HSE
Health & Safety
Executive

A report of the collision that occurred on 8 January 1991 at Cannon Street Station

HSE
Health & Safety Executive

A report of the collision that occurred on 8 January 1991 at Cannon Street Station

London: HMSO

First published 1992

Enquiries regarding this or any other HSE publication
should be made to HSE's Information Centre at:

Broad Lane
Sheffield S3 7HQ
Tel: (0742) 892345
Fax: (0742) 892333

ISBN 0 11 886303 7

CONTENTS

The Permanent Under Secretary of State
Department of Transport

HM Railway Inspectorate
Health and Safety Executive
Baynards House
1 Chepstow Place
Westbourne Grove
London W2 4TF

2 March 1992

Sir

I report for the information of the Secretary of State for Transport in accordance with the direction dated 14 January, 1991 the result of my Inquiry into the collision of a passenger train with the buffer stops at the end of one of the platforms at Cannon Street Station, London, on Tuesday 8 January, 1991.

At approximately 08 44 hours, the 07 58 passenger train from Sevenoaks to Cannon Street Station collided heavily with the hydraulic buffer stops of platform 3 at the terminal station. The most significant damage to the train occurred where the fifth coach partially overrode the sixth coach. Regrettably two passengers lost their lives as a result of the collision. Of the other passengers on the train 542 suffered injury, 277 were treated in hospital and 33 of those were detained for one or more nights.

As a result of the accident, Cannon Street Station was closed while the emergency services attended to the injured and released those trapped in the wreckage of the fifth and sixth coaches. Platforms 5 to 8 were re-opened in time for the evening rush hour and all platforms, with the exception of platform 3, were available by the following morning. Platform 3 was re-opened for the morning of Monday 14 January after the buffer stops had been restored and following the normal weekend closure of the station.

In addition to establishing the cause of the accident I was asked by the Secretary of State to consider as part of my Inquiry what part the age and construction of the rolling stock, and the number of passengers on the train, may have played in the accident and in the number and severity of the injuries.

I started my investigation at the scene of the accident and, once the emergency services had completed their tasks, I agreed with the senior railway officers present the way the examination and testing of the train was to be undertaken.

The work was directed and supervised by Mr D A Sawer, Principal Inspecting Officer of Railways, who provided valuable assistance to me throughout my Inquiry. I heard evidence in public from 25 February to 28 February and on 4 March 1991. Following the public hearing of evidence I undertook further investigations on a number of matters. These investigations were either not suitable or not appropriate to be undertaken in public. These matters are included in my report.

