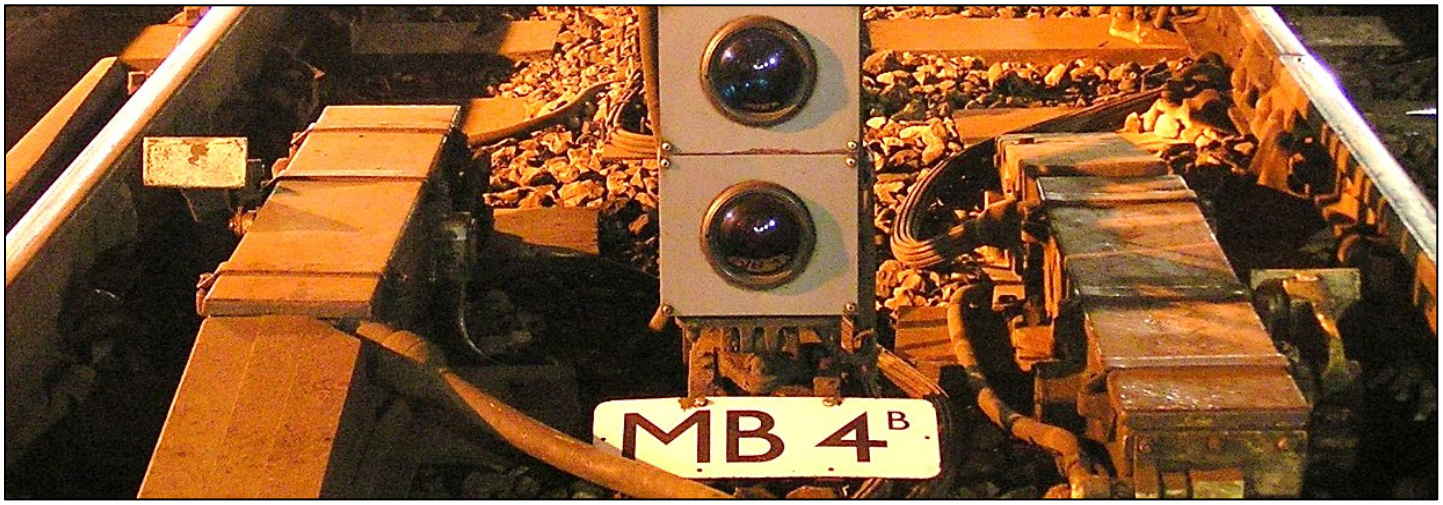
‘STOP AND PROCEED’ COLLISIONS

by David Millard

The purpose of this article is to look at ‘stop and proceed’ collisions. ‘Stop and proceed’ was needed to keep the service moving in the event of an automatic signal failure, and required ‘line of sight’ driving. Common factors associated with these collisions are identified and considered in the context of the overall safety performance of the trainstop and tripcock signalling system.

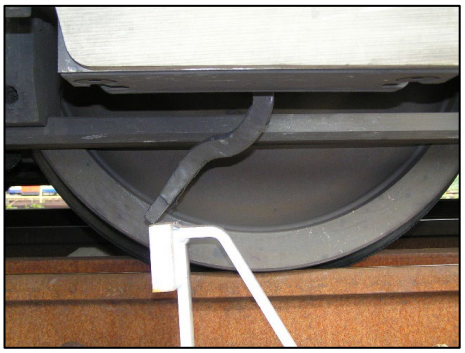
When the first Underground line opened in 1863, the signalling was manually controlled from each station and junction. This limited the number of trains that could be operated – only one train was allowed in each section at a time. With increasing numbers of trains, this soon became a problem on long sections: intermediate boxes were opened, such as at Granville, between Farringdon and King’s Cross. This increased the operating cost, and the system still depended on trains being offered and accepted from one signal box to the next – this was slow, labour intensive and did not provide the security needed for high frequency train services.

