THE UNDERGROUND ELECTRIC TRAIN

by Piers Connor

40 – LOOSE ENDS …… AND FINALLY

LOOSE ENDS

Now that we have had a look at the new developments in signalling planned for the Underground, I can follow up with a quick look at a couple of developments which have helped to improve signalling performance, in the engineering sense at least. These relate to block joints and train detection. Then, to tie up some loose ends, I look at driver's cabs and reflect on the some issues affecting train design today.

BLOCK JOINTS

As I am sure you realise by now, one of the essentials of track circuit operation is to maintain the separation of each section from its neighbours. Traditionally, the "insulated block joint" (IBJ) was used to keep the circuits electrically separate. It consists of a small piece of insulating material shaped to the rail profile and inserted in the gap cut into two the rail. The fishplate used to bolt the two rails together is also insulated. The name block joint arose from the practice of referring to the sections of line protected by signals as "blocks". Nowadays they are usually referred to as sections.

A feature of block joint operation is the tendency of the rail head to deform with the passage of trains. Eventually, the steel becomes plastic and spreads. If not regularly checked and cleaned, bits of steel can spread across the joint and connect two circuits. This will usually result in the protecting signal(s) staying at danger. Once it has been determined that this is the cause, someone then has to go along to the offending joint and clean it up. Naturally, this is not a quick operation and it leaves trains hanging around waiting. To try to reduce the effects of block joint failures, many locations are provided with double block joints. This is OK but it does mean more rail joints, more wear and more noise. Eventually, a technical solution arrived in the form of the Jointless Track Circuit (JTC).

JTCs

The jointless track circuit does just what it says on the tin – track circuits without joints. It's no longer necessary to physically separate train detection circuits because now sections can be defined electrically without the need for IBJs. This is done using electronically tuned, coded track circuits with different frequencies. Rails do not need to be cut to define sections and the problem of defective blocks joints is eliminated. Less rail joints also means less noise and a smoother ride.

The principle is simple. If you set up two circuits at different frequencies next to each other on a length of track and you provide a filter for each at the boundary between them so that the frequency on the left hand filter is matched to the track circuit frequency on that side and the frequency of the other is matched to the right hand track circuit, you get electrical separation. There will be a short "dead" section between them – up to 9m is allowed on the Underground – but you just make sure you run trains with longer wheelbases than that and the system will maintain train detection.

JTCs were first introduced on the Bakerloo Line during its resignalling in 1988-89. Although they first appeared in the late 1960s and LU carried out a lengthy series of trials with them, the Bakerloo saw the first wholesale conversion. Now they are

standard for all new and resignalled schemes. A schematic of the basic idea is shown in Fig. 1 below.

In order to ensure that there is no interference between circuits, a set of seven different frequencies are used, for the Westinghouse version of JTC at least, which is the most common on the Underground. The frequencies are given code designations of F1, F3 and F6 for the track in one direction and they are normally used in that order. F2, F5 and F7 are used for the other, also in order. The differences are necessary to ensure there is no "crosstalk" between adjacent tracks. Additional frequencies, F4 and F9, are used for separation at crossovers and other odd locations[1].

