

AUTOMATIC FARE COLLECTION ON THE LONDON UNDERGROUND

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INTRODUCTION

A ticket is a curious thing. Usually an inexpensively produced piece of card, it is given in exchange for hard-earned cash and is rarely regarded as an inexpensive purchase. In most cases a passenger having completed the journey would have been required to hand it back. Even along the route there could be any number of people who might demand to scrutinize it or punch a fancy hole in it. There is no product quite like a ticket. Of course, when somebody 'buys a ticket' they do not actually 'buy' anything of the sort. It is travel they are buying. Nor is a ticket strictly a receipt because it remains the property of the railway.

A ticket is probably best regarded as a kind of token. The old pre-printed ticket started life, valueless, in a printing works. It might then languish briefly in some secure railway store. When the responsible official took the tickets out of store and entered the serial numbers in the appropriate book of tickets despatched to stations they then acquire their full face value. The station received them at that value and gradually sold them. In due course every single sale was recorded and the cash representing the sales value was banked. It was the job of some audit department to reconcile every sale of every ticket type with its cash value. Within the ticket office the ticket is a token that represents cash yet to come.

Meanwhile a passenger wants to make a particular journey on the railway system. He states that he wants a ticket for that journey and usually he would have been given a specific ticket for that journey with start and ending stations on it, and the route, ticket type and price. The passenger pays the price and the ticket then acts as a receipt insofar that it is clear he has paid neither too much nor too little for the journey required and that the journey asked for is possible. The ticket would have been dated at time of issue in a special date press, thus validating it. It would have been punched by a ticket collector early in the journey both to certify where the journey actually started (ticket nippers punched distinctive marks) and to prevent it somehow getting back to the ticket office in a condition where it might have been pos-

sible to sell it again (to the clerk's benefit rather than the company's). With the route marked on the ticket anyone else wanting to see it could tell whether the passenger was going the right way or not. At the end of the journey the ticket (or forward portion if it were a return) was collected and batched up for officials at the sorting office to enjoy. This was useful for journeys between two or more companies where revenue had to be apportioned and the various punch marks helped identify routes taken. It may therefore be seen that the humble ticket is part of a complex system covering legal, accounting and operating matters. Any changes to such a system must be viewed in this light.

For more than a century the London Underground ticket system was essentially a development of the ticketing practices adopted by the main line railway companies. When the Underground began operation in the middle of the nineteenth century all tickets were issued by clerks located in ticket offices (or 'booking' offices, as they were then more commonly called). As the Underground became larger and busier so pressure emerged to speed up and simplify ticket issuing, and at the same time contain the costs of employing ever-larger numbers of booking clerks. This pressure led to automation. Initially ticket offices were supplemented by free-standing ticket machines, and later on automation was introduced within the ticket office itself. Finally, a technology emerged which was capable of reading a coded ticket and controlling passenger access to the system accordingly. This entire field is called Automatic Fare Collection (AFC), and this book tells the history of AFC on the Underground.

Before delving too deeply into Automatic Fare Collection it will probably be helpful to examine the ticket system employed, although this is not the place to provide the full historical treatment of ticket and ticket machine history, so only relevant developments will be mentioned and by and large unsuccessful experiments are ignored.

THE ORIGIN OF THE LONDON UNDERGROUND TICKET SYSTEM

The earliest component parts of the Underground, the Metropolitan and Metropolitan Dis-

trict Railways, employed exactly the same ticket system that the main line companies were using in

the latter half of the nineteenth century. This was the so-called 'Edmondson Card' System where a standard sized ticket containing full details of the journey to be made was issued to the passenger from the ticket office. The ticket clerk selected the ticket from the appropriate ticket tube (or rack) and dated it in a special press at the time of issue. Ticket issuing was naturally slow and the number of different denominations of tickets very large, with every station having to stock the whole range of tickets to every other station on the railway, or on neighbouring railways with which through booking arrangements were in force. This already potentially large range of tickets then needed to be multiplied by the different types of ticket available (for example single, return, privilege, animal, soldier's leave, and so forth). These types of tickets are known as point-to-point tickets and are still generally employed in one form or another by the main line railways and in a very limited form on the Underground, though in both cases they are no longer of the 'Edmondson Card' type. A slight reduction in the size of the ticket stock was made by combining tickets for particular stations where the fare for both was the same and they were on the same route (this is why sorting collected tickets was useful as it was only possible to determine the journey actually made when, in fact, it had been made).

When the electric tube lines opened in the period 1890 to 1907 a much-simplified system was initially used. The City & South London (1890), Central London (1900) and Baker Street & Waterloo (1906) Railways all charged a flat fare at the start. While tickets were issued from ticket offices, they were collected or cancelled before proceeding to the platforms, and on the CSLR turnstiles ensured that passengers proceeded the right way. On the first two railways this arrangement lasted a few years, but on the Baker Street and Waterloo it was abandoned after a few months. In each of these cases, and where new lines opened, graduated fares were then deployed, necessitating the introduction of ticket checking at the end of the journey.

The gradual inauguration of through booking facilities between the tube, District and Metropolitan Railways made point-to-point ticket issue increasingly awkward. London Underground traffic was steadily increasing—each (usually very small) ticket office had to keep on hand several thousand different ticket stocks and this would have made ticket issuing impracticably slow. Between 1911 and 1927, whilst through booking systems were blossoming, the introduction of the 'scheme' ticket took place. This was a ticket that

listed all the stations available to the passenger at a particular fare. This simplification alone significantly reduced the number of tickets that were needed in the ticket offices, since one scheme ticket could do the job of ten or more point-to-point tickets. In the last of the scheme ticket introductions it proved possible to withdraw about 7000 sets of tickets from the ticket offices. By about 1926, once the scheme ticket system prevailed, a special check of ticket sales took place lasting about three years. As a result some very little used tickets were withdrawn enabling the total scheme ticket stock to be reduced from about 50,000 to about 20,000 sets. (A passenger wanting to undertake a journey for which there was a quoted fare but not a printed ticket was issued with a handwritten paper ticket – a slow but mercifully infrequent event.)

The scheme ticket prominently displayed the station at which it was purchased, together with the fare paid, but the range of destination stations was such as to render the type size rather small. This led to the discovery that it was possible for ticket collectors to establish a ticket's validity simply by noting its originating station and fare paid, and rapidly calculating whether or not the passenger had paid enough money for his journey. The stations to which the ticket was available were printed on the face (sometimes the back as well) of the ticket largely for the benefit of the passenger and was a final arbiter in cases of dispute.

The advantage of the scheme ticket was that it allowed a better concentration and distribution of tickets in the ticket office, which greatly speeded up ticket issuing, eased accounting processes and improved ticket stock control. From the passenger's point of view it eased congestion at the ticket office window and introduced an element of freedom as to which route could be used. Unfortunately, in the 1920s and 1930s statutory obligations and restrictive agreements meant having to keep point-to-point tickets for bookings to stations of the main line railways, although some individual concessions were granted (such as to Wimbledon and Richmond line stations on the Southern Railway and from Wood Lane to Ealing on the Great Western). Some of these restrictions still leave traces today, for example Richmond is regarded as being wholly within the Underground's overall ticket framework, while Wembley Central is only in part.

After the Second World War virtually all scheme tickets were replaced by a new type of ticket called a 'Station-of-Origin' Ticket (SOO ticket), and these are still the staple of modern

Underground ticket practice. SOO tickets were the ultimate acknowledgement that a good ticket collector did not need to be troubled by the clutter of listing destination stations, and the space freed up allowed even more prominence to be given to the originating station and the fare paid. SOO tickets are available for a journey to any Underground station from the station at which

purchased to the value of the fare shown on that ticket.

All the tickets mentioned so far were the standard 'Edmondson' size and were generically known as ticket office 'card' stock. Latterly these were all coloured green but in earlier years other colours had been used.

EARLY MOVES TOWARDS AUTOMATION

Ticket issuing had been speeded up only slightly by the judicious management of ticket stocks and improved ticket office layouts, but this alone barely compensated for the extension of through booking facilities and the need for greater stocks of tickets caused by extensions to the Underground.

To improve matters some booking office mechanization was inevitable. In 1922 a mechanical ticket machine, known as a 'Rolltic' machine, was first introduced. Each separate 'Rolltic' device consisted of a bank of three or four printing units that could deliver tickets through a common chute to the counter directly in front of the passenger (so the clerk did not have to touch it). Often two or more machines were installed. To issue a ticket all the clerk had to do was to turn the handle on the appropriate issuing unit; the tickets were pre-printed and joined in a continuous strip wound on small rolls. About 1000 tickets per hour could be issued in this way and ten years later there were 95 machines in service.

Almost at the same time as the Rolltic machines entered service came the 'Automatic' machines, introduced in 1921 (similar ones are still used by some cinemas today). These were motorised, key operated devices, which, for the selected denomination, could issue up to six tickets at a time through slots in a change plate mounted in the counter facing the passenger. Again the tickets were pre-printed. In 1932 there were thirty of these in service.

The real breakthrough came in 1926 with the use of the AEG 'Rapid Printer'. This comprised eight or more separate printing units each of which printed a particular denomination of ticket on a blank roll of paper (generally the machines at first used on the Underground were of fifteen units). Once the ticket was printed and guillo-

lined it was shot along a conveyor and ejected onto the counter for the passenger to take. Both the paper rolls and the printing blocks could be changed with ease. The machine was electrically operated and very fast—up to four tickets per second could be printed. By 1932 there were 90 machines in service with 15 more waiting to be installed; at about the same time they were first constructed in this country under licence by Westinghouse Garrard, the earlier ones were built in Berlin.

Whilst other attempts were made to automate the issuing of tickets from ticket offices, the rapid printer became the general workhorse of the ticket office for many years, only being abandoned when the UTS equipment was introduced in the late 1980s. Furthermore many rapid printers underwent a modification enabling them to encode tickets for modern 'Automatic Ticket Examination'—had this fortuitous design feature of rapid printers not been available there is no doubt that the introduction of ticket gates for the Victoria Line AFC programme would have been hampered.

After the Second World War a smaller and much simpler machine was introduced called a mini-printer, this worked on similar lines to the 'rapid' but lacked the belt conveyor, so requiring the clerk to physically move the ticket from the machine to the passenger. 'Minis' were often provided at busy secondary ticket windows, or at the less busy stations. Card stocks were always required where a 'mini' or 'rapid' was provided, either as back-up stock or for the less commonly used fares. When the 'rapid' wasn't working the clerks had a very hard time.

