



DEPARTMENT OF THE ENVIRONMENT

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**Report on the Accident  
that occurred on 28th February 1975  
at Moorgate Station**

**ON THE  
NORTHERN LINE  
LONDON TRANSPORT RAILWAYS**

**LONDON: HER MAJESTY'S STATIONERY OFFICE**

95p net

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RAILWAY INSPECTORATE,  
DEPARTMENT OF THE ENVIRONMENT,  
2 MARSHAM STREET,  
LONDON SW1.  
4th March 1976.

SIR,

I have the honour to report for the information of the Secretary of State, in accordance with the Order dated 3rd March 1975, the result of my Inquiry into the serious accident that occurred to a passenger train at 08.46 on Friday, 28th February 1975, at Moorgate Underground Station, the southern terminal of the Highbury Branch of the Northern Line of London Transport Railways.

A 6-car train of 1938 Tube Stock failed to slow down on approach to the station, overran No. 9 platform at speed, and came into heavy collision with the end wall of a short extension tunnel beyond the station, with the result that the first and second cars of the train and the front portion of the third car became impacted and crushed into approximately half their normal length.

The train was carrying some 300 passengers and I much regret to report that 42 passengers and the driver of the train lost their lives and a further 74 passengers sustained injuries that required treatment in hospital.

The serious nature of the accident was at once appreciated by the staff on duty at Moorgate and immediate calls were made for the Emergency Services. These resulted in a first request for assistance at 08.48 by the Headquarter's Control at St. James's Park followed by a full emergency call at 08.51. The first ambulances arrived at 08.54 and units of the London Fire Brigade began to arrive from 08.58. London Transport's own breakdown gangs from Neasden and Hainault, in each case with a considerable distance to travel by road through the morning rush hour traffic, had some difficulty in reaching the scene, the first of the gangs arriving at 10.00.

The task of rescuing the injured and of recovering the bodies from the wreckage was of unprecedented difficulty. The last survivor was not freed until 22.05, 13 hours and 19 minutes after the collision and the last body, that of the driver, was not removed until 20.00 on Tuesday, 4th March. Control of the incident was carried out by the City of London Police and subsequently by the British Transport Police. Medical teams from St. Bartholomew's, Guys and The London Hospital operated in the wrecked cars and on the platform throughout the period of the rescue.

As a result of the discharge of traction current, two trains were stranded on the southbound line in the tunnel between Old Street and Moorgate. The 376 passengers on these trains were detained and walked to Moorgate station by 09.45.

Services on the Highbury branch were suspended for the rest of the day and from Saturday, 1st March until Sunday, 9th March, the passenger service only operated between Drayton Park and Old Street, where passengers were detained before trains continued empty to reverse in Platform No. 10 at Moorgate. Clearance of the wreckage was not completed until 07.00 on Thursday, 6th March, and, after the whole area of the station affected by the accident had been thoroughly cleaned, normal services were resumed from Monday, 10th March 1975.

In presenting this Report, I would like to pay my own tribute to the magnificent achievements of all those involved in the rescue and relief work after this accident. It would be invidious to single out any one individual or organisation for special praise because the outstanding feature was the co-operation that existed between the Fire Brigade, the Police, the medical teams, and London Transport's own breakdown crews over the whole period of the rescue work, which was carried out under difficult and unpleasant conditions with untiring devotion to duty. I would also like to record and commend the support given to the rescue operation by the voluntary services, including the W.R.V.S., the Women's Transport Service (FANY) and the Salvation Army, and by members of the public who gave blood at a temporary National Blood Transfusion Service centre set up close to Moorgate Station.

#### DESCRIPTION

##### *The Site*

1. Moorgate Station, located just within the City of London, is a major London Transport interchange. It is also a terminal for British Railways suburban services to Hertford North and Welwyn Garden City (E. Region) and to St. Albans and Luton (L.M. Region). It has altogether 10 platforms, Nos. 1 to 6 at sub-surface level used by Metropolitan Circle and British Railways services, and No. 7 to 10 at deep level serving the Northern Line, of which, at the time of the accident, Nos. 9 and 10 formed the southern terminal of the Highbury Branch. London Transport services have subsequently been withdrawn from the Highbury Branch, which has been handed over to the Eastern Region of British Railways to form the City terminal to the Great Northern suburban electric services.

2. The Highbury Branch, which was electrified on the standard London Transport 4-rail system at 600 v DC, was physically separate from the rest of the Northern Line and ran from its northern terminal at Drayton Park a total distance of 2 miles 1,113 yards to Moorgate, with intermediate stations at Highbury, Essex Road, and Old Street. With the exception of Drayton Park Station, which was in the open, the line was in tunnel throughout, the single bore tunnels between stations being of 16 ft diameter, in contrast to the normal 12 ft diameter of tube tunnels, since the line was originally constructed to permit its use by rolling stock of main line dimensions. The tunnels were provided with the normal tunnel wires for cutting off the traction current and for communication purposes and were also provided with lights spaced at roughly 50 ft intervals on the left hand side in the normal direction of running. As well as being switched on automatically if the traction current was cut off for any reason, the tunnel lights could be controlled from switches located on the tunnel headwalls at the adjacent stations. At Moorgate separate switches were provided for the two running tunnels and for the area of a scissors crossover which was located immediately north of the station. The gradient between Old Street and Moorgate is falling, mostly at 1 in 150, from the south end of Old Street Station for a distance of 642 yards from where it is level as far as the south end of No. 9 platform at Moorgate, a further distance of 233 yards.

3. Beyond the end of No. 9 platform there was an overrun tunnel 66 ft 9 ins. long ending in a solid end wall. This tunnel was of elliptical cross-section, 16 ft high and 13 ft wide. The track continued into it, on a falling gradient of 1 in 80, as far as a single central hydraulic buffer mounted on a cross-beam extending between concrete blocks against the sidewalls and located about 12 ft from the end wall. This hydraulic buffer was no longer functional but a sand-drag, heaped up to about 2 ft above rail level, had been provided extending from 19 ft outside the overrun tunnel to about 17 ft within it.

4. The track on the branch consisted of 95 lb bull-head rail on chaired hardwood sleepers, ballasted in the running tunnels and set in concrete through the stations. On the southbound line between Old Street and Moorgate there was a short right-handed curve of 25 chains radius about halfway between the stations and another of 12 chains radius immediately before entering the crossover at Moorgate. The overall speed restriction on the branch was 40 mile/h, with a permanent restriction to 15 mile/h over the crossover.

#### *The Signalling*

5. The branch was controlled from signal boxes at Drayton Park and Moorgate where the only connections were located. The signal box at Moorgate opened off the north end of No. 9 platform. It contained an 11-lever power locking frame. The signalling, which was installed in 1937, was to the normal London Transport standards with 2-aspect (Red/Green) stop signals controlled by track circuits and preceded where necessary by 2-aspect (Yellow/Green) repeater signals working automatically with the stop signals. Electro-pneumatic train stops were provided at all stop signals; they were mounted on the right hand side of the track and took the form of an arm extending 3 ins. above rail level when the associated signal was at Danger. The point mechanisms were also electro-pneumatically operated.

6. The signal sequence for a train running on the southbound line from Old Street to Moorgate was as follows. Automatic 2-aspect stop signal A.53 was located 25 ft to the south of the platform at Old Street; 850 ft in advance there was another, similar, signal, A.51, with a sighting distance of 460 ft. The next stop signal, 546 ft ahead, was the Moorgate outer home, ND11, which was provided with a repeater 166 ft in rear, extending its sighting distance to 610 ft. Located beneath the outer home signal was a repeater for the inner home signal, ND9/10, which was located 408 ft in advance of ND11, just at the point where the gradient levels out and at the beginning of the 12 chain right-handed curve preceding the crossover. Signal ND9/10 had an effective sighting distance of 690 ft and was fitted with a junction indicator which displayed 3 white lights set at 45° when the route was set into No. 9 platform. As a train rounded the 12 chain curve the driver got a view straight ahead through the crossover of a fixed red light on a post at the beginning of the sand-drag at the far end of the platform at a distance of 600 ft.

#### *The Train*

7. The train involved in the accident, which carried the service number 272, was composed of two 3-car units of 1938 Tube Stock, marshalled as follows:

South end:	Driving motor car	11175
	Trailer car	012263
	Driving motor car	10175
	Driving motor car	11115
	Trailer car	012167
North end:	Driving motor car	10115

Each 3-car unit was semi-permanently coupled within the unit and provided with automatic couplers at the outer ends. The total length of the train was 316 ft 6 ins. and its total tare weight 151 tons.

8. The car bodies of the 1938 Tube Stock are of steel, mainly riveted but with some welding. Because of the size of the door openings on tube stock it is not possible to make significant use of the superstructure in carrying the main horizontal and vertical loads and it is, therefore, of light construction, the main loads being carried by the underframe which consists of two central longitudinal members up to 15 ins. in depth and two solebars of 6 ins. by 6 ins. bulb angle. The whole underframe is capable of withstanding a 50-ton static end load applied at the centre buffers without permanent deformation.

9. The body layout follows the normal tube practice with a mixture of longitudinal and transverse seating and large standing areas in the door bays. The trailer cars are provided with 2 double leaf and 2 single leaf sliding doors on each side. On the driving motor cars a full width driver's cab replaces one end door bay. The cab is provided with 4 hinged doors, one on each side opening inwards, a front access door, opening inwards, with a receptacle for the display of the train number, and, at the rear, a door opening into the passenger compartment. On each driving motor car, in the end door bay away from the cab, a guard's position is provided with door controls and an emergency brake handle.

10. The braking system is a combination of the Westinghouse Automatic Brake with a self-lapping electro-pneumatic brake, both using the same brake cylinders and controlled by a combined brake controller moving in a horizontal plane and arranged for operation by the driver's left hand. In the 'Release and Running' position the handle is in the 'nine o'clock' position and is pulled back anti-clockwise to apply the brake, giving an increasing electro-pneumatic application as far as the 'seven o'clock' position. In the event of any failure of the electro-pneumatic brake mechanism the driver receives an audible warning in the form of a loud hissing noise and he can then restore braking action by moving the handle round to the 'six o'clock' position to obtain a normal Westinghouse application. Further movement of the handle then brings it into the Emergency position where both a full Westinghouse and electro-pneumatic application is made. When a driving position is not in use, the driver's brake valve is isolated by means of an isolating cock located low down on the right of the brake controller, between it and the master controller. Passenger emergency brake handles are provided adjacent to each door bay throughout the train and each driving motor car is fitted with a tripcock mounted on the off-side shoe beam of the leading bogie to apply the brakes in emergency should a signal be passed at Danger.

11. Each motor car is fitted with one traction motor in each bogie, providing a total horsepower of approximately 1,000 for a 6-car train. Following normal tube practice no bus line is provided along the train and the traction current circuits on each motor car are entirely separate. The traction control equipment, mounted on the underframe of each car and operated remotely by the master controller in the driving cab using a 50-volt auxiliary supply, consists of a single air-oil operated camshaft with two line circuit breakers, an overload relay, a transfer switch which changes the motor circuits from series to parallel, and a reverser.

12. The camshaft has 10 positions and as it notches up from position 1 to position 10 it cuts out the starting resistances until the traction motors are operating in the full series mode. For further acceleration the transfer switch operates, bringing the motors into parallel and reinserting the starting resistances. The camshaft then notches back from position 10 to position 1, once again cutting out the resistances. Acceleration is automatic under the control of the notching relay. When power is shut off from the full parallel position the transfer switch restores the motor connections to series, the camshaft being already in position 1 ready for the next operation.

13. The master controller, which is positioned for operation by the driver's right hand, is put into operation electrically by closing a control switch by means of a key removable only in the off position. This switch is located on the back wall of the cab, below and to the left of the driver's tip-up seat. The controller is divided into two interlocked parts, the main drum and the reversing barrel. The main drum is operated by a handle moving clockwise through an arc of 180° and having four positions, namely 'Off' to the right, 'Shunting', 'Full Series' towards the driver, and 'Full Parallel' to the left. The circuitry of the controller is arranged so that, once the camshaft has reached the full parallel position, the train will remain on full power even if the controller handle is moved away from the left hand position. It is possible, therefore, for the driver to move the handle towards himself into a position in which it requires less strain to keep the deadman depressed. The reversing barrel is operated by a reversing key, formed like a spanner, and has four positions, namely 'Reverse', 'Off', 'Forward 1' and 'Forward 2'. The key can only be put in or taken out at the 'Off' position. The controller handle cannot be moved unless the key is in a position other than 'Off' and, conversely, the reversing barrel cannot be moved unless the controller handle is at 'Off' and the deadman depressed.