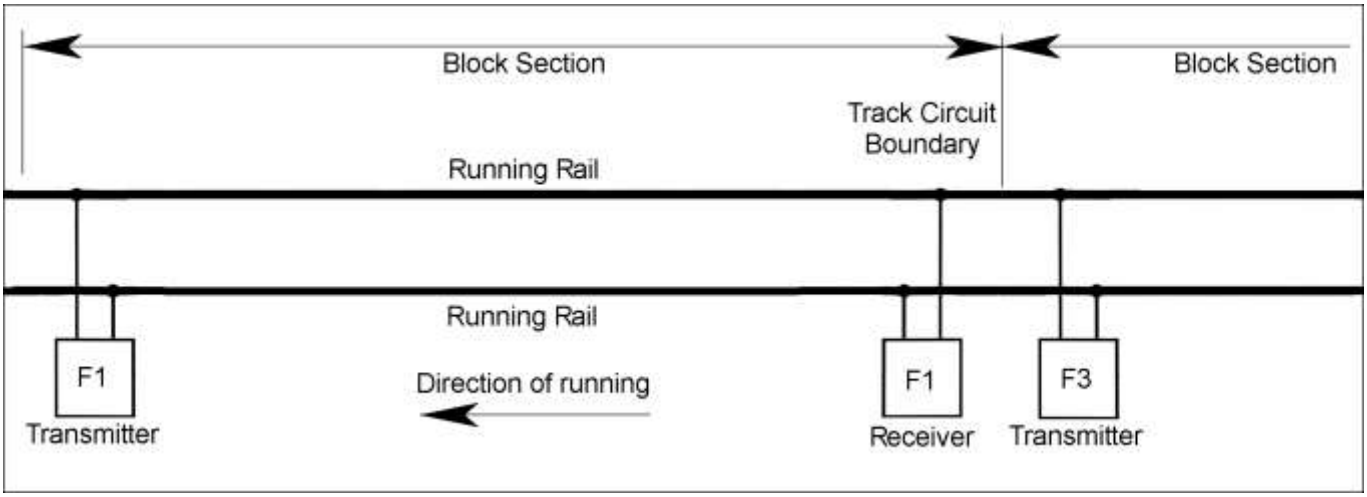

Fig.1: Simplified schematic showing principle of jointless track circuit where a transmitted frequency (F1) is detected by the receiver tuned for that frequency. The adjacent track circuit uses a different frequency. When a train enters the section, the electrical inductance levels sent to the receiver vary so the receiver ceases to send the OK message to the track relay (not shown) and the signal will change to red. In reality, there are many other parts but I have omitted them for simplicity.

TREADLES

As we have seen countless times in this series, life in the railway business is never simple and one of the lessons we have learned is that there is always a price to pay for new technology. In the case of JTCs, the price is the inability to use the normal London Underground delta track. This is usually a 10kHz circuit used, as you may recall from Article 31[2], as a position detector. When the Bakerloo was resignalled, they had to install mechanical treadles instead of delta circuits, because of this incompatibility issue.

The treadle is a mechanical device which is mounted next to the rail so that the flange of a wheel passing it will cause it to be depressed. This operates a switch which is used as required in the signalling circuits.

Treadles have a long and distinguished career on the railways. The first is said to have been introduced on the Eastern Counties Railway but the definitive version was introduced by W.R. Sykes in 1874 when he used treadles to release signal locks.

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1 F8 is not mentioned in any literature I have seen.
2 *Underground News* No.553, January 2008.

These were totally mechanical in operation but later versions were used to actuate electric circuits and relays.

POSITION DETECTOR

As with any mechanical device these days, treadles are no longer the preferred option for train position detection. Indeed, some of those on the Bakerloo have been replaced. In their place, we have what is called a "position detector" but it is really a cut down version of the axle counter – a sort of axle counter without the counter.

As I described last month, the device is really an electronic wheel detector. An electromagnetic head is located close to the rail and, as a wheel passes, the electromagnetic field is altered and the detector registers it. The information is used in the same way as the delta track to free routes or actuate timing circuits as required.

FORBIDDEN TERRITORY

One of the few areas of a train which passengers rarely see is the driver's cab. It has always been forbidden territory, officially available only to the privileged few – even amongst staff – a mysterious place where the man (or lady) driver practices his art, mostly unseen and unappreciated. Perhaps a few people wonder what it is like to be "on the front" and some of these are even lucky enough to get a look inside the cab. A very few get to ride with the driver, usually illegally and surreptitiously, standing against the back wall of the cab in the hope that they won't be spotted by a lurking manager. Any driver allowing an unauthorised person to ride in his cab with him certainly risks losing his job. Almost all railway administrations require visitors to cabs to have a specially obtained pass and "civilians" are always accompanied by a supervisor.

From the driver's perspective, the cab is his place of work, his office, his workshop. He might have aspirations that it should be reasonably comfortable. He might hope that it will be warm and dry in the winter and cool in the summer[3]. He might expect it to be proofed against noise and draughts. He might hope that the seat will be comfortable enough to permit him to sit in it for long periods without it numbing his backside, jolting his spine or stretching his neck and arm muscles as he operates the controls. He might even hope that the controls in question will be easy to reach and adjust and that he might be able to get to those he uses most often without requiring him to have three arms, any of which have to be bent in shapes which resemble a twisted balloon at a children's party in order to reach what he wants. He might hope that he could drive the train standing up with the same ease as he could while seated, that he could see clearly out of the front and side windows (including the coupler) and that the window wiper might actually wipe. In almost all of these things, he will be disappointed.