THE INTRODUCTION OF PASSENGER OPERATED MACHINES

Even while thoughts were turning to simplifying the operation inside the ticket offices, measures had already been adopted to speed passenger

handling at stations by the cautious introduction of passenger-operated ticket machines. The first 'mechanical' machines were provided in 1904 on

the Central London Railway. These were of the 'pullbar' type which required passengers to insert the appropriate coin or coins and then pull a handle, which caused the ticket to be issued through a chute; tickets were of the usual card stock type, and the machines did not give change. Their use did spread to other lines after a while—and after slight modification; it seems that the first specimens lent themselves to fraudulent operation by spurious coins (it was reported that on at least one occasion receipts from several machines at one particular station amounted to half a bucketful of soft iron washers). By 1928 only 44 such machines remained in service on the Underground group of lines. The Metropolitan Railway first used automatic machines in January 1906 and had 30 in service by the end of 1913 (26 selling penny tickets and four at twopence), with a further 17 on order. All were of the 'pullbar' type which cost between £37 and £43 each, depending on coin denomination accepted.

By 1908 further technical developments had been made and an electrically operated machine was introduced within the Underground Group. This also issued pre-printed card tickets but the coin mechanism was more discerning than that of the pullbar type. Detection of the correct money activated the ticket issuing mechanism, so that all the passenger had to do was to insert the money. In 1928 there were 121 of these in service. Soon after this the original mechanisms were in many cases replaced by AEG printing units that printed the tickets as required from blank ticket rolls rather than pre-printed stock.

It was also in the late 1920s that a similar type of printing unit was employed in another type of machine (the 'Pearce' machine), this time in combination with a change-giving mechanism. The Pearce machines issued one denomination of ticket between 1d and 5d and gave change if a 6d or 1/- coin were inserted. Unfortunately this did not prove robust and this early attempt to offer change presented some challenging difficulties and the facility was withdrawn. Change giving remained a major problem for many more years.

After 1930 a succession of new types of machine caused rapid progress to be made. The combination of an AEG printing unit with a new type of coin acceptor called a 'bunch-hopper' allowed passengers to purchase tickets even if they flung all the coins into the machine simultaneously. The alternative 'Hall' machine employed a coin counting (rather than weighing) mechanism and accepted halfpennies. It is worth pointing out here that many fares were under sixpence and that pre-decimal bronze coinage (comprising merely a

halfpenny and a penny – the former weighed half the latter – so coins could be 'counted' by weight).

The first 'modern' type of machine (in use by 1932) was the BMR (Brecknell, Munro and Rogers) device. This accepted coins indiscriminately, sorting them and picking them up on revolving wheels where they were counted. Whenever the amount inserted was found to be equal to or greater than the value of the ticket issued by that machine then a ticket was automatically issued and any extra coins were 'stored up' until the machine received some more coins to complete what it presumed was a second transaction. For example, in the case of a machine set to issue 2d tickets a passenger might insert 3½d in one go, in which case only one 2d ticket would be issued and the remaining 1½d would be 'stored' until the last ½d (or more) had been inserted, completing the second transaction.

The familiar sloping front machines with the illuminated fare panels were first introduced in 1937, again by the Brecknell concern, and with a mechanism similar in operation to their earlier type of machine. The use of these machines spread very rapidly and by about 1960 there were over 750 in service, with all the earlier devices superseded. In the mid 1960s a modernized version of this long-lived design was introduced (similar in shape but painted silver instead of blue). The mechanism required a 50 volt rather than a 240 volt supply, which was felt to be safer in public areas.

Two particular branchline developments of are worth mentioning here, just to prove that no idea is entirely new. Firstly, at the newly reconstructed Ealing Common Station in 1931 a **triangular** section booking office was installed. This was arranged so that one apex of the office pointed towards the station entrance in a way that rendered two of the three faces visible to passengers entering the station. Along one face the usual ticket office windows were provided and along the other a bank of automatic machines. This allowed passengers to form into two distinct streams for their ticket purchases, and because the machines were built into the ticket office they could be serviced from within, avoiding the need for staff servicing machines to obstruct passengers using other machines or to carry sums of money around the booking hall. Many of these advantages were subsequently claimed to be novel over 30 years later when the 'multifare' machine was installed at Hammersmith.

The second branchline development was an attempt to mechanize what was called the 'Passimeter' system. The original 'Passimeter' at Kil-

burn Park in 1921 was a free-standing ticket office kiosk in an arrangement that required passengers entering the station to file past a ticket office window. Here their ticket would be issued and cancelled by the booking clerk in one operation (or simply checked if they already had one), avoiding the need for separate ticket collectors to check way-in tickets (except in the rush hour). At quiet times outward passengers also filed past a ticket window and the booking clerk (rather than the ticket collector) was responsible for collecting or otherwise scrutinizing the tickets. The arrangement allowed useful staff reductions to be made and was deemed a great success, though enforcement was encouraged through the provision of turnstiles which could be released (or not) by the clerk. A number of 'Passimeter' installations followed, and this system gave rise to the familiar wooden ticket booth which took on board the name, although the majority of later installations lacked any mechanical passenger control (nor the

clerk check tickets)—they were in truth merely free standing booths. The branchline was the further automation of the 'Passimeter' philosophy through coin-in-the-slot technology. This took the form of extended trials at, amongst other places, Earls Court and Westminster. In parallel with the normal Passimeter arrangements electric slot machines were provided. Upon inserting the requisite coins, the passenger would receive a ticket (and if necessary change) and a mechanically locked turnstile would be released to allow entry to the platforms. This was probably the first ever example of automatic ticket gating on the Underground, but like later some schemes the feature was not long lived. The Underground company spokesman said 'The London Public seems to dislike turnstiles, and it is unlikely that they will be adopted to any extent unless a simple flat fare system similar to New York is introduced'. That was in 1932. Forty years later that issue was still being debated!

BACKGROUND TO AUTOMATIC GATING TRIALS IN LONDON

Once the post-war demobbing of the armed forces had ceased, London Transport found it more difficult than ever to recruit suitable staff to work in the railway or bus operating departments. The situation eventually became so bad that by the late 'fifties they had resorted to opening recruitment offices overseas, to entice the local inhabitants with promises of free air fares and hopes of an improved lifestyle to come to London and work for London Transport. This exercise, though costly, ameliorated the staffing situation to some extent. Nevertheless, for many years thereafter London Transport was not able to establish its full complement of staff, although some years have been very much worse than others.

It is against this background of staffing difficulties that the detailed planning of the Victoria Line took place. Although many aspects of the line were given much attention before Parliamentary authority was granted in 1955, much of the highly detailed planning took place immediately afterwards, with some new ideas thought up and some previous ideas reconsidered. London Transport now found itself in the slightly awkward position of being committed to a new railway which it had not the facilities to staff but with the eyes of the world resting upon it, anticipating forward-looking developments. The Victoria Line was London's first entirely new line to have been built since 1907 and the world expected something new.

The Chief Signal Engineer at this time was Robert Dell, and his various responsibilities included ticket machines. His inventive mind had already turned towards the concept of a totally automated railway. In his own field he had achieved a certain amount of economy by the centralization of signal cabins where, for example, one large cabin might take over the function of several smaller ones with consequent staff savings. He also installed remote control facilities where either new or existing 'cabins' at outlying locations could be controlled from a central point. Dell became very aware of the possibilities that automation offered—especially against the climate of continuing staff shortage. By 1957 he was able to replace conventional signal cabins altogether by means of pre-programmed signalling equipment controlled by 'programme machines'. These machines could replace signalmen entirely when the train service was running normally but required supervision during times of disruption, when human intervention might be needed to reorganize the service. Large-scale trial installations were made on the Northern Line and their apparent success made their installation on the Victoria Line, in lieu of signalmen, an imminent proposition. In other words the new line would not present any demand for new signalmen (although the watchful eyes of some supervisory staff were needed).

Dell was very aware of the many operating problems existing on the Underground, and soon

after his achievements with programme machine installations he turned towards other aspects of possible automation—especially with regard to the impending Victoria Line. It was vital that the new line should not be forced to steal too many staff from elsewhere and Dell believed almost complete automation could be attained, not only for signalling. One area in which he considered automation would be most useful that of ticket issuing and examination—this was labour intensive, unreliable and to a large extent exceptionally boring for staff; consequently the job was not done well and passengers were allowed to get away with a large amount of fare evasion. Staff fraud was also suspected, mainly in the process of ‘excessing’ passengers without tickets. The staff shortages meant that ticketless travel was not only condoned but sometimes necessary; when passengers went to pay at the arrival end of the journey (if they did) then the money was very difficult to account for.

Dell could see no reason why a machine should not be capable of checking a ticket for validity—this was in principle a very easy thing for a machine to do but very difficult for a human to do accurately and consistently, especially when presented with tickets at the rate of upwards of 40 a minute, even assuming that the collector was both keen and good at his job.

Whilst Dell was contemplating these matters the planners of the new Illinois transit system in the USA had also begun to wonder about the possibilities of automatic ticket examination and had employed a new company called Advanced Data Systems (of Los Angeles) to see how feasible this would be. Between them they concluded that full automation of ticket issuing and examination was possible, and their system was so equipped. This set a precedent, and not only provided London Transport with the incentive to proceed with a system of its own but also produced a background of operating experience which sought to avoid repeating any mistakes. For example on the first day of the Illinois Central system 5 out of the 7 barriers at their most intensively used station went out

of commission. Quite apart from that, many of the new gates were severely tested by passengers experimenting with such things as chewing gum wrappers (rather than tickets) and many of the remaining 35,000 passengers who were let loose managed to get themselves or their luggage trapped. London had to avoid all of this.

The quickly-produced Advanced Data Systems report was presented in April 1963. It highlighted the cost of fraud (passenger and staff) and thought an Automated Revenue Collection (ARC) system would largely eliminate it. It referred to the existence of over 100 different types of ticket types of ticket being in use of which 4-ticket types accounted for 75 per cent of the revenue and the various types of season accounting for a further 20 per cent. The balance were for obscure or unusual purposes which appeared to be tying up a lot of management time for no practical reward. Simplification appeared possible. The accounting and auditing functions were firmly rounded upon as wasteful and capable of automation in conjunction with ARC (one 3-day test to confirm which routes passengers took occupied 16 man-years of clerical effort). The report hinted that the ability of passengers to pre-buy tickets would generate a massive reduction in peak hour queuing, to everyone’s benefit (the Bay Area Rapid Transit system was already using an ARC system based on stored fare tickets).

The Victoria Line was finally authorized in August 1962, and with a proposed construction time of just five years there was mounting urgency in knowing whether or not a system such as that in Illinois would also work in London. Advanced Data Systems was therefore called in and a report produced which, whilst acknowledging tremendous difficulties, suggested that a system not unlike that in Illinois would be feasible in London. Both Advanced Data and Dell learnt a lot from each other whilst experimental schemes were being considered and some of London Transport’s ideas were used in Illinois before London had its own system.