A COOKSEY
HM Deputy Chief Inspecting Officer of Railways

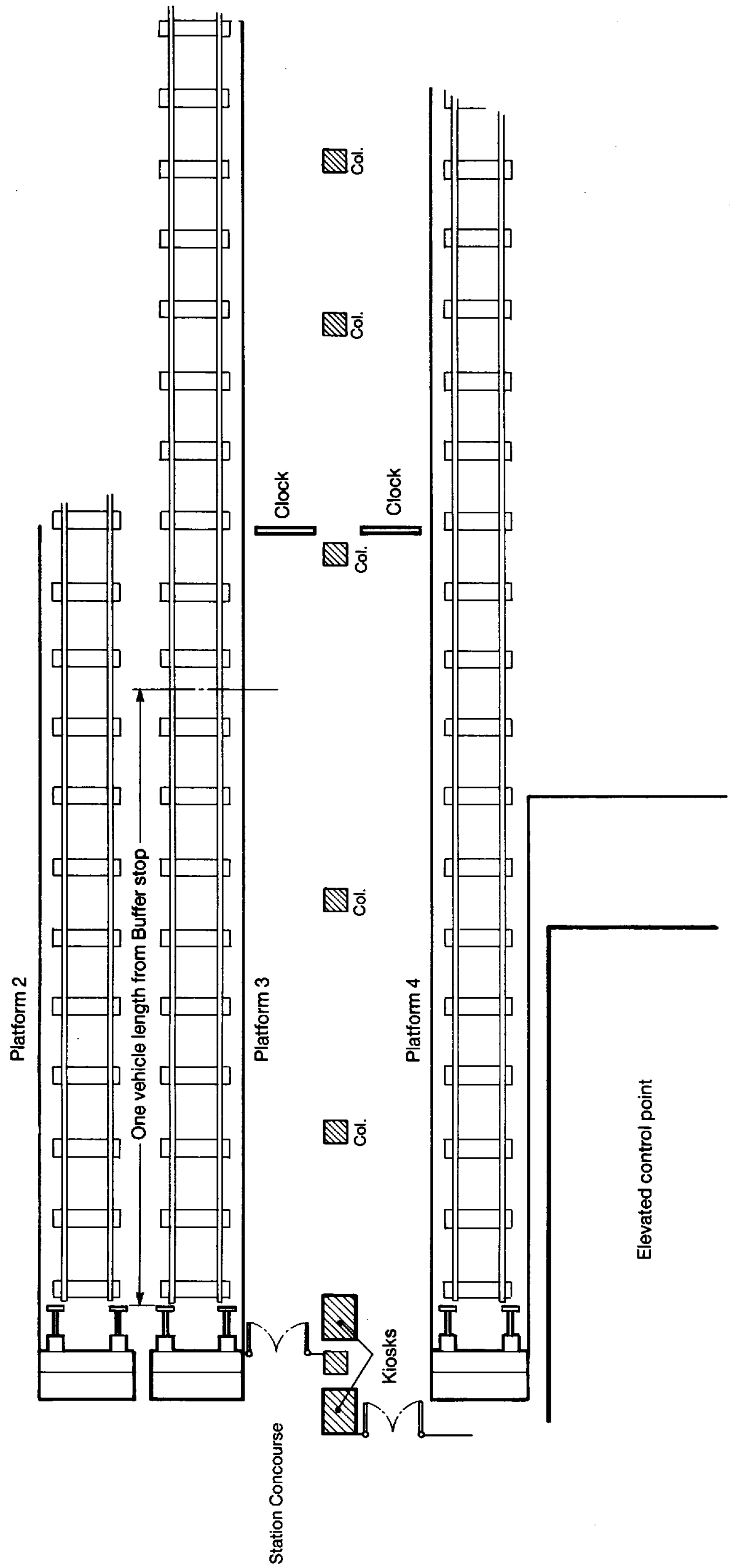

Figure 1 Cannon Street Station plan of buffer stop area.

DESCRIPTION

Cannon Street Station

1 Cannon Street Station is one of the busiest of British Railways (Southern Region) London terminal stations. It largely caters for commuters working in the City of London. The station also provides an interchange with the Circle and District lines of London Underground. The station is open between the hours of 05 00 and 20 00 Monday to Friday only, with the predominant train movement taking place between 07 30 and 09 30 and between 16 30 and 18 30 on each of these days.

2 During the peak times train services emanating from coastal and London outer suburban areas, such as Hastings, Dartford and Hayes, operate into Cannon Street Station and vice versa. At off-peak times a shuttle train service between London Bridge Station and Cannon Street Station is provided at 15 minute intervals. There is no service at the weekend.

3 The station comprised eight platforms with platforms 1 to 4 capable to taking trains of up to ten cars in length and platforms 5 to 8, trains of up to 12 cars in length. Each platform was provided with hydraulic buffer stops of considerable age. The layout of the station is shown in Figure 1.

4 For some 18 months prior to the accident extensive rebuilding of the station had been taking place. All the platforms were covered for the major part of their length by a structural raft, supporting new buildings constructed above the platforms. Trains proceeding along the covered part of the station do so under artificial lighting conditions. At the time of the accident the work of reconstructing the station was not complete and, in particular, there was still temporary lighting beneath the raft on some platforms, including platforms 3 and 4.

The track layout and signalling

5 The track layout at the time of the accident on the approaches to Cannon Street Station is shown in Figure 2. From Borough Market Junction to Cannon Street Station there are four running lines: up fast; down fast; up slow; and down slow; from left to right in the direction of approach to Cannon Street. A permanent speed restriction of 20 mile/h applies on all lines between Borough Market Junction and the platform approaches at Cannon Street with a 15 mile/h permanent speed restriction applying thereafter.

6 There is also a reversible line, adjacent to the up-fast line, serving the main line side of the station and used by empty coaching stock trains running to and from various depots and stabling points via Metropolitan Junction. There are two sidings to the west of the main line side of the station. The outermost of the two is used for stabling empty coaching stock and the other is retained for engineers' trains.

7 The lines are electrified on the 750 V dc third rail conductor system. All running lines are worked under the British Railways Board's Track Circuit Block Regulations and are equipped with multiple-aspect colour light signals and an automatic warning system (AWS). The lines are controlled from the London Bridge signal box.

The train

8 The train was the 07 58 passenger train from Sevenoaks to Cannon Street where it was due to arrive at 08 40. It was timetabled to call at: Dunton Green, 08 01; Knockholt, 08 07; Chelsfield, 08 10; Orpington, 0814; Petts Wood, 08 16; Grove Park, 08 24; and London Bridge, 08 36.

