THE 67s AND THE VICTORIA LINE
5 – THE STOCK SETTLES IN
by Piers Connor

STAGES

The Victoria Line opened in stages. The first stage, between Walthamstow and Highbury & Islington, opened on 1 September 1968, the second stage exactly 3 months later on 1 December. Both days were Sundays. The full opening to the then terminus at Victoria took place on Friday 7 March 1969, with the Queen performing the opening ceremony. By this time, all the original order for the 1967 Tube Stock had been delivered to Ruislip depot (the last arriving on 18 December 1968) and all (apart from the original unit, 3001) had been commissioned and were available for service by 19 February 1969. There was a slow down in delivery for the Brixton extension stock, which only arrived at the rate of one train a month, instead of 1½ a month.

Figure 1: The first 4-car unit of 1967 Tube Stock (Unit No. 3001) on test at South Ealing, 3 November 1967. As a driver on the Piccadilly Line at the time, I used to see this unit regularly. It was sometimes stabled in Northfields depot where I was based, so I would sneak a look inside from time to time. There was a lot of instrumentation, I recall. The testing was done on the fast tracks while the Piccadilly Line service used the local tracks. LT Museum photo.

THE LINE IN OPERATION

In February 1970, less than a year after the opening, F. Gordon Maxwell, the Operating Manager of the Underground, gave a paper[1] to the Institution of Railway Signal Engineers outlining the planning and describing the operation of the Victoria Line. Another, similar paper[2] was given to the Underground's own Signal Engineer's Technical Society by Colin Cray, the Divisional Superintendent of the Northern & Victoria lines. Although Cray was present at the Maxwell presentation, his paper covered a number of different subjects and, in their reading, they complement each other quite well. Neither paper was specifically aimed towards the rolling stock but there were lots of comments about the technology and its operation in service that are worth recounting here. Maxwell's paper provoked a lively debate during the discussion afterwards and some of the points made were interesting in showing the thinking of the day. There were also some sharp comments by senior engineers about their brothers in other departments and some witty responses by Maxwell himself. There were also some interesting lessons that could have been learned and some interesting predictions. The discussion following Cray's paper was not recorded but he provided some interesting insights into how he saw the railway's operation at the time.

DAMP & VENTILATION

Both papers mention the problems they encountered with water in the tunnels. Cray spoke of "pools of water" that they tried to dry with "large and cumbersome heaters of various sorts". Maxwell

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1 Maxwell, F.G. (1970), "The Victoria Line in Operation", Technical Meeting of the Institution of Railway Signal Engineers, 17 February 1970, London.

2 Cray, C.M. (1970), "The Victoria Line in Operation", Meeting of the Signal Engineers Technical Society, 25 November 1970, London.

describes how the sleeper blocks were set into position with wet patches around the concrete and the blocks became saturated with water as a result. This prevented the track circuits from working properly. Trains under test were getting code tripped when they lost the ATC signal and the wet rails caused them to skid to a stop, causing flats. Cray recalls that they had complaints of vibration from nearby residents and that these were largely the result of running trains "with square wheels". Repairing these resulted in a shortage of trains for the opening of Stage 1. Maxwell records how they had to lift 48,000 rail chairs and provide insulating pads under them to improve the track circuit performance. They also fitted nylon bushes to the coach screws securing them. This work occupied much of the planned testing time and left them with less than two weeks to try out the trains and the ATC equipment for Stage 1.

Once the line opened, they watched the track rather carefully. They were worried that the rails would wear into patterns under automatic operation. It had been assumed that such wear didn't appear on manually operated lines because of the different drivers' variable braking techniques but that it could appear on an ATC railway. It didn't happen. Apparently, the performance of the 1967 Tube Stock was sufficiently variable in its own right.

Maxwell said that there was a desire to keep the temperature in the running tunnels down to 70°F (21°C). It was realised, even then, that temperatures in tunnels would rise as more trains were run. The Victoria Line was provided with purpose-built ventilation shafts at suitable locations and these were used to help dry out the tunnels before the start of operations. For other lines, although Maxwell didn't say so, the trouble was that they were experiencing an almost continuous fall in passenger numbers year on year. This was to accelerate during the 1970s and it was getting more and more difficult to spend money on things that couldn't be justified to the politicians and that couldn't be seen by the public. Nowadays, after almost 20 years of rising traffic numbers, temperatures are regularly recorded at 30°C[3].

