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## Computer-controlled Signalling on the Underground

London Transport has begun to introduce computer control of its signalling system. In order to understand the reasons for its introduction it is worth looking at the system in use at present.

### PROGRAMME MACHINE CONTROL

As a train approaches a controlled area its description (destination) is compared with that of the next timetabled train. If it is the same, the train is signalled away at the timetabled time on the correct route for its intended destination. If the description of the train is not the same as the next timetabled departure ie. it is out of turn, the programme machine will immediately sound an alarm to the regulator, and, after a pause, will direct the train (without delaying it) to its described destination. The programme machine will store the fact that a train has left for this destination and will continue to wait for the 'missing' timetabled train. This process can be repeated several times until the 'missing' train arrives, which will then be signalled away normally and the machine will 'step' to the next timetabled train. Should this train have gone, the machine will go on stepping until it reaches the next timetabled departure for which it has no corresponding stored train, at each step decreasing the store of trains by one. In this way the programme machine keeps in step with the train service.

Similarly, at a converging junction the machine will allow trains to run 'out-of-turn' should the timetabled train be delayed, and will keep in step by storing the passage of the 'out-of-turn' trains. Hence it can be seen that the normal operation of a controlled area is fully automatic. There remains, however, the need to supervise the operation of the train service and to deal with exceptional situations. These functions are performed by the Regulators. Each Regulator is responsible for the supervision of several interlockings.

### THE REGULATOR

The Regulators for the Northern and Victoria Lines are centralised in one room together with the Line Controllers. Each Regulator is provided with a track diagram depicting the occupation of tracks and the setting of the controlled signals; a programme machine diagram on which is shown the next train timetabled to arrive at each programme machine, together with the description of the next train due at each interlocking; and a warning panel which indicates any anomalous situation which the programme machine has detected. The Regulator is seated at a desk from which he can control the programme machines should the service conditions require it. The basic controls enable him to set the machines to signal trains:

- i) Normally ( as previously described),
- ii) According to their description alone, without holding them to time,
- iii) Strictly to timetable, or
- iv) Finally to operate the signals, manually by push-buttons.

In addition he can instruct the programme machine that a train has been cancelled or that an extra train will run.

At first sight, therefore it would appear that we have the ideal situation, with the Regulator only needing to intervene when the service is disrupted and being provided with all the necessary tools to restore the service to normal. However, several years of operation of this system have highlighted certain difficulties which the Regulators experience under present-day conditions - a far cry from the service which operated in the 1950s when these machines were first designed and one or two cancellations were the order of the day. The Regulators must enter the number of each cancelled train into all programme machines. As there can now be over 20 trains cancelled at any one time, mainly due to crew shortages this imposes a heavy mental and physical load on them.

In addition, he must scan the diagram to detect a train running slowly or stalled, interpret alarms from the machines, and communicate his observations and decisions to his colleagues on adjacent desks, to the controller, and to all staff affected. Therefore the time he is most needed is the time when he is overloaded. Conversely, at times of normal running when he is underloaded his concentration drops and his response to a service anomaly becomes correspondingly longer so that a bad situation develops before he can control it.

For these reasons it was decided that a process control system should be installed on the Northern & Victoria Lines, connected directly to the existing system in order to relieve the Regulator of his routine tasks and free him to act as an information source from which all staff on the line can learn of the train service situation. From this initial trial, further systems will be developed for the control of the other lines.

#### THE NORTHERN AND VICTORIA LINES

Due to the need for a high degree of reliability a duplicated computer system will be used, the 'off-line' computer normally being used to predict the effects of different control philosophies. In the event of the 'on-line' computer failing a manual change-over will be made, the simulation programme being suspended. The change-over will require a single switch operation, both computers containing all the necessary information for the 'on-line' operation, the 'off-line' computer being updated at 30 second intervals from the 'on-line' computer, thus enabling a rapid change-over to be made. The total number of digital inputs will be 4500 of which 500 are push-button inputs from the Regulator's desks. The system will also receive

information from some 50 Positive Train Identification points, from which it will determine the identity of trains - the set number, crew number and destination. The 1500 digital outputs will be connected to the Regulators' pushbuttons and will enable it to control the trains via the programme machines.

Each Regulator's control panel will have additional buttons to control the computer, which will operate as a master programme machine. In addition, he will have a Visual Display Unit on which will be shown the current cancellations and extra trains, any alarm messages and any information called for by the Regulator.

The Line Controllers will be provided with a Visual Display Unit and keyboard, on which they can type commands to the computer system and receive not only information about the present state of the service but also the effects of the different control strategies or of a potentially bad service situation which will occur if preventive measures are not taken.

The Automatic Equipment Technician, based at the control centre, will also be provided with a Visual Display Unit and keyboard on which he will be informed of equipment failures, both inside the computer and in external equipment. He will use his keyboard to inform the computer when he has corrected a fault or to obtain information from the computer.

In addition the computer will be connected to thermal printers in the offices of those Station Managers who have crew responsibilities. These will be used to inform them if a train due for crew relief is not running to time and to enable them to enquire as to the whereabouts of any specified train or crew. Similarly, each train depot on the line will be equipped with a thermal printer to inform the Depot Foreman of the arrival of unscheduled trains and to enable him to give up to date information on the trains which will be available. Thermal printers will also be installed at the Headquarters Controller's Office, the Divisional Manager's office, and in the Chief Signal Engineer's Report Centre.

Finally, the system will be linked to the London Transport Data Processing Computer Centre by a high-speed data link. This will be used to load the timetable and crew duty information, and to 'off-load' the details of the day's running.

#### THE STAGES OF INTRODUCTION

The Central On-Line System will be installed in a series of stages, no stage being introduced before the previous one has been proved on both lines. The first stage of introduction will be restricted to monitoring only.

##### STAGE 1

Input:- For this stage the system will follow the train movements from the changes of tracks and signals alone and generate a list giving each train's position and the time at which it



arrived at that position - the 'Train Matrix' eg., Train 1; Set 104; Crew 372; Description Edgware; is on track 25; having arrived at 10:23:32; Train 2.....The Train Matrix, giving the positions of all trains on the system, is the basic source of information for the whole computer system. From this matrix the Interrogation Programme enables Regulators, Controllers, Station Managers and Depot Foremen to ascertain the exact position of all trains and crews.

The first programme (Input Update) will filter each input to overcome spurious operations, a second feature of the input programme will be to build up a list of trains for each control point. This list will give the order of the trains which will pass the point during the next quarter of an hour, together with the times at which it is predicted they will do so, if they continue to run normally. This list, the 'Control Point Train Queue' will be updated whenever a train moves from one track to another, and could be displayed to the Regulators or Controllers if called for.