14. The deadman's control feature consists of the vertical movement of the handle end of the main controller through an angle of about 10 degrees. When the handle is depressed and the reversing key put into either a forward or the reverse position, a mechanism is made operative which causes an immediate emergency brake application to be made if the handle is released. It requires 15 lbs force to depress the controller handle in the first instance and up to 3½ lbs to hold it down thereafter. The effort required to keep the deadman operative during running is thus reduced. The deadman's control remains operative at any position of the controller handle and can normally only be cut out by putting the controller handle to 'Off' and then putting the reverser key also to 'Off', the latter movement requiring some force.

15. A further safety device in the form of a control governor links the braking system with the traction control. It prevents traction power being applied unless there is adequate air pressure available to ensure a braking capability.

#### *Servicing and Inspection Procedures*

16. The scheduled inspection and maintenance periods, as far as they applied to 1938 Tube Stock allocated to Drayton Park depot for service on the Highbury branch, were as follows:

- i. *Nightly Test* in which the working of the deadman's handle and tripcock are checked and any minor defects reported by the train crew during the previous day's service are corrected.

- ii. *Seven day Examination.* This includes a full test of the brake equipment, including replacement of worn brake blocks as necessary, tests of the door mechanisms, compressors, traction equipment, shoe gear, etc. Like the nightly test, it is carried out in Drayton Park depot.
- iii. *Shop Inspection.* This inspection covers every item of equipment on the train that has to be inspected on a regular basis. It is carried out in the line maintenance workshop at Neasden on a six-weekly basis.
- iv. *Programmed Lift.* This is also carried out in the line maintenance workshop at Neasden, approximately once per year. It entails lifting the cars from their bogies, changing the wheels and a complete examination and replacement of wearing parts as necessary.

17. In addition to the foregoing preventive maintenance procedures, 1938 stock is given a heavy overhaul in the main workshops at Acton, normally at 250,000 mile intervals, though cars in good condition may be allowed to run longer if others are in a poor state and need attention before their due mileage. The heavy overhaul covers the complete overhaul of the entire car and includes re-painting and, as necessary, replacement of corroded panelling, worn flooring, re-upholstering and reglazing.

18. All examinations, overhauls and inspections are noted in the car log book which is maintained in respect of each unit. The maintenance history in respect of the train involved in this accident was as follows:

	<i>Unit 10115 (North end)</i>	<i>Unit 10175 (South end)</i>
7-day examination	27/28th Feb. 1975	27/28th Feb. 1975
Shop inspection	17th Jan. 1975	28th Jan. 1975
Last lift	May 1974	Nov. 1974
Last heavy overhaul	May 1969	March 1967
Mileage since overhaul	179,780	306,070

#### *Train Preparation and Brake Testing*

19. Before a train is brought into passenger service, a laid down procedure must be carried out by both the driver and the guard, for which the time allowed is 15 minutes for a 6-car train of 1938 Tube Stock. The driver's duties involve checking the controls and equipment in each cab on the train and the working of the Westinghouse brake on each car. The guard's duties include the checking of car lighting and door operation throughout the train. On completion of their separate checks the driver and guard jointly test the working of the train telephone and the continuity of the Westinghouse train pipe.

#### *The Course of the Accident and Damage Caused*

20. The layout at Moorgate and the arrangement of the overrun tunnel are shown in the drawing attached to this report. The train entered the station at a speed which has been variously estimated at between 30 and 40 mile/h, ran through the platform without slowing down, knocked down the red marker light, dispersed the sand-drag and came first into heavy collision with the hydraulic buffer stop, causing the leading car, No. 11175, to rear up so that the cab impacted into the tunnel end wall close to the top of the 16 ft high tunnel. The excessive end loading thus exerted on the underframe of the car caused it to buckle in 3 places, a tight 'V' with the point uppermost immediately in rear of the cab, an approximately right angled bend with the point downwards near the mid point of the car and a further bend of some 30° towards the rear of the car, which was impacted against the tunnel roof. The complete 52 ft length of the car was crushed into some 20 ft of tunnel. The second car, No. 012263, had driven forward beneath the rear end of the leading car and, though the underframe was not significantly buckled, the bodywork at the leading end was crushed and concertinaed. The effect at the rear end of the second car, where it had been overridden by the leading end of the third car, was similar. The third car, No. 10175, was relatively undamaged except at the leading end up to and including the bogie and at the rear cab where, due to the vertical angle that had developed between it and the fourth car, both cabs were slightly damaged. The fifth and sixth cars were undamaged.

#### *The Train Crew*

21. The driver of Train 272, who lost his life in the accident was *Motorman L. B. Newson*, aged 56 years. He had been employed by London Transport since March 1969 and was initially trained as a guard, working from Barking depot. In January 1974 he had been passed out as a guard/motorman and between that date and January 1975, when he was transferred to Drayton Park, he had 6 days driving experience on 1938 Tube Stock on the East London line and a further 31 days on C69 Stock on the Hammersmith and City Service on the Metropolitan line. On transfer to Drayton Park, Motorman Newson received road training in respect of the Highbury branch, movement into and out of Drayton Park depot, and empty stock movement between Drayton Park and Neasden. Between 23rd January and 28th February 1975 Motorman Newson's duties involved working trains into Moorgate on altogether 228 occasions and between 15th February and 28th February, during which period No. 10 platform was out of use in connection with engineering works, he worked trains 121 times into No. 9 platform, where the accident occurred. On Sunday 23rd February Motorman Newson was off duty and he commenced No. 2 Duty, signing-on time 06.24, on Monday, 24th February. He worked this duty each day up to the day of the accident except for his Rest day on Wednesday, 26th February. The duty involved a first departure from Drayton Park at 06.56, getting back there at 07.16. On the day of the accident Train 272 left Drayton Park on its fourth and final trip,  $\frac{1}{2}$  minute late, at 08.39.

22. The guard of Train 272 was *Guard R. P. Harris*. At the time of the accident he was 18 years old. He entered the service of London Transport in August 1974 and qualified as a guard after 4 weeks training. After a short period at Barking, he had been transferred to Drayton Park on 4th November 1974 and had worked regularly with Motorman Newson since the latter came to Drayton Park in January 1975.

#### EVIDENCE

##### *Relating to the working of Train 272*

23. *Acting Leading Car Examiner F. Wager*, stationed at Drayton Park, carried out on the night of 27th/28th February the 7-nightly examination of the units that were to form Train 272 on the morning of 28th February. He was assisted by *Car Examiner J. James*. They confirmed that they had carried out all the laid-down tests and had found everything in order. The Westinghouse and electro-pneumatic brakes were effective on all cars; no brake blocks required renewal and only 5 blocks needed adjustment.

24. *Relief Clerk C. Brown* was Acting Station Manager at Drayton Park on the morning of 28th February. Part of his duty was to book on the train crews as they reported for duty. Since it was not his normal duty station, he did not know all the men by sight and he remembered having to ask Motorman Newson his name when he arrived at about 06.10, in good time for his duty which commenced at 06.24. As far as Mr. Brown was concerned, Newson appeared perfectly normal. A facility is provided at the booking on point for the testing of telephone hand sets but, to Mr. Brown's knowledge, Motorman Newson did not test his hand set before going to prepare his train.

25. Mr. Brown told me that he was in some difficulty that morning because some members of the staff had not arrived in time for their rostered duties. He had to put his only available spare guard on to the first train out, 271, and when at about 06.30 Guard Harris telephoned from Moorgate to say that he would be late and would pick up his duty at Moorgate, he had no guard for Train 272. At this point, a spare motorman who was waiting in the office volunteered to act as guard to Motorman Newson and went over to join the train at about 06.40.

26. The spare motorman who volunteered to act as guard on Train 272 was *Motorman B. Rozario*. He had 5 years' experience as a motorman, most of it on the Highbury branch. When he reached the train he found Motorman Newson, whom he only knew by sight, sitting in the north end cab. They agreed to 'double-end' the train, i.e. that each man would drive in one direction only, without changing ends, with the other man acting as guard. He then went to the south end cab where, in co-operation with Newson and on the latter's insistence, he carried out a brake test by reducing the train line pressure to below 20 lbs/in<sup>2</sup>. He did not carry out any other part of the guard's normal train preparation duties. Newson then drove the train into the shunting neck, where he shut down the north end cab.

27. Motorman Rozario told me that he then opened up the south end cab and drew the train forward into the platform at Drayton Park and subsequently drove it in passenger service from there to Moorgate. He said that the train handled in a perfectly normal manner and he confirmed that he had used the Westinghouse brake when stopping at Old Street, in accordance with the standing instructions that it should always be used at the station before a terminal, and that he found it good. I asked Motorman Rozario about his driving technique on the section between Old Street and Moorgate. He told me that it was his practice to put the controller straight into the full parallel position on starting from Old Street and to leave it there until reaching the outer home signal, at which point he would close the controller and make an EP brake application to bring the speed down to below 15 mile/h through the crossover. He thought his normal speed on entering the platform at Moorgate was about 10 mile/h. After stopping at Moorgate and shutting down the south end cab he walked back along the train and collected the guard's key from Newson and handed it to Guard Harris who was waiting on the platform. He told me that, although he did not know him, Newson appeared in every way fit and normal that morning.

28. *Motorman H. Lang* was rostered to take up No. 1 Duty at Drayton Park on 28th February. When he arrived at the signing on point at about 06.10, Newson was already there, sitting drinking a cup of tea in the company of Motorman Bray. He did not know Newson well but thought that he looked cheerful, as usual. They had little conversation, but Newson told him on which track his train, No. 271, was standing.

29. Motorman Lang, driving Train 271, made one of the last trips into Platform 9 at Moorgate before the accident, arriving there at 08.33. He confirmed that the red marker light on the sand-drag was alight at that time. He also recalled that the tunnel lights, which had been switched on when he made his first run that morning, were by then switched off.

30. I also asked Motorman Lang, who had about 8 years' experience of driving on the Highbury branch, to describe his technique for driving on the southbound line between Old Street and Moorgate. Like Rozario, it was his practice to motor in full parallel as far as the outer home signal, but he would then allow the train to coast for a short distance before making a full EP application to bring the speed down for the crossover. Unlike Rozario, he said that he sometimes but not always centralised the controller once the train had built up speed because it was easier to hold down the deadman in that position.

31. *Motorman C. A. Gladding*, driving Train 273, also confirmed that the red stop lamp was illuminated when he last saw it shortly before the accident. He had also spoken briefly with Newson whilst they were drinking a cup of tea before starting duty on the day of the accident. He did not know Newson well, but he seemed quite all right that morning. He recalled asking him for some sugar and Newson replying "Go easy with it, I shall want another cup when I come off duty."

32. *Motorman J. P. Bray* had only known Motorman Newson since the latter came to Drayton Park in January 1975. He had observed that Newson was a cautious driver and that his approach to stations was normally slower than most other drivers. He had drunk a cup of tea with Newson before starting work on the morning of the accident and described him as being perfectly normal.

33. One of the few members of the staff at Drayton Park who knew Newson well was *Guard J. T. Catney* who had known him since 1973, when they were both stationed at Barking. He described him as a cheerful chap one could have a joke with and when he saw him on the morning of 28th February he seemed absolutely normal and fit. Catney had only worked as guard to Newson for one week since the latter came to Drayton Park and he, also, stressed that Newson's normal pattern of driving was very cautious and that his approach to stations was slow. On the approach to Moorgate he recalled that Newson's practice was to shut off power fairly early and to coast some distance before braking for the crossover. He estimated his normal speed on entering the platform would be 5 to 10 mile/h. He could not recall any occasion when he had misjudged a stop.

34. The road training instructor who had trained Newson over the Highbury branch was *Motorman R. C. Deadman*. He told me that he had carried out the training on 22nd January 1975 when he was booked on No. 3 Duty and that he had picked up Newson at Moorgate, by previous arrangement with the yardmaster, at 07.12. After one complete round trip, during which he described the features of the line, he handed over the controls to Newson. The latter then drove under supervision, including into and out of both platforms at Moorgate. Deadman described Newson as a cautious but competent driver. He confirmed that he had a tendency to shut off power rather early and he recalled that at the outset his handling of the electro-pneumatic brake was slightly erratic, possibly because he was being careful in strange surroundings. Motorman Deadman told me that he did not have much conversation with Newson. He struck Deadman as a deep-thinking man and not the type to hold conversations. On completion of the duty at Drayton Park at 13.05 he was satisfied that Motorman Newson was competent to drive on the Highbury branch and he so informed the station manager.

35. I asked Motorman Deadman whether Newson had expressed himself satisfied with the training he had received or whether he had indicated that he considered that he should have more training. Deadman assured me that he had put this question to Newson before the termination of his training and that Newson had expressed himself as being perfectly satisfied. I also asked Motorman Deadman whether he had completed a road training certificate in respect of Newson but he was not aware that such a document existed.