NOISE AND IBJs

Even though they eliminated the difficulties causing flats, there was still considered to be a noise problem. Maxwell spoke of their disappointment at the high noise levels but he did say they were surprised that there hadn't, so far, been any complaints from the public about it. Of course, there was the comparison with existing lines, which were all rather noisy. At the time, LU did some tests with a '67 Stock train on the Piccadilly Line and a '59 Stock on the Victoria Line to compare noise levels and Maxwell reported that there wasn't any real difference between the two types. Of course, the noise got worse with time and wear.

The line was equipped with welded rail but the signalling system required insulated block joints (IBJs) at frequent intervals and these were a significant source of noise. Maxwell noted an average of 100 block joints for each route mile of the railway. The discussion after the paper included some comments about block joints and noise from Harry Hadaway, Robert Dell's Deputy Chief Signal Engineer. Hadaway said that, like the Chief Civil Engineer (who wasn't at the meeting), the signal engineer didn't like block joints either. They caused failures. He said that there were "block-jointless systems around the world" but LU (he meant his boss Robert Dell) didn't consider them proven yet and they would have to do more testing with them before they were convinced they were safe to use. It was the late 1980s before they appeared in service on the Underground – see box.

AF TRACK CIRCUITS

Audio frequency track circuits were first introduced on the Chicago Lake Street line in 1965 (R.J. Hill, 1996) but there was a 20-year long path to the acceptance by LU of what was, at first, called the "block-jointless" or, as we now know it, AF track circuit. There were tests at various locations, including South Ealing, Totteridge and Highgate.

LU tested their own design, perhaps to overcome the cost of patents already registered by suppliers like Alstom and to try to match to performance of the existing circuits – a vain hope that was already realised on BR, who were also testing AF circuits.

LU also tried some signalling manufacturers' versions and eventually settled on the Westinghouse type FS2500, which was ultimately used on the Bakerloo resignalling of 1988-90. *My thanks to D. Burton and M. Horne for many of these details.*

[3] Douglas L, "Air-conditioning of London Underground – reality or dream?", Engineering & Technology Magazine, 2 Vol. 5, Issue 10 July 2010, IET, London.

He also took issue with the idea, which he said was put forward by the Chief Civil Engineer, that the block joints were the main reason for the noise and suggested, tongue in cheek, that since they were to be "with us for some little time yet" he (the CCE) should redesign them, if he thought he could do better. He also mentioned the possibility of resting block joints on chairs, after "Continental" practice, as he described it.

Hadaway referred to the "dampness" of the line that they discovered when they wanted to start running trains. He compared it to potholing where people, "went hundreds of feet below the ground and through several feet of water to get to some distant objective". There was, he said, so much water that it was impossible to get the track circuits to function.

DRIVERLESS TRAINS

In the discussion following Maxwell's paper, both Dell and Hadaway mentioned driverless trains. In a time of serious staff shortages in all public services and especially on the Underground, it was the ultimate goal. The engineers knew it was possible and they wanted to show what they could do. Hadaway described the Victoria Line as "not automatic; only a system where the level of manual operation had been reduced". He was right, of course, since a fully automatic railway would have unmanned trains and stations like an airport people mover. Maxwell's view was, predictably, that the problem with driverless operation was that, when something went wrong with the train, it couldn't answer back to an enquiry from the controller. He went on to say they would need someone on the train and that it could be "a pretty lady"; they didn't necessarily need someone with technical expertise. Hadaway tentatively suggested that, even if they couldn't have a "fair damsel", a "black box" could offer the control centre all the information it needed. Nowadays, it seems, we have both.

There was a curious exchange between Dell and Maxwell about train set numbers. In his paper, Maxwell criticised the control room system because it displayed the number of the next train due at a location, not the number of the train actually there. This was always a problem for the operators in control centres using programme machines in that, when the "job went up the wall" and trains arrived out of turn or very late, no one knew which train was which. The train describers on platforms also showed the wrong destination confusing both staff and passengers on site. Dell offered a simple solution – have driverless trains and abandon the use of train numbers. Maxwell responded by saying that this might be possible on a simple line like the Victoria Line, as long as there were no crews needing a meal relief but other lines with complicated services needed them. He then put Dell firmly in his place by telling him that, in reality, train numbers were necessary because, not only did the crews want to get back to their home depot but "also the passengers had some interest in going to Richmond and not being taken to Ealing Broadway in order to make the train system simpler".