An opportunity for change came on the Ealing and South Harrow Railway, which opened in 1903 with electrically operated automatic signalling. Although in use in America, this was quite a departure from traditional British methods, and was viewed with some scepticism by the establishment, including the Railway Inspectorate. One concern was how motormen would be supervised: what would happen if a train ran past a red signal and continued unaware? The answer was the tripcock and trainstop system: this would ensure an emergency brake application if a train passed a red signal. Although there have been refinements behind the scenes, the fundamentals of the tripcock and trainstop system have changed little over the following 100 or so years. This is illustrated in the following photos:



***Previous Page**: (Lower) Taken in 2007, in engineering hours: shows adjacent trainstops at Baker Street Met. in the raised position (left hand side – signal MB 4B) and lowered (for trains in the opposite direction – right hand side). (MB 4B is ‘approach lit’).*

Tripcock arm on 1995 Tube Stock, Northern Line, in the set position.



1995 Tube Stock in Golders Green Depot in the process of being tripped, for demonstration purposes, on a specially installed fixed trainstop.

Same picture, looking back towards the train.

Compared with the previous manual system, automatic signalling represented a considerable improvement in cost, safety and capacity. It greatly reduced the need for signal boxes (except at

junctions and termini), avoided the irregular release of block signals and enabled peak train frequencies to be increased from around 20 to 40 trains per hour. Its safety performance can be confirmed by a look through the National Archives' bound volumes of Railway Inspectorate accident reports. This shows that the number of signalling related accidents on the national rail network vastly outnumbered those on London's tube railways, even allowing for the smaller scale and lower speeds on the latter.

However, the appearance of large numbers of automatic stop signals effectively passed to the motorman the responsibility of responding to a persistent red signal. With manual signalling and signal boxes at every station and junction, the driver could contact the signalman. Automatic signals did not have telephones, and waiting for someone to walk to the train to give authority to move would cause major disruption. On a high frequency railway, a signal remaining at danger quickly results in a long queue of trains.

Initial rules for automatic signals remaining at danger involved the conductor moving to the leading cab to be with the driver and, on curved sections of track, walking ahead of the train. Later, the rule was for the motorman to pass an automatic signal remaining at danger after one minute, informing the guard at the rear of the train. In order maintain safety, the train had to be driven slowly enough so that it could be stopped short of any obstruction until two stop signals showing a proceed aspect had been passed.

A critical point is that the motorman was usually unaware of the reason for the signal remaining at danger (except in rare cases at an automatic signal when the motorman could see that signals ahead had cleared). He therefore did **not** know whether it was due to a signalling fault or a train in the section. A survey conducted on the Bakerloo Line after the collision at Edgware Road in 1972 found that trains were worked past signals at danger on 46 occasions in 16 weeks. Approximately half were at danger because of a fault, and half due to congestion. The motorman **had** to drive as if a train were in the section – hence the term 'stop short of any obstruction' in the rule. This figure is broadly consistent with a 1985 survey over the network, which estimated 800 occasions for the network over 12 months, or roughly 15 times per week. (1992 inquiry report into Leyton and Stratford collisions.)

In contrast with these rules, practical experience meant that motormen developed a sense of the state of the road ahead – a succession of green signals meant that the train ahead was probably well clear. In peak periods, when trains were much more closely spaced, the train ahead may be in view on straight sections, perhaps departing the station ahead with the home signals clearing in sequence behind it. In most cases (including the ones which resulted in a collision and a Railway Inspectorate Inquiry) the signal was remaining at red with nothing else in view, owing to tunnel curvature or fog. In these circumstances, there was a natural tendency for the motorman to imagine where the next train might be. This could be 'in competition' with the rule which required the motorman to drive as if the train was just around the next corner, regardless of his expectations. Driving close to automatic signals inevitably resulted in some of them being overrun from time to time. When I was an Area Manager in the 1980s, very few automatic signal overruns were reported, despite the considerable majority of signals being automatic.