36. *Station Foreman G. Fox*, who had worked at Drayton Park for 5 years, was on duty on the morning of 28th February and was present when Newson arrived. He told me that he did not know him well, but that he appeared quite normal. He confirmed that Newson had not tested his hand set but admitted that in fact very few drivers at Drayton Park tested their hand sets regularly, although there were instructions that required them to do so. Mr. Fox described Newson as a very conscientious railwayman and said that he always wore full uniform. He thought that he liked his job. He was on the platform when Train 272 set off from Drayton Park to Moorgate on its fourth trip and recalled that Newson waved to him as the train left.

37. The guard of Train 272 when the accident occurred was *Guard R. P. Harris*. After completing his training he had had some 9 weeks' experience on the Highbury branch and he had worked with Motorman Newson for 4 or 5 weeks. Harris told me that although he had worked regularly with Newson he did not really know him well, though he thought he was a normal stable person with a good sense of humour. He did not converse with him much and he thought this was because of the big difference in their ages. He confirmed that Newson's usual driving technique was to shut off power early and to coast some distance before making a series of fairly gentle brake applications and that his normal speed through the crossover and into the platform at Moorgate was about 10 mile/h. When his guard's position passed the signal cabin the train would be just on the point of stopping, travelling at about 5 mile/h. He said that he felt very safe when working with Newson.

38. On the morning of the accident Harris was late for duty and confirmed to me that he had telephoned the acting station manager at Drayton Park from Moorgate. He could not remember the exact time but thought it might have been between 06.40 and 06.50. It was agreed that he should wait at Moorgate and pick up his duty when Train 272 arrived there shortly after 07.00. He told me that he was standing near the signal cabin when the train came in and that Motorman Rozario handed a guard's key over to him. From then until the accident he made 3 round trips with Train 272 and Motorman Newson's station stops were all very good, using the Westinghouse brake at Highbury on each northbound trip and at Old Street on each southbound trip. He had chatted briefly between each trip with Newson who appeared to be in perfectly normal health. The only subject of conversation that he could remember was camping. Harris said he mentioned to Newson that he was going camping that night and that Newson had commented that he must be mad.



39. When I asked Guard Harris to describe the final trip from Old Street to Moorgate, he admitted that he had left his position at the leading end of the last car shortly after the train left Old Street and that he had gone into the rear driving cab to look for a newspaper. As he returned, he paused near the leading double door bay and was reading the advertisements when he was suddenly aware that the train was entering Moorgate station at a speed of 30 to 35 mile/h. Before he was able to take any action he was thrown to the floor when the impact occurred. He thought during the few seconds prior to the accident that the train was not under power and was coasting. He was sure that no brake application had been made.

40. I asked Guard Harris whether he had thought of using the emergency brake. He told me that, until he was suddenly aware of the station lights, he had no idea that the train was close to the station and that it never crossed his mind to take any action to stop the train. He thought that if he had been aware that they were coming into Moorgate too fast he would have applied the emergency brake.

41. *Relief Signalman W. Wade* commenced duty at Moorgate at 06.40 on the day of the accident. When he arrived he found Guard Harris waiting in the signal cabin and he let him use the telephone to ring Drayton Park. He had a few words with Motorman Newson that morning and remembered the conversation between Newson and Harris about camping. He recalled Newson saying, "I would not go camping this weather. I loved it at Dunkirk, but I would sooner go into a hotel." He seemed quite cheerful and normal. Signalman Wade told me that the service ran normally up to the departure of Train 274 at 08.44, after which he set the road for Train 272 into Platform 9 in plenty of time for the train to have an unrestricted approach. When the train arrived it was his impression that it was like an express going past. He left the cabin and looked out onto the platform in time to see the last two cars going past and realised that it could not possibly stop. He then watched the train continue along the platform at a speed he estimated at 35 to 40 mile/h until there was a terrific crash and a cloud of what looked like black smoke. He at once returned to the signal cabin, telephoned the line controller, told him that a major disaster had occurred, and called for all the emergency services. From his experience, Signalman Wade was quite sure the train was under power as it went through the platform.

42. On duty on No. 9 Platform at Moorgate that morning was *Railman T. Andrews*. He was standing about one car's length up from the red marker light when Train 272 entered the station: it was travelling very fast and he formed the impression that it would not be able to stop. He at once decided to ring Control from the nearest telephone, which was on Platform No. 10, but the crash occurred before he could do so. He then went to the upper part of the station and told the Station Inspector what had occurred. Railman Andrews told me that he thought the train was under power and that he heard no sound of braking. He did not recall seeing the driver at all.

43. Also on the platform, waiting for a train to Drayton Park on his way to take up duty, was *Guard B. A. Friar*. He was standing quite near to Railman Andrews and estimated that there were some 20 to 30 people waiting on the platform. The noise of the train coming in too fast attracted his attention and he looked round and saw the driver for a split second in profile through the side window of the cab. He was sitting up in a normal position with his hat on his head and apparently looking straight ahead. He could not actually say whether his eyes were open or see what his hands were doing. He watched the train knock down the red marker light and saw the sand being thrown into the air as the train ran on into the dead-end tunnel. He estimated its speed as 30 to 35 mile/h.

44. *Mr. C. H. Cope, Assistant Chief Operating Manager, Railways*, told me that although he had no personal knowledge of Motorman Newson, he had some evidence that gave every indication of his being a conscientious employee. He based his view on the contents of Newson's bag which was recovered after the accident from the north end cab of Train 272. It was found to contain his copy of the rule book, the working time table and other notices, and two notebooks, one of which contained hints on how to deal with defects and failures on trains. Notably, both the rule book and this notebook had been covered in a plastic material to protect the covers from wear, an action which in his, Mr. Cope's, view underlined the fact that Motorman Newson conducted himself in a most conscientious manner in respect of his job on the railway.

45. *Dr. P. A. B. Raffle, Chief Medical Officer, London Transport*, told me that Motorman Newson was 56 years of age and that, when he entered the service of London Transport in 1969 he had been medically examined to the required standards and had been passed fit. Since then, he only had 2 days of non-certificated sickness absence recorded on his staff record. However, it was recorded that, on 21st June 1974, he was assaulted by a passenger when he went to the assistance of a woman passenger who was being annoyed. He sustained bruising of the left side of his face and of his eye and a cut on his left cheek. He was not rendered unconscious and apparently refused medical treatment. He was due to start leave the next day and was away for a period of 16 days. (I was subsequently informed that he was medically examined in hospital at the request of the police and no treatment was recommended).

46. Dr. Raffle told me that he had been present at the post-mortem on Motorman Newson but explained that the forensic examination was not yet complete, the bio-chemistry and histology reports not yet being available. In Dr. Raffle's view, the injuries were consistent with the driver having been seated at the controls at the time of impact and it was his opinion that the left hand had been on the brake handle. There was no indication that the driver's hands were in front of his face at the time of impact.

*Evidence of members of the public*

47. Of the intending passengers waiting on Platform 9 at Moorgate when the accident occurred, three came forward to give evidence at the public Inquiry. *Mr. I. A. Butt* was standing almost exactly opposite the red stop lamp at the beginning of the sand drag. He first became aware that the train was running into the station faster than normal when it was about one and a half car lengths away from him and he thought that it was motoring and not braking at all. He recalled seeing the driver, through the front window of the cab, sitting erect with his arms forward as though on the controls. He could not remember seeing his face at all, but recalled that he was wearing his cap.

48. *Miss H. M. Stewart* was standing about halfway along the platform and realised as soon as the train entered the station that it was travelling faster than usual; she estimated its speed as 30 to 40 mile/h and she did not hear any sound of braking. She saw the driver through the front window of his cab, sitting upright and looking forward and said that he seemed quite aware of the situation but she thought he looked very tense. During the time she could see him he did not move his head at all. She could not recall seeing his arms.

49. *Mr. A. R. Board* was also standing about opposite the red stop lamp. He told me he saw the lights of the approaching train in the tunnel coming towards the platform and it was clear to him that it was going too fast as soon as it entered the platform. He estimated its speed as about 40 mile/h. Mr. Board was able to see the driver as the train came all the way along the platform. He was sitting completely upright and his hands appeared to be in the normal operating position; with his right hand on the dead man's handle more or less in the middle of the cab window and his left hand hidden behind the corner pillar. He made no movement as the train approached and Mr. Board gained the impression that he was paralysed or frozen in his position. He was particularly struck by the appearance of his eyes which seemed to be staring straight ahead and to be somewhat larger than life. He recalled that his mouth was closed and the colour of his face appeared normal.

50. I also interviewed a number of passengers who had travelled on the train involved in the accident. *Mr. C. B. McGovern*, a regular traveller on the Highbury branch, was sitting in the rearmost seat on the right in the leading section of the rear vehicle. He thought that the train had seemed to slow down slightly coming to the points, and then, as it crossed the points, to accelerate very fast. He was sure the train was under power as it entered the station. Realising that it was going to crash, he hung on to the bar at his left hand side and braced himself for the impact, in which he was knocked out of his seat. At the moment of impact, the guard, who he had seen go to the rear of the train, was standing quite close to him.

51. Also travelling in the last car was *Mr. M. F. Taylor*, another regular traveller. He told me that at about the time he would have expected the train to slacken speed, it began to accelerate rapidly and that it entered the station under power without any sign of a brake application having been made. In his opinion, the speed of the train was about 35 mile/h. Mr. Taylor said that, when the impact occurred, it was preceded by a sudden lurch which nearly threw him out of his seat. He gathered himself and sat down again, only to be thrown out of his seat along the carriage about 2 seconds later.

52. Another witness travelling at the leading end of the last car was *Mr. R. C. Stewart*. He recalled the journey as being quite normal until the final run into Moorgate and in his view the train continued under power. He also felt a deceleration before the final impact which he had hoped was due to a brake application, but which he now believed was caused by the sand drag.

53. *Mr. J. M. Ball*, who had been travelling on the Highbury branch for about a year and was travelling in the third car of the train, told me that the journey was perfectly normal until the final run into Moorgate. He thought that the train was coasting as it ran through the crossover at 50 mile/h and that there was no brake application as it entered the station. He sat waiting for a brake application that never came but when they were halfway along the platform there was a deceleration, not very strong, followed almost at once by a very sharp deceleration.

54. Travelling in the centre section of the second car and sitting facing the direction of travel was *Mr. H. H. Holderness*. He had no book or paper to read that morning so he was passing the time by guessing where the train was in relation to features on the ground above. At the moment he thought the train was just coming under Finsbury Square he was suddenly aware that they had reached the crossover without the normal preliminary braking. He told me that, at that time, he was not particularly alarmed and he merely thought the driver was leaving it a bit late. It was not until entering the station that he had any reason to believe that they were travelling at an excessive speed. He described the movement of the train through the station as being very smooth—"just as though we were on ice." Mr. Holderness had taken particular care to try and make a good estimate of the train's speed which he put at 44 mile/h. He also estimated that he covered the length of the platform in 7 to 9 seconds.

55. Standing in one of the centre door bays of the second car was *Mr. E. Markwardt*. He thought that all the seats in the car were occupied but that there were fewer standing passengers than usual. He was conscious of nothing abnormal in the running of the train until, running through Moorgate Station, he realised that it was still running as fast as it would normally go in the tunnel between stations. He was under the impression that the train was coasting and did not think that any brake application was made.

56. Also standing near the centre of the second car was *Mr. P. Paterson*, who told me that, on a bend between Old Street and Moorgate, he heard an unusual thumping from the suspension of the car. At the time this occurred he thought the train was under power and there had been no brake application. Later, he said, there seemed to be an emergency braking motion lasting perhaps one second or, at the most, a second and a half, during which time the train seemed to be under restraint. This restraint, which he thought had occurred as the train entered the station, was removed before the final impact and to him it seemed that the train proceeded in a smooth way through the station before the collision occurred.

*Evidence in respect of events subsequent to the accident*

57. *Mr. S. J. McManus*, Depot Engineer at Neasden, reached Moorgate about 45 minutes after the accident had occurred. After reporting to the breakdown engineer on duty he checked the brake cylinder pressure gauges on the rear 3 cars. He found a zero reading on each of the motor cars but the gauge on trailer car No. 012167 was standing at 8 to 10 lbs/in<sup>2</sup>. To confirm that the gauge was operative, he pulled the air release chain, and heard the sound of escaping air. The time was then about 10.10.