PARKING BRAKES

Both Cray and Maxwell complained about the hydraulic handbrakes on the trains and their habit of dumping their fluid on the track at inconvenient times. Cray noted one occasion when a train ran from Seven Sisters to King's Cross before anyone noticed the handbrake was applied. The resulting flats were "very serious". Cray suggested that part of the problem was that it was difficult for the Train Operator to get a "feel" for his train in the way a manual driver would and that this would prevent detection of these sorts of problems[4]. Dell, in his comments, suggested that the Underground should adopt a spring applied parking brake and they did but only 10 years later with the introduction of the D Stock on the District Line. They finally got rid of the dreadful hydraulics during a "panic" replacement programme following the King's Cross fire. The thought was that the fluid was inflammable and anything that came close to inflammability was expunged, regardless of cost or disruption. The removal of wood from escalators comes to mind as one programme like that. The replacement of the hydraulic parking brake by a spring applied system was rather more justifiable, especially given its unreliability. It was carried out in 1989-90.

PERFORMANCE

Both papers give some numbers for performance. Since we are now at the stage where the new 2009 Tube Stock and new Distance-to-Go signalling system is roughly in the same position as the

[4] In my experience, this was no guarantee that these sorts of problems would be detected. I recall and incident where a C Stock was dragged for several stations in service by a driver who was only alerted to the problem by a passenger complaining of the smell of overheating.

Victoria Line was when these two papers were written, I thought it would be interesting to offer a comparison. However, this data comes with a health warning. My somewhat hazy memory suggests that the methods of calculation are now rather different. Data collection is more robust now but the figures are also more easily massaged, especially in view of the higher political profile enduring these days.

TABLE 1: COMPARISON OF PERFORMANCE OF VICTORIA LINE – 1970 AND 2011

Data	**1970**	**2012**
Number of passengers per day	200,000	308,000[5]
Number of passengers per peak hour	20,000	31,000 est.
Mean distance between train failures (kms.)	7,200	11,000

In general, the numbers of passengers have increased by 50%, including the inclusion of the Brixton extension, which opened in 1971. Cray noted that, at 200,000, the line had reached its design capacity and that it was still increasing. Surprisingly, new train performance has improved, also by about 50%, quite contrary to what you might believe from media reports and from taking into account the enormous increase in complexity in today's new trains. Whilst on the subject of train performance, it is worth recording that, in 1970, the average speed on the Victoria Line was 25-30% higher than older lines.

STEPPING BACK

A feature of Victoria Line operation planned from the very beginning was "stepping back". Maxwell described how well it was working at Victoria when the initial service was reversed there. It had long been in operation at the Elephant & Castle terminus of the Bakerloo and it was a good way of getting 30 trains per hour service turned round in a 2-platform terminal.

Stepping back starts when the driver of the first arriving train shut down the cab immediately after opening the doors. With the doors open the relief driver would walk into the rear cab and wait for the "Other cab on" light to switch off to show him that it was OK for him to enter the cab and "open up" for departure. The arriving driver now walked up the opposite platform so that he reached the departure end in time for the next train to arrive and the process was repeated. When the terminal was moved to Brixton, the procedure was moved there too. Assuming prompt action by the train crews, the process can work very well but it does require precision and proper supervision.

Interestingly, the whole train turnround process was carefully studied during the design stage for the 1967 Stock. A network analysis was carried out and Webster provided a diagram for it in his 1969 paper as shown on the next page (Figure 2). Time was allowed for drivers to exchange comments over the cab-to-cab phone if necessary and for drivers to collect their belongings or settle in. Looking at the detail in Figure 2 shows how many tasks are actually involved in something the driver does several times a day, almost without thinking about it. The whole process was timed to be completed in 84 seconds. It was often done in less.

OVERRUNS

There were some comments by Hadaway about the overruns at the terminals. The ATC system, as designed, allowed trains to run into the terminal platforms at full speed. The assumption was that, if a train failed to respond to the station brake commands, it would get tripped at the platform end and would therefore need a full speed braking distance beyond. The cost of providing these had been questioned, particularly as people were used to the short dead end terminals seen at most termini like those at Cockfosters, Baker Street or Aldgate. Hadaway said that the number of buffer stop collisions at existing terminals was such that he thought the usual design was too short. He also noted that a cautious driver could put up to 20 seconds on the run in and that this "this kind of timing could be fatal for the headway". He felt that the full speed overrun was completely justified. A few years later, following the Moorgate collision of 28 February 1975, manual terminals were fitted with speed controlled trainstops and this proved his point about being fatal to the headway. It cost two

[5] www.londonfirst.co.uk, since TfL doesn't seem to provide daily line figures. Accurate and meaningful figures for comparisons are very hard to get, particularly from the days before full automatic fare collection.

trains an hour on every line. It would be interesting to know what his comments might be today on the new 20m overruns provided at Baker Street and Aldgate at huge cost.