Drivers had an incentive for driving 'briskly' after an inadvertent automatic signal overrun – to avoid being asked why their train had lost time. In 1980, I recall rounding the curve at speed into Regent's Park southbound as a guard, when the brakes suddenly applied and the train came to an emergency stop. I observed the train line air pressure fall steadily from 65 to 10 psi, then immediately creep back to 65. The train resumed normal speed almost immediately. When asked what happened on arrival at Elephant & Castle, the driver told me that he had 'dropped the handle'!

Over the following 80 years, 10 Railway Inspectorate inquiries were held into following train collisions after the 'stop and proceed rule' was applied. Many of these collisions had such similar characteristics that it is possible to quote middle values (some of the speeds were estimated from inquiry data).

Distance from signal to point of collision:	290 metres
Average gradient from signal to point of collision:	1 in 100 down
Visibility of train ahead reduced by:	
Tunnel section: (driving position on left hand side of cab),	left hand curve
Open section:	fog
Number of tail lights lit:	2
Speed prior to final braking:	20 mph

Speed at point of collision:	11 mph
Stationary train pushed forward:	6 metres
Time since motorman passed oral driving exam:	15 months.

Another striking similarity was the perspective of the motorman after the collision – in nearly all cases, they were convinced that they were **not** going to encounter a train in the position where they found it. The following extracts illustrate this point.

Warwick Avenue, 1918, page 4.

The motorman, conductor and linesman appear to have been taken completely by surprise by the unusual position of a train standing outside Warwick Avenue station.

Northwood, 1945, page 12.

I find it difficult to avoid the conclusion that the motorman may have started and accelerated his train from Northwood Hills in the ordinary way, without any special degree of caution, not expecting to be stopped before reaching the next signal.

Stratford, 1946, page 4.

When asked soon after the collision why he was going so fast, the driver said "I did not expect to find one here".

Stratford, 1953, page 5.

The motorman did not know that A 491 signal was also remaining at Red. He said –

"I was expecting to find a signal at Danger, but definitely not a train in that position …"

Watford Junction to Watford High Street, 1962, page 7.

When asked what he thought when he saw the (small yellow) light (on the signal) he said that he associated it with the advice that he had received of a signal failure and not with the possibility of the line ahead being occupied.

Victoria to St James's Park, 1962, paras 19 and 23.

The motorman said at one time that he was expecting to run up to the next signal ahead (A803), as he had done from signal A797 to signal no. A799^{A} and that he was not expecting to find a train standing at (the) signal ahead (statement later disputed by the motorman).

An apprentice in the cab formed the impression that the motorman had not expected to find a train standing at the signal ahead.

Edgware Road (Bakerloo), 1972, paras 14 and 17.

The guard said that the train came to a sudden stand with the gauge indicating a loss of air in the braking system. He said that the train was at a stand for not much more than a minute.

The guard motorman … thought that the collision had occurred because he had been preoccupied or distracted in some way, possibly by looking at his instruments or possibly by looking at the southbound platform at Edgware Road, which comes into sight before the northbound because of the curvature and the presence of the crossover tunnel, and consequently had not seen the red tail lamps of the train ahead until it was too late.

Leyton to Stratford, 1979, para 14.

The motorman said at the Inquiry "I was of the opinion that the train that had left was well on its way to Stratford, but by now I was not aware that the other signals were playing about, I was only concerned with one signal".

Leyton to Stratford, 1984, para 28.

Therefore not only was the driver's reaction time slow but he must also have allowed the train to build up to the maximum possible in notch 2 ('series'), because, unless his reaction had been unbelievably slow, he would have been able to stop short of the preceding train.

Kilburn (Metropolitan), 1984, para 41.

After overrunning the protecting signal, the guard confirmed to the driver that the signal was red. The driver's response was: "I'll proceed; it is clear".