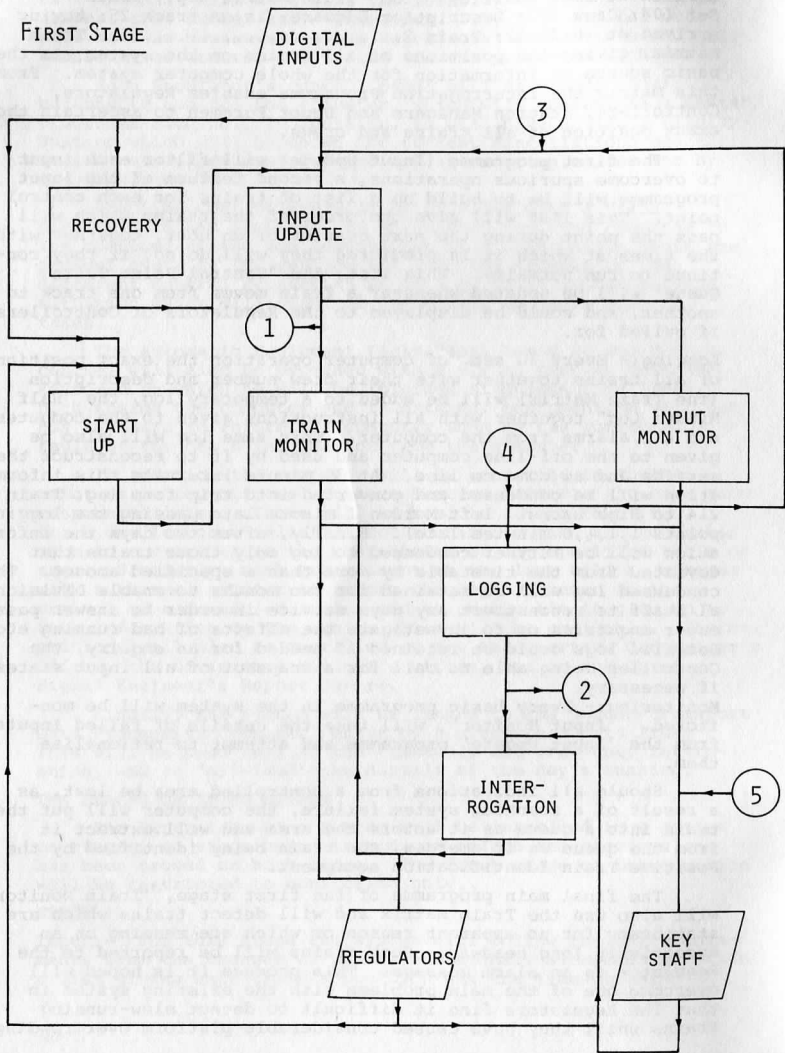
Logging:- Every 30 sec. of computer operation the exact position of all trains together with their crew number and description (the Train Matrix) will be added to a temporary log, the 'Half Minute Log' together with all instructions given to the computer and all alarms from the computer. This same log will also be given to the off-line computer and used by it to reconstruct the service and so come on line. At 30 minute intervals this information will be condensed and converted into trip form (eg. Train 214 to High Barnet left Morden 1 minute late passing the logging points 1,1,½,0 minutes late). Finally, after two days the information will be further condensed to log only those trains that deviated from the timetable by more than a specified amount. The condensed log will be retained for two months to enable Divisional Staff to reconstruct any days service in order to answer passenger enquiries or to investigate the effects of bad running etc. Detailed logs could be retained if needed for an enquiry, the Controller being able to call for a snapshot of all input states if necessary.

Monitoring:- Every basic programme in the system will be monitored. 'Input Monitor', will take the details of failed inputs from the 'Input Update' programme and attempt to rationalise them.

Should all indications from a controlled area be lost, as a result of a scanning system failure, the computer will put the train into a queue as it enters the area and will extract it from the queue as it emerges, the train being identified by the Positive Train Identification equipment.

The final main programme of the first stage, 'Train Monitor', will also use the Train Matrix and will detect trains which are stationary for no apparent reason or which are running on an excessively long headway. Such trains will be reported to the Regulator as an alarm message. This process it is hoped will overcome one of the main problems with the existing system in that The Regulators find it difficult to detect slow-running trains until they have caused considerable platform overcrowding.

FIRST STAGE



Hence it can be seen that in the first stage of operation the system will act as a monitor on the movement of trains and as an information source to all staff directly concerned with the operation of the trains. However, there is still a need to bring the computer into operation and so the following programmes will also be necessary.

**Start Up and Recovery:-** It is intended that the system will function automatically, and so a 'Start Up' programme will be written. This programme will use the Positive Train Identification points to generate the Train Matrix and will set the system on line. However, this programme will normally be used only at the start of the service when very few trains are running.

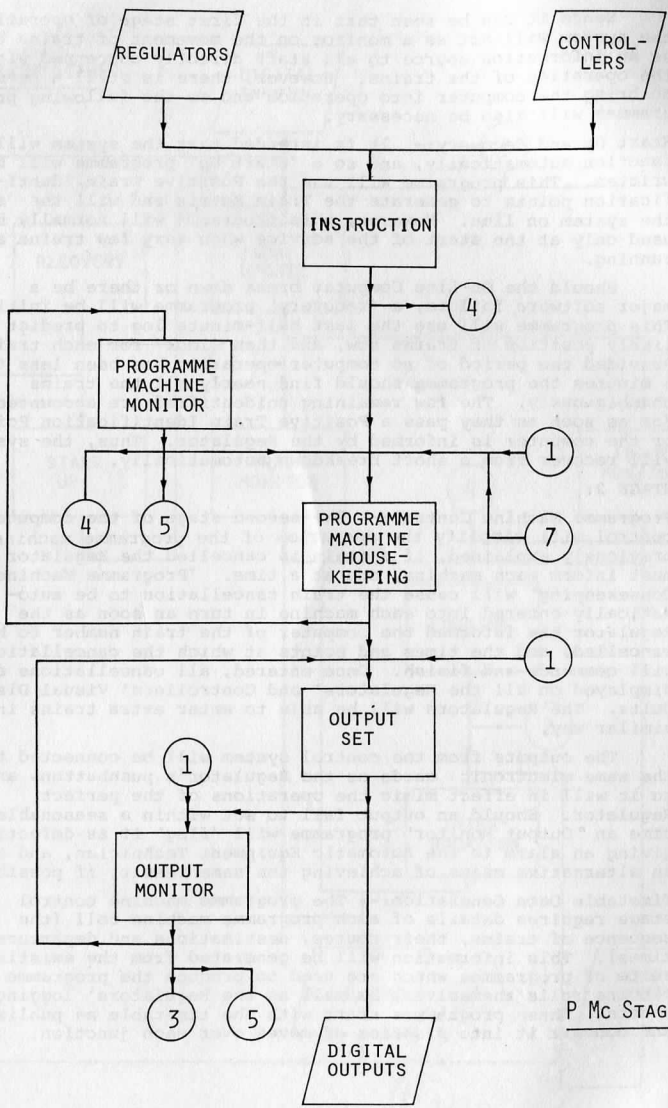
Should the On-Line Computer break down or there be a major software failure, a 'recovery' programme will be initiated. This programme will use the last half-minute log to predict the likely position of trains now, and then 'look' for each train. Provided the period of no computer operation has been less than 5 minutes the programme should find nearly all the trains unambiguously. The few remaining unidentified are accounted for as soon as they pass a Positive Train Identification Point or the computer is informed by the Regulator. Thus, the system will recover from a short breakdown automatically.