INITIAL TICKET HANDLING TRIALS

The first practical move towards a fully automated ticket system for London came towards the end of 1962. Some early contemporary sources soon came to call the idea ‘Magic Eye’ ticket checking, though it is now difficult to tell if this had official currency.

The name ‘Magic Eye’ ticket checking implies a possibility of an optical check on information

coded in some way onto a ticket. No doubt LT performed numerous rough and ready experiments to see what was and what was not feasible. Having come up with a few ideas that appeared practicable, there then came the essential task of seeing what the public made of it; a ticket that operated perfectly in the laboratory might not

work so well after being subjected to the uncompromising attentions of its keeper.

This initial 'survival' test was instituted towards the end of March 1963. The printing block for 9d tickets at one of the ticket office windows at Earls Court (A) office was exchanged for a new block that included a code. The usual printed information was retained, with the code printed towards the top right hand side. It consisted of a series of almost square markings arranged in three rows. Normal green ticket machine paper was employed, but what sort of ink was used is not now known. After use, the tickets were sorted out by the revenue office and subjected to an 'electronic check' to see how the code had withstood handling. This is believed to have been an optical check by photo-electric cells, and it is therefore unlikely a magnetic ink was used. The coding seems to be a form of binary, with the series of 'squares' in the top row forming a reference track.

Although trials continued on this particular 9d ticket stock, towards the end of 1963 the 'square' code format was altered to a 'bar' code format, with the arrangement of code bars similar to the earlier 'squares'. This time the ink was almost certainly magnetic. At roughly the same

time tickets at additional fares (notably 3d, 6d and 1/-) were also issued with the bar-type codes but in these instances the lower row of code bars was printed along the bottom edge of the ticket (with the top two rows of bars staying in the same place).

The final development was supposedly introduced from Thursday 21st November 1963 but the tickets were noted on issue earlier in the week. In this case the three rows of short code bars were replaced by two rows of rather longer bars, one along the top edge of the ticket and one along the bottom. In combination, the code-bars formed a ternary code system (ie a system of numbers to base three, in contrast to binary, which is to base two). There were 15 code positions reading from right to left as opposed to the double set of 10 code positions of the earlier tickets. Magnetic ink on green card was used, and tickets issued from Numbers 1 and 2 rapid printers (again at the Earls Court (A) office) at 3d, 6d, 9d, 1/-, 1/6 and 1/10 fares. This last code arrangement appears to be very much more robust than the earlier, tiny markings which we may have proved inadequate. The 2-track ternary code set the pace for the future.

FIELD TRIALS

The next stage was to move from ticket handling (or survival) trials to the testing of automated ticket reading on site, using a real automatic gate (which would reveal new challenges to the engineers). The initial experiment focused on 'Way In' ticket checking, so there was not much opportunity for tickets to be subjected to the normal rigours of use in the few yards from the ticket office where they were issued.

The first experimental installation was made at Stamford Brook early in 1964 with equipment of London Transport's own design. The existing manual ticket barrier remained in use for all 'exit' passengers and 'inwards' seasons, while an 'inwards' automatic ticket gate was erected close by, being commissioned on Sunday 5th January. This was prominently marked 'EXPERIMENTAL TICKET GATE' and the normal barrier received an equally prominent sign marked 'SEASON TICKETS WAY IN'. The new automatic gate consisted of two box frames between which the passenger passed. The left hand wall, slightly higher than waist height, had rollers along the top for passengers to push their light hand luggage along. The right hand wall had a slot at the front for the ticket to go in, and a second slot at the top for the ticket to make its reappearance. The

physical gate consisted of a metal frame filled with foam-rubber and covered in 'leather', but the bottom of the barrier was sufficiently far from the ground to allow heavy luggage to be pushed underneath.

The method of operation was as follows. The passenger was issued with a yellow coloured ticket (the normal ticket colours being green or pink) and was directed to the experimental gate by a sign (YELLOW TICKETS HERE). The ticket was inserted into the slot, the code was checked and the ticket returned. If it was deemed valid then a 'GO' sign illuminated and the gate was released to let the passenger through. If the ticket was not valid then a 'STOP' sign would light and the gate would remain locked. In practice only a very rudimentary code marking was given to the tickets and was equivalent to the ternary code 80 (understood to be the station number for Stamford Brook). The tickets were of the ordinary single or return type (Adult and Child). The (visible) code markings comprised two rows of 'bar' shaped marks along each edge made in magnetic ink. The actual code was unimportant since the equipment was provided largely to test the barrier itself, to see whether or not a code could be read with any

degree of accuracy and also to test passenger reaction.

On Sunday 15th March 1964 a second experimental automatic gate entered service—this was installed at Chiswick Park. The barrier was of a quite different design to the one at Stamford Brook although it obviously shared some common features. Again it was situated in parallel with the manual barrier and dealt only with inwards passengers holding yellow single or return tickets coded with the special ink. It comprised two steel box 'walls' with the right hand wall containing the reading equipment. Between the walls were two sets of gates, one behind the other and with enough room for a person in between. Each gate consisted of two doors that could be retracted into their respective barrier wall. This type of equipment was known as a 4-door barrier and it operated as follows. A valid ticket opened the first pair of doors and allowed the passenger to enter the centre section. This done, the first pair of doors closed and the second pair opened to let the passenger continue on his way. This action was extremely fast and in practice the passenger's progress was not impeded at all. A further refinement was that the equipment could retain information from up to three tickets and hence a continuous stream of people could use the gate, there being no necessity to wait for one passenger to leave the barrier before the next one entered. The doors themselves were quite deep and no luggage rollers were provided. The mode of operation of the doors could easily be altered by minor changes to the wiring.

The tickets were issued from both the ticket-office rapid printer and from card stock, although the latter was printed on ticket machine type paper. Most fare values were catered for. The tickets were similar to those at Stamford Brook but the code along the edge was more complex. The code was in ternary form and all coded ticket issues were on Yellow card.

On Sunday 12th April of the same year (1964) a third Way In automatic barrier was introduced, this time at Ravenscourt Park. It was again installed in parallel with the manned barrier and whilst having some similarity with the previous two experimental gates it differed in its mode of operation. This gate consisted of the usual pair of metal 'walls' with the ticket reading equipment in the right hand wall. However, doors were dispensed with and a 'tripod' type of gate mechanism was employed instead. The gate arrangement was normally locked with a horizontal bar preventing passengers from proceeding. A valid ticket would release the lock and allow the arrangement to

turn so as to allow just one passenger through. No indication was provided to show whether or not the gate had released after a ticket was inserted.

The coding initially employed at Ravenscourt Park was 2-track ternary as at Chiswick Park, but following problems with ticket recognition, two changes were implemented from 13 August 1964. Firstly a modified printing plate was provided (with a different coding) and secondly a new formula was used for the magnetic ink which now appeared light brown in colour as opposed to the former black ink. The initial plate was for tickets at the 6d fare, which covered Chiswick Park. The plate seems to have been produced in rather a hurry as the station name and wording was much smaller than usual and there was a typographical error—however it was pressed into service immediately to avoid waiting for the new plate to arrive—LT helpfully pointed out to staff that the ticket's illegibility not a major drawback because it was readily distinguishable because of the brown print! Modifications of a similar type were subsequently made at Chiswick Park.

At Stamford Brook and Ravenscourt Park (and almost certainly Chiswick Park as well) coded return tickets at certain fares were issued. The coding was exactly the same as for a single ticket of the same fare value, which is curious considering its reduced availability and the fact that no coded indication was given that it was a return ticket. The same sort of thing applied to the children's tickets (at least at Ravenscourt Park) where again the fare actually paid was encoded with no indication that it was a child's ticket and therefore had a wider availability. In practice, at this stage of the experimental work, the coding on the tickets was largely irrelevant as no 'exit' gates were ever provided which could read tickets coded in the ternary, magnetic ink system. The printing format of the return tickets was horizontal, unlike the usual vertical format return tickets of the period; the printing type was very small because of the reduced printing area caused by the provision of the code. A broken 'tear' line was provided down the ticket where the 'forward' and 'return' halves were intended to be separated by the passenger—after being put through the entry gate at the station of purchase, of course. The code (or rather, part code) on the return half was not needed for the return journey since coded return tickets were not at this stage issued to other stations with automatic gates. Fairly obviously, the system of tearing return tickets in half was open to question in the face of impending automatic ticket checking.

After a long pause in development the next step occurred on 17th May 1965 when an experimental 'outward' barrier entered service at Acton Town, working to a design by Advanced Data Systems. The barrier itself was of a '4-door' type of similar design to that at Chiswick Park. The electronics were necessarily much more complicated than for the inwards gates because a simple 'local station' check was not enough. The equipment had to read the ticket and then work out whether or not the fare paid covered the journey from the station at which the ticket was issued. London Transport was even more ambitious than this, however. Apart from ordinary single tickets from other stations, weekly seasons, coded staff passes, day off-peak returns and children's tickets (single and returns) were also used in the experiment; the equipment had to handle all these.

Return tickets issued at Acton Town for the first time came in two parts — forward portion and return portion. The latter ticket operated (and was retained by) the Acton Town gate on completion of the return journey, whereas the 'forward' ticket was collected manually when the passenger reached his outward journey destination, and did not ordinarily pass through an automatic gate. Posters provided passengers with full information about the new type of return tickets.

**AUTOMATIC FARE COLLECTION
EXCESS FARES**

If you have to pay an excess fare, no matter what ticket you hold, or if you do not hold a ticket at all, please go to the official at the excess fare window.

There were two basic types of ticket. Those issued by ticket office rapid printers had two ink code tracks (this time using a binary code) printed along each long edge of the face of the ticket. On the other hand, ticket office pre-printed 'card stock' tickets were of a new type, about an inch longer than normal, and with the coding on the back. The code appeared in three code tracks, one along each edge and one in the centre; the code used was a form of 'heptal' (ie to a base of seven). The gate electronics obviously had to discriminate between the two code systems, a matter presumably achieved through one appearing on the face and the other on the reverse.

Fifteen stations (with high sales of tickets at the Acton Town fare) issued suitably coded tickets from rapid printers. A further five stations participated by selling card stock tickets but not tickets

from rapid printers. Thus twenty stations were involved in selling tickets capable of opening the Acton Town automatic gates. As the experiment progressed, this list was varied.

Acton Town, of course, issued a range of its own encoded tickets and this included weekly season tickets. These were the same length as the special card stock tickets but of a yellow plastic material which was more durable than card. A range of preprinted weeklies (with the 3-track code on the back) was available, and the booking clerks stamped them with the usual security overprint number and expiry date upon issue—a special quick drying ink being used with a miniature overprint number stamp.