Railway Inspectorate inquiry recommendations

In order to gain an impression of the contributing factors (old fashioned inquiries tended to say 'I blame X for not carrying out the rule properly'), I have summarised the recommendations of each inquiry

relating to the events leading up to each collision. It has to be said that the Railway Inspectorate were inquiring into substantial numbers of National Rail derailments and collisions, many with large numbers of fatalities, on lines with no automatic train protection at all. The London Underground's relatively low speed 'shunts,' mostly free of fatalities, were comparatively modest. However, there is an increasing sense of frustration from the 1970s onwards, for example at the lack of progress in getting trainee drivers to apply the rule during their training, and thereby gain practical experience of how slow 'extreme caution' can be.

Warwick Avenue, 1918, page 5.

Either ensure a gateman is posted on the rear platform of trains, or fit an oil tail light to supplement the electric tail lights. (The tail lights of the train ahead had inadvertently been switched off).

Northwood, 1945, page 13.

Permanent Way staff to report at once to the signalman when fog occurs during their working hours.

Fit telephones and 'P' sign to signals (illuminated by the signalman when he confirms that the signal is not at danger because of a train in the section, and that the train may pass it at caution).

Stratford, 1946, page 5.

Continually remind motormen of the risks that are run if the prescribed procedure is not observed.

Stratford, 1953, page 15.

(Mentions (para 62) stop and proceed collisions at Harrow (1947), between Eastcote and Rayners Lane (1948) and between South Ealing and Acton Town (1949)).

Develop scheme for installing 'round the bend' signals on curves (stop signal repeating the limit of control of the preceding signal, to reduce the time without a signal in view of the motorman).

Clarify rules on what instructions should be given to drivers to apply the rule and ensure all staff are instructed.

Watford Junction to Watford High Street, 1962, pages 8 to 10.

(Mentions (para. 41) stop and proceed collision at Willesden New (1962)).

Consider retaining this unconventional system on the electric line to Watford.

Install plunger at London Midland Region signals – this has to be operated by the driver (who has got down onto the track) before a small yellow aspect clears allowing him to proceed cautiously into a potentially occupied section.

Provide 'A' signs at all semi-automatic signals when these are working automatically.

Improve the 'omnibus' telephone system at signals.

Provide a demonstration of stop and proceed operation to every driver under training under service condition, so as to bring the meaning home to him.

Victoria to St James's Park, 1962, pages 8 and 9.

Endorsed Watford Junction to Watford High Street inquiry recommendation regarding applying the stop and proceed procedure during training. Refers to simulation of running conditions on a screen.

Better cleaning of tail lights.

Experimental introduction of portable flashing tail light.

Edgware Road (Bakerloo), 1972, pages 4 to 6.

Trainee drivers to carry out the stop and proceed rule during training under varying conditions. Refers to a machine which simulated running conditions on a screen as being unreliable in operation and not being used as a regular training aid.

Regretted the fact that carrying out the stop and proceed procedure under service conditions was not part of the basic training of motormen.

Supported the limiting of a train's speed after tripping to 10 mph.

Cab light to be out when carrying out the rule or entering a dead end siding.

Leyton to Stratford, 1979, page 6.

Notes the provision of control of speed for 3 minutes after tripping on new rolling stock.

Repeats the recommendation that trainee motormen be required to apply the Stop and Proceed Rules while driving under the control of an instructor, with a train not in passenger service.

Station staff to only use specified wording when communicating with motormen about passing signals at danger.

Notice to be placed in cabs regarding the need for caution after passing a signal at danger.
When tripped at a signal remaining at danger, only motormen to reset the trip.

Leyton to Stratford, 1984, and **Kilburn (Met.), 1984**. (One report for both accidents, pages 24 and 25).

London Underground's management must infuse their staff with a common and continuing desire to eradicate avoidable accidents of the kind which occurred at Leyton and Kilburn.
Improve the quality of maintenance of their signalling equipment.
LUL to improve the quality of maintenance of their signalling equipment within a framework of improving the whole quality of their operations.
Aim to eliminate all Stop signals, apart from those controlling junctions, which are not required for headway purposes.
Improve training and testing of recruit drivers.
Rules to be clarified beyond peradventure.
Drivers to have a fixed number of hours at the driving controls.
The driver's road test to take a full day and include one or more front trips in an unlit tunnel towards a stationary train or a suitable mock up.
Recommend the fitting of speed governors (after tripping) to all trains which have a residual life beyond 1994.
Make proposals within 12 months for one person other than the train crew to be involved with the decision to pass a signal at danger, and implement it by 1994.