9 The train consisted of three electric multiple units (EMUs) with a total of ten coaches. From front to rear it was formed from:

4-car unit No 5618	
Driving motor brake coach	No 61585
Trailer coach	No 70444
Trailer coach	No 70443
Driving motor brake coach	No 61584
4-car unit No 5484	
Driving motor brake coach	No 14046
Trailer coach	No 15308
Trailer coach	No 15031
Driving motor brake coach	No 14061
2-car unit No 6227	
Driving trailer coach	No 77526
Driving motor brake coach	No 65341

10 Unit No 5618 was of class 415/6, introduced in 1960 and built to the British Railways Board's Mark I passenger coach design standards. Unit No 5484 was of class 415/4, introduced in the 1950s. However, the individual coaches of this unit were initially in different units and were rebuilt from earlier vehicles. (Details are given in paragraphs 213 to 217). Unit No 6227 was of class 416/2, introduced in the mid-1950s and also employing the British Railway Board's Mark I standards.

11 The general external appearance and internal fittings of the units were similar. The driving motor brake vehicles had a driving cab at the outer ends with a brake (guard's) compartment adjacent to it. Access to the driving cab was through the brake compartment. Vehicle Nos 61585, 61584, 14046 and 14061 had 82 standard class seats in an open saloon. Vehicle No 65341 had the passenger area divided into two saloons and a total of 84 standard class seats.