#### STAGE 2:

**Programme Machine Control:-** The second stage of the computer control will simplify the operation of the programme machines. As previously explained, if a train is cancelled the Regulator must inform each machine, one at a time. 'Programme Machine Housekeeping' will cause the train cancellation to be automatically entered into each machine in turn as soon as the Regulator has informed the computer of the train number to be cancelled, and the times and points at which the cancellation will commence and finish. Once entered, all cancellations are displayed on all the Regulators' and Controllers' Visual Display Units. The Regulators will be able to enter extra trains in a similar way.

The outputs from the control system will be connected to the same electronic cards as the Regulator's pushbuttons and so it will in effect mimic the operations of the perfect Regulator. Should an output fail to set within a reasonable time an 'Output Monitor' programme will 'flag' it as defective, giving an alarm to the Automatic Equipment Technician, and try an alternative means of achieving the same result, if possible.

**Timetable Data Generation:-** The programme machine control stage requires details of each programme machine roll (the sequence of trains, their routes, destinations and departure times). This information will be generated from the existing suite of programmes which are used to produce the programme machine rolls themselves, as well as the Regulators' logging sheets. These programmes start with the timetable as published and convert it into a series of moves over each junction.



P Mc STAGE



A check is then made for timetable conflict situations and the corrected timetable data used to generate a paper tape which is in turn read by the punch machines. These programmes will be modified to enable the crew duty information to be added. The output will be temporarily stored in the London Transport Time-Sharing System and then transmitted during the day to the off-line computer.

**Instruction Programmes:-** These programmes will provide the Regulators with additional controls to those at present available, which will enable them to hold, divert or reverse trains, the programme performing all the necessary train cancellation and extra train operations automatically.

#### FINAL STAGE:

**Regulation Programme:-** The next stage of operation will be the first which shows tangible benefits in the train service. The 'Regulation Programme' will control trains every 5 minutes of running time. This control will be through the station starting signals and so any delay to trains will be whilst a train is in a platform. The object of the regulation programme is to provide the optimum service possible without altering any train's destination. Such an optimum service varies from place to place and time to time. For example, at Archway southbound at 08.30 the ideal regulation will provide an even interval service to maximise train carrying ability, but northbound the ideal is no regulation, to let the trains reach their destination as soon as possible. During the off-peak the objective will be to keep trains to timetable whenever possible, especially at the ends of branches.

In operation the programme will look at each control point in turn, and if a train is able to be regulated i.e. less than a minute away from the signal, it will determine the time at which the train should leave. This time will be determined by i) a time which will provide even intervals, ii) a time to keep to timetable, iii) a time to provide even intervals to each destination.

These will be weighted according to a series of factors, variable at quarter of an hour intervals, and a final time calculated. If this is later than the present time the train will be delayed, the signal being cleared 15 seconds before the calculated time, to allow for the crew's reaction time.

The net result of the Regulation Programmes can best be seen from the point of view of the train operator. If he is proceeding at the desired speed he will approach each control point with the starting signal at danger. On stopping in the platform the starter will clear. Thus he knows that if the signal is clear on arrival he is required to make up time.

A routine will apply for trains approaching a trailing junction to determine the optimum running order after the junction. The effect is that two streams of trains approaching a trailing junction will be adjusted in a series of small changes so as to merge smoothly at the junction, thus optimising the





Above. Double-ended G-stock car at South Acton.  
Below. 1959 tube stock train to Hounslow passing  
through disused Osterley & Spring Grove  
station on 8 July 1971  
Both photographs from R J Greenaway Collection.



Control Programmes:- In the final stage of operation the system will be largely automatic. The last programme will be concerned largely with the overall running of the line. The object of these programmes is to detect serious situations developing in the service and to overcome them by alterations to train destinations, by diversion, turning short or reformation.

A fast simulation programme will run on the off-line computer starting with the current train's position. At regular intervals the simulation will be stopped and the predicted situation reviewed through a modified "train monitor" procedure. If an excessive interval is found various strategies will be tried in an attempt to overcome it. If one is found which will have the desired effect the Controller will be advised and the necessary steps taken.

In addition, the alarm messages from the monitor programmes will be reviewed and, in the event of a long train delay, trains approaching the stalled train are stopped, to prevent a queue forming in the tunnel. The Controller will be asked to estimate how long the delay will last and from this the optimum strategy will be determined.

Off-Line Programmes:- In addition to the 'Future Monitor' and 'Strategic Decision' programmes already mentioned the off-line computer will be used to evaluate new timetables (through the simulation programme), to run Regulator's and Controller's training procedures, and for programme development.

#### OVERALL EFFECTS

The complete system will control 130 trains simultaneously through the operation of 74 programme machines and thus release the Regulators from the need to perform a large number of routine operations. It should therefore free them to communicate their decisions and to answer staff enquiries which will result in an improvement in the information given to the public. Indeed, it is possible that the computer could be used to provide set announcements to passengers over the public address system.

The effects of computer control will probably not be noticed by many passengers but it will provide a more reliable and efficient service. Train crews should notice that they no longer become 'lost' after a service dislocation and so miss fewer reliefs. Station Managers should be able to keep track of their staff and so not be surprised by the sudden arrival of a hungry crew demanding relief!

#### LOCAL COMPUTERS

The programme machine concept of signalling provides several levels of fall back in the event of equipment failure. Normal supervision is from the control centre but should control be lost the programme machines will take over. Should a programme machine fail, the service can be controlled by push-button from the Centre, and should that also become impossible the area can be operated manually from the Interlocking Machine. Hence no single failure will stop the service, and indeed large areas of line have been operated entirely by programme machine, the control cables having been severed, without passengers being aware that anything was wrong at all.

Since this feature has been found to be invaluable in maintaining a reliable service it is intended to keep the same philosophy of a tiered control system in the conversion from programme machine to computer. This conversion has recently become possible as both the cost and reliability of computers have reached the level where they can be comparable with those of programme machines.