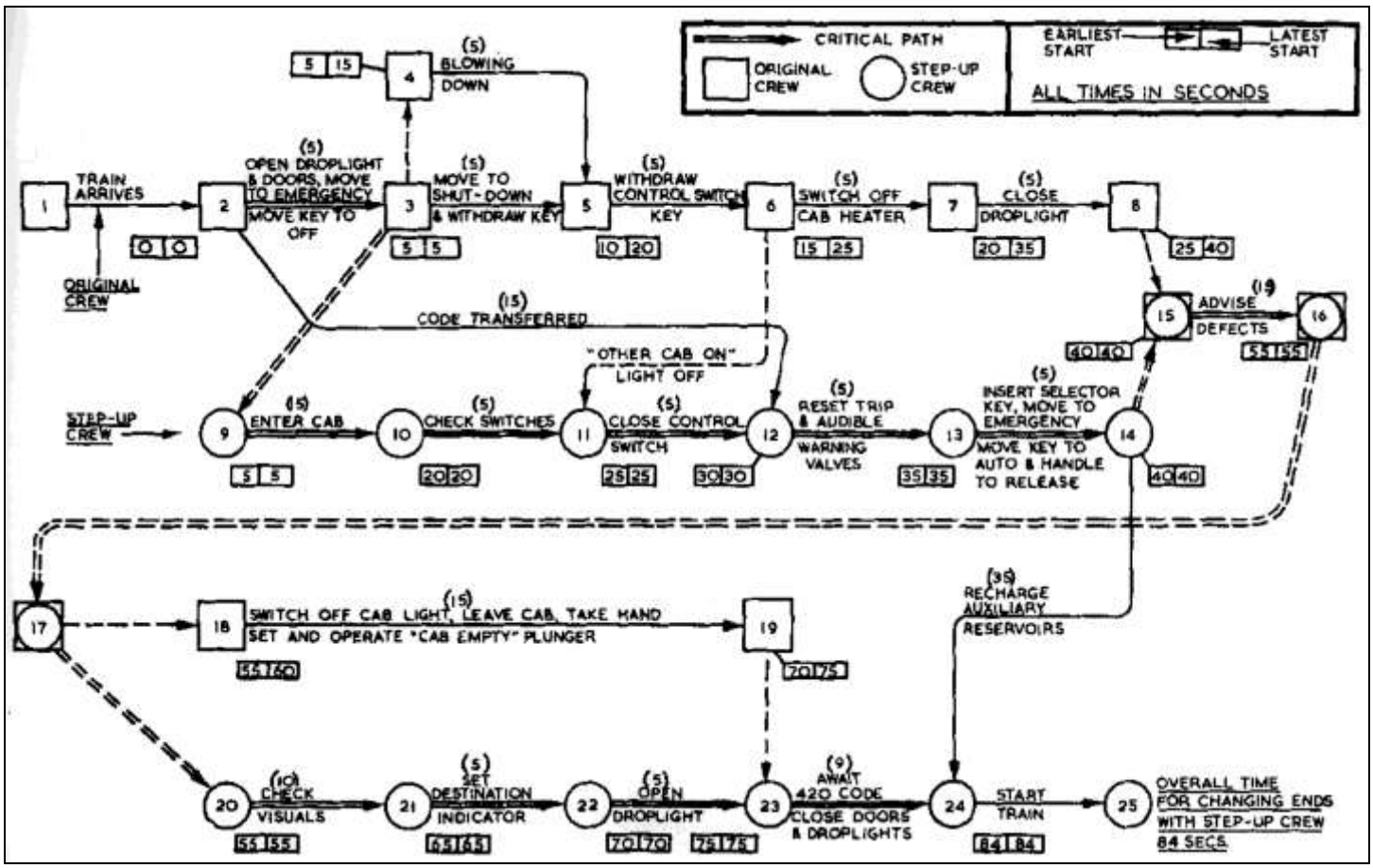

Figure 2: Network analysis of train reversal procedure at terminal using stepping back of drivers (Webster 1969).