Dennis Tunnicliffe, formerly managing director of London Underground (1988-1998), once told me he considered drivers' cabs to be "industrial slums". He was driving a C Stock at the time so who could blame him, but he was right – in general the older

[3] Cabs always used to smell of damp. You might think this strange on an Underground railway but it was because dust would accumulate on the wooden floor and then get regularly soaked with rain and train washing machine water which leeched in under the doors. The floors used to become mouldy as a result and eventually a dark grey mould, resembling mushrooms, would appear. Many a trouble card was adorned with a comment pleading, "Please remove mushrooms from cab floor".

ones were fairly grim. Newer ones are better but the 1990s stock traction/brake controller is not ideal and has caused some positional problems.

Whilst my description shows what the driver wants in the way of comfort, his most ardent and perhaps most forlorn hope would be for consistent braking. Yes I know I've banged on about braking performance before but, for the driver, it doesn't matter how strong or weak brakes are as long as they perform consistently from train to train. You do not want to be constantly wondering why this train's brakes are weaker than the one you had "before grub" and why you have to keep re-adjusting the brake rate to get the train to stop in the right place. This is more of a problem today than it ever was because of the peculiar combination of traction voltage variations, software driven train control, dynamic braking and load-weigh technology which exists on modern trains. Remember, brakes engineers out there, drivers don't brake according to speed but according to location.

As a driver, I was considerably disenchanted with the C Stock cab when it first appeared. I expected it to be better than the CO/CP Stock we had then, but it wasn't. In some ways it was worse. The controls were all over the place. For example, the cab light switch was on the offside console and a long stretch from the driving position. The controller was on the left, even though 90% of the population is right-handed. After I had got used to it, I spent a not inconsiderable amount of time going round the cab with a tape measure and note pad listing all the control positions and dimensions. I then set about re-designing the control locations and the driving desk. I also proposed a new type of stand-alone adjustable cab seat, which I had seen during a cab ride on a Western Region Hymek diesel locomotive. I drew a set of sketches and wrote a rationale for each new location. I sent the whole lot in as a staff suggestion and, after a few weeks, forgot about it. About 6 months later, I was summoned to the Divisional Superintendent's office upstairs at Baker Street (it was then Jim McKinnon) and handed a cheque for roughly a week's wages for my trouble. That was about right for the amount of time I had spent on it, so I was quite pleased with it. I was even more pleased that someone had noticed it and done something about it.

The file containing my suggestion then disappeared into the design office at Acton until it was resurrected some years later during the time of the design work for the D Stock. Someone in the drawing office was asking about driver's desk layouts when the late Bob Greenaway, who was an engineer at Acton and a long-standing committee member of this society, reminded the questioner of my suggestion file. So, the dust was blown off it (thinking about it today, I'm amazed they actually managed to find it) and the D Stock driving desk layout was born, complete with the new cab seat. Of course, it was fiddled about with a bit to fit new ideas, like the forward and aft controller, but it is substantially as I had suggested. It even included the cup holder I proposed.

REFLECTION

As we have reached No.40 in this series and I generally write each article at least two months in advance of the publication date, it's actually four years ago that I tentatively suggested to our editor that a series like this should be written. My original thought was to produce a history of the development of train systems so that there was a record of what was done and why. Having now got this far, it turned out to be a lot longer than I envisaged but, in some areas, it hasn't gone into as much detail in some areas as I expected. Time and space have prevented it.

A couple of generations ago, this sort of task would not have been thought necessary. The memory of most organisations, particularly those in public service, was retained by its staff, who usually started in a lowly post, as a trainee or manual worker but who could, if they applied themselves and had the necessary will and ability to learn and develop, rise to supervisory, management or even senior executive positions. During their careers, they would learn the technical, functional, operational, safety and organisational culture of the company and would use this knowledge to help run the business as they rose in the ranks. Nowhere was this more evident than in the railway industry.