#### THE WATFORD EXPERIMENT

In order to test the practicability of local computer control the programme machines at Watford were replaced by a computer in 1973. This computer was programmed to perform in exactly the same way as the programme machines, but they have been retained to act as a standby and continue to run in parallel with the computer.

The computer contains the timetable in much the same form as does a programme machine (Train number, Description, Route and Time of Departure). As soon as a train enters the area from Croxley it is given the number and description of the next train due. When the train moves from signal berth to signal berth its number and description are moved inside the computer. Each time the computer determines if and when the signals should clear. Once in the platform the computer waits for the train's departure time, checks that it has had an adequate lay-over time and then signals the train away.

The added complication of the Watford site is that shunting movements occur and these too are computer controlled, the computer checking for immediate and potential conflicting situations before clearing a signal, to prevent the 'locking-up' of the terminus. Watford also happens to be one of the last sites at which coupling and uncoupling moves are made, and these are also handled by the computer, which checks that there is another half of the train to couple to before clearing the calling-on signal!

The signalman is provided with much the same facilities as a Regulator. The system constantly checks that it is working correctly and if a fault is found in the input-output circuitry appropriate messages are typed on thermal printers, one in the Interlocking Machine Room beside the computer, the other in the Chief Signal Engineer's Report Centre.

#### HEATHROW

As a result of the successful experiment at Watford, the computer having proved reliable and compatible with signal equipment and practice, it has been decided to instal computers for the local control of the signalling at Heathrow Central. These computers will be supervised from the existing control centre for the District and Piccadilly Lines at Earls Court. They will be programmed to operate as a modern programme machine site with conventional controls and display. In order to provide the high degree of reliability required until a central computer is installed, the computers will be duplicated. The two computers will run in parallel and an automatic switch over will be made should the on-line computer fail to service the 'watch-dog' or detect an error in its operation. The method of operation will, at least initially, be the same as for Watford.



## THE FLEET LINE

The developments so far described have been completed or are under way. Plans are at present being made for the control system for the Fleet Line, one possible solution being to combine the techniques so far described in a completely computer based system.

The local computers could perform the basic programme machine functions and would monitor the operation of the safety signalling, detecting and reporting any failures which occurred. Normal operation of the sites would, however be from the central computer, the local computer taking over control if it detected a failure in the central computer function.

The central computer would operate in much the same way as previously described. The Controllers would be provided with a desk, on which would be a number of displays. The first would be a colour display depicting the complete line. The second display would also be in colour and would be of any selected site, a third display would portray written alarms from the central computer, and replies to the Controller's questions. The fourth would be a closed-circuit television monitor showing the platforms, as on the Victoria Line at present. Finally a portable display would be available should any of the fixed displays fail.

Control of the line would be via a keyboard through which the computer could be instructed to perform the necessary actions (e.g. reverse train 012 at Wembley Park). Pushbutton facilities would be provided to enable routes to be cleared manually, and a keyboard to instruct the local computers directly if necessary. Further control panels would be provided to select the television picture required, operate the telephone and communications facilities and to answer drivers' enquiries through a continuous radio link.

The proposed system would retain all the features of the present one but would be automatic. Should the central computers fail, or be disconnected from a local computer site, the local computer will continue to run the service according to the last regulated timetable instructions. The local computer will therefore be able to maintain a very high level of service for some time, dropping back to a sophisticated form of programme machine operation when the regulated times no longer apply. As Positive Train Identification will be available by then, a better service will be provided than is possible at present with programme machines when operating unsupervised.

## CONCLUSION

Thus it can be seen that the development of the non-safety signalling system will continue in a series of stages each based on the lessons learnt from the previous stage and whenever possible tested in a controlled way before being applied to the system as a whole. Local computers will be developed independently of the central computer system but in such a way as to be compatible with the developments on the Northern Line and Victoria Lines. The central computer, by being installed on a line already equipped with programme machines, can be developed in a series of stages without prejudicing the level of service provided to the passenger

## Letter to the Editor

15th March 1975

Sir,

'Spagnoletti on the Underground'

There are one or two items that I can add to Colin Bett's article on the early signalling of the Underground, although I am unable to further the question of the method of block-working, one of the more interesting aspects of railway signalling.

With regard to intermediate signal boxes, there are many others to be added to Colin's list. 'Farringdon North' was a junction signal-box at the south end of the Clerkenwell tunnel, in use from the original opening until alterations were made to accommodate the City Widened Lines (CWL). 'Barbican' was approximately midway between Aldersgate Street and Moorgate Street stations c1870 but closed a year or so later, being replaced by 'Whitecross Street', somewhat nearer to Moorgate Street. 'Barbican' reopened in 1878 to control entry to Whitecross Street goods depot (Midland Railway). At 'Granville Street' there were in fact two separate boxes, one perched on the cross girders over the Circle Lines (the rebates in the brickwork for the floor joists may still be seen) at the north end of the Clerkenwell tunnel. The second one stood at ground level in a recess on the CWL side. 'Midland Junction' controlled the confluence of the Midland and the Great Northern tracks outside Kings Cross (Metropolitan) station and was the successor to the 'Kings Cross Junction' box which originally worked the 'triangular' junction of the GNR with the Circle rails from a 'roundhouse' between the tunnels from the beginning of October 1863 to the virtual closure of the GNR lines in 1866 for alteration to the tunnel layout prior to the CWL opening.

Further to the west there was 'Devonshire Street' between Portland Road and Baker Street, where the junction signal box was also at first in a roundhouse, but later stood in the bell-mouth of the tunnel itself, occupying the space left by the removal of the down line to the Metropolitan and St. Johns Wood Railway. There would appear to have existed at one time a cabin named

'Exeter Street', but even the site, believed to have been at the tunnel-mouth east of Edgware Road station, is conjectural (it may have been in substitution for a cabin between Harewood Street and Quebec Street which was not executed). West of this station, again in a roundhouse, was 'Praed Street Junction', later the locale of the Met's first all-electrically-operated signal installation. Three further boxes were constructed at 'Craven Hill', 'Chapel Side' and 'Campden Grove', respectively between Paddington/Bayswater, Bayswater/Notting Hill Gate and Notting Hill Gate/High Street Kensington; they were never equiped, in the absence of the expected traffic, and were ultimately demolished.

On the Hammersmith and City Railway there was 'Grove Road Junction' at the lower end of the connection to the London and South Western Railway's Kensington and Richmond branch outside Hammersmith (the structure stands today, 50 years after the closure of this rail link, on the up side of the H and C. 'Shepherds Bush', originally the station cabin, was isolated when, in 1914, old Shepherds Bush station was replaced by Shepherds Bush (new) to the north and Goldhawk Road to the south.