58. *Mr. T. B. Savin*, Assistant Divisional Manager, told me that he had supervised a brake test on the rear 3-car unit of the train on Sunday 2nd March, after it had been removed to Drayton Park Depot. However, it was found that it was not possible to carry out an effective test on what had been the fourth car of the train, Motor Car No. 11115, on account of the damage that had been done to its leading end in the process of separating it from the third car after the accident, so it was blanked off. On the other two cars the main line was charged to just over 80 lbs/in<sup>2</sup> and the train pipe to just over 60 lbs/in<sup>2</sup> on the duplex gauge. The driver's brake valve was then moved to the 'Emergency' position and left there. The train pipe pressure fell to zero with the main line pressure remaining at 80 lbs/in<sup>2</sup>. The driver's brake valve isolating cock was then left open and the brake cylinder pressures on the two cars recorded every 10 minutes, with the results shown in the table below.

Car No.	10115	012167
At start of test	28 lbs/in <sup>2</sup>	28 lbs/in <sup>2</sup>
After 10 minutes	11	22
„ 20 „	5	20
„ 30 „	—	16
„ 40 „	—	12
„ 50 „	—	10
„ 60 „	—	10

59. *Mr. G. H. Hafter*, Rolling Stock Engineer (Railways), told me that he reached the scene of the accident at about 10.00. He made a personal inspection of the track in rear of the train and back over the crossover into the southbound running tunnel towards signals ND9/10, and found no skid marks or other indication of heavy braking. From then until the last survivor had been extricated he and his staff were fully committed in support of the rescue operation. At about 22.00 on the Friday evening he was able to make his way into the front car, through a hole that had been cut in the roof for getting casualties out. He found that the car floor had been buckled in an inverted 'V' against the door giving access to the cab and that the distance from this door, not the front of the train, to the tunnel wall was only about 6 ins. He was unable to see anything of the driver or the position of the controls.

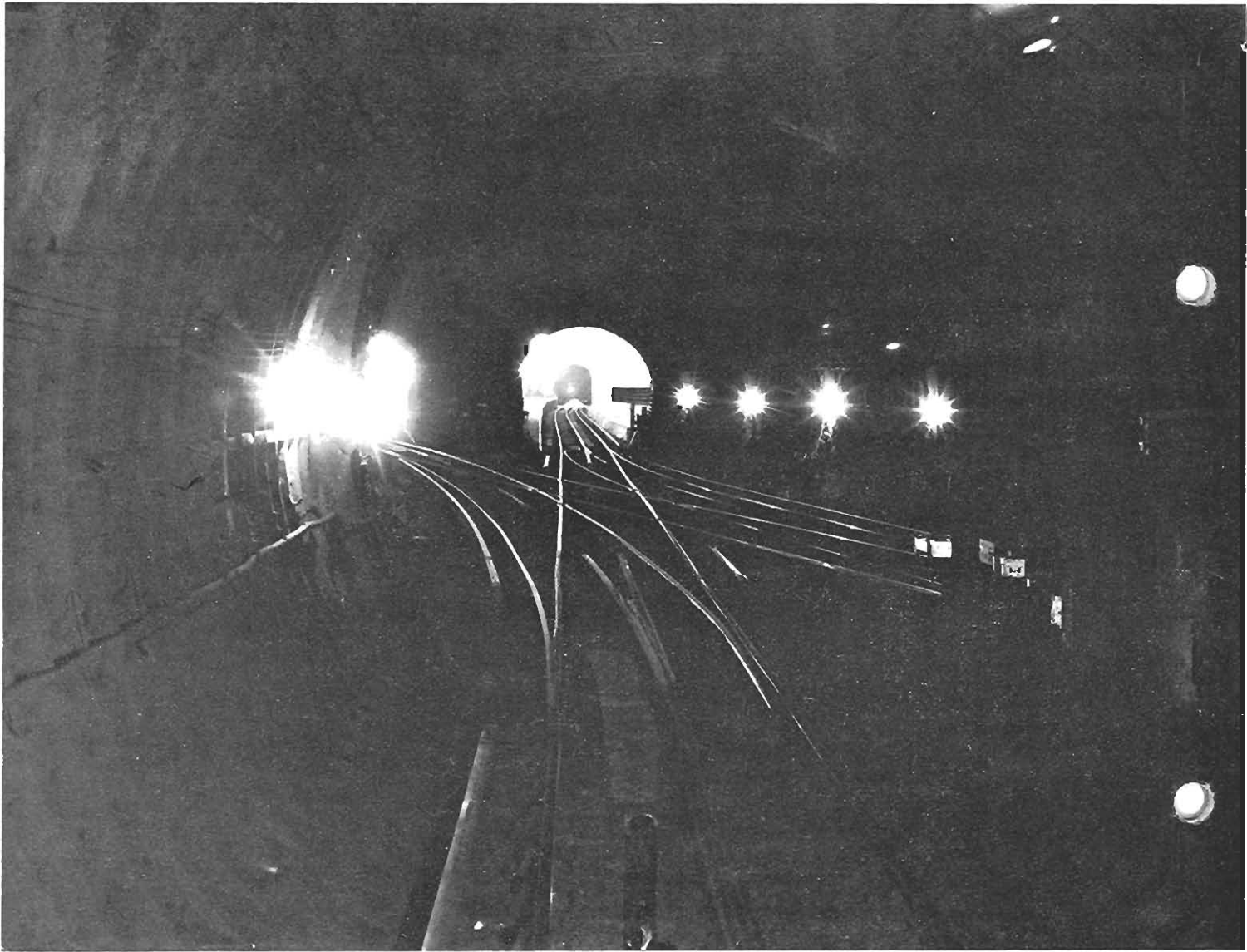
60. *Mr. Hafter* then told me that, on the afternoon of Tuesday, 4th March, after the removal of the last passenger, it became possible to make a further inspection and he was able to see that the driver had his head through the cab front window and the master controller was in the series position, the deadman having been released. At the same time he was able to see the position of the switches in the auxiliary control cabinet behind the driver, and noted that the air compressor switch was 'ON', the cab light was 'OFF', the EP brake switch was 'ON' and that the control governor cut out switch was cut in, although the seal was not in position. At this stage it was not possible to see any further, and he then gave instructions for the wreckage of the car to be winched further away from the end wall.

61. After a further movement of approximately 2 ft, *Mr. Hafter* was able to see that the driver's brake valve handle was a short distance away from the 'Release and Running' position, into the EP sector, and that the reversing key was trapped in the gate, apparently in a forward position. After recording photographically as much as was possible, the driver's body was moved sufficiently to establish that the reverser key was in the 'Forward 1' position. It was not until after the body had been finally removed that *Mr. Hafter* was able to see that the driver's brake valve isolating cock was in the open position. Despite a search outside the cab, he was not able to find any trace of the tripcock isolating cock or the deadman's valve isolating cock, both of which are mounted on the headstock. They were both recovered later from the debris and found to be in the open position.

62. *Mr. Hafter* then showed me, with the aid of photographs taken before the driver's body was moved, the position in which he was found relative to the controls. His left hand was close to, but not actually on the driver's brake handle and his right arm was hanging down to the right of the main controller. His head was to the left of the deadman's handle which had been forced upwards, beyond its normal travel, and was resting on his right shoulder.



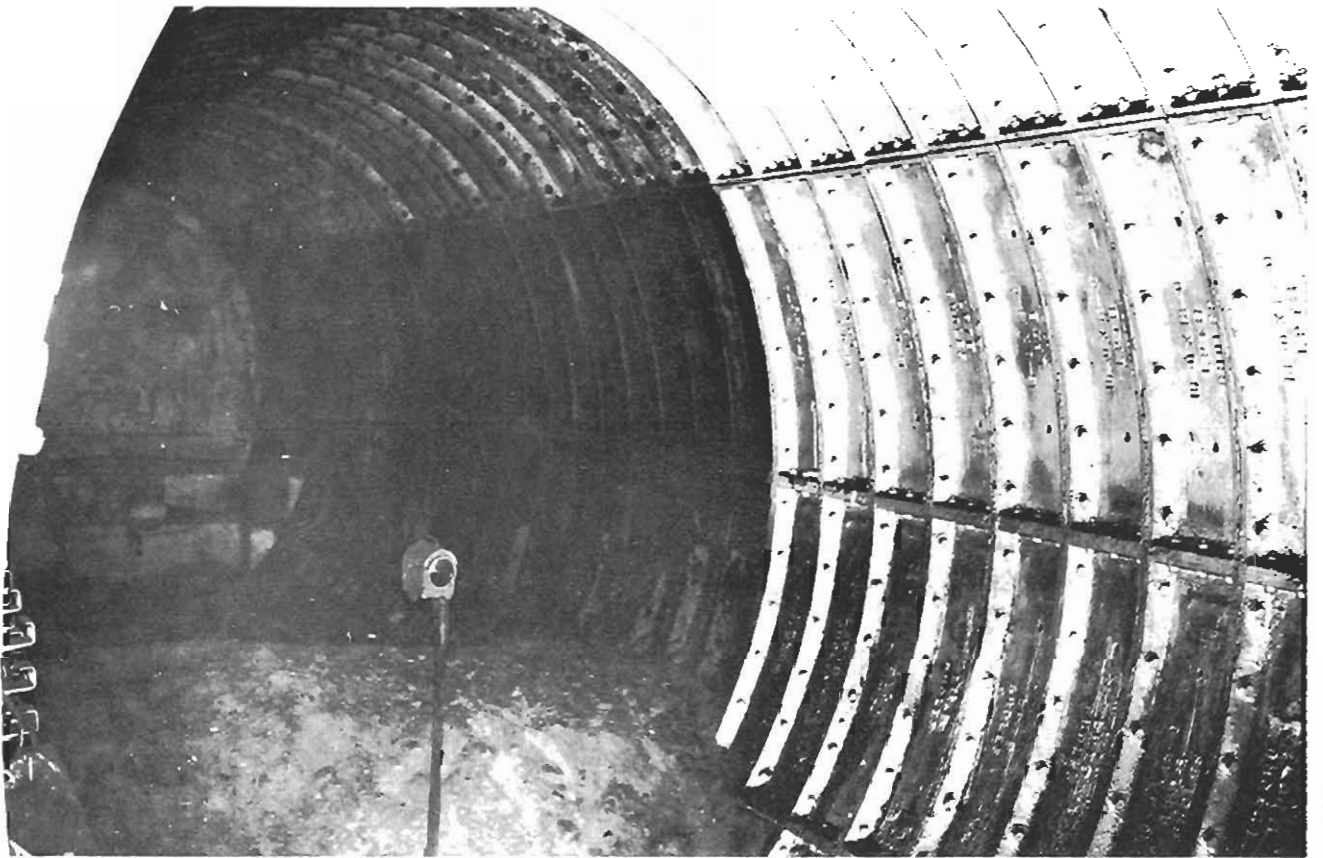
*Photograph 1. Train arriving at Platform 9 at Moorgate Station after resumption of service.  
(Press Association)*



*Photograph 2. View into Platform 9 at Moorgate from Southbound Running Tunnel.  
(By Courtesy of London Transport)*



*Photograph 3. Driver's Cab of 1938 Tube Stock, showing, on the left, the Driver's brake handle and, on the right, the Master Controller with the Deadman's handle.  
(By Courtesy of London Transport)*



*Photograph 4. Platform 9 overrun tunnel as at May 1974. The Sand drag was subsequently lengthened.*



*Photograph 5. Wrecked train showing position of third car.  
(By courtesy of City of London Police)*

63. Mr. T. J. Lowe, Mechanical Engineer (Design) described the technical investigation he carried out of the cab and controls and components of the traction control apparatus and brake equipment. He explained that the tests carried out were designed to seek answers to the following questions:

- i. Was there a failure of the driver's brake controls on the leading car which prevented the brakes from being applied?
- ii. Was there a simultaneous failure of the brake equipment on each car throughout the train?
- iii. Was the train coasting, braking or motoring at the time of the accident?
- iv. Did the driver make any attempt to stop the train by other means, namely motoring in reverse?

64. Mr. Lowe told me that, with regard to the brake controls, the cab was found fully operational with all isolating cocks and switches correctly set, though the brake controller itself was quite severely damaged. It was possible, however, to remove all the pneumatic valves associated with the Westinghouse air brake without disturbing them in any way in order to test them. All were found to be functioning correctly when set up on the test panel at Acton Works. They were then fitted to a 6-car train of 1938 stock and again tested and were found to give a satisfactory emergency brake application. The damage to the brake controller was such that the top part which contains the driver's brake handle had broken away from the main body of the controller and in doing so had distorted the operating spindle. This distortion was consistent with the broken handle being in or near the 'Release and Running' position at the time of impact. The brake control handle itself was bent and could not be moved beyond the 'Full Service' position. Test on a similar handle showed that a vertical force of 480 lbs was required to reproduce the same distortion. In Mr. Lowe's opinion the distortion of the brake handle was caused in the collision.