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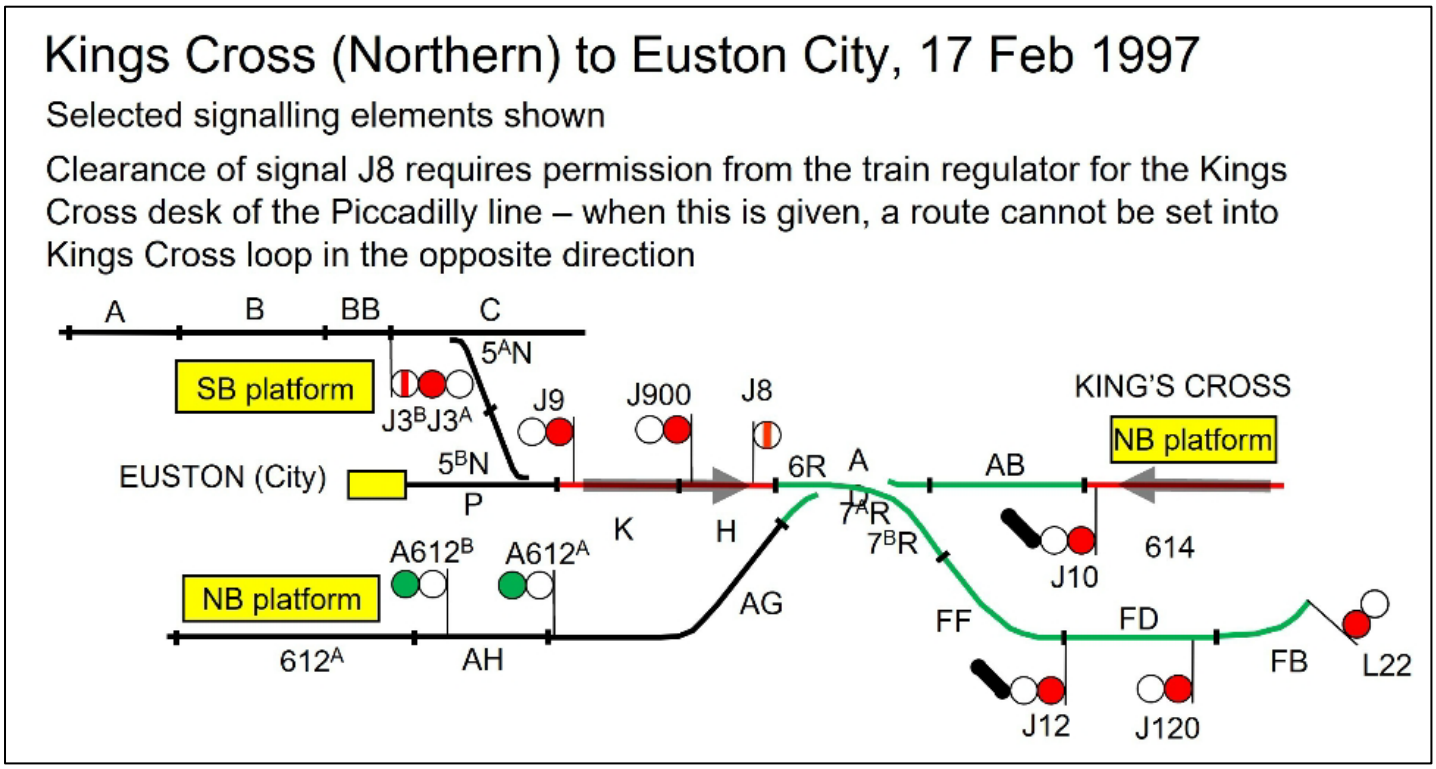
In the end, fitting of SCAT (Speed Control After Tripping) equipment to trains meant that if they travelled above 10 mph in the first three minutes after the train was tripped, the train would be given a full service brake application. From memory, the three minutes started when the trip was reset.