On the District, mention may be made of 'Minorities Junction' intermediate between Aldgate East and Mark Lane. Actually, like all the line from east of Mansion House station to west of Whitechapel, it was jointly owned by the two companies, and stood almost at the end of the Aldgate (Met) platforms. To the west there were the 'Gloucester Road' 'A' and 'B' Junction boxes and another box, 'Cromwell Road' (?), controlled the Earls Court leg of the Cromwell Road triangle at one time. Beyond Earls Court was 'Hammersmith Junction' (later 'West Kensington East'). 'West Kensington Junction', to the west of North End station, afterwards West Kensington, essentially controlled the entrance to the Midland coal yard - the station cabin was on the eastbound platform. 'Hanger Lane Junction' is the only box requiring mention on the Ealing and Harrow lines but there was a 'Lampton Junction' box where the line to Hounslow Barracks left the spur to the old Hounslow Town station. We must not overlook, but nearly did, 'Smithfield Market' which controlled the western outlet of the market sidings and the junction of the old spur from Snow Hill (London, Chatham & Dover Rly) with the CWL towards Moorgate Street.

It is getting away from the true Underground to mention all the boxes along the main line but there were, briefly, 'Tower Siding' (a ground-frame west of Wembley Park); 'South Harrow Junction'; 'Harrow Yard' (later Harrow North Junction); 'Watford Road' (later replaced by Watford Junction); 'Rickmansworth Yard' (about  $\frac{1}{4}$  mile south of the station); 'Mastler Wood' between Amersham and Great Missenden; 'Dutchlands' between Great Missenden and Wendover; 'Quainton Road Junction', a  $\frac{1}{4}$  mile north of the station and 'Verney Yard', a  $\frac{1}{4}$  mile south of the junction.

The Metropolitan also provided boxes for the GCR at 'Canfield Place' (Finchley Road); 'Mapesbury' (between Kilburn and Willesden Green); 'Brent' (North added later?). Temporary

cabins in use on the Metropolitan during construction included 'Canfiled Place', 'Neasden Junction' and 'Preston Road Junction' (subsequently replaced by 'Kenton'). It is not suggested that this list is complete, but such have come to my notice as being in existence down to the beginning of the twentieth century.

There is an article in the Railway Magazine for May 1907 describing some of the tunnel boxes and the conditions under which the men worked. As the reporter was accompanied by a senior supervisor one cannot be certain that the opinions expressed were entirely unbiased.

I do not think we can accept that the wooden signal post in the first opening east of Sloane Square is a relic of the 19th century. There is very little positive information available about 'roadside' station signalling but, in general, unless junctions were to be found in the station area, the usual provision was a distant signal (at which the driver was required to stop, then draw his train within it if at danger and await the guard's instruction to proceed when the signal was taken off) and a starting signal, non-interlocked.

"The Engineer" for October 4th 1895 reproduces (on p 327) a condensing diagram showing the tunnel areas for each direction of running in which drivers were forbidden to exhaust to atmosphere. This was intended to ensure reasonable sighting of the signals, which are also shown. The up distant signal is hereon shown as being about 50yd west of the second opening to the east of Sloane Square station, or approximately 85ft from the platform; it would have been of the rotating disc type located in the 6 foot way. The diagram had not been modified since 1872 and it is very unlikely that any of the old mechanical signalling should have been repositioned at any time in the 40 years of steam operation. The post under notice is a mere 450ft from the platform - too close for safety for a distant, and there would have been no home provided in those days. A home signal is known to have been provided at that point in 1911 together with a repeater for an inner home signal nearer the station. The post, which bears a skeleton finial similar to that used by McKenzie and Holland, and Westinghouse after them, is similar to those of the period installed at Wood Lane, Golders Green and elsewhere. The post drillings for the two signals are located in the side of the post at very close centres, suggesting bracket supports for two signals of the lamp-relay-signal or of the UDX type (the latter being a D.I.Y. multi-aspect arrangement built up from a number of superimposed single loop units, still to be seen on the District). This assembly appears to have remained in service until 1928 at Sloane Square when modernization, involving a 4-home-signal arrangement, made the position redundant. Owing to the presence of the cable-run in front, no attempt had been made to remove the post after the equipment had been stripped off.

Yours faithfully,

Claygate, Surrey.

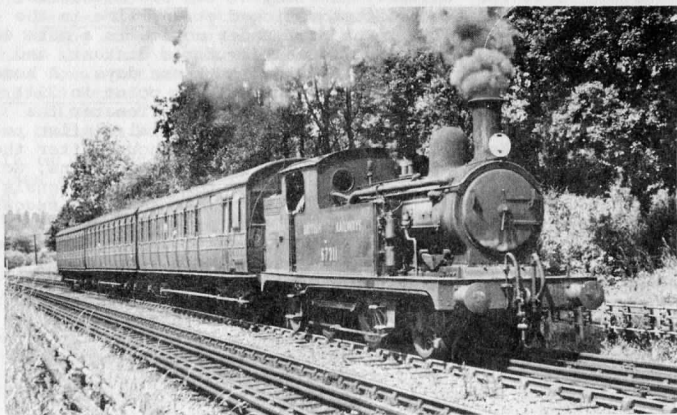
K. Benest.



Above. S15S (ex-LT 3273) being removed from Acton Works for Ryde IoW. 20 March 1971

Below. Loughton - Epping train approaching Theydon Bois in August 1949. (Photomatic)

Both photographs from R J Greenaway Collection.





## The Underground Guide 1936-1972

The present hiatus in the publication of the Underground Guide, caused largely by the fluctuating level of service which London Transport has been able to provide over the last few years, provides a suitable opportunity to bring up to date the list published in Underground for April 1970 and to place on record such information as is available about earlier timetable booklets which were mentioned briefly at that time.

Public timetables have always been available in some form on the Underground. On the Metropolitan and District systems in the nineteenth century, as well as posters displayed at stations, timetable books (for which a charge was made) and free leaflets were issued at regular intervals. The books usually contained complete timetables of passenger services, and those of associated companies and information about fares and other services provided by the company such as conveyance of parcels. There were also advertisements for other railways, hotels and places of interest. The leaflets were produced for individual stations and showed much briefer details of trains from that station, fares (particularly cheap facilities) and generally advertised the issuing company. Sometimes a map of the system was also included. A number of these early leaflets are on display at the London Transport Collection at Syon Park.