The railway is a complex technical and operational organisation, with many systems and interfaces, all of which rely on each other to make the organisation function safely and efficiently. Today, they are also run, partly at least, as commercial enterprises, which adds more interfaces and creates more risk. Uninformed tinkering with these systems, or the interfaces, can interfere with the operation, ruin a technical system or even increase risk to passengers and staff. In the last ten years, since the upheavals caused by the privatisation of the main line railways, the results of this tinkering have been seen in accidents like Hatfield, Potters Bar and Grayrigg. On the Underground, incidents like the Chancery Lane gearbox failure, the Camden Town derailment, the fiasco of the Northern Line tripcocks and the on-going Central Line stock shortages, show how tinkering has affected the railway here too.

Another feature of today's railway is rapid staff turnover. People no longer expect to join a company and stay with it for the rest of their working lives. Gone are the days when 50 years service was a normal part of railway life. Gone are the George Balaams of this world, who started life as a gateman on the Piccadilly Line in 1916 and who retired, aged 65, in August 1966 as a guard on the Piccadilly Line. Gone are the Wally Doyes, who was a gateman on the GN&C, became a motorman on the Met's electric locomotive link and who kept his Metropolitan Railway "protected" staff status right up to his retirement as a Station Master at Baker Street in the late-1970s. Gone are the George Collinses, who qualified as a motorman on the Central London Railway on Christmas Eve 1923, served and was wounded in the Second World War and who was still a motorman at Northfields in 1968 when he retired. When I passed out for the front, aged 21, I expected to be driving trains for the rest of my working life.

Today, two years in a job is a long time. In fact, two years with the same company is a long time. Personal career progress is now made by moving into a new position with a new company. Look at the changes in the senior management of the Train Operating Companies (TOCs) which we read about today. I can't keep up with all the movements of the people I know in the industry. Only the other day I greeted an old friend with, "How are things at Arriva these days?" to which the response was, "Oh, I'm not with them any more, I moved to First a couple of months ago". With a constantly changing picture like this, no wonder the industry gets into a mess sometimes. No one knows who to talk to, to "get things fixed" anymore.

CORPORATE MEMORY LOSS

One of the results of the change from long term employment to short term jobs is that the corporate memory is destroyed. Railways relied on the long term employment of staff to maintain the memory and understanding of the system, its equipment, the rules, the way to use the rules and who to phone to get out of trouble. Promotion was achieved through a combination of long service and learning by

experience. Training was provided (sometimes by the unions as much as the management) and the service abounded with “mutual improvement classes”. On the Underground they were latterly called “voluntary classes” as you had to attend in your own time. If you did, it helped when you applied for promotion.

Gradually the railways developed management and engineering training programmes, many including graduates on degree courses. The trainees were given a wide scope of experience over a two-year period to prepare them for middle management positions and professional recognition in their chosen discipline. They were widely respected for their quality and importance in succession planning. When the railways were broken up, these programmes disappeared until, after a few years, their value and importance was missed and many railway companies, including London Underground, have restarted them.

Nowadays, the high staff turnover means that no one remembers why things were done, or where things are, or what the settings for this machine were, or how long that section is, or where the gauge restrictions apply. They weren’t there. They never saw it. They never used it. They only joined last week.

How did this happen? Why did it happen? When the nationalised British railway system was broken up into 100-odd separate companies in 1994, many of the new company executives were convinced that they had to get rid of people because they were “old railway” and the business was overstaffed and inefficient[4] and getting rid of people was a quick way of reducing costs. Staff were offered cash to leave and, not surprisingly they took it – in droves, with the brightest people at the front of the queue. In the mid-1990s, following the “Company Plan”, London Underground slashed their staff from 21,000 to 16,000, and this was before the PPP was introduced. After privatisation, South West Trains went through a similar exercise but with such enthusiasm that they ran out of drivers and had to cancel trains every day for months while they persuaded enough of them to come back to run the service.