The special coded staff passes issued to certain staff working in the Acton area were similar in type to the special weekly tickets—card not being feasible for tickets continually being re-used. Again the passes were yellow in colour. In fact all the coded tickets involved in the Acton Town experiment were yellow except the Day Off-Peak types which retained their customary pink colour. The passes and weekly tickets were returned to passengers after automatic checking, but most of the other tickets were captured by the gate on the basis that the journey had been completed.

For the benefit of those passengers who had tickets which for some reason failed to operate the gate or who had a fare to pay, an extra booking office window was provided on the 'train' side of the barrier to which attention was drawn by the following poster:

At the 'excess' Window the passenger would explain his difficulty to the clerk, who would give him an 'exit' ticket which would let him out through the automatic barrier; the

clerk would himself collect any existing ticket held or any fare due. The usual ticket collectors were retained purely to deal with tickets which were not intended to operate the automatic barrier—they did not, at least in theory, now collect any excess fares.

One of the stations that participated in the Acton Town experiment was Chiswick Park, which issued the relevant tickets through a rapid printer. This meant changing over from the ternary coded tickets used in its own experimental gate to ones coded in binary, involving a number of equipment changes. It was probably at the same time that the original entrance gate there (photo B) was replaced by an improved type with a rotary ticket transporter (photo 32). Binary coded ticket plates were also produced at some

time for Ravenscourt Park. This station is not listed as one of the original stations taking part in the Acton experiment but it could well have taken part subsequently. Again alterations to the electronic equipment would have been undertaken,

window was provided. The Turnham Green, barriers were designed to cope with weekly season tickets of conventional size (unlike the special ones at Acton) and this required an additional ticket slot (provided in the left hand barrier wall) with a

AUTOMATIC FARE COLLECTION HOW CAN YOU HELP

1. Please do not crumple, bend or mutilate your ticket. Any disfigurement of the ticket may cause delay because the scanners may not be able to read the code bars.
2. Please do not place more than one ticket at a time in the ticket slot of an automatic gate.
3. Please remove weekly or season tickets from any case or covering before inserting them in the slot of an automatic gate.
4. Please make sure that you use your return ticket in the right way. The new type takes the form of two separate tickets, one for the forward journey and one for the return journey. It is **ESSENTIAL** that these are used in the correct order.

Your co-operation will ensure that you are able to pass through an automatic gate without any delay.

separate ticket transporter and associated reading equipment; single and return tickets were handled by equipment in the right hand barrier wall. The layout of the weeklies was very similar to the normal card stock types but two code tracks were provided on the back below the conditions of use; the tickets were also made of yellow plastic. Issues of these stopped on 8th May 1966, although only some of the range of weeklies from Turnham Green had actually been involved in the automatic ticket checking experiment.

although the automatic gate was not replaced.

The last station to be equipped with a purely experimental installation was Turnham Green. This station received an automatic WAY IN barrier on 27th June 1965 and also a WAY OUT barrier on 25th July 1965; both were designed and built by London Transport. To facilitate the experiment about 50 stations started to issue coded tickets for fare values covering Turnham Green—the coding again being of the binary two-track type with the coding on the front. The coding arrangement was extremely similar to that used at Acton Town, but in fact the two ticket

Two posters were provided at Turnham Green to encourage passengers to make the experiment successful. One was provided at the WAY OUT automatic barrier and read:

The second poster reads as though a great deal of experience was gained from the previous exit gate experiment—the strange ways of passengers having been identified and assumptions about common sense dismissed! It read as follows:

Quite what contribution the poster made in helping habitual infringers (particularly in regard to point 3!) can only be the subject of speculation.

From 16th June 1966 a completely new type of encoded ticket was issued experimentally from one of the rapid printers at Earls Court. This was a yellow ticket with a coating of iron oxide on the back—a characteristic chocolate-brown coating. It was possible to put code bars on the oxide coating electronically, using a magnetic recording head like that in a tape recorder. The coding on this type of ticket was thus invisible. Since the code was generated electronically as the ticket was issued there was a new problem in securing that

AUTOMATIC FARE COLLECTION IS YOUR TICKET YELLOW?

If the ticket which you hold is yellow please use the automatic ticket gate as you leave the station. This is how it works:

1. Put your ticket in the slot, ordinary tickets on the right hand side, seasons on the left of the gate. Valid ordinary tickets will be retained by the machine and the gate will open. Valid seasons will be returned and the gate will open.
2. If the gate does not open or your season ticket is retained please go to the excess fares window. Please lift your luggage, briefcase or umbrella well clear of the gate. The station staff will help you in case of difficulty.

systems were incompatible. Again an excess fare

the spacing between the code bars was correct

(this was not a problem before because the coding was applied by the printing block where the spacing was fixed). The method used to ensure accurate code bar spacing was to link the equipment which discharged the coding to the writing heads with the mechanism of the rapid printer, using a device known as a phonic wheel. This wheel was geared to the printing mechanism and was arranged to revolve once every time a ticket was issued. As it did so, teeth on the perimeter of the wheel sent impulses to the coding unit, which fed out the code to the encoding heads. Consequently it did not matter whether a ticket was issued at an even, constant speed or not, the coding would always be correctly spaced—and this was critical to the success of automatic ticket examination.

Because the code was now electronically generated it was now much easier to incorporate a code for the date, and provision for this was made (although the facility was not actually used at this stage). The tickets were issued at the 4d (minimum) fare purely to see how they stood up to handling by passengers. During July 1966 the experiment spread to individual 4d printers at Piccadilly Circus, Blackfriars and Alperton—again just to find out how they stood up to handling.

On 13th July 1966 the 'Exit' gate at Turnham Green was withdrawn from service and re-

placed on Sunday 17th July with new equipment capable of deciphering oxide-backed tickets. The tickets were initially issued at six stations but another 34 were intended to participate later. Eventually many of these stations were equipped with switches enabling the date code to be changed, but until this was done a special 'pass' code was used—the Turnham Green gate would accept either form of code, what it would not allow was a wrong date code. By now of course the experiment had become very complicated because there were three totally independent types of ticket in use concurrently, viz:

1. 'oxide' tickets issued by stations at the Turnham Green fare, for use in the Turnham Green 'exit' gates;
2. yellow 'magnetic ink' tickets issued at the Acton Town fare (2 and 3-track types), for use in the Acton Town 'exit' gates;
3. yellow 'magnetic ink' tickets issued for use with inwards gates at Turnham Green, Chiswick Park, Stamford Brook and Ravenscourt Park. At the latter three stations, of course, normal green tickets had to be issued for local journeys at the Turnham Green fare because the 'ink' tickets would not work the 'oxide' gate; furthermore the Turnham Green binary tickets were not compatible with the Acton binary tickets.

THE HAMMERSMITH PROTOTYPE

The results of the tests at the various experimentally-equipped stations looked very promising. Apart from the obvious success from the technical point of view the gates were rather more importantly also a success from the operating point of view. On the first morning of operation of the inwards barrier at Turnham Green, for example, some 500 extra tickets had been sold. Significantly these sales also stayed at a higher level, and after many weeks an additional 2300 extra tickets per week were still being sold. Obviously with the majority of passengers using the new gate it was possible for the collector to scrutinize more carefully the remainder of the tickets, mainly seasons, with the result that entry onto the system was virtually impossible without a valid ticket. Exit gates, too, had shown their worth. These gates dealt with a proportion of the passengers the collector would previously have seen, leaving him more time to examine the tickets of the remainder. The real advantage, though came from the use of the excess fare window. This advantage was twofold. Firstly, the collector was relieved of calculating and collecting excess fares which made his job easier (if only because dealing with an ex-

cess fare transaction, especially when change is required, takes both time and concentration, enabling ne'ere-do-wells to slip through without paying the right fare). Secondly passengers had to pay any excess to the booking clerk who issued an excess fare ticket for the amount required, which ticket was financially accounted for. During the first week of this arrangement at Acton Town the extra cash shown in excess fares averaged £5 a day, which then represented about £500,000 a year if this increase could be shown over the whole system.

A review of the experimental installations was made in mid 1966 and it was decided to proceed with a prototype installation which, if successful, would be a forerunner of the system hopefully to be employed on the Victoria Line. The station selected to receive this equipment was Hammersmith (District & Piccadilly) which had had the benefits of a spacious booking-hall, proximity to the existing experimental stations and the workshops in Kensington. It also had a brisk traffic of about 22 million passengers per annum. An added complication was that it was also an interchange station with the Metropolitan (Hammersmith and

City) Line station across the road, but this did not present any serious problem.

The station was converted in stages. Following certain structural work involving a new ticket office, a note-changing machine was introduced on 25th May 1966—this gave change in florins (10p) for either 10 shilling notes (50P) or £1 notes. At about the same time additional automatic ticket machines were introduced to bring the total up to 14 and all but two of these (at the 4d fare) were able to give change if this was required. The machines were prominently positioned—passengers having to make a positive attempt to avoid them rather than having to deviate to use them as was so often the case.

The new ticket office itself was commissioned on Sunday 17th July and it replaced the two existing 'Passimeter' offices. It had just two normal ticket windows but in addition had one window for the issue of season tickets and also a prospective excess fare window. On 24th November 1966 a large multi-fare ticket machine was installed next to the note changer. This issued 20 different fare denominations of ticket and accepted a wide variety of coins, giving change where appropriate.

The multi-fare machine was used in concert with a large fares list, incorporated in the front of the machine. It was operated by inserting any combination of copper or silver coins and pressing a button corresponding to the selected fare. The machine then delivered a ticket into a tray and change (if any) into another tray. If a higher fare had been selected than had been paid for, a display lit up to indicate the extra money required. If the passenger decided to abandon the transaction at this stage he could press the 'reject coin' button to lay claim to his money and clear the machine. The 'gubbins' within the machine was essentially nothing more revolutionary than a pair of rapid printers (not dissimilar to the type introduced over 30 years earlier!) connected to a coin acceptor/control logic mechanism. The machine was intended to be serviced from inside the new ticket office, and it is understood that during the first few weeks of operation the rear access facility proved invaluable to the engineers dealing with 'teething troubles'.

The exact date of introduction of the automatic gates at Hammersmith has been disputed. LT announced that two inwards gates were to have become operative from Sunday 30th October 1966. For this, ticket office-issued and Multifare-issued tickets were changed over from green to yellow oxide-backed types (except for those at the Acton Town (1/-) fare as oxide tickets would not operate the gates there). The tickets were laid out

differently from the normal style and incorporated an arrow marked 'for automatic gates INSERT THIS WAY' (and in the case of tickets from the Multifare machine the 'window' number was replaced by the letters MV). Whether the automatic gates were introduced on this day the author has not yet been able to ascertain, but less than a month later the barriers were seen under covers and boards, and the source suggests that this may have been due to their inability to cope with a passenger flow of up to 5000 passengers an hour. Three inwards barriers (presumably incorporating the first two) were introduced from Sunday 19th March 1967.