When the tube lines came, each individual company issued its own publicity material and did not always mention other lines, even at interchange points. Quite elaborate folders were issued at the time of opening, printed in two or three colours and giving details of first and last trains, fares and other facilities. As they were re-issued, these folders became simpler and less attractive, but they continued essentially unchanged for many years - until 1936 in fact. From the 1920s on, when lines were longer, perhaps with branches and the services more complicated, timetable information for a complete line was no longer given in one leaflet, but in a number of them, each one dealing with a branch or a group of stations at one end of a line and showing times of trains from each of the stations to Central London in some detail (and of course times from London) but very little information indeed about the rest of the line, let alone the rest of the system. The format of these timetable 'leaflets' varied - sometimes they were simply a sheet folded in half, sometimes they came in small booklet form and stapled; so far as is known, no charge was made for any of them. There was a good coverage of the suburban and country sections of lines but apparently not of the Central Area. Perhaps it was felt that services here were too frequent to need publicity.

The Metropolitan Railway at this time issued a series of timetable booklets jointly with the LNER showing complete timetables for the 'Wood' (Main) and joint lines, with first and last times for its other lines such as Hammersmith, Addison Rd, and Inner Circle. A penny (1d) was charged for these booklets but there were also free leaflets issued though not much is known about them.

No attempt has been made here to list these pre-LPTB issues since so few are available; whilst it can be argued that two

items constitute a list, many more examples will need to be recorded before the present compiler will feel that he has a worthwhile list to offer.

The formation of the London Passenger Transport Board had little effect for a year or two upon the existing arrangements for dispensing timetables to the public. On the Underground group lines, individual local leaflets continued until 1936 whilst the MET & GC penny booklets also continued under the new management but were produced by the LT publicity machine - at first the Met's printers, Knapp, Drewett & Sons Ltd continued to print them but this contract was soon transferred to Index Publishers (Dunstable) Ltd, a then new printing organization whose early development was very closely linked with the fortunes of the new LPTB (Index printed a very large proportion of London Transport's timetable work and 'free' publicity until the early 1960s when their share of this work decreased. They were taken over by IPC soon after and now produce mainly the ABC series of travel guides). Known details of the 1933-6 series of MET & GC 1d booklets are summarized in Table 'A'.

Table A. MET & GC Line TT Booklets 1933-6

DATE	REFERENCE	NOTES
13 November 1933	No.1. New Series. 10,000. 33. 3308	1
22 January 1934	No.2. New Series. 20,000. 34. 6.	2
-	34-741-6,000	3
9 April 1934	No.3. New Series. 20,000. 34. 1160	4
1 October 1934	No.4. 20,000. 34. 3434	4
<u>NOTES</u>		
1. Blue cover. Name of printer not shown. 88 pages		
2. Green cover. Printed by Knapp, Drewett. 124 pages		
3. Alterations & additions leaflet to 22 January 1934 booklet. Printed one side only, in blue.		
4. Blue cover. Printed by Index Publishers (Dunstable) Ltd. 72 pages.		
5. An alteration leaflet is also known to a timetable dated 29 April 1935 (Possibly No.6) - the leaflet (5"x3½"), printed in red on cheap white paper, has no reference and the timetable booklet has not been seen.		
6. All these timetable booklets, as indeed all other issues listed in this survey were trimmed to 6½"x4½".		

A complete reorganization of the presentation of public timetables took place in 1936. So far as the Underground is concerned, all existing leaflets and booklets were abandoned and a book (size 6½"x4½") titled 'Underground Guide' was published containing timetables for all lines, a map (printed in black only) and a few pages of advertisement matter. Curiously, the first few tables in the book dealt with the Metropolitan

Line. This is one of very few cases where the Metropolitan was given prominence at the head of a list by its new masters. No doubt it was convenient, when compiling the first edition, to take the existing Met & GC booklet as it stood and add tables for the other lines to the back. A study of the order in which the tables appeared in the years to come is beyond the scope of the present article, though it is an interesting aspect in itself.

The timetables in this new publication and its successors to 1939 (12 issues; details in Table 'B') were printed so that it was necessary to hold the book with the spine horizontal in order to use it. For the first two issues, however, the cover was arranged in the conventional manner with the wording parallel to the shorter edges. This was changed from the 1937 No 1 edition whenceforth the cover alignment coincided with the rest of the book. With this issue also, the title was changed to 'Underground Timetable' and the colour of the cover became red, with lettering in white and black. The first two editions, for 1936, had blue and light brown covers, with the title in white.

Most of this series of Underground Guide contained a map in the back; the first two had the by then familiar Beck diagram though printed in black only and on the same paper as the rest of the book, folded twice and approximately the same size as the conventional pocket folder. The back of the map had an enlargement of the Central Area in contemporary style. The 1937 and 1938 issues had very different maps. They opened out to approximately 24"x18" and were printed on thin translucent paper. The system, although semi-stylized, was not diagrammatic and was shown on a base-map of major roads printed in grey, with Underground lines at first in red and later in black. 1935-40 New Works Programme extensions were shown, with anticipated opening dates and the variations in these are another diverting feature worth studying. The Artwork for the maps was prepared by Geographia Ltd, and probably also printed by them, whilst the rest of the Guide was printed by Index. The 1939 issues did not contain a fold-out map, instead a diagram of the Central Area occupied two pages.

Work on the 1939 No 3 edition was far advanced before it was abandoned as a result of events in early September.

After a brief pause to get used to the new situation - the period, whilst by no means one of chaos, nevertheless is one about which it is EXTREMELY difficult to establish any concrete information as to what exactly did happen - the country settled down to wartime conditions. The next complete Underground Guide was not to be published for nearly twenty years, but this of course was not good enough for one particular line where the tradition of being a REAL railway was not yet dead. The Metropolitan and Great Central Joint Committee, through the LT publicity machine, reissued its old penny timetable booklet (though it now cost 2d). The first issue came into force on 20 November 1939 and consisted of 48 pages printed (by Index) on Railway Handbill paper, plus a four-page salmon-coloured thin card cover. No 2, with a green cover came on 1 January 1940, No 3 with a buff cover on 14 April, No 4 (red cover) on 5 August and No 5 (dark green cover) on 9 December, whereafter the issues were numbered within each year instead of in a continuous sequence, until 1947. The first two issues of 1941 had a fairly bright coloured cover,

incorporating the joint LNER/Underground totem in the design, but from No 3, 1941, until 1947 all the covers were dark blue with lettering and totems reversed-out of white; very much like any other LNER local timetable in the London area in fact, many of which were also printed by Index. The main table, showing trains from Baker Street and Marylebone at first showed them as far as Quainton Road, but later the Marylebone trains were shown as far as Woodford & Hinton (subsequently renamed Woodford Halse).