However, this modification was not applied to 1959 Tube Stock, which was believed to be about to be replaced. Although not caused by a signal failure, an incident at King's Cross (Northern) in 1997 showed again the risk of incautious speed after tripping. This incident involved a semi-automatic station starter.

At the end of a disrupted morning peak, an empty train was in Euston Loop, waiting to be routed to King's Cross Loop to reverse south to north bound. A train then arrived in King's Cross northbound platform. In the absence of the route being set across the train, clearance of signal J10 required occupation of the platform track for 15 seconds, so this signal was always at danger when the train arrived, and normally cleared within a few seconds of the train coming to rest. The platform repeater was on the headwall; on the morning in question, the bulb for the yellow aspect did not work. The guard closed the doors and gave the driver the starting bell. The driver started the train and was tripped. He called the guard on the train telephone and asked whether the signal had cleared. The guard said that he did not know. The driver reset his trip, restored air, released his brakes and set off at close to normal speed. When traversing 7^{A} points, which were set against him, the leading truck derailed, throwing him off his seat. The train came to rest on the concrete some 2½ cars (41 metres) beyond the point of derailment. Some test runs were arranged for a subsequent night which indicated a speed at the point of derailment of 22 mph. Had the train split the points and remained on the rails, it would have encountered the train in Euston Loop at some speed. The driver clearly had it firmly in his mind that the road ahead was clear, despite the starting signal (directly in front of him) remaining red, and being tripped when passing the signal. This incident did not result in a Railway Inspectorate inquiry, perhaps because no one suffered more than shock. In general, there were a fair number of signals passed at danger incidents where the driver continued without authority, although most were at low speed.



A common factor among stop and proceed collisions was the driver's mindset, that a train was not expected in the position where it was encountered.

It is also the case that a report of a signal remaining at danger was just that. It could be:

1. The result of routine or non-routine congestion (no failure).
2. Congestion due to a different signal remaining at danger.
3. A failure affecting several signals (track circuit or signal power supply problems).
4. A failure at the indicated signal.

All of these affect trains differently, and the picture of what is failing (or not) is only built up gradually during an incident.

Perhaps the clearest explanation to staff is over 100 years old.

Special Traffic Notice No 24/17 dated 9 June 1917

(quoted in the report on the collision at Warwick Avenue in 1918).

7 – Rule 73a (Automatic Stop Signal Failures)

The attention of Staff is generally drawn to the risk that is run in assuming that, because an automatic signal has been held at danger unusually, it has failed. In nearly all cases this will be caused owing to the presence of a train in the section ahead. If, however, after proper steps have been taken, it is found that the signal has failed, the only safe course to follow is for the train to proceed as if the section is blocked by the presence of a train ahead, and the provisions of Rule 73a must be strictly carried out.

The information that is missing from all this is the number of times the stop and proceed rule was carried out correctly – substantial collisions were a tiny proportion of these events. If the figure (from the 1992 report into the collisions at Leyton and Stratford) of 800 occasions per year where signals were passed at danger is a representative average over say 80 years when the network was somewhere near its present size, that makes 64,000 times a signal was passed at danger, with roundly 10 serious collisions, or one in 6,400 occasions.

The absence of speed control after tripping equipment on trains was perhaps the final loophole that needed to be closed on a very effective mechanical system of train protection, which certainly saved many dozens, and perhaps hundreds, of lives over its lifetime. For many years it was regarded as 'best in class'. That was certainly the view of Railway Inspectors of the day, judging by their inspection reports on new lines/extensions prior to opening.

I am most grateful to Bob Thorogood and Ron Hart, former trainmen and Railway Instructors with great experience and expertise in this area, for reviewing this article and for their helpful comments, all of which I have adopted.