65. The master controller operating handle was found approximately 10° beyond the 'Series' position with the reverser key in the 'Forward 1' position: the controller had been damaged and distorted. Mr. Lowe said that a very close examination had been made of the deadman's mechanism which was found latched with the latching arm broken. It appeared that the damage to the controller caused the reverser key shaft to lift and for the pin valve cam on this shaft to engage with the operating lever either resetting the latch or preventing it from delatching. The fracture of the latching arm was, in his view, a result of the damage caused to the controller in the collision. The fracture was a clean brittle fracture, consistent with the arm having been forced beyond its limit of travel. The part of the deadman's mechanism which interrupts motoring was slightly bent but operational, with the contacts open. There was no defect in the master controller which could have caused it to jam in a motoring position.

66. Mr. Lowe then described the examinations made of the brake equipment on each and every car of the train. The EP brake equipment was found to be in a satisfactory condition, with no defects that could have caused brake failure; the triple valves on each car were found in the emergency position, on the wheelsets there was no indication of the wheels having locked, and all the brake blocks were in position with a correct clearance between block and wheel. The only irregularity that was found was that when the recovered brake equipment was examined at Neasden depot it was discovered that both the electro-pneumatic brake isolating cock and the Westinghouse brake isolating cock from the second car of the train, Trailer car No. 012263, that had been cut up on site at Moorgate, were in the closed position. Mr. Lowe pointed out that it was possible that somebody had interfered with the cocks before they were examined at Neasden but even if the brakes on this car had been isolated, it would in no way have prevented an emergency brake application being made throughout the remainder of the train.

67. Mr. Lowe then described the examination that had been made of the traction equipment. On the three undamaged motor cars the main equipment fuses had not operated and the main line circuit breakers were in each case open. The overload relay panels were set and the traction canshafts were in the 'Off' position. The reverser on each equipment was correctly set for movement in the southbound direction. The traction motors were generally in a satisfactory condition and showed no signs of a recent flashover. He deduced that reverse power had not been applied in an attempt to stop the train.

68. The traction equipment on the leading motor car had sustained some damage in the accident. The main equipment fuses were damaged but had not operated. The line breakers were severely damaged and Mr. Lowe was not able to comment on their position. The traction motors were again satisfactory, with no signs of recent flashover. The camshaft, however, was found mechanically jammed between positions 2 and 3. It was jammed because the equipment case was damaged in the accident and the main power contact had been broken, stopping the camshaft moving.

69. Mr. Lowe then described the tests that had been carried out on the camshaft after it had been freed. It was found that it took 2.3 seconds to run back from position 10 (the full series position) to position 1 (the 'Off' position). From this he concluded that the train had been motoring up to within 2 seconds of the moment the traction equipment case was damaged in the accident and that, because that portion of the deadman's mechanism that interrupts motoring was found in a satisfactory condition it appeared that the deadman's handle had not been released up to within 2 seconds of impact.

70. Mr. Lowe then summarised his findings as follows:

- a. The emergency brake control in the leading cab was not defective and was capable of correct operation.



- b. The braking system throughout the train was in a satisfactory condition and capable of correct operation.
- c. The traction equipments were in a power mode up to within 2 seconds of the collision.
- d. No attempt had been made to stop the train by reverse motoring.

In response to questioning, he confirmed that the position of the triple valves throughout the train indicated that the final brake application was one achieved through the Westinghouse system and not the EP system.

71. I also asked Mr. Lowe whether he could comment on the condition in which the tripcock was found after the accident. He told me that it was slightly damaged and in its normal operating position, but he agreed that there was every possibility that the tension on the resetting cord that would have been brought about by separation that occurred between the car body and the bogie in the course of the accident would have reset the tripcock if it had been operated by its passage through the sand drag.

#### *The Inquest*

72. The inquest on the passengers who lost their lives in the accident and upon Motorman Newson was held by Her Majesty's Coroner for the City of London, opening on 14th April 1975. The evidence adduced in respect of the condition of the train before and after the accident, and in respect of the working of the train prior to the accident, established no additional facts which could have had any bearing on the cause of the accident, except that it revealed a conflict of evidence in respect of the state of the tunnel lights in the southbound running tunnel between Old Street and Moorgate during the final journey of Train 272. At my own public hearing on 13th March, evidence was given by Motorman Lang, who was working Train 271, that the tunnel lights were illuminated at the time he made his first run but were extinguished when he made his final run shortly before the accident, and he confirmed this evidence at the inquest. A similar statement was made by Motorman Gladding to LT Officers at the preliminary inquiry on 1st March; he said that the tunnel lights were not illuminated when he went through just after 07.00. He further said that, if they had been switched on, he would have made positive inquiries to ascertain the reason.

73. At the inquest, Signalman Wade said that it was his practice to leave the lights switched on in the southbound tunnel because there were engineering works in progress at Moorgate and he confirmed that he had left them on on the morning of the accident.

74. Of 10 passengers who were travelling in the train when it crashed and who gave evidence at the inquest, 9 were asked by the Coroner whether they had noticed if the tunnel lights were on. Six of them either did not notice or could not remember, but three others definitely recalled seeing lights flashing past, but in each case they thought that they had seen them either just before or while the train was passing over the crossover points.

75. The post-mortem examination of the body of Motorman Newson was carried out by Professor C. K. Simpson, Professor Emeritus, University of London, Head of Department of Forensic Medicine at Guys Hospital Medical School, assisted by Professor J. M. Cameron, University Professor of Forensic Medicine at the London Hospital Medical College. He found the cause of death to be shock from multiple injuries and reported that the deceased appeared to have been a perfectly healthy man. In particular he found no brain disease and nothing to suggest that a seizure of any kind had been likely or had taken place; there was no coronary thrombosis or other abnormality of the heart; the lungs were healthy; there was no undissolved drug or poison matter in the stomach and no smell of alcoholic drink, and the liver showed no indication of heavy drinking habits. These findings were confirmed by microscopic examination. Professor Simpson also confirmed that he had made a particular examination for the possibility of electrical injury, but that he had found no mark of electrical burn or electrical pattern anywhere on the body, nor was there any sign of electrical injury to the clothing.

76. Professor Cameron arranged for bacteriological and toxicological examinations of specimens of blood and body fluids taken from Motorman Newson's body to be carried out by appropriate specialists, together with similar examinations of the contents of a screw top milk bottle found in Motorman Newson's equipment bag after the accident.

77. Professor Cameron also arranged for X-ray photographs to be taken of Motorman Newson's hands and forearms. In his view the fractures on the hands and forearms indicated that the left hand had been gripping an unyielding object whereas the right hand had been resting with the heel of the hand on some object. He agreed that this was in keeping with grasping a large circular knob.

78. The toxicological examination of the specimens taken by Professor Cameron from Motorman Newson's body was made by Dr. Ann Robinson, Senior Lecturer in Forensic Medicine at the London Hospital Medical College. As a check, she also made similar tests on specimens taken from 8 of the passengers killed in the accident whose bodies had been under the same conditions underground as Newson's. It was her view that the bacterial and yeast content of the specimens and also of the sour milk contained in the bottle was in no case such that it would have caused any significant formation of alcohol by fermentation or otherwise, and as a result of the tests she carried out, she concluded that Newson had drunk alcohol on the morning of his death, but that the highest possible level of alcohol in the blood at the time of the post-mortem was of the order of 80 milligrams per 100 millilitres. She thought, however, that the true level, as a result of drinking, might be less than this figure. She also analysed the sour milk in the bottle found in Motorman Newson's equipment bag and found that it contained 0.1 per cent weight in volume of ethyl alcohol.

79. An alternative view of the significance of the alcohol levels found by Dr. Robinson, in particular as to whether the alcohol was present at the time of death or formed subsequently, was taken by Dr. Roy Goulding, Director of the Poisons Unit at Guys Hospital, who was called to give evidence at the request of counsel representing Mrs. Newson. Though he accepted the results of Dr. Robinson's analyses, he said that he could not come to the inescapable conclusion, on the information available, that alcohol had been present in Motorman Newson's body prior to death. He could not state, unequivocally, that no alcohol at all had been consumed before death but, if any had been so consumed, it must have been a very small amount. Dr. Goulding also pointed out that up to 0.2 per cent weight in volume of ethyl alcohol was often found in soured milk.

80. Evidence in respect of Motorman Newson's habits and temperament was given by his wife, Mrs. Newson, and by a friend, Mr. J. R. G. Simmonds, a bus inspector working for London Transport. The picture that emerged was of a man of quiet orderly habits who had never suffered from any serious illness and never had black-outs or attacks of giddiness. He was not a day-dreamer and had never been known to overrun a traffic light when driving his car. He was not a drinking man though he enjoyed an occasional glass of brown ale; he rarely touched spirits, though there were both whisky and Bacardi in the house, and Mrs. Newson had never known him to take a tot of spirits before going to work on a cold morning or to take spirits to work with him. Nor, to Mrs. Newson's knowledge, did he take any sedatives, tranquillisers or sleeping pills. He did not eat any breakfast, but always made himself a cup of tea before going to work. Both witnesses said that he was never depressed and loved his work as a motorman. They also told of his plans to purchase a car for his daughter, for which purpose he was actually carrying a sum of money in excess of £270 on the morning he died.

81. Evidence was also given by the various members of the staff on the Highbury Branch who had seen or spoken with Motorman Newson on the morning of the accident to the effect that he seemed perfectly normal. None admitted to knowing of any custom of taking a tot of spirits before starting work on a cold morning and Motorman Lang, who had poured milk from Newson's bottle into his tea before they started work, did not taste or smell spirits. Signalmán Wade also confirmed that he did not put any spirits into a cup of tea he gave to Newson at Moorgate on one of his trips, nor did he smell spirits on Newson's breath.

82. The Coroner questioned Professor Cameron on the possible effects of a blood alcohol concentration of up to 80 milligrams per 100 millilitres. The latter thought that, in a man unused to drink as Newson appeared to be, a concentration of 80 would have had quite severe results but that the results would be less severe at lower concentrations. It would not necessarily be enough to make him drunk but it would impair his ability and possibly slow him in his reaction time. It was his opinion that a concentration of 80 or even below could make a person more susceptible to fatigue and to the risk of automatism and the production of a trance like state and that this would be further accentuated by the effects of hunger, excessive warmth and flashing lights.

83. Doctor Raffle, in his evidence, after describing himself as someone who had taken a professional lifetime interest in the factors which may affect peoples' capacity to do skilled jobs, like driving, and one of those factors must be alcohol, said that he was inclined to disagree with Professor Cameron. It was his view that a blood alcohol level of 80 milligrams per 100 millilitres could not, by itself, have such an adverse effect upon the driver's control of the train and he was disinclined to accept that alcohol played a significant part in the cause of the accident. In trying to establish a possible cause, he postulated two little known medical conditions which could, in his view, explain Motorman Newson's actions, though he admitted that there was no evidence to support them. The first, 'akinesis with mutism' is caused by a tiny clot in the area of the mid-brain which could cause a person to freeze in such a way that his muscle tone would not be affected, thus leaving him sitting up and depressing the deadman's handle. Such a condition could only be diagnosed by a microscopic examination of the brain and this was not possible owing to its condition. The second possibility was 'transient global amnesia' caused by a spasm of blood vessels in part of the brain which could cause a complete obliteration of all Newson's previous training and experience but would not otherwise affect his physical ability to drive a train. This latter condition would leave no trace whatever at post-mortem, but, since it would not have prevented normal muscular movement, Dr. Raffle would have expected Newson to have raised his hands in a last moment attempt to protect his face. In his view the absence of such a gesture was one of the most inexplicable things of the whole incident.

84. The verdict returned by the inquest jury was 'Accidental Death', both in respect of Motorman Newson and the 42 passengers who lost their lives.

#### OBSERVATIONS

85. The available evidence is not entirely conclusive in a number of areas, nevertheless it is possible to draw some reasoned inferences which provide the most probable explanations for the circumstances which actually obtained at the time of the accident.

86. Though both brake isolating cocks from trailer car No. 012263 were found in the closed position when inspected after removal to Neasden, there remains some doubt as to when they were actually closed. Car Examiner Wager and his assistant, in carrying out the 7-day examination of the train during the night before the accident, had no reason to close them and should certainly have discovered if they were closed

during the course of the brake examination they claimed to have carried out. Furthermore, Motorman Newson should have discovered the isolation while carrying out his train preparation, for which he had adequate time. Whether or not the brakes on this car were isolated while the train was in service before the accident, it clearly made no difference to the braking capability of the train, as confirmed by Motorman Rozario who drove it on its first trip from Drayton Park to Moorgate. It is my personal opinion that the two isolating cocks were interfered with by someone after the accident but, in any case, it is not significant to the cause of the accident.