After nationalization, London Transport continued the series unchanged but provided a brighter cover. The price remained 2d until the end of 1950 but from the July 1951 issue this became 4d. Both 1948 issues had grey covers but then until 1952 alternate issues were pale blue/grey and a not easily describable shade of pink. From 1953 to 1957 covers were cerise, blue, brown or lilac, successive issues bearing different colours but there being no apparent order in the four; shades varied slightly. The cover design from 1948 to 1957 remained generally unchanged apart from minor typographical variations which are not recorded here..Not every issue of these booklets has been seen, but it has been assumed that there were two a year. Details of those known are shown in Table 'C'.

Table B. UNDERGROUND GUIDES 1936-9

COVER DATE	REFERENCE	PERIOD VALID	NOTES
May 1936	36. 1337. 30,000		
Winter 1936-7	36. 4655. 30,000	From 1 November 1936	
1937 Number 1	37. 1453. 25,000	3 May - 4 July	
1937 Number 2	37. 2786. 25M.		
1937 Number 3	37. 4086. 25M.		
1938 Number 1	37. 6018. 21M.	31 January - 1 May	
1938 Number 2	38. 1235. 33M.	2 May - 3 July	
1938 Number 3	38. 2431. 20M.	4 July - 25 Sept	1
1938 Number 4	38. 620B. 15,100	3 October - 20 Nov	2
1938-9 Number 5	38. 1786B. 30M	28 Nov - 30 April	
1939 Number 1	39. 4285B. 30M	1 May - 2 July	
1939 Number 2	39. 5232K. 17M		

NOTES

1. Validity later extended until 2 October
2. Validity later extended until 27 November
3. Some of these timetables bear the code LT 149 (1) near the reference. This is of no value in identifying issues and is not part of the reference; it merely identifies the first signature of this particular book and is used by the printer and binder to get sections in the right order.

Table C. Metropolitan Line Timetable Booklets 1939-1957

COVER DATE	VALID FROM	REFERENCE
	November 20, 1939	20,000. 39. 2141G.
No.2	January 1, 1940	15,000. 39. 3229K.
No.3	April 14, 1940	15,000. 39. 4304K.
No.4	August 5, 1940	8000. 40. 5555G.
No.5	December 9, 1940	1240. 6941G. 15M.
No.1. 1941	March 31, 1941	341. 1633GX. 11250
No.2. 1941	May 5, 1941	441. 1994GX. 15000.
No.3. 1941	October 6, 1941	941.3178G. 15000.
No.1. 1942	May 26, 1942	542.1088H. 15000
No.2. 1942	November 2, 1942	1142.2298H. 20,000
No.1. 1943	May 3, 1943	543.-780H. 20,000
No.2. 1943	October 4, 1943	543-1632H. 25,000
No.1. 1944	May 22, 1944	444-749H. 30M.
No.2. 1944	October 2, 1944	944-1764H. 30M.
No.1. 1945	May 7, 1945	445-699H. 35M.
No.2. 1945	October 1, 1945	945-1555H. 35M.
No.1. 1946	May 6, 1946	446-1096H. 40M.
No.2. 1946	October 7, 1946	846-2572F. 40M.
No.1. 1947	June 16, 1947	846-2572F. 40M.
No.2. 1947	October 6, 1947	1047-1832B. 40M.
	May 31 1948	548-954B. 40M.
	September 27th 1948	9/48-1952D. 40M.
	May 23rd 1949	5/49-1952D. 40M.
	November 7th 1949	10/49 2158B 35M
	June 5th 1950	4/50 889B 35M
	September 25th 1950	8/50 1879J 40M
	July 2nd 1951	6/51 1052J 30M
	September 10th 1951	8/51 1695J 30M
	June 30th 1952	5/52 994Z 18,000
	November 3rd 1952	9/52 1954Z
	June 8th 1953	4/53 977Z 20M.
	November 2nd 1953	9/53 2005Z 20M.
	June 18th 1954	5/54 1180Z 20M.
	September 20th 1954	8/54 1946Z 20M.
	May 2nd 1955	4/55 596Z 20M.
	November 7th 1955	10/55 2152Z. (15M)
	June 11th 1956	5/56 1010D. (20M)
	June 17th 1957	4/57 911Z. (20M)

A new series of Underground Guides was started in late 1957 and was an immediate success. It was maintained until the end of 1972 when it became increasingly difficult to maintain advertised services. Generally, there were two editions a year and up to four in earlier years when alterations to timetables were more frequent, but from 1968 new editions became slightly erratic.

Table 'D' follows on the next page and lists all known issues of the Guide together with amendment leaflets and booklets which are known about. Further details of individual items will be found in the Notes after the Table.



COVER DATE	REFERENCE (Books)	REFERENCE (Leaflets)	NOTES
Winter 1957-58	none	-	1
Winter 1957-58	none	-	1
-	-	158/28S/10M	2
Spring 1958	none	-	-
Summer 1958	558/1124S/40000	-	3
-	-	858/1806S/25m	4
-	-	1058/24635/15m	5
Spring 1959	259/386S/20m	-	6
Summer 1959	559/1202S/20m	-	-
Autumn 1959	859/2184S/10m	-	7
-	-	1059/2685S/3M	8
-	-	1059/2766S/3½M	8
-	-	1159/2829S/1M	8
Autumn 1959	1059/2712S/15m	-	9
Winter 1959/60	1159/2890S/25m	-	10
March 1960	360/456S/10m	-	-
June 1960	560/888S/20m	-	-
Autumn 1960	860/2116S/30m	-	-
-	-	960/2370W/10M	11
Summer 1961	561/1249S/30m	-	12
Winter 1961	761/2090S/30m	-	13,14
Spring 1962	262/534S/10m	-	-
Summer 1962	562/1462S/30m	-	-
-	-	862/2412S/12,000	15
Winter 1962	862/2651S/30m	-	-
Summer 1963	563/1429S/30m	-	16
-	-	no ref	17
-	-	863/2195S/7½m	18
Winter 1963	863/2348S/25m	-	-
-	-	1263/3334W/10,000	19
-	-	no ref	20
16 March 1964	264/426S/15m	-	-
-	-	364/961S/6m	21
16 March 1964	464/1352S/15m	-	22
7 September 1964	864/2415S/25m	-	23
-	-	964/2953S/25m	24
14 June 1965	565/1715S/30m	-	-
11 October 1965	865/2595S/30m	-	25
-	-	1165/3494S/20M	26
2 May 1966	366/988S/30m	-	-
17 October 1966	966/2910S/30m	-	-
June 1967	467/1138S/25m	-	-
16 October 1967	967/2226S/25m	-	25
14 October 1968	868/2330S/25m	-	-
-	-	968/2915S/20M	27
10 March 1969	269/2365/25m	-	28
-	-	969/3484C/5000	29
2nd February 1970	1169/4065S/25m	-	30
-	-	270/577M/45M (3ch)	31
-	-	970/2250M/4000	32
30 November 1970	770/1604M/25m	-	-
-	-	1170/2697H/15,000	33
-	-	1170/32688/10,000	33
-	-	471/1939H/10,000	34
-	-	671/2545H/6000	35
7 February 1972	172/1317M/25m	-	36
-	-	172/1302L/25,000	37
-	-	372/1816J/25,000	38
13 November 1972	772/2746M/15m	-	39