At first, the card stock tickets were dated by hand and then put in a hand operated encoding unit before issue to passengers. Soon after this (from 12th July) the automatic 'exit' barriers were brought into use, together with the excess fare window which was operated along similar lines to those at Turnham Green and Acton Town but with a device which could issue oxide backed excess fare tickets. This was the cash register which was an adaptation of a standard NCR design.

The use of the cash register for 'normal' tickets (also in July) was a further major innovation. Most ticket offices held stocks of up to 150 different denominations and types of ticket and every ticket of each type had to be accounted for each day, whether sold or not. With the introduction of the cash register it was hoped to cut this number down to six basic types—Adult, Child and privilege types, each in singles and returns. Unavoidably a few other types of ticket could have proved necessary. The breakthrough was that these new card stock tickets would be valueless until passed through the specially adapted cash register which would print the date and the fare, and keep a register of sales on the tally roll—saving an enormous amount of bookwork. The cash register also incorporated an encoding unit so that the ticket would be correctly encoded as well as printed as it passed through the special mechanism attached to the register.

In the event at Hammersmith only Adult single and return and Child single and return tickets were issued by cash register, special types of ticket (such as privilege) remained 'non automatic gate' card stock. Two tickets were now issued for returns—the forward portion and the return portion, both were passed through the cash register the latter ticket being dealt with first. A problem arose with Child returns necessitating a fifth blank ticket known as a '*Child return'. The need for the '*Child Return' ticket arose from the inability of the Cash Register to print halfpennies,

a need which then existed as a Child's ticket was half the adult fare. For example—if the Adult Single Fare was 1/3 then the Child Return fare would also be 1/3 so both the *forward* and the *return* portions should have been marked 7½d. Since this was impossible, the practice was adopted of issuing the *forward* half showing 8d and the *return* half showing 7d—the asterisked return ticket stock being used to show any human ticket collector that the extra halfpenny had been paid. One might suppose that automatic barriers needed to be warned of this inconsistency, but in practice the normal adult fares were always coded on children's tickets—possibly to avoid dealing with halfpennies or, more likely, to simplify the decoding equipment. No attempt was made at this stage to automate the issue of special tickets (Day tickets, Privilege, Cheap Day and so forth).

After a limited trial with Cash Registers, Hammersmith started to issue Season Tickets which could operate the barriers. A further cash register was added, together with additional encoding equipment, and gradually most season tickets were changed over to the 'yellow' type. These were the same width as normal tickets but rather longer—the long-period season tickets were also plastic rather than card based.

The whole concept of automatic ticket issue and checking had become known officially as Automatic Fare Collection—AFC for short. By the end of 1967 Dell had become convinced that

AFC was viable in London—if not essential. Certainly he considered it possible to equip the Victoria Line (by then rapidly approaching completion).

From 7th April 1968 Hammersmith issued AFC seasons to all British Rail stations, in addition to those of LT (although the coding used was that for the farthest LT-served station along the route from Hammersmith, apart from the handful of BR stations served by LT trains where they were included in the coding system). From then on, all season tickets issued at Hammersmith were AFC type (apart from a handful of special Road/Rail tickets).

Before closing this section it is worth noting that from Sunday 3rd December 1967 a further experimental ticket barrier (inwards) was installed at Alperton (the home of one of the oxide-backed ticket experiments). The author has not been very successful in finding out anything about this particular gate but it probably represented a field trial of the design of automatic barrier to be used on the Victoria Line (which represented an advance over the ones used at Hammersmith). It is possible that this was the same barrier used at the Engineers Day exhibition at the Science Museum in late 1966. (There was also an experimental automatic barrier at the 'Progress Underground' Exhibition at Charing Cross station in May 1965—the fate of this barrier, a primitive magnetic ink reading type, is unknown).

THE VICTORIA LINE PROPOSAL

Around mid 1967 Dell proposed the following advantages for AFC:

1. AFC will improve the efficiency of stations;
2. AFC will speed up the movement of passengers;
3. there will be substantial staff economies;
4. fraudulent travel will be reduced.

It must be clearly understood that these advantages were expected to result from the AFC scheme as a whole, but that some of the advantages were to be gained from other elements of station automation, with stations controlled from a station operations room. Particular points were:

TICKETS. Virtually all to be sold automatically from a wide range of individual fare slot machines or, for the little used fares, a multi-fare ticket machine. Most machines would give change and note-changers would also be provided. A small proportion of tickets would necessarily have to be issued by

ticket clerks through cash registers, for example children's or privilege tickets. AFC season tickets would also be issued from ticket offices through Cash Registers. London Transport intended to sell no less than 95% of tickets by automatic coin operated machines.

TICKET OFFICES. Reduced number of 'windows' necessary because of low usage for normal tickets. Probably a special window for Seasons and another one for excess fares would be needed. Each window would have a cash register.

BARRIERS. Two types of automatic barrier were considered, these being a tripod barrier and the 4-door barrier similar to that used at Hammersmith. The tripod barrier was appreciably cheaper than the 4-door type but it was considered that experience on the Victoria Line would determine future policy. Many barriers were to be reversible (ie WAY IN or WAY OUT so that peak traffic flows could be catered for.

TICKET HALLS. The layout of the ticket hall had received much thought, The ticket office was generally to be sited centrally to-give a good view of all the ticket gates and to be accessible to passengers on both sides of the barrier. At some locations the ticket office was to be situated to one side of the hall. Historically, because many of the ticket halls would have to be built before AFC had been proved, it was necessary to design them for use equally efficiently with or without AFC. Furthermore the ticket halls had to cope with layouts for 'partial' AFC and yet be capable of 'convenient adaptation. to a 'final' layout.

The above approach potentially formed the basis of a 'total' AFC system, but there were some not-inconsiderable practical difficulties to overcome. For a start, there was not the money for widespread installation of AFC, and for the immediate future it would have to be restricted to the Victoria Line. There were also going to be problems at the British Rail interfaces, and their enthusiasm and co-operation would be essential. LT hoped, of course, that BR would take a sufficient interest in AFC to the extent where an LT-type system would be used in the London area and facilitate easy through ticket arrangements (and LT allowed for this in the ticket coding system). More subtle problems included the necessity to familiarize passengers and staff with the battery of alien equipment and to test thoroughly the whole concept of AFC under service conditions with normal ticket issuing and collecting procedures readily available as a back-up.

These constraints meant that the 'total' AFC concept would need modification in the short term, and the Victoria Line system had therefore to be designed as 'First Phase' AFC. The main changes required were the provision for varying degrees of manual ticket issuing and checking. Obviously Victoria Line stations would themselves issue a majority of coded tickets and it could be

expected that after a while many users would be able to use the gates. However this was less likely to be so for passengers leaving the station having bought tickets elsewhere. Furthermore the vast majority of season tickets (generally purchased at suburban stations) would not be of the AFC type for a considerable time.

The 'final' phase of AFC (which never came about in this form) could only take place when every possible Underground journey was covered by coded yellow tickets and this had to include all seasons and passes. When this had taken place it would prove possible to replace the manual ticket barriers by further automatic barriers. Under these conditions every ticket would be checked by an automatic gate upon entry and exit and no facilities would be provided for manual barriers. Any passenger with a defective or invalid ticket would have to see the booking clerk and obtain a ticket that would let him pass through the barrier.

Dell also gave consideration for further development beyond even the 'final' phase, as new doors would then be opened. In particular, the use of stored fare tickets would become feasible: even in 1967 stored fare tickets were considered to be the ultimate goal. The passenger would buy a special ticket encoded only with the fare paid—say £1 (a lot of travel in 1967!). When the passenger entered the system the entry station would be encoded by the barrier onto the ticket. When the person left the system the exit barrier would calculate the fare required and re-encode the ticket with a new fare value which would obviously be the old fare value minus the fare for the journey made. It was envisaged that these tickets could be sold at a discount and possibly replace at least weekly tickets—perhaps £2 worth of travel might be sold for £1 15 Shillings (£1.75). Whilst the Victoria Line equipment was obviously not so equipped, the equipment ordered was not wholly incompatible with such a scheme one day being introduced.

THE VICTORIA LINE AFC SYSTEM

By now readers may not be surprised to learn that the AFC equipment was not quite ready for the opening of the various stages of the Victoria Line and that green card stock tickets had to be issued from the cash registers until the gates were ready. Automatic gates were to be provided at all stations except Finsbury Park and Walthamstow Central where the arrangements on site made provision very difficult. At Walthamstow tickets were sold in the British Rail booking hall, and intending Victoria Line passengers had to walk

along the BR platforms to gain access to the Underground. Even though issued by BR the actual tickets were of the normal AFC type and fully coded. At most stations the ticket hall followed the philosophy used at Hammersmith, with automatic coin operated machines displayed as the obvious means of buying one's ticket. However, multi-fare ticket machines were not provided and booking offices were expected to deal with a variety of the less common tickets and fares for which automatic machines were not provided.

As a basic requirement was to give change, a new type of ticket machine was developed, called the SE510, which had a number of advantages over previous models. Theoretically it required less maintenance by ticket office staff during the day because the machine was 'self-charging'. This meant that money the passenger put in became available as change for following passengers. The machine only dealt with silver coinage ie 6d, 1/-, 2/- and 2/6, also 3d pieces but not coppers. When the initial order for 150 of those was placed it was not known whether or not there would be a requirement for machines to issue tickets for fares for which coppers were essential, and provision was made for some recently introduced standard 50 volt machines to be used if there was a requirement to accept coppers. In fact they were used quite liberally for the then 5d and 9d fares, with change, and also for some higher fares for which they did not give change, notably 1/- and 2/-.

The SE510 machines were quite elaborate pieces of equipment. In addition to the variety of coins they accepted, they gave change in whatever coins were available. If change ran out a sign lit up asking for exact fares only. These machines also utilized a larger roll of paper than the older equipment so this enabled it to survive longer without attention, which was a very useful feature at a busy station. Most of the 510s issued single tickets but a very limited number issued tickets at the ordinary return fare. In this case two ticket slots were provided next to each other, and the forward and return ticket portions appeared simultaneously. A feature of all the 510s was that if an amount of money had been inserted which was less than that required to issue a ticket then that money would be automatically returned to the passenger after a brief delay. This made the machine available for a fresh transaction whereas the older machines, unable to distinguish between transactions, would have kept the money, perhaps forcing the passenger to abandon it or to buy a ticket he may not have wanted.