87. Though it is the general experience of London Transport that the tripcock is operated when a train enters a sand drag even at a low speed, the tripcock on the leading car was found in the running position after the accident. Since the leading bogie became separated from the car body when the train hit the hydraulic buffer stop it seems likely that tension on the resetting cord, which was found to be broken, had reset the tripcock. This hypothesis is confirmed by the position of the camshaft on the leading car which indicated that traction power had been cut off less than 2 seconds before the final impact. If the tripcock had been operated by the sand drag, the traction power would have been cut off by the control governor at the same time, regardless of the position of the master controller handle.

88. Mr. Hafter, in his initial examination of the cab after the accident, found the cab lighting switch in the 'off' position and Station Foreman Fox, at the Inquest, gave evidence that the cab light was off when he saw the train pulling out of Drayton Park on its last trip. In order to assess the actual ability of witnesses on the platform at Moorgate to observe such details as Motorman Newson's facial expression, I paid a visit to Moorgate in company with London Transport officers and Messrs Batt and Board, who had given evidence at the public Inquiry. We observed the arrival, at a normal slow speed, of a number of trains at No. 9 platform, of which the motormen were, by arrangement, wearing their caps, some with the cab lights on and some with them off. The level of illumination provided by the station lighting, which takes the form of incandescent fittings at intervals in the upper part of the tunnel above the platform edge, was low and, with the cab lights extinguished, the driver's face was in partial shadow. Though it was possible to see his general posture, it was certainly not easy to discern such details as the expression in his eyes, or the colour of his face.

89. I have already drawn attention to an apparent conflict of evidence with regard to the tunnel lights in the southbound running tunnel between Old Street and Moorgate. I am inclined to accept the evidence of the motormen that the lights were out at the time of the accident, because they were in the best position to see. However, I believe that the lights in the crossover chamber were on and it was these lights that were seen by various passengers.

90. There was also a conflict of evidence at the Inquest on the interpretation to be placed on the levels of alcohol found in the various specimens taken from Motorman Newson's body. There was common ground between the expert witnesses, however, in that there was no suggestion that the alcohol level in Motorman Newson's blood at the time of the accident was greater than 80 milligrams per 100 millilitres. Dr. Robinson thought that the true level as a result of drinking might have been less than this figure and Dr. Goulding thought that, if any alcohol had been consumed, it must have been a very small amount, it being his view that the greater part of the alcohol present had been formed post-mortem.

91. There was also some difference of professional opinion as to the possible effects of alcohol at a concentration of 80 milligrams per 100 millilitres or less on an individual such as Motorman Newson. Professor Cameron thought that it could have been a contributory factor by impairing his ability and slowing his reaction time, and also possibly making him more liable to the risk of automatism which could be caused by flashing lights. In contrast, Dr. Raffle believed that alcohol alone could not have been a significant factor.

92. In trying to reconstruct the events of the final journey of Train 272 from the evidence available, it does not appear that there was anything out of the ordinary in the handling or performance of the train from the time it left Drayton Park at 08.39 up to the stop at Old Street at approximately 08.45. At the Inquest, one passenger alleged that the train stopped short at Old Street some 15 yards from where he would normally have expected it to stop. However, no one else commented on it and, since the platform at Old Street is some 100 feet longer than a 6-car tube train, there may well be some variation in the actual stopping point used by different drivers, and I do not therefore regard this piece of evidence as of any significance.

93. According to all witnesses, the train accelerated normally away from Old Street and would have reached a speed of 30 mile/h in some 28 seconds, after travelling 250 yards, about one-third of the distance to Moorgate. At this point, from the descriptions of Motorman Newson's driving technique by various witnesses, he might have been expected to shut off power and coast for some 15 seconds before making a fairly gentle EP brake application in the general area of the outer home signal to reduce speed to 15 mile/h or less at the crossover. As it was, it appears that the train continued to accelerate on full power and, on this basis, it would have reached a speed of about 35 mile/h as it entered the crossover about 56 seconds after leaving Old Street. Based on the position in which the main controller handle was found after the accident and the position in which the camshaft of the traction control equipment on the leading car was found jammed, it would seem that Motorman Newson centralised the controller, in a manner which is not uncommon amongst drivers to reduce the effort required to hold down the deadman's handle, soon after leaving Old Street and held it in this position until the collision took place. One effect of this would have been

that, as the train passed over the current rail gap at the crossover causing the traction current supply to be momentarily interrupted to each of the traction control equipments in turn, the transfer switches would have reverted to the series position and, on restoration of the current, the camshafts would have notched up to the full series position, corresponding to the position of the main controller. The train would then have continued along the platform under power but in the series mode until the traction power was cut off by the control governor when the tripcock was operated by the sand drag. As soon as this happened the camshafts in each of the traction control equipments would have started to run back to the 'off' position but the damage to the equipment case on the leading motorcar, brought about by the final impact, which occurred less than 2 seconds later, caused the camshaft to jam between positions 2 and 3, as described by Mr. Lowe in his evidence.

94. The most notable feature about this sequence of events is that it means that there was no positive action of any kind by Motorman Newson from the time that he brought the main controller handle back from the full parallel position to the series position, presumably within 30 seconds of the train starting away from Old Street until the accident occurred some 36 seconds later. During this period of 36 seconds the train continued in what was almost certainly an unlit single bore tunnel for some 25 seconds before entering the illuminated crossover chamber. The sudden change in environment; both in respect of the change in noise level and the opening up of a direct view through the crossover chamber into the station ahead, with the red light on the sand drag clearly visible at a distance of some 200 yards, should have been enough to bring to his senses a man whose mind had merely wandered from his job and, even at this stage, Motorman Newson had only to release the deadman in order to avert the accident. As it was, he took no action of any kind as the train ran through the station and into the overrun tunnel, although he was seen by several witnesses to be sitting up and looking forward in an apparently alert position with his hands in the normal position on the controls, and the medical evidence indicated that his hands were still on the controls when the impact occurred.

95. Any hypothesis as to the cause of the accident must take into account this period of inactivity on the part of Motorman Newson, during which time he remained sitting upright on his tip-up seat and holding down the deadman's handle, despite the lateral accelerations he would have experienced on traversing the 12 chain curve outside the station at about 35 mile/h. If he was in some less than fully conscious condition, it must have been a condition in which he retained his balance and muscle tone during this whole period of apparent inactivity.

#### CONCLUSIONS

96. The evidence presented at the public Inquiry, supported by my own personal examination of the various components of the braking and traction control equipments described by Mr. Lowe in his evidence, led me to the initial conclusion that there was no fault or condition of the train involved in this accident which could have prevented Motorman Newson making a normal, controlled, approach to Moorgate and stopping correctly in the platform. Nor was there any evidence given at the Inquest which would cause me in any way to alter this conclusion and its inevitable corollary, that the accident was solely due to a lapse on the part of the driver, Motorman Newson.

97. I am satisfied, too, that there was no fault on the deadman mechanism of the train prior to the impact and had Motorman Newson collapsed at the controls, fallen asleep, or otherwise lapsed into unconsciousness, the deadman would have acted promptly and correctly to bring the train safely to a stand. All the eye witnesses who saw him as the train ran through the platform at Moorgate were in agreement that he was sitting up in an alert posture with his hands in front of him in a normal driving position and this was confirmed by the X-ray photograph made of the fractures to the bones in his hands and arms. I must therefore conclude that Newson was conscious up to the moment of collision and that he made no effort of any kind to stop the train.

98. Although he was less experienced as a driver than his colleagues on the Highbury Branch, I am satisfied that Motorman Newson was both competent and safe in the way he normally drove his train and that he had adequate knowledge of the route between Drayton Park and Moorgate to rule out any possibility that he either mismanaged his train or misjudged his approach to the extent that he could not have brought his train under control in plenty of time to avert the accident. The signalling and track layout on the approach to Moorgate are such that it is quite impossible to mistake it for any other location on the Highbury Branch and it is possible to stop a train well short of the sand drag, even if it is still travelling at the maximum attainable speed when the red stop lamp at the end of the platform comes into view.

99. Though there is some evidence to suggest that Motorman Newson might have consumed alcohol in some form prior to the accident, there is none to suggest that he was drunk or that he was in any way incapable of performing his duty as a driver. The amount of alcohol in his blood stream was certainly not above the permitted limit for a driver of a road vehicle under present legislation, and there was nothing in his behaviour or appearance that morning which led any other member of the staff to suspect that he might have been drinking. Certainly, he was able to carry out his duties in a perfectly normal manner from the time he booked on until just before the accident, some 2½ hours later.

100. I have, moreover, subsequently been advised by Professor Simpson that it is generally accepted that as much as 80 milligrams of alcohol may make its appearance as a result of the growth of micro-organisms and fungi in a decomposing body, particularly after 4 days at a high temperature. Though there can be no way now of telling whether this occurred in the case of Motorman Newson, it makes it dangerous to draw the firm conclusion from the alcohol levels found in the specimens taken from his body that he had consumed alcohol prior to his death. It is my view, therefore, that alcohol was not a significant cause of this accident.

101. It has also been suggested that Motorman Newson may have been 'day dreaming', possibly thinking about the car he was planning to buy for his daughter after he finished duty that afternoon, and paying no attention to his surroundings. If this were so, I would have expected that the lateral accelerations and the noise as the train negotiated the crossover would have shaken him out of his reverie and, even if it had not, he would surely have come to his senses before the final collision and made an effort to protect his face and head. In the circumstances, the possibility that the collision was the outcome of a deliberate, suicidal act cannot be ignored, although there is no positive evidence to support it.

102. Of possible physical conditions that could have caused Motorman Newson to act, or to fail to act, in the way suggested by the evidence, many are ruled out by the post-mortem findings which showed him to be an apparently perfectly fit man up to the moment of the accident. His body and clothing bore no traces of electrical burns and thus the possibility of the controls having become alive at such a voltage that he could not release his grip can be excluded. Other conditions which would not leave any trace at post-mortem can also be ruled out if they would lead to collapse or loss of muscle tone, and thus epilepsy can be discounted. The two little known conditions of 'akinesia with mutism' and 'transient global amnesia', postulated by Doctor Raffle at the Inquest, remain possibilities, but without any evidence in support of either one of them.

103. Whatever the reasons for Motorman Newson's lapse, I am satisfied that there was nothing in his behaviour prior to leaving Old Street on the final run that could possibly have caused any other member of the staff any worry or suspicion as to his driving capability. This particularly applies to Guard Harris who, in addition to being young and inexperienced, which he could not help, displayed himself as idle and undisciplined. Apart from being late for duty, he went to the rear cab shortly after leaving Old Street to look for a newspaper and still had not returned to the guard's position by the time the collision occurred. He clearly paid no attention to the running of the train and only became aware that something was amiss when he saw the station lights at Moorgate less than a second before the head of the train entered the sand drag. Even if he had been paying particular attention to the running of the train, I do not believe he could have been expected to realise that anything was wrong until the last car entered the crossover, by which time the front of the train was halfway along the platform and an emergency brake application could not have prevented the accident. Apart from this, it would not have been easy for a young and inexperienced guard to come to a decision to make an emergency brake application on a train driven by a driver in whom he had confidence. In my view Guard Harris's behaviour cannot be regarded as having contributed in any way to the accident.

104. I must conclude, therefore, that the cause of this accident lay entirely in the behaviour of Motorman Newson during the final minute before the accident occurred. Whether his behaviour was deliberate or whether it was the result of a suddenly arising physical condition not revealed as a result of post-mortem examination, there is not sufficient evidence to establish, but I am satisfied that no part of the responsibility for the accident rests with any other person and that there was no fault or condition of the train, track, or signalling that in any way contributed to it.

#### DISCUSSION

105. A buffer stops collision is not a particularly unusual type of accident on London Transport Railways. In most cases, however, it takes the form of a slow-speed overrun caused either by mismanagement of the brakes or by misjudgement. In the 5 years prior to the Moorgate accident, 6 buffer stops collisions were reported, of which 4 occurred to trains in passenger service. These were at Finchley Central in 1970, at Baker Street in 1971, at Epping also in 1971, and again at Baker Street in 1973. Only in the last case were there any passenger casualties, when 19 persons sustained minor injuries. The other 2 cases involved the use of reversing sidings by empty trains: one occurred at Tooting Broadway in 1971 when a driver sustained fatal injuries when he drove a 7-car train of 4938 stock into the end wall of a siding in tunnel at about 30 mile/h, apparently through inattention, believing himself to be on the main line, and the other at Rayners Lane in 1972, when a driver was killed when he misjudged his speed and hit the buffer stops at the end of a reversing siding in the open at about 10 mile/h. In this last case the driver was subsequently found to have a blood alcohol level of 91 milligrams per 100 millilitres, which was possibly a contributory factor.