NOTES to Table 'D' The Underground Guide, 1957-72

1. Two printings were made of this edition owing to the first selling out sooner than expected. The first was of 30,000 copies, the second is not known. The only obvious difference between the two is that one has the printer's name on the last page; it is not known which printing appeared first. Neither bears a reference.
2. 4-page leaflet with new Epping-Ongar service starting on 13 January. Replaces pages 24-25.
3. Reference and printer's name inside back cover.
4. Amendment booklet containing alterations to Metropolitan Line starting 15 September 1958. Certain complete pages revised and other minor changes. Booklet printed throughout in brown ink of a similar shade to the cover of the guide. Note on the front advises that the Summer 1958 edition will be current throughout the winter months until a new book is necessary, when it will be advertised at Underground stations. Reference is on p.2 of the booklet.
5. Amendment booklet containing further alterations mainly to Metropolitan (commencing 22Nov) and District (from 1 Dec) Lines and the 15 September changes from the previous leaflet, and in addition a list of stations to be closed on Sundays. Reference on p.4. Colour blue.
6. Printer's name on inside back cover, reference moved to inside front cover, for next few issues.
7. First Autumn Edition. MF times for Central Line announced in table of contents as starting on 12 October.
8. Amendment leaflets (three printings), Metropolitan Line changes starting 2 November 1959. "...leaflet to be used in conjunction with the first Autumn Edition of the Underground Guide. A second edition (available shortly) includes these changes". 4 pages, printed in magenta (similar to the later Underground Guide covers) by Kelly & Kelly.
9. Second Autumn Edition, including alterations commenced 2 November 1959.
10. Metropolitan Line timetable from 4 January 1960
11. Erratum slip, referring to 6.26 a.m. Chesham - Chalfont train. Printed in vermilion. Size 5"x3".
12. First glue-bound edition. Previously they had been stapled.
13. First magenta cover. Previously they had been dark brown.
14. Reference on inside back cover from now on.
15. Alterations from 10 September 1962 to Bakerloo, District, Metropolitan, Northern and Piccadilly Lines. 4-page leaflet printed in Prussian blue.
16. Timetables current from 17 June except Central and Northern Lines which are current from 1 July.
17. Postponement slip. Central Line timetable to start on 8 July. Size 4½"x2½". Printed in scarlet. No reference.

18. Amendment booklet containing alterations to Bakerloo, Metropolitan, District and Piccadilly Lines commencing 9 September 1963. Certain complete pages revised and a number of minor alterations. Printed in blue.
19. 2-page alteration leaflet commencing 16 December containing temporary alterations on Metropolitan Line due to staff shortage. Colour Prussian blue.
20. Substantial alterations booklet of 52 pages. Due to staff shortages, cancellations on District, Northern and Piccadilly Lines from 20 January 1964 and new timetable on Metropolitan Line from 3 February. Printed in cerise.
21. Amendment slip refers to Central Line train on p.18. Size approximately  $3\frac{1}{2} \times 2\frac{1}{4}$ ", colour magenta.
22. Also dated 16 March 1964 on the cover, this is a reprint of the first issue but incorporating information published in leaflet described by note 21 and other minor changes.
23. There was an additional leaflet, not issued in conjunction with the Guide, but relevant. Printed by Kelly & Kelly in a deep shade of red, size approx  $12\frac{1}{2} \times 6\frac{1}{4}$ ", folded into three panels, it refers to Northern City Line changes in connection with the withdrawal from Finsbury Park. Reference: 964/2971Z/15000(A).
24. Supplement to 7 September Guide including alterations from 12 October and postponing validity of entire Guide to 12 Oct. Colour prussian blue.
25. All the examples of these editions studied have the map stuck in back to front so that the index shows when it is unfolded.
26. Alterations slip (colour Prussian blue) concerning minor alteration to District and more substantial to Central Lines, starting on 22 November.
27. More temporary alterations to Metropolitan Line due to staff shortage. Colour magenta.
28. Another relevant leaflet but not a supplement to the Guide, describing the "New Pattern of Northern Line Services from March 10". Printed in black, with no printer's name or reference, on glossy paper trimmed to  $12 \times 7\frac{1}{4}$ ". It was essentially a miniature of a double-royal ( $40 \times 25$ ") two-colour publicity poster displayed at stations.
29. Supplement containing alterations to Northern and Victoria Lines starting on 20 October 1969. Colour Prussian blue.
30. Starting with this issue, price of the Guide increased from 1/- to 2/-. In this issue a note on the Bakerloo Line table advises reduced services "due to rolling stock difficulties".
31. 16-page amendment booklet containing new pages for Central, Metropolitan and Northern Line tables in 2nd February book, and other minor alterations.
32. 52-page amendment booklet, incorporating the one above but including more changes, current from 5 October 1970.
33. Two printings of an otherwise identical leaflet listing temporary train cancellations on the District Line. No printer's name, colour blue.

34. 16-page booklet printed in blue containing amendments current from 2 May 1971.
  35. Similar to above (Note 34) but printed in red and current from 24 July. Includes new Victoria Line timetable for the Brixton Extension instead of a full-page advertisement for 'Tube Trains Under London' and 'Steam to Silver'.
  36. First decimal-price edition (10p).
  37. Alteration slip issued WITH 7 February Guide (as opposed to issued after the Guide has been available for a time) correcting Chesham branch service. Not an Erratum slip as the service was temporary and not intended to last for the full currency of the Guide. Printed very dark blue (almost black).
  38. 4-page leaflet incorporating above but also giving new Bakerloo Line timetable current from 1 May 1972.
  39. Redesigned cover, with roundels and a broad white strip down the left-hand side of the cover. Colour still magenta.
  40. General Note Unless otherwise stated, the folded size of all leaflets etc, is approximately the same as (or rather smaller than) that of the Guide, so that they fit neatly inside. Furthermore, they were usually printed by Waterlow & Sons Ltd, who also printed the Guides from 1957.
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### Cover photograph captions

- Page .v. (Front) Northbound tunnel headwall at Rotherhithe, East London Line, on 13 February 1971.
- Page .viii.(back) Q-stock No.4197 (complete) and debris of scrapped Q-stock at Ealing Common depot on 13 October 1970.
- (both photos courtesey R J Greenaway)
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