Of course, overruns at terminals were not the only problem. Most of the original lines were stretched to their limits in terms of the platform lengths in relation to train lengths. The Victoria Line was built with platforms 25 feet longer than the trains. This was deliberate. It was not certain that the ATO stopping accuracy could be contained within the planned ± six feet.

INTERFERENCE

During the discussion on Maxwell's paper, Colin Cray mentioned that they had suffered a number of examples of people getting into the rear cabs and messing about with the equipment. There were even occasions when empty cabs were used as toilets (by passengers)[6]. He also quoted instances where someone had lifted seats and cut out brake equipment[7], although they had been caught. This was, he felt, cause for concern on a driverless train. Maxwell responded by suggesting that perhaps, if Mr. Hadaway was able to offer a black box, "would it also have a black truncheon in its hand?".

Cray brought up the subject of electrical interference. It was found that arcing from collector shoes interfered with code receipt but this was quickly rectified with capacitors fitted in the circuitry. However, there was an obstinate problem when Victoria was the terminus. Some trains, when standing in the northbound platform would experience an unexplained emergency brake when a train departed northbound from the adjacent southbound platform. After some serious head scratching and some experiments, it was found that the arrangement of the negative traction feed meant that when the reversing train crossed over onto the northbound road just north of the station, the sudden rise in current in the negative rail caused the runback detector to trip in the north end car of the train in the northbound platform. The problem was neatly solved when a wooden block was inserted into the negative rail so that the section of rail under the north end runback detector would not actually carry current to the train further along. The connection was via a feeder cable laid along the floor of the suicide pit. The solution remained in position for many years thereafter[8].

6 This was not unusual in the days before cabs were locked.
7 Not possible these days with seats being secured shut.
8 Letter from Mr. P. Creswell, *Underground News* No.494, February 2003 and E-Mail from Ted Robinson February 2012.

BRIXTON

The Brixton extension was opened by Princess Alexandra on 23 July 1971. This was advertised as "completing the picture", despite an extension to Croydon being mooted from time to time both earlier and since. There was also a serious suggestion in the early 2000s that the line should be extended in a single track loop towards Herne Hill but this was after an analysis, in which your author participated, found that it would require two additional trains and that the additional traffic would be more than the already overcrowded line could cope with.

Nine additional trains were purchased for the Brixton extension, as mentioned in an earlier article and, to house some of them, an additional four roads were built at Northumberland Park depot in a new shed to the east of the original building.

Figure 4: One of the Brixton extension trains is shown in Northumberland Park depot in 1973. The Brixton trains were identical to the original order. The photo is a posed shot with the train standing with almost half outside the inspection shed. Photo: LT Museum.

SETTLING IN

By the time the Brixton extension was opened, the existing line had pretty much settled down and the extension followed the pattern, with few serious problems. The traffic continued to grow until the line became the busiest on the system. The stock performed well, perhaps the only real issue being the stopping accuracy under ATO. As mentioned above, there was already some flexibility for train stopping positions. Trains tended to overrun or stop short but drivers soon learned to step in in time and adjust the stop manually. The TV monitors were originally positioned against the platform wall to widen the visible range. They were replaced by colour monitors on the platform edge in 1988-89.

The '67 Stock was inducted into the standard Underground overhaul process where units were transferred to Acton Works on a time/mileage basis. Unit 3024 went early, in May 1973, as a trial to see how the work would be done. The first unit to go under the regular scheme was 3004, which went in June 1974. The last unit (3069) went for its first overhaul in December 1981. From 1986, heavy overhauls were transferred from Acton to line depots. Only 21 units had two overhauls at Acton, the last one (3068) going there in 1985. Northumberland Park tried its first overhaul with units 3029 and 3035 in October 1986. Most subsequent overhauls were done there apart from a few that, during 2007-08, had an overhaul at Acton instead of Northumberland Park while the depot was being altered and expanded for the arrival of the 2009 Tube Stock. The last '67 unit to get an overhaul was 3059 in November 2008. It is interesting to see how overhaul periods were extended over the life of the stock. At the time of the first 1967 Stock overhaul in 1973, most older stocks were getting 6-yearly visits to Acton. The plan for the '67 Stock was 9-yearly and this was, on average, achieved while Acton was doing them. When the work went to Northumberland Park, the period was pushed out to 10 years and some units went to 12 years between overhauls. That said, the workload was altered somewhat as techniques for maintenance improved and efforts were made to see that work was concentrated where most needed. Some work formerly done on overhaul was done during the programme lift or during inspections.

To be continued …….