106. Following the Tooting Broadway accident, which was the subject of a public Inquiry, London Transport installed a time-released train-stop halfway along the siding, arranged so that a train entering the siding under full power would be brought to a stand before reaching the end of the siding, and put in hand a programme to provide similar protection at other reversing sidings in tunnel. After the Rayners Lane accident, this programme was extended to cover reversing sidings in the open. At no time, however, was it thought necessary to provide similar protection at terminal stations where there seemed to be no reason for a driver to mistake his position, provided he was conscious and in effective charge of his train.

107. It is nearly 30 years since a buffer stops collision occurred on London Transport Railways as a result of a driver being taken ill. This was at Edgware in 1946, when a 7-car train of 1938 stock, after making a normal controlled approach to the station ran through the platform at about 15 mile/h and, after traversing a sand drag, hit the buffer stops and an abutment wall at 5 to 7 mile/h crushing the leading cab and causing minor injuries or shock to 8 passengers. The driver, who was trapped but not seriously injured in the collision, had suffered a coronary thrombosis as the train entered the station, from which he died before he could be released from the cab. It was not possible to establish exactly what the driver's last actions had been, but it appeared that he had neutralised the deadman prematurely by a movement of the reversing key into the 'Off' position, possibly under the impression that the train was already at a stand. Although the Inspecting Officer, in his Report on the accident, commented on the desirability of regular medical examinations for motormen, he made no comments on the signalling or station layout other than to note that the sand drag was only 20 feet long.

108. No previous incident or accident in the whole history of London Transport Railways can be regarded as in any way comparable with the Moorgate accident. Though, with hindsight, one could postulate that such an accident was certain to happen sooner or later, and that special arrangements should therefore have been made to control the approach of trains to terminal stations, it is not my view that any criticism can attach to London Transport on this account.

109. It has long been one of the established signalling principles in this country, both on London Transport and on British Railways, that the normal signal aspect presented to a driver approaching an unoccupied platform at a terminal station should be 'clear', represented in colour light signalling by a green light. The responsibility for controlling the speed of his train on the approach to a terminal station has thus rested entirely upon the driver, relying upon his route knowledge and experience with no assistance from any automatic warning device or, except in some exceptional locations, upon the delayed clearance of a signal or signals. In accordance with this principle, therefore, there was no special warning to a driver approaching Moorgate other than the fixed permanent speed restriction sign indicating the 15 mile/h speed restriction through the crossover, and no fixed train stop at the platform end.

110. Although the verdict at the Inquest was one of Accidental Death, there being insufficient weight of evidence to support any other finding, there must remain the possibility, which cannot be disproved, that the actions of Motorman Newson were deliberate. However unlikely this may be, no preventive measures can be truly complete unless they make provision for this eventuality. Thus any device for limiting the approach speed of the train that can be cancelled or overridden by the driver or which, having ensured a reduction in the train's speed, leaves the driver free to reapply traction power cannot be regarded as a complete protection against an accident of the kind that occurred at Moorgate. From this it follows that the only effective means of preventing a recurrence is to provide a fully automatic control of the train's approach to the terminal, using 'fail safe' signalling techniques, as installed on the Victoria Line of London Transport Railways.

111. Before recommending such a course of action, it is necessary to examine the real risk of such an accident being caused by a deliberate, suicidal, act on the part of a driver. In every form of public transport operation in which the control of a vehicle rests in the hands of an individual this risk exists. The mere fact that there are no known instances of an accident being caused in this way shows that the actual risk must be extremely small and, in my view, could not justify the enormous expenditure required to automate the approach of trains to terminal stations as a general policy.

112. However, in the special circumstances which exist at Moorgate and also at a certain number of other locations, the effects of an accidental overrun, arising from misjudgement or mismanagement on the part of the driver, can be so serious that there is, in my view, a justification for the installation of a system which will take charge to bring the train safely to a stand in the event of the driver becoming incapacitated for any reason.

113. When considering possible ways in which a recurrence of an accident of the kind that occurred at Moorgate can be prevented, there are two distinct ways in which a train can be brought to a stand without the driver's intervention. Firstly, by use of an on-train braking system, brought into operation automatically at the correct point, dependent upon the speed of the train, to stop it within the available distance by utilising the natural adhesion between wheel and rail. The maximum achievable deceleration by this means is of the order of 0.15g (say 5 ft/scc<sup>2</sup>). The alternative is by the application of an external decelerating force, not subject to the limitations of adhesion, but which must be restricted so that the deceleration experienced by passengers is within tolerable limits and which is applied in such a way that the forces imposed on the vehicles can be sustained without causing structural deformation. The factors which must be taken into consideration in devising such a system include the speed and weight of the train, the strength of the vehicles involved, and the available stopping distance. It would of course be possible to rely on a combination of these two methods in which an initial automatic brake application reduced the speed of approach to a level at which an external decelerating force could bring the train safely to a stand within a restricted overrun. Amongst the possible methods of applying an external decelerating force that have already been developed for railway use are friction buffer stops, which slide back along the rails, and various types of rail brakes or retarders designed for use in yards. None of these, however, is designed to deal with initial speeds of impact of more than about 20 mile/h.

114. The theoretical maximum speed that an average loaded 6-car train of 1938 Tube Stock could attain between Old Street and Moorgate was calculated by London Transport as 41 mile/h, assuming that the train resistance in the 16 ft diameter tunnel was approximately the same as that in the open air. In fact, the resistance would be somewhat higher and, based on the fastest of a number of test runs made after the accident, when a train ran through the crossover at 34.7 mile/h before the brakes were applied, the speed on entering the sand drag, assuming the train was still motoring in full parallel, is unlikely to have been higher than approximately 37 mile/h, and would probably have been a little lower if the traction equipment had only notched up into the series position after passing the current rail gap at the crossover. On this basis it seems likely that the speed of the train on entering the sand drag was about 36 mile/h (53 ft/sec).

115. A sand drag is a crude method of applying an external decelerating force and its justification in a location such as Moorgate is to contain a slow speed overrun arising from an error of judgement on the part of the driver, in which role it is both cheap and effective. It would appear that the sand was dispersed by the leading bogie and in the process a short sudden deceleration was applied to the train, sufficient to throw the guard to the floor and some passengers out of their seats and described by some witnesses as something like a sudden brake application. An approximate calculation which gives some measure of support to this subjective estimate can be reached by assuming that the total weight of sand above rail level, estimated at 20 tons, was accelerated from rest to the speed of the train during dispersal. The equivalent loss of kinetic energy by the train would result in its speed being reduced from 53 ft/sec to 50 ft/sec over the 37 foot length of the sand drag giving an average deceleration rate of 4.0 ft/sec<sup>2</sup> lasting  $\frac{3}{4}$  seconds. This would entail a jerk rate amounting to perhaps 15 ft/sec<sup>3</sup>, which would account for the guard being thrown to the floor and some passengers out of their seats. For comparison, the emergency braking rate for a tube train rises to a peak of about 4.4 ft/sec<sup>2</sup> but the accompanying jerk rate does not exceed about 3 ft/sec<sup>3</sup>. It seems likely that the tripcock was operated during the passage through the sand drag and that an emergency brake application was initiated as a result, though no significant retardation of the train could have occurred as a result of this brake application before the leading car hit the buffer stop at a speed which, in my estimation, was close to 50 ft/sec.

116. The immediate cause of the destruction of the two leading cars of the train and the consequential heavy casualty toll was the sudden deceleration imposed on them, the forces involved being far greater than their structures were capable of resisting. In contrast, the absence of damage to the rear three cars indicates that the decelerating forces they experienced were of a level that they could withstand without structural deformation taking place. The approximate distance travelled by the rear of the train after the front hit the buffer stop, the point at which significant deceleration commenced, was 78 ft which, assuming an impact speed of 50 ft/sec, gives an average decelerating force, calculated at the leading end of the fourth car, of about 42 tons, ignoring any contributory braking effect during the period of 3 seconds that the deceleration would have lasted. On the same basis, at the leading end of the third car the force would have been increased to 55 tons, just over the design strength of the underframe, and some small degree of structural deformation in this area could be anticipated and did, indeed, occur.

117. From this admittedly approximate calculation, it follows that the decelerating force that would have to be applied at the front end of a complete 6-car train to bring it to a stand between the beginning of the sand drag and the tunnel end wall, a total distance of some 85 feet, would be of the order of 80 tons and that this itself would result in some degree of structural deformation to the leading cars and the consequent risk of passenger casualties.

118. If a decelerating force is to be applied solely at the leading end of a train, its maximum value must be lower than that at which structural deformation is likely to occur. In the case of 1938 Tube Stock it should not exceed 50 tons, and thus for a fully loaded 6-car train with a weight of about 170 tons the maximum achievable safe retardation is about 9.5 ft/sec<sup>2</sup>. This retardation gives a stopping distance of about 150 ft from 36 mile/h.

119. From this it follows that at Moorgate there can be no safe way of bringing a train to a stand from full speed within the available length of overrun by any form of arresting device, such as a friction buffer stop, in which the decelerating force is applied at the front of the train, and that it would therefore be necessary to reduce the speed of approach to, say, 20 mile/h, from which the train could be safely brought to a stand within 50 ft.

#### RECOMMENDATIONS AND REMARKS

120. Though automatic train operation is the one certain way of preventing the recurrence of an accident such as occurred at Moorgate, it is neither practical nor economic to provide a system of full automatic control of the approach to terminal stations on lines otherwise equipped with conventional signalling and manual control of braking. Nevertheless, it is my view that, as and when the resignalling of tube lines becomes necessary, the introduction of automatic train operation should be regarded as a normal requirement, in view of the overall safety benefits that it confers.

121. In the meantime at underground terminal stations such as Moorgate, where even an incautious approach or accidental overrun could have serious consequences, I recommend that a supervisory control of the train's speed be provided, using the existing and well proven train-stop system, in conjunction with

short speed-check track circuits or timing devices, arranged so that a train will be brought safely to a stand should a driver become incapacitated and for some reason continue to hold down the deadman's handle or misjudge his approach and leave his braking too late. The exact number and location of the individual train-stops must depend upon the individual circumstances but they should be so arranged that a train following a normal safe braking curve and entering the platform at a safe speed will remain fully under the control of the driver.

122. Once the train has entered the platform at a safe speed it is still necessary to ensure that it does not re-accelerate. This can be done by locating additional train stops at ever decreasing intervals towards the end of the platform, or more simply, by using a device to prevent the train drawing from the conductor rail a current great enough to permit any significant acceleration. Such a device would remain effective until an outward route from the platform was set. In this way a high speed buffer stops collision can be prevented.

123. Such a system cannot, however, effectively guard against a driver who, having entered a platform line at a safe speed, then fails to make his final brake application and thus cannot prevent the more common type of buffer stops collision, in which the speed of the train on impact is 10 mile/h or less. Though such collisions are unlikely to result in passenger fatalities, large numbers of injuries could be expected on a crowded train. It is my view, therefore, that consideration should be given to the provision of a more effective external decelerating device than a sand drag at important terminals where, in the opinion of railway managements, even a slow speed collision could have serious results. Furthermore, I recommend that at all terminal platforms on underground railways a fixed train stop be provided immediately beyond the normal stopping point of the longest trains required to use the platform, whether or not any further precautions are considered necessary.

124. Of more general application, I believe that there are good grounds for reconsideration of the signal aspect sequence leading into terminal stations. The present arrangement, using a green aspect for entry into a platform line clear to the buffer stops, derives directly from the traditional use of 2-aspect semaphore signals and provides no reminder to the driver that he is approaching the end of the line. I am pleased to be able to report, therefore, that I have been informed by London Transport that, in future, no train will be permitted to enter a dead-end terminal under clear signals until its speed has been reduced to that which is appropriate to the location and that, in addition, large illuminated speed restriction boards are being provided at the entry to all terminal platforms and dead-end sidings.

125. I have also been given to understand by Officers of the British Railways Board that consideration is being given to altering the signal aspect sequence leading up to the buffer-stops lamp at Red. It has been proposed that, in future, the normal 3- or 4-aspect sequence will be followed with the final signal allowing entry to a platform showing Yellow when clear and that, where the Automatic Warning System is in use, the drivers of trains approaching terminal stations will receive the appropriate audible warnings which, if not cancelled, will be followed by an automatic application of the brakes. I welcome this development, which will ensure that drivers are reminded that they are approaching the end of the line.