The staff who left the railways in the mid-1990s took the corporate memory with them and left the new companies understaffed and with little clue as to what assets they had, where they were and what to do with them. Fortunately for them, technology was becoming widely available which, it was hoped, would solve the problem. This was the database. Databases are useful in listing assets, equipment, staff, distances, incidents and all the everyday stuff you need to run a company. Also, modern computer systems let you access the databases quickly and you can distribute the information to anyone in the company who needs to know. So, databases were needed to replace the corporate memory formerly maintained by the long term employed in the staff. Now, everything has to be recorded and inserted into a database and kept updated so that, regardless of who is in the company, they have access to the knowledge they need to run the company. One just hopes that the databases are being kept up to date.

In many respects, this development is a good thing. It’s related to the social changes going on worldwide. Railways have had to develop new systems to replace the long term employment system, with its built-in memory, which just doesn’t exist any more. Everyone needs to be able to get the information needed to do their job properly and to run the railway safely and efficiently. Databases with proper

[4] Believe it or not, in 1994 British Rail was the most efficient nationalised railway in Europe, by 300%.

updating processes will do this and they are essential to help run the railway. Provided, of course, they are managed properly.

Unfortunately databases can't tell you everything. Stuff does get forgotten or missed. Examples abound – there is, for instance, an official Network Rail database of all the lineside signs and indications which will be seen around the railways over the whole country. However, not all the signs are on it. There are some which escaped the survey carried out to determine what all the signs were, where they were and which are still in use today. You sometimes see requests for information about the meaning of signs on the internet and there are people (often interested amateurs) who can and do supply the answers.

Databases are no substitute for experience. In my view, nothing can beat "working at the coal face" on the railway. The interface with passengers, the shift system, train operation, station management, maintenance on the line and in the depot, interfaces with suppliers and other agencies, dealing with problems – all need to be understood before a person can be left alone in a responsible railway job. Here's a thing – how do you record in a database the method for dealing with a naked man handcuffed to a hand rail inside a train? When he was cut free, quick thinking staff at Hammersmith provided him with a spare uniform so he could go home with most of his dignity intact. That's a stag night he'll not forget.

DRIVER TRAINING

A good example of the present cycle of change is in driver recruitment. Originally, the driver's position was in the "line of promotion", i.e. you had to have been through a few years of experience in jobs leading towards the driver's job before you could get one. On the main line, it was usually locomotive cleaner, fireman and then driver. On the Underground, the route was station staff, guard and driver. Even in the worst years of staff shortages, it took two years to get on the front.

When guards were withdrawn, drivers were recruited from suitable candidates within the organisation, with more or less success. The idea suffered largely because there is no way training can prepare you for the lonely life of a train operator on the front of a train. It is lonely because you have almost no one to turn to if you get into trouble. Yes, you can radio the controller (most of the time – dead spots permitting), yes you might get help from the station, if you are at one and, yes you might find someone on the train who can help. But, you are really on your own most of the time. It can be daunting.

Even if you get help, it might not be too useful. Pity the driver of a train on the Piccadilly Line one day last January who had a fuse blow which left him with only the battery to help him drive the train out of service. People turned up to help him and advice was offered from various sources but every decision which was made about what to do with the train was the wrong decision and, in an incident which should have delayed the service by 10 minutes, the train took 4½ hours to get home.

Another new feature of the modern train driver's job is workload. There has been a huge increase in driver workload since I was on the front. In my day, preparation was a walk through the train to check it and test the controls at each end, followed by a shout from the shunter over the depot PA to tell you to go down to the exit signal, and all you had to do after that was drive to the next stopping point and stop in the right place. Equipment was simple and relatively easy to sort out if there was a failure and you had a guard who, even if he couldn't help you too much technically, could give you support. Most were very good. There was no radio and no electronic

train management system. You were the train management system – nothing happened unless you made it happen.

Today, one person has to drive the train, open and close the doors, watch out for passengers rushing to get on at the last minute, monitor the platform CCTV as you leave (on some lines) as well as check the signal before you go, monitor your speed closely (now you have on train data recording checking on you), make announcements every so often, avoid overrunning red signals and try to keep to time. On top of all this, train radio is going on and off all the time, distracting you – it is often interesting to hear what is going on elsewhere but it is a real distraction. And you have to have a good technical knowledge of the train, in case something plays up. On modern trains, there is a lot more kit than in my day, so there is a lot more to go wrong[5].