The automatic gates were generally of the 4-door type and very similar to those used at Hammersmith, although their construction was slightly lighter and the gate-arms not so deep. The "Tripod" type gates had the benefit of not being as wide as the 4-door type and were used at Euston and Warren Street where space considerations were at a premium.

The gates, naturally, were strategically placed. Generally, inwards automatic barriers

were sited as close as possible to the ticket machines and ticket office. The manned barrier was generally sited as far as possible from the ticket office to make it just slightly more inconvenient to use than the AFC gates. There was usually an exit gate close to the booking office primarily for those having just purchased an excess fare ticket. Many barriers were 'reversible' so they could be switched from entry to exit work according to the flow of traffic. At Oxford Circus the old station was converted for exit-only use and had only exit gates and excess fare offices; the new circulating area was thus generally used for entry purposes. Late at night, however, and on Sundays, a few reversible gates in the new station enabled the exit hall to be closed down completely and the entry hall catered for all traffic.

At Kings Cross a special problem arose because of the need to cater for passengers changing from the tube lines to the Metropolitan Line, a journey requiring passengers to pass outside barrier limits. In the normal course of events any check by AFC exit gates, would consume the passenger's ticket, unless it was a season, and so two special 'exit' gates were provided to cater purely for interchange passengers and these returned all tickets to the passengers.

No such facility was provided at Warren Street where for passengers other than those holding season tickets, the previously-allowed interchange between that station and Euston Square was withdrawn on and from Saturday 1st March 1969. Had the facility not been withdrawn, the AFC gates would have collected the tickets of passengers trying to change lines (since the withdrawal of the original exit gates an unadvertised interchange facility was re-introduced).

Most booking or excess fare offices had an emergency control panel which could be used if the clerk spotted a passenger 'in difficulty' whilst trying to use the gates. The panel contained switches to open particular barriers if someone had become trapped and a microphone unit from which he could speak via loudspeakers to individual barrier positions to offer 'ex machina' condolences and advice.

Associated with each automatic barrier position was an illuminated sign suspended from the ceiling. On the earlier standard installations the sign displayed IN or NO ENTRY depending on the directional flow of the gate as one approached. The later installations employed a downwards pointing arrow or a cross sign which had the same respective meanings.

EXTENSION OF THE VICTORIA LINE SYSTEM

After many months of operating experience with the new equipment many problems highlighted themselves; for example, far more people became trapped in the 4-door barriers than were expected. This particular problem was largely due to people's tendency to precede or pursue themselves with amazing selections of general impedimenta—usually, of course, briefcases or suitcases—and this confused the equipment. After many trials the mode of operation of the gate mechanism was altered so that the first pair of gates in each barrier did not close behind a passenger as hastily as they had done, and the capture rate dropped. Much effort also went into rectifying ticket encoding faults—some of these were due to equipment problems and some to staff errors.

Whilst adjustments to the AFC system were being made a small number of busy stations started to issue AFC coded tickets at fares covering Victoria Line stations; this was intended to increase usage of the automatic equipment. This was usually a two-stage process. The first stage caused tickets to be issued with a fixed unchangeable code at particular fares. As the date could not be changed a master 'date' code was applied which would be acceptable on any day (the tickets were visibly dated with the correct date for manual inspection). The second stage involved the fitting of date switches in the ticket office; these switches had to be altered each day, following which the proper date code was encoded instead of the master code. On 20th December 1969, for example, 28 stations commissioned date code switches. In general no additional automatic barriers were installed.

One of the features of the Victoria Line was the heavy through BR season ticket traffic with which the AFC barriers could not cope. A variety of stop-gap measures were therefore considered in an attempt to reduce the level of manual checking these tickets caused. Tickets to BR stations could of course be of the AFC type, but most through season tickets were issued by British Rail and were of their normal card type. Following agreement with BR, experiments took place at several Southern Region stations which proceeded to issue of LT-style AFC Season tickets for the whole journey. The only problem was that having been issued by BR the tickets were not coded, and it was necessary for passengers to call at the LT booking office at the exchange station to have this done (on their first journey only) if they desired to avail themselves of the improved speed of the

AFC gates thereafter. The coding put on the ticket only applied to the LT portion of the journey.

As a further experiment to increase gate usage, AFC style seasons were issued from Sunday 21st June 1970 at Wood Green, Furnpike Lane and Manor House for Monthly and Quarterly tickets to Green Park. Again passengers had to call in at Green Park Ticket Office to get the tickets encoded the first time they were used. This particular scheme lasted just over a year (the equipment installed to enable ordinary tickets to be issued and coded AFC-style was not capable of adaptation to issue season tickets).

Amongst the teething troubles passengers encountered with their new tickets was a propensity for some of the keener (but misguided) among the ticket collecting fraternity to cancel AFC tickets by punching a hole in them. This created fresh hazards for the code reading apparatus and caused numerous reminders from LT headquarters imploring staff not to cancel AFC tickets.

Further problems then came to light with the automatic barriers. Passengers seemed to have some difficulty in using the tripod gates, and this caused undue delay. The problem was probably partly due to the lack of any obvious sign that a valid ticket had released the barrier, but there was also a tendency to be put off by having to push the barrier round as one passed through. An experiment to solve this latter problem was introduced at Euston in 1970 by motorizing the arm in such a way that once having pushed the barrier arm the device rotated 'with the passenger' as he passed through.

The 4-door gates also continued to exhibit undesirable behaviour. In addition to residual tendencies to capture people the gates suffered heavy wear and as a result of this some experiments were carried out at Seven Sisters with the barriers arranged for 'open mode' working. In this mode of operation all four doors were normally open. A Passenger inserting a valid ticket caused a green lamp to be shown, indicating that the ticket was acceptable, and he then just walked through with the barrier remaining quite impassive. On the other hand, a passenger attempting to walk through without having first inserted a ticket, or having inserted a spurious ticket, would be abruptly brought to a halt by the gates closing in front of him; in this case the gates would not reopen until a correct ticket was inserted. As a preliminary warning a red light would be shown if an incorrect ticket had been offered. This experi-

ment showed some promise and was extended to one or two other places, including Green Park. The number of gate-movements was very substantially reduced with this system but inevitably the new arrangements did create problems of their own.

Decimalization of Britain's currency caused some interesting complications. Prior to 'D' day on 15th February 1971 (or 14th February 1971 in LT's case) a strategic fares revision took place which employed a fares scale rising in shilling (ie 5p) steps, and tickets were printed with the fare shown in both shillings and new pence. Once the new scales had been introduced the range of coins accepted by ticket machines was largely cut down to decimal-compatible coins (ie 1/- [5p] and 2/- [10p]); coppers were not generally acceptable. Change giving facilities were also reduced. On the SE510 machines the acceptance of half crowns had already been withdrawn from mid-1969 (when that coin was demonetised). Sixpences (worth 2½p) continued to be legitimate currency for a further year or so, and although not part of the fares structure some machines continued to accept them.

To avoid the need for mass alteration to the printing and accounting units of cash registers, some curious intermediate changes had to be suf-

fered. from 20th November 1970 they were progressively altered to a decimal compatible format. Cash registers at Excess Fare positions were temporarily adapted to show the fare paid in (old) pennies only. Thus a fare of 1/8 would, for example, be shown as :20. Season ticket cash registers were converted to show the fare in shillings only, so that a fare of £22/10/0 would have been shown as 4.50—the decimal point, of course, being ignored. After 'D-day', the numeric point positions assumed their correct values of *(new) pence* or *pounds-(new) pence*. These figures were printed on the tickets themselves and it is of interest to note that at some stage, probably when the above alterations were made, the facility for showing (new) halfpennies was installed, doing away with the need for the *Child stock cash register tickets. The author has as yet been unable to establish whether the 'normal-ticket' stock cash registers (ie those vending single/returns etc) were altered in advance of D-day, nor has the author established whether decimalization caused the last death throes of the few change-giving facilities or whether this died from some other cause (a note change-giving machine had been put in at Oxford Circus shortly after the rebuilt station opened).

SECOND THOUGHTS

As an essential pre-requisite to possible extension of AFC throughout the Underground a comprehensive review of fare collection methods was undertaken, including an examination of the operational performance of the existing AFC equipment. At that time AFC existed only on the Victoria Line with new equipment being provided on the Brixton extension and at Charing Cross (now Embankment). Additional installations were being planned for Marble Arch and Piccadilly Circus. Nevertheless it is convenient hereafter to refer to the technology thus far as 'the Victoria Line system' and it is this that the review would have addressed.

But in June 1971 (before the results of the review were known) the Greater London Council (now LT's political masters) authorised the new London Transport Executive to spend up to £675,000 on installing further AFC equipment at a number of heavily used stations—this would have brought the Executive's total investment in this field up to about £4,000,000.

The money would have been spent on installing full AFC equipment at 5 major sites (Waterloo [Shell building], Notting Hill Gate, Earls

Court, Waterloo [Main] and Holborn). In addition a further 67 stations would be equipped with AFC ticket encoding and dating equipment, thereby issuing yellow tickets which would be acceptable at fully equipped AFC stations and so making better use of the existing AFC installations.

It was anticipated that the additional equipment would create an increased revenue cost of about £155,000 but that gains from reduced fraud of between £200,000 and £250,000, would more than offset the costs. At the time it was felt such a margin was sufficient to justify the capital expenditure of well over half a million pounds.

{Was it actually authorised?}

This extension of 'Victoria Line' AFC was not to be. As the AFC review progressed, the facts were to somewhat dilute the initial enthusiasm. Not only did the review arrest moves towards system-wide expansion of 'Victoria Line' style AFC, it raised serious questions about the success of the programme thus far.

The points the review brought out were as follows.

1. All the existing AFC gates required manned barriers in parallel to deal with non-AFC type tickets. Even if all LT-issued tickets could be directed through the AFC gates there remained a very large number of BR through seasons to be catered for. Little progress had been made in gaining any commitment from BR to issue compatible tickets, and in their absence it was not seen how manned barriers could be withdrawn (although BR were aware of the technology and had indeed installed a broadly similar AFC system of their own in Glasgow).

2. Given that parallel manned barriers were provided, it was proving extremely difficult to persuade all passengers with AFC tickets to use the AFC gates. The result was that the anticipated degree of fraud resistance of the new barrier lines was not being met. Among the reasons which were speculated were a natural resistance to change, a 'too complicated' appearance, and an easy channel for opportunist fraud. This did not auger well for future installations. Clearly all the unfortunate shortcomings of manual ticket checking were bordering on being imported into the AFC age. On reflection, improved publicity and targeted enforcement were, however, not impossible options if the will were there. One might with hindsight also query 'resistance to change' in the context of passengers at new stations on a new railway.

