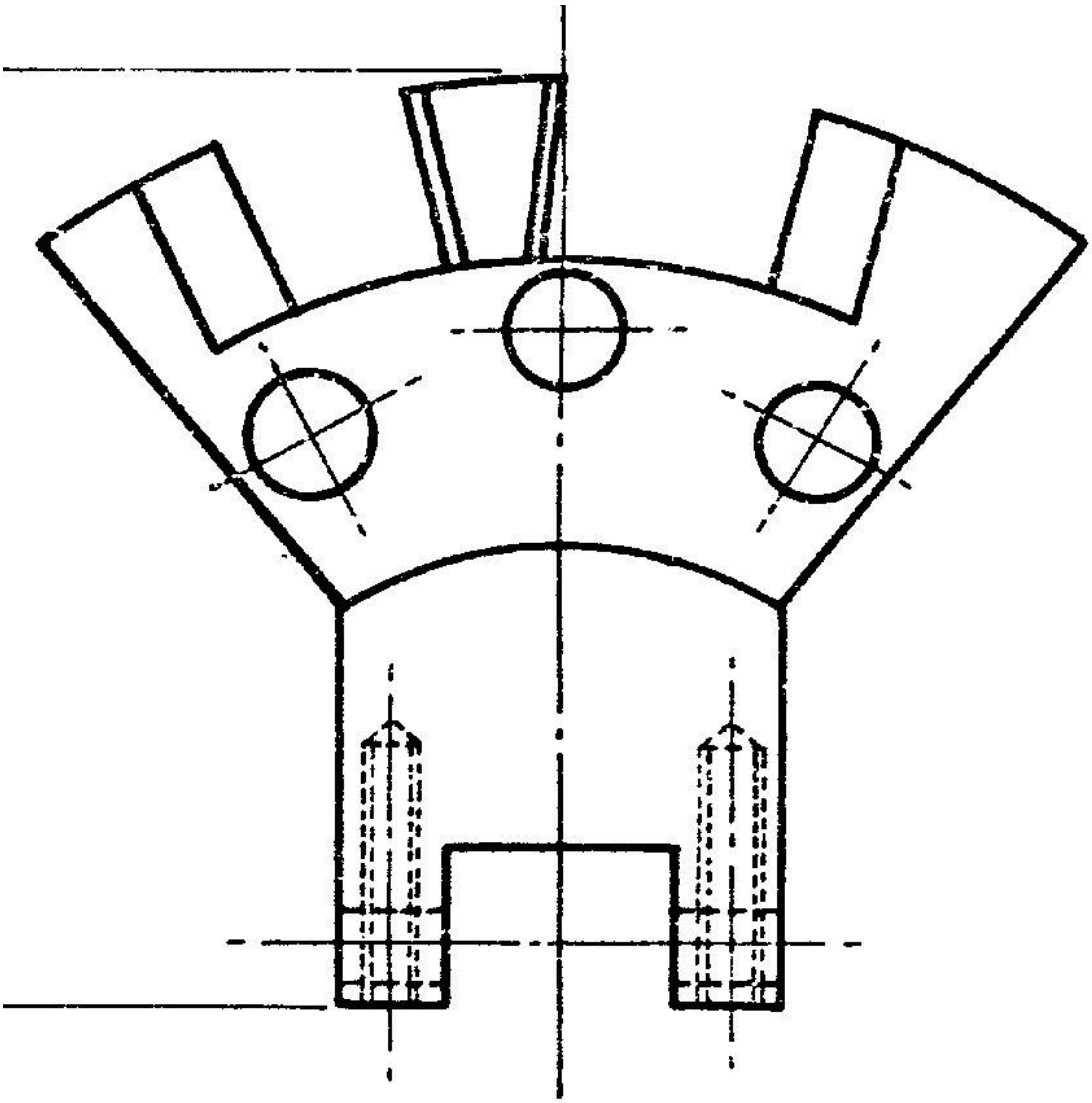
[40] Some doubt as to date; Board minute 2513 says 24th Jan; Information held by The Signal & Control Systems Engineer says 26th Jan.

[41] Operating Manager's report to L.T.E. Board, minute No 2513, 1.2.55.

[42] Commonly known as DELTA track circuits. It is not known when thin term became used hut it was in use at Ealing Broadway in 1952.

[43] A number of sites on the Northern, Circle and District lines had their "B, K & N" style frames converted to air operation.

[44] Acton Town and Barking have more shafts (72 each) but these are spread between 2 and 3 machines respectively. Kings Cross has had the most machines on one station (4) but each controlling different railways - Piccadilly, Victoria, Circle and City Widened Lines.



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