A few years ago, the Underground tried an experiment in recruiting drivers "off the street". A 22-week training programme was devised and a batch of hopefuls was put through it. They were called "DROPS" (Direct Recruit OPeratorS). It was not a roaring success. The failure rate was high and subsequent performance was not always as good as hoped for. Now they are trying again. With over 200 new drivers needed to cover the training and expansion associated with new train delivery and line upgrades, a recruitment campaign started in March was overwhelmed with 10,000 applications. Needless to say, they had to close the campaign rather quickly and they are still trying to process the applications. By all accounts, the recruitment process is complex and counter-intuitive. In one case, a former driver of good standing was turned down after waiting 6 months to hear the result of his application to rejoin.

Why do I say "counter-intuitive? Well, not unreasonably, the modern focus is on "customer care". New station staff are recruited on their willingness to deal with people and help others in trouble, plus an apparent ability to sooth angry or puzzled passengers, not get upset when abused and to cope with various forms of safety and evacuation processes. Most train staff are recruited from "Customer Service Assistants" (CSAs). This is not usually the type of person who is happy to sit alone in a cab, content amidst the flashy control technology of the train, testing his braking skills at each platform, watching the road ahead for hours on end in the dark and generally waiting long periods for something unusual to happen. From this, it might be thought that people inclined towards train driving skills would not necessarily be the same sort of people who would be happier coping with hordes of lost Eurostar tourists at King's Cross, helping people with white sticks up the escalators at Oxford Circus or coaxing drug users out of the toilets at Baker Street.

This paradox might explain the increasing number of strange incidents of the past few years, where trains have been driven in the wrong direction, lengthy train failures have disabled services and train operators have made errors which are completely at odds with their training and with railway operation generally. Mindful of this problem, a possible solution presented itself to me after a conversation with someone working for c2c – the London, Tilbury and Southend Railway to you and me.

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[5] Yes, modern trains have Train Management Systems but they are often less than helpful. "MA lost" is OK but it doesn't remind the driver than he only has a battery left to get home with and that he should get the train reversed at the next siding so he can drive it from the other end, otherwise the battery will die on him and leave him stranded and blocking the line for hours.

The LT&S operates trains of 4, 8 and 12-car formation. The routes are all equipped for DOO (Driver Only Operation) for up to 8-car trains but they have to employ guards on 12-car trains because of their length. My friend was engaged in a plan to get rid of these guards because of the expense of keeping them. I told him I would keep them. "Why?" he asked. "Because," I replied "You have a pool of new train drivers there. The guards get train operations experience, they will develop some experience of the technology and of rules for train operations, they will understand the issues which occur during disruptions, they will understand depots and how they interface with trains. They will learn something of signalling and control issues and they might even learn a bit about train failures and how to help handle them. You keep your guards" I told him, "It will ultimately be cheaper and safer than recruiting and training people off the street".

Thinking about this later, it occurred to me that the Underground could do the same. If they restored guards to, say, the Bakerloo Line, you would get a training ground for your future drivers. All prospective drivers would have to spend a set minimum time on the Bakerloo as a guard – maybe six months and no time off for good behaviour. Why the Bakerloo? It's got tunnel and open sections and it interfaces with the main line railways. Currently, the stock would take guards with little alteration and there was CCTV equipment arranged for guard operation from the rear cab. It might be possible to re-install it.

Of course, there will be all sorts of obstacles to getting guards back on trains but it could be seen as a more effective training system. Even if you look at the training time required for a present day internally recruited train operator – 15 weeks excluding leave – and compare it with the total time provided for guard and driver training – 9 weeks, it looks promising. If external recruiting is applied, add another 10 weeks to make it 25 weeks. As I wrote elsewhere some time ago when comparing today's training with past experience, I recorded that the old system had "training to get on the front = 9 weeks = cheap! Two years experience on the trains as a guard = Priceless!"

THE END

Now it is time to call it a day and finish the series. I have reached a suitable point to end but it has been fun writing it and, I hope, fun for those who read it. Thank you to all those former colleagues, new found friends and kind people who helped me get facts and updates for the series. You made it better than I could on my own.

Now it is time for me to do what our editor has been asking me to do for a long time and re-write the history of District Electric Rolling Stock, which was published by this society in the early 1970s. All being well, the first part will appear in a few months time.

Concluded.