3. A study of system reliability led to the unfortunate conclusion that the AFC system had become too dependent on 'manual servicing and other manual intervention' and either despite of this, or because of this, the system was failing to perform at the very high levels of reliability necessary if the passenger is to enter and leave the Underground successfully and without incident every time! This factor of unreliability inevitably caused a proportion of passengers to avoid automatic barriers, especially exit barriers, putting an extra burden on the collectors (some simplification, including conversion of 4-door barriers to 2-door, had made some improvement).

4. In association with point 3 there was an emerging problem with correct ticket encoding where, for example, staff occasionally forgot to alter date switches or otherwise incorrectly encoded a ticket (a not wholly straightforward process!¹). So far as the pas-

senger was concerned this either meant that his ticket would not work at all or, in the case of a Season, it might work in an apparently arbitrary manner (a possibly disquieting feature in a ticket costing a lot of money).

In the face of reality there was little option but to reconsider the approach to AFC. Clearly the most pressing immediate requirements were a significant improvement in system reliability, coupled with an improvement in control at manned barriers (for as long as these had to be provided). Matters now resolved themselves into discussions about the long term nature of AFC on the Underground, and short term solutions to immediate problems. The fresh approach was timely in relation to the inventor of the original system, Robert Dell, who had just retired.

'coverpoint' station, and the route code and set these up on his season ticket issue equipment. He had also to set up 'local/distant' switch (which will be explained in a future article). After setting up the expiry date he would then pot up the accounting information on the season ticket cash register and pass the ticket through the machine where it would be encoded. He would then complete the normal clerical duties such as stamping the expiry date on the ticket and filling in the passenger's record card. He would then sell the ticket. If under pressure, it must be expected that the clerk might well make a coding error.

Another problem was that the ticket encoding and checking apparatus comprised vast numbers of discrete electronic components, and the failure of just one of these could remain undetected for a long time. Just one component failure could result in a ticket receiving the wrong code or being read incorrectly and would have resulted in very irritating 'random' examples of tickets not operating the gates in the expected manner. Additionally, a slight lack of foresight resulted in some season tickets **not** operating AFC gates on the authorized line of route. Revised encoding instructions were hence issued in c.1972.

¹ Taking the issue of a season ticket as an example the booking clerk had to look up the code number of the destination, or

THE REVISED LONG TERM OBJECTIVE

After due contemplation the long term objective was established, fuelled by a desire for flexibility while realising that much fraud could be reduced by ensuring a passenger had a ticket at the beginning of the journey. The basis was the issue of single journey tickets pre-printed and pre-encoded with only the ticket-type and fare value at the time of sale. When the tickets were to be used, they would be inserted into an automatic barrier at the station of entry where the fixed code would undergo a simple check. If the check was successful the station of entry would be encoded onto the ticket by the barrier, together with a special 'cancellation' mark. These bits of information would simultaneously be printed on the face of the ticket to facilitate visual checking. When the passenger reached the destination the ticket would be collected and checked at a manned barrier or possibly by an automatic barrier.

The advantage of this system, apart from improved reliability, was that tickets could be sold in advance of the time they were to be used and they could be sold in bulk. One possibility was that a number of tickets could be sold together at a discount price—this method of ticket issue would then have superseded the use of weekly tickets. It was also envisaged that the tickets could be employed on an adapted AFC system on buses (at that time Red Arrow buses had a flat fare, pay on entry system with tripod barriers, and numerous suburban routes had automatic ticket machines and barriers in parallel with a pay-the-driver channel).

REVISED AFC IMPLEMENTATION PROGRAMME

Like the original AFC proposals, the new system necessarily had to be introduced in two stages with the preliminary stage operative until equipment had been installed at all stations. The long term scheme described above eventually became termed 'System B'; but as the possibility of its widespread adoption receded into the far distant future, the so-called interim scheme took on an air of permanence and became styled 'System C'. Thereafter great confusion over the names has occurred. It must be presumed that 'System A' was the existing system.

Under the interim scheme (ie System 'C') only single tickets were initially to be AFC coded: more complicated tickets such as privilege-rate or season tickets would pass through the existing Way In manned barrier. This temporary arrangement

Although it was originally thought to be the ultimate ideal for which to aim, the concept of stored fare tickets did not feature in the new long term plan. Many, but by no means all, of the advantages of stored fares could be achieved by selling tickets in 'carnets', and the complexity of stored fare equipment, which in any case demanded complete gating, was probably viewed as over-ambitious.

To what extent would gating have been employed on exit? There were two serious problems with manned barrier checking. Firstly the ticket collector could not properly examine several tickets simultaneously—a factor which manned barrier design had thus far failed to address. Secondly the ticket collector was not well placed to delay a passenger for long enough to examine his ticket effectively nor to stop a passenger if the ticket were not correct (sometimes collectors would position themselves outside the collector's booth with these thoughts in mind, but a rising tendency for staff to be assaulted made managers officially discourage this practice). The solution proposed here was the installation of a new type of manned ticket barrier at AFC stations. These barriers would operate in association with a tripod gate which could be released by the collector when he was satisfied that the person passing his barrier had a valid ticket. This new arrangement would force people to file singly past the collector so that he would only deal with one client at a time. It also forced the collector to remain in the relative safety of his booth.

would ensure, because of its simplicity, extremely high reliability at AFC inwards barriers but would necessitate the withdrawal of AFC exit barriers (with a considerable simplification in station equipment). Advantages of removing exit gates included removing a considerable cause of system unreliability, and the simplified coding now specified would make exit-gate checking impracticable. An additional spin-off from this was that many of the redundant exit barriers could be installed elsewhere as inwards barriers. System 'C' was naturally very much cheaper than the cost of the original proposal for extending AFC.

It must be remembered that £675,000 had already been authorized for extending the Victoria Line system in 1971 and this money was more or less unspent. To adopt an experimental form of

System 'C' at the original list of stations would cost only about £440,000 (and to include further stations to make use of every spare gate would only increase this cost to £600,000). The GLC authorised LT to adopt the new proposals—by now it was September 1972. The proviso was that LT carefully monitored the results of the experimental installations. LT authorized £441,000 to be put aside for the expenditure.

The stations selected for experimental System 'C' installation were:

GROUP A—Stations on original list

Waterloo (Shell building)
Notting Hill Gate
Earls Court
Waterloo (Main)
Holborn

GROUP B—additional stations Hammersmith (Dist. & Picc.)

Tower Hill
High Street Kensington
Trafalgar Square

GROUP C—to use equipment mainly ex Victoria Line 'exit' gates.

Sloane Square
Turnpike Lane
Wood Green
Morden
South Wimbledon
Colliers Wood
Tooting Broadway
Tooting Bec
Balham

Hammersmith was included on the list because its prototype equipment was non-standard; Tower Hill was included because the station had a new building and had been built with AFC in mind in the form of booking hall layout and the provision of an underfloor air main (though, in the

event, System 'C' was not fitted there). London Transport was authorized to vary the content of the programme within the cash limit allowed.

The first public sign that the original AFC policy had changed was when Pimlico Station (a late opener on the Brixton extension) opened to Traffic in 1972—no exit gates were provided. A few months later the exit gates at Victoria Line stations were progressively taken out of commission and removed, some extra manned barriers being installed in their wake. AFC season tickets disappeared from use almost immediately although some coded staff and visitor passes lingered on for a while. The issue of return tickets by coin operated machine also stopped. A number of season ticket cash registers now became redundant and available for use elsewhere for issuing card stock tickets. A little later, cash registers at excess fare windows were similarly redistributed and they were replaced by much simpler 'Almex' bus ticket type machines which issued highly inferior, virtually unreadable paper receipts. It ought to be mentioned in passing that for most of the relatively short life of Oxide backed AFC excess fare tickets the face of the ticket carried a pink stripe across the yellow ground. This feature was introduced in mid 1969 at Hammersmith and Turnham Green and distinguished them more easily from other cash register tickets (helping to indicate that they were not valid for travel).

The full ticket encoding and inwards checking at Victoria Line stations progressively died a death (including date encoding) until, in effect, they became System 'C' stations—standard in operation though with non-standard System 'C' equipment. The Victoria Line system was now dead and the near empty equipment racks and mass of amputated wiring remained in the Victoria Line AFC coding rooms as a salutary reminder of higher aspirations.

A NEW AUTOMATIC BARRIER FOR SYSTEM 'C'

The 1971/2 prototype System 'C' proposals were largely executed by 1974 and were more or less contained within the budget figure of £441,000. The balance of £234,000 of the original amount authorized for AFC expansion was now destined for further System 'C' installations, approval by LT being gained in September 1973.

Although the prototype System 'C' stations utilised existing AFC gates it was obvious that a new design of gate would be required for more a more comprehensive installation programme. Firstly new internal equipment was needed if tick-

ets were to be overprinted and re-encoded as they passed through; secondly the physical design left something to be desired, and in particular they were rather bulky, which would make installation of the necessary number of gates at many existing stations rather difficult. As a result work proceeded on the design of a new 'slimline' gate. As completed it was a much narrower unit and only needed a single stanchion per gate (the left hand gate leaves were mounted on the adjacent gate stanchion). Gate leaves were lightweight red-coloured moulded paddles instead of the earlier

padded frames. The prototype slimline gate was installed at High Street Kensington.

However, thoughts of providing the new 'full specification' ticket handling equipment were not proceeded with. The main problem lay in the design of a suitable ticket transporter unit which could accommodate additional magnetic heads and inking and printing units. Worries about reliability of this potentially complex arrangement

cannot have helped. Clearly the re-used Victoria Line gates were expected to be not wholly System 'C' compatible, but neither, now, were to be at least the first tranche of the new gate design. This, of course, now locked 'Phase 1' System 'C' into using conventional coded tickets, though with a simplified coding. The AFC code on the back therefore remained uncanceled when the ticket passed through the barrier.

PROPOSED SYSTEMWIDE EXPANSION OF SYSTEM 'C'

The proposals for system-wide full-specification System 'C' AFC were put forth in June 1974 at a proposed cost of £11,000,000. The rationale behind the scheme differed little from the thoughts on the subject in 1972 but perhaps a recap of the essential principles would be helpful.

System 'C' was based on the concept of an absolute ticket check on entry to the Underground Network—in other words every passenger travelling will have a ticket which is valid on that day. This was to be achieved as follows:

1. Ordinary single tickets would have to be dated and validated in an AFC entry gate. Once this was done they would be valid for the journey commenced for the fare marked on the ticket and would not operate any entry gate again (so preventing misuse).

2. All other tickets (which would be already be dated and valid, eg seasons) would have to be presented to a ticket examiner at a manual barrier. This barrier would be fitted with a tripod gate released by the examiner when he was satisfied the ticket offered him was valid.