126. In considering the special case of Moorgate, it must be borne in mind that London Transport services over the Highbury Branch have already been discontinued and the line will be reopened in due course as part of the Great Northern suburban electrification scheme of the Eastern Region of British Railways, when Moorgate will become the in-town terminal of inner-suburban services to Welwyn Garden City and Hertford North. The rolling stock to be used will be dual-voltage electric multiple-units of Class 313, fitted with both pantographs for overhead collection at 25kV AC north of Drayton Park and collector shoes for use on a 750 DC conductor rail between Drayton Park and Moorgate. Trains will normally consist of two 3-car sets with an overall length of 398 feet and weighting 214 tons tare.

127. The maximum permitted speed between Drayton Park and Moorgate is to be 30 mile/h and provision is being made in the control circuit of the stock, when drawing power from the conductor rail, to shut off power when this speed is attained by means of a relay connected to an electronic speedometer circuit. It has been calculated that, when the air resistance in the tunnel is taken into account, the coasting speed on the falling gradient of 1 in 150 between Old Street and Moorgate will not be significantly greater than 30 mile/h.

128. New 3-aspect signalling is being provided throughout, the red aspects of all stop signals will be supplemented by train-stops similar to those in use by London Transport, and the trains are being provided with tripcocks and control governors to ensure an immediate emergency brake application should a signal be passed at Danger. In addition to the train-stops associated with the signals, a series of 3 additional train stops is being provided on the approach to both platforms at Moorgate. The first, located at the facing points, will be preceded by a timing section arranged so that the speed of the train must be reduced to 15 mile/h by the time it reaches the facing points. The second and third will be located at the entrance to the platform and towards the middle of the platform respectively. Each will be preceded by a timing section arranged to permit a maximum average speed of 12.5 mile/h to allow some tolerance on the permanent speed restriction of 10 mile/h. A further fixed train-stop will be located adjacent to a red stop light at the end of the platform beyond which friction buffer stops will be provided capable of bringing a fully laden train safely to a stand from an impact speed of 12.5 mile/h within the existing length of the overrun tunnel. I am satisfied that these precautions are adequate, both to prevent another accident of the kind that happened



at Moorgate and also to cope with a slow-speed buffer stops collision caused by mismanagement or mis-judgement. In addition, an examination is being made of the practicability of providing a traction current limiting device which will stop the train re-accelerating once it has passed the third train stop, and so prevent an impact with the friction stops at a speed greater than they are designed to cope with.

129. In carrying out my Inquiry into this accident, both in the course of taking evidence from members of the staff of London Transport employed on the Highbury Branch and during visits to the site, I became aware that the level of observance of routine instructions and safety precautions on this line fell short of the high standards expected of London Transport. The late arrival at Drayton Park of various members of the staff on the morning of the accident resulted in trains entering service with scratch crews and without proper preparation. The neglect by the motormen to test their hand-sets before taking up duty is also to be deplored, even though traction current can be cut off by pinching the tunnel wires together and other train-borne telephone equipment enables communication to be established with the Line Controller. The circumstances to which I have drawn attention are clearly not isolated instances of neglect and could, conceivably, lead to situations in which passengers are put at risk. I have subsequently been assured by London Transport that immediate action was taken to bring home to all staff working on the Highbury Branch the importance of strict observance of all the laid down safety procedures.

130. I must also express my concern at the non-completion of a road training certificate in respect of Motorman Newson by Motorman Deadman. Although I am satisfied that Motorman Newson received adequate training and I accept that in this case the absence of a certificate was not relevant to the accident, it did reveal a lack of responsible management at Drayton Park. I am pleased to be able to report that new procedures have been introduced with a view to preventing any recurrence.

131. In concluding this Report I should like to acknowledge with thanks the large number of letters I have received from members of the public embodying suggestions as to why the accident might have occurred or as to how a recurrence might be prevented. Some of these suggestions bore evidence of careful thought and I am grateful for the interest in railway safety which prompted them. I also acknowledge the help I have received from the Officers of London Transport, from members of the medical profession and other interested parties in the course of this investigation.

I have the honour to be,

Sir,

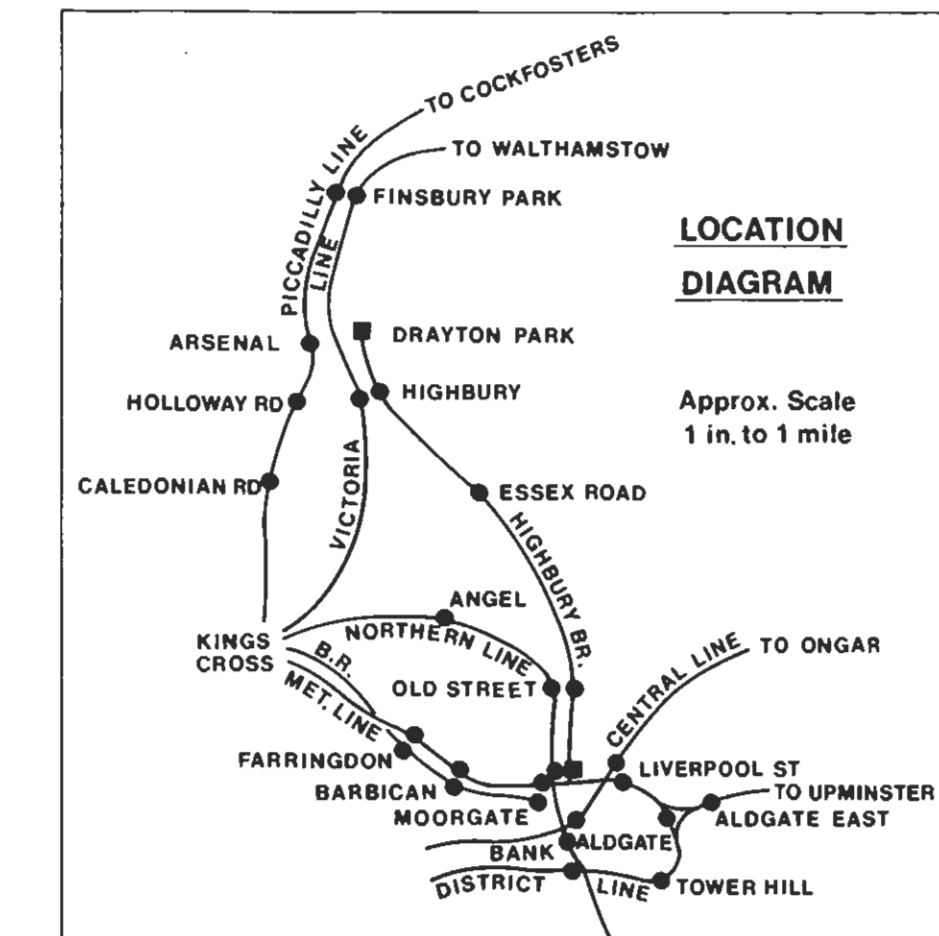
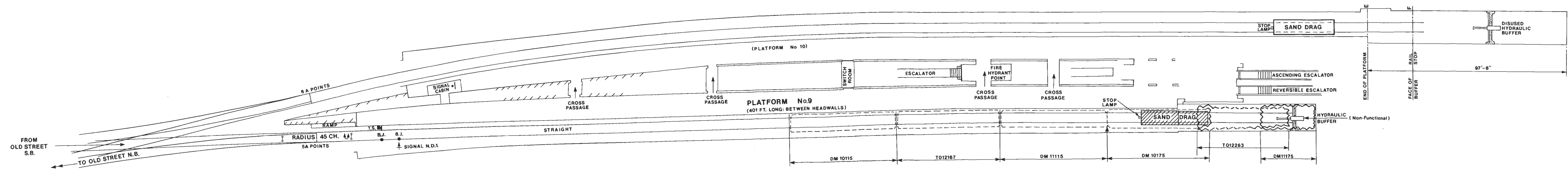
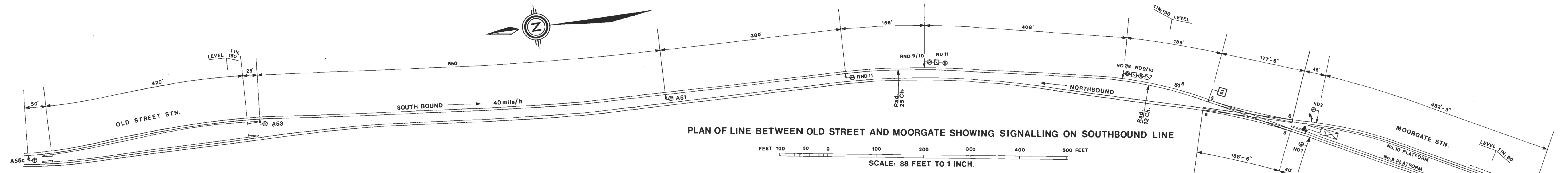
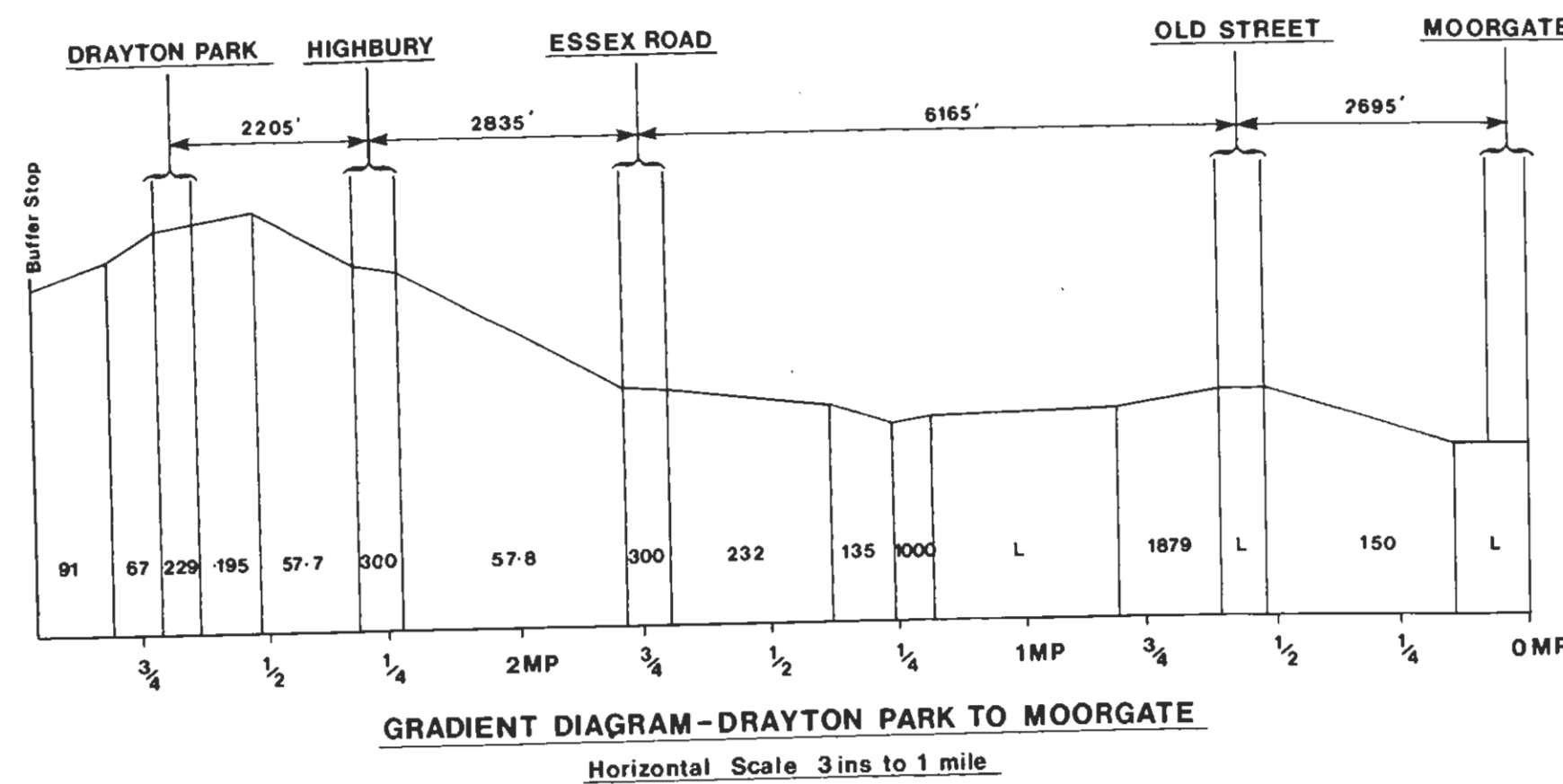
Your obedient Servant,

I. K. A. McNAUGHTON

*Lieutenant Colonel.*

The Permanent Secretary,  
Department of the Environment.

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