London Transport at that time was convinced that the vast majority of fraud could be eliminated by improved checking on entry. For years the quality of checking on entry had deteriorated, and it was a popular view that not having a ticket didn't matter.

It has already seen that manual barriers were envisaged at exits from the system, but it had been anticipated that the conventional 'open' barriers would be used (without parallel AFC gates). Tripod-type manned barriers, whilst more efficient than the conventional type in terms of ticket checking, had a commensurately much lower flow capacity and would have been required in far greater numbers to cater for comparable flows of people; this of course, would have pushed up staff requirements. However, an experiment at St James's Park illustrated that a simple dividing

'fence' down the middle of a conventional double-manned barrier significantly improved matters at little cost. Making passengers file singly past the collectors only slowed down the flow slightly but greatly improved the ticket collectors' ability to check tickets. Such barriers were henceforth considered for use at exits system 'C' stations. Another undesirable feature of 'tripod' type manned barriers at exits was that they could not accommodate surges of people, which might happen at many stations—this would be dangerous for example at stations equipped with escalators where passengers might be deposited at the top landing faster than the gates could let them out. There was also some evidence that the tripod barriers were very unpopular with the public.

The proposal for full System 'C' installations at each of LT's 250 stations at a total cost of £11,000,000 was broken down as follows:

Cost of ticket issuing and barrier control (including all installations and architectural work at 'easy' stations).

Additional architectural work at 'difficult' stations (about 50 stations where full system 'C' was justified)

Architectural work at about 20 stations where a special variation on System 'C' would be needed.

The financial effect of going ahead with the scheme was likely to be an increased annual operating cost of £1,840,000 (which included additional staff costs). For this expenditure to be justified the average increase in station receipts would have had to have been in the order of 3½ per cent. In this connection LT looked with optimism at the results of an experimental AFC gate/tripod manned barrier installation for inwards passengers which had yielded a 15 per cent increase in station receipts over a 25 week test period. LT realized that this may not have been typical and that it would be better to assume a lower figure for the system as a whole until actual

results could be ascertained (an 8 per cent improvement was decided upon).

It was not easy to estimate the actual improvement. For example the obvious increase in receipts at modified stations would, amongst other things, have to allow for the reduction of receipts paid in elsewhere (such as excess fares). Nevertheless, System 'C' looked financially viable and so on 23rd July 1974 the GLC authorized LT to install AFC at every one of its stations, at a capital cost of £11,000,000 to be spent between 1974-8.

The concept of System 'B' (for which over £20,000,000 had been provisionally allocated to the years 1976-85) continued as a vague future promise for reduced staffing levels. But the reality was that with an apparently viable system actually in course of installation System 'B', as originally defined, faded away under the nebulous heading of 'future systems', and was open for reconsidera-

tion. Although the exact form of this future system was uncertain, no less than £45,910,000 was provisionally allocated for the complete programme between the years 1977 and 1980—but we must wait for a future article to describe exactly what happened here.

A factor not entirely taken into account when proposing System 'C' was the impact of the prevailing staff shortage. System 'C' required separate ticket collectors to operate the tripod 'inwards' barriers to those required at the 'conventional' outwards barriers. During a time of acute staff shortage conflicts arose as to which barrier to man and which one to leave closed (or left open, but unattended). In practice it seems that when staff were not available there was a tendency to retain the ticket collector at the tripod barrier only (thus maintaining some sort of ticket control), with consequential clashes in Passenger flows.

THE COLLAPSE OF SYSTEM 'C'

When the GLC gave authority in mid 1974 for LT to spend money on system-wide AFC they made three short-term provisos (which allowed the GLC to suspend the programme if doubts arose):

- a) that no installation is made which is not expected to be financially justified; and
- b) that the result of the early installations and their implications for the programme as a whole, be reported to the Council as they became available; and
- c) that a decision on that part of the programme related to non-standard solutions at 20 stations estimated to cost £1,000,000 be deferred until the majority of standard installations has been made.

On 29th May 1975 the Council enquired of LT to see whether they had yet been able to produce any data covering the results of the new AFC installations. LT replied that progress was being made but that they regarded the judgement of the results so far as premature. In the absence of detailed information about progress on System 'C' the GLC specifically excluded authority for further work to be done when the time came to authorize the LT budget for 1976.

Meanwhile LT had busied themselves in installing the system. As a provisional move they had provided for the expenditure of £1,700,000 of the £11,000,000 as indicated in the following table:

1974 programme of work (12 stations)	£25,000
1975 programme of work (50 stations)	£150,000
1976 programme of work (advance purchase of equipment only)	£300,000
Total	£1,700,000 (approx)

(Further work in 1976 had been frozen by lack of GLC authority).

By March 1976 LT felt able to demonstrate the preliminary financial implications of System 'C'. By this time they had made the following progress:

- a) installation was complete at 22 stations;
- b) site work 80-90% complete at 8 stations (ready for commissioning in April);
- c) contracts were let for structural work at 4 further stations;
- d) planning and design was complete, and layout plans approved, for 12 stations;
- e) preliminary design work had been carried out at 4 stations.

The GLC noted that the expenditure authorized for just the 1974/5 parts of the programme was £1,400,000, and so far £1,376,000 had been spent or committed and the work was far from complete—costs, especially labour and materials, had risen by as much as 35%. Whilst explaining the delay in getting the information, this did not augur well for any systemwide installation pro-

gramme, and the GLC were concerned at the implications of some of the explanations given.

The following table enumerated the results at the stations monitored.

TABLE OF RESULTS OF AFC INSTALLATIONS

Y	PRELIMINAR	RESUL			
	TS	Capital cost	An nual cost	Ad- ditio P.a. nal Receipts	Net savings p.a.
Station	£000	£000	£000	%	£000
Manor House	28	7	12	41.3	5
Bounds Green	16	2	10	4.9	8
Arnos Grove	13	5½	5	2.2	-½
Brent	28	3	4	4.5	1
Hendon Central	24	6½	8½	3.9	2
Colindale	19	6	9½	6.9	3½
Burnt Oak	24	6	8½	4.6	2½
Edgware	39	7½	9½	3.3	2
Hyde Park Corner	20	6	15½	8.1	9½
TOTAL	211	49½	82½	4.5	33

FINAL RESULTS					
Manor House	28	6½	12	4.3	5½
Bounds Green	16	1½	10	4.9	8½
Arnos Grove	13	5½	5	2.2	-½
Brent	28	2	4	4.5	2
Hendon Central	21	6	8½	3.9	2½
Colindale	19	5½	12½	9.1	7
Burnt Oak*	24½	2	8½	4.6	6½
Edgware	39	7	9½	3.3	2½
Hyde Park Corner	20	6	16	8.1	10
Leytonstone	31½	2	7	2.4	5
Cockfosters	24½	2	9	6.1	7
Stanmore	25	6	13	6.7	7
Canons Park	23	2	4	3.7	2
Dollis Hill	19½	1½	8½	7.5	7
Willesden Green	20	2	6	2.4	4
Kilburn	28	2½	10	3.	7½
West Hampstead	20	1½	9	5.0	7½
TOTAL	400	61½	152½	4.5	91

Additional staff originally allowed for not required

LT's comments on the figures may be summarised as:

a) The quality of ticket checking was lower than expected because of the ongoing difficulty in designing the full 'System C' ticket transporter/printer unit, this required the continuing use to be made of conventional tickets with only the most elementary code.

b) Ticket checking quality also suffered because, for flow or other reasons, many stations with automatic entry gates have not been equipped with the manned turnstile entry barriers (providing an easy route for fare evaders, especially at a time of staff shortage).

c) At some stations with manned tripod entry barriers passengers were able to avoid using them by entering through an 'open' Way Out barrier.

d) the financial results may have been lower than expected (on average) because many of this batch of 'System C' stations were in suburban areas rather than in the more lucrative central area.

Reasons for the selection of suburban stations were:

(i) A number of Central Area stations were already equipped for Victoria Line AFC, reducing the available number to be equipped with 'System C' at that stage.

(ii) There was a preponderance of suburban stations on the system, and it was believed that there was an advantage in equipping all stations along a particular line of route.

(iii) Many of the stations in the initial AFC programme involved relatively low conversion costs and had already been planned for conversion in earlier AFC programmes, so there was an advantage in sustaining momentum there.

e) the results had been considerably modified to take into account various factors LT considered necessary. They were modified:

(i) for fares inflation above the General rate, to correct for fraud opportunities due to the low (5p) minimum fare and to allow for the better checking logic they wished to see.

(ii) to allow for loss of excess fares paid in elsewhere and to allow for the loss of initial staff enthusiasm and for increased Pas-

senger adeptness at the frauds which remained possible,

LT added that to establish the net effect of these upward and downward adjustments, estimated factors of 0.75 and 1.10 were applied to the receipts increases at inner and outer stations respectively. LT did indicate that the results were still not entirely likely to be representative and that there were naturally some speculative elements in the figures (the actual results were not offered).

Although LT's figures suggested that the majority of 'System C' stations would cover revenue costs, the business case appeared weak in the light of the capital required, and some retrenchment was needed. They therefore suggested the following course of action to the GLC:

a) to complete the 1975 programme—ie to finish the work at the remaining 34 of the 50 programmed stations at which physical work had been done or contracts let;

b) to adopt as the 1976 programme the provision of the outstanding manned tripod barriers and to improve the gate checking logic;

c) to examine and analyse the further results of the 'System C' installations thus far and to report again on the findings.

The GLC accepted the proposals but took the opportunity to press home the urgency of securing an automatic system which would both save manpower and financial resources. The remaining committed work was completed and at that point the prevailing programme was terminated.

The long term outlook also changed. A warming of climate with regard to BR-compatible AFC caused LT reflect on the whole approach, and a grass-roots reconsideration began. This also took on board the GLC Transport Committee's distinct lack of enthusiasm for the further installation of tripod barriers. In the short term the only new work undertaken was an improvement in the gate checking logic, so that a ticket would only be acceptable to a gate at the station of issue—hitherto any yellow ticket would operate any System C gate. A subsequent refinement was the provision of a special magnetic roller that destroyed the code on a ticket once it was inserted in a gate, so preventing its re-use.

OTHER NOTES

First 810 machine installed end 1973 at central London stations. Held two ticket rolls and had electronic checking mechanism. LTN16. Introduced Leicester Square Jan 1974. LTN20

Reference to full System 'C' gate (with sample tickets). Also ref to need for temporary validators at some stns as intermediate step. Clear tripod on way in. Dual on Way Out. Front end restyled to make insertion easier. 2-doors closed type. LTN31 [5 Jul 1974].

First new slimline gate installed Earls Court W.Rd Prob Feb 1975. At time of writing also being put in at TCR and Manor House. LTN 46.

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