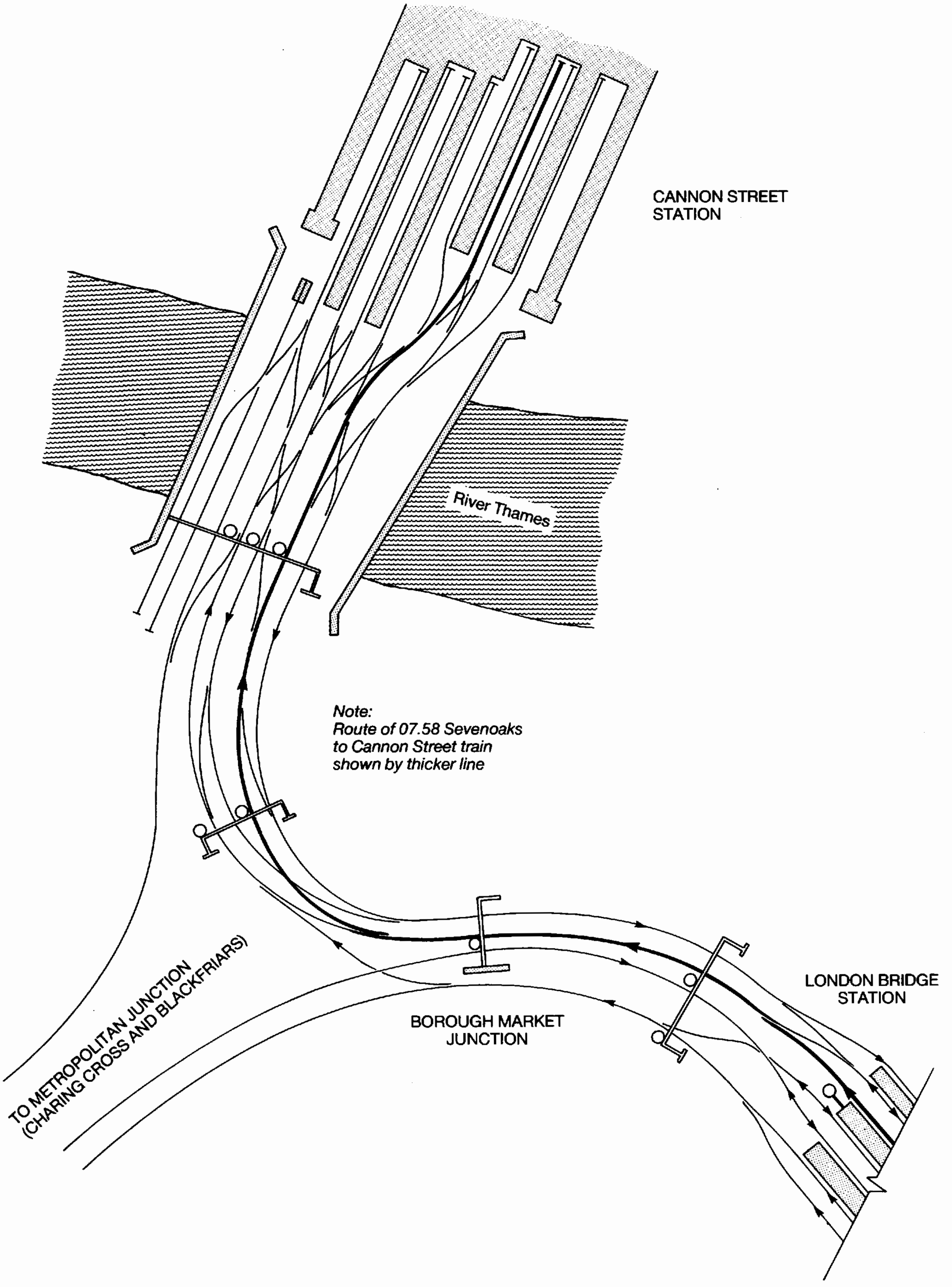

Figure 2 Track layout on approaches to Cannon Street Station

12 The intermediate trailer coaches of unit Nos 5618 and 5484, that is, vehicle Nos 70444, 70443, 15308 and 15031, each had 102 standard class seats in an open saloon. The driving trailer coach No 77526 of unit No 6227 had a driving cab with an access vestibule at the end and 102 standard class seats in a mixture of open saloon and individual compartments. The typical seating arrangement is shown in Figure 3.

13 There were no gangway connections between the units or individual vehicles in the units. Each compartment or seating bay had individual hinged, passenger-operated (slam) doors. The outer ends of the units were equipped with side buffers and an automatic coupler. The internal couplings within the unit were provided by a centre buffer and chains. This arrangement is shown in Figure 4.

The train's braking system

14 Units of classes 415 and 416 are collectively known as EPB units because of the electro-pneumatic brake equipment fitted to them. The brake equipment, though not identical throughout the train, was wholly compatible. The oldest unit was built between 1948 and 1954 and the latest in 1960. During this period Westinghouse, the manufacturer of all the equipment concerned, had updated their product within the parameters of the performance specification. The description which follows covers the basic principles of operation of the braking system.

The basic equipment

15 The basic components of the brake equipment are as follows:

Air compressor - one per unit. Electrically driven.

Auxiliary reservoir - one on each vehicle - with the brakes released it is charged to air brake pipe pressure - in full automatic application it discharges into the brake cylinder equalising at the maximum braking pressure.

Brake cylinder - one on each vehicle - when supplied with air causes the brake blocks to be applied to the wheels of that vehicle via the mechanical rigging.

Brake pipe - charged via the driver's brake valve which is in use - runs continuously throughout the length of the train.

Driver's brake valve - controls the charging air supply to the brake pipe in release and running and the application lapping and release of the train's brakes in the other positions, including electro-pneumatic (EP), automatic and emergency brake operations.

The control handle has five positions as follows:

1 Release and running (both brakes);
2 Full EP application;
3 Lap (automatic brake);
4 Automatic brake application;
5 Emergency (both brakes applied).

EP application valve - one on each vehicle - when energised it admits main reservoir air into the brake cylinder via a 50 lbf/in sq limiting valve.

EP holding valve - one on each vehicle - when energised via the train line it seals the exhaust port of the brake cylinder on that vehicle.

Lap position - position 3 for the driver's brake valve. In this position the brake pipe is isolated from the air supply but is not connected to exhaust. Brake pipe pressure, therefore, remains constant at the pressure set prior to the brake valve being moved to the lap position.

Main reservoir pipe - connected directly to the air compressors and running the length of the train.

Train line - a 27-way electrical cable running the length of the train with dedicated wires for the control of the electro-pneumatic brake.

Triple valve - one valve on each vehicle - operation controlled by pressure in the brake pipe - allows air from the auxiliary reservoir to the brake cylinder when a brake application is made and from the brake cylinder to atmosphere during the release of the brakes.

The electro-pneumatic brake operation

16 This is controlled by operating the EP valves throughout the train via the 70-volt train line. Any interruption of this supply results in the degraded operation of the brake at or beyond the point on the train at which the interruption occurs. Hence the EP brake is not fail safe. It is, however, very responsive when operating instantaneously throughout the train and is virtually inexhaustible, using main reservoir air. It is used almost universally by train drivers in service, apart from the obligatory stop with the automatic brake they are required to make during each journey.

17 Movement of the brake handle away from release and running and into EP closes a contact at the brake valve. This, in turn, energises contactor coils mounted on an equipment panel in the back of the cab which, in turn, through the train line, energise the holding and application EP valves at each carriage. Air from the main reservoir is admitted to each brake cylinder until the application valves are de-energised by the opening of the contact at the brake valve by a small piston sensing the pressure in the brake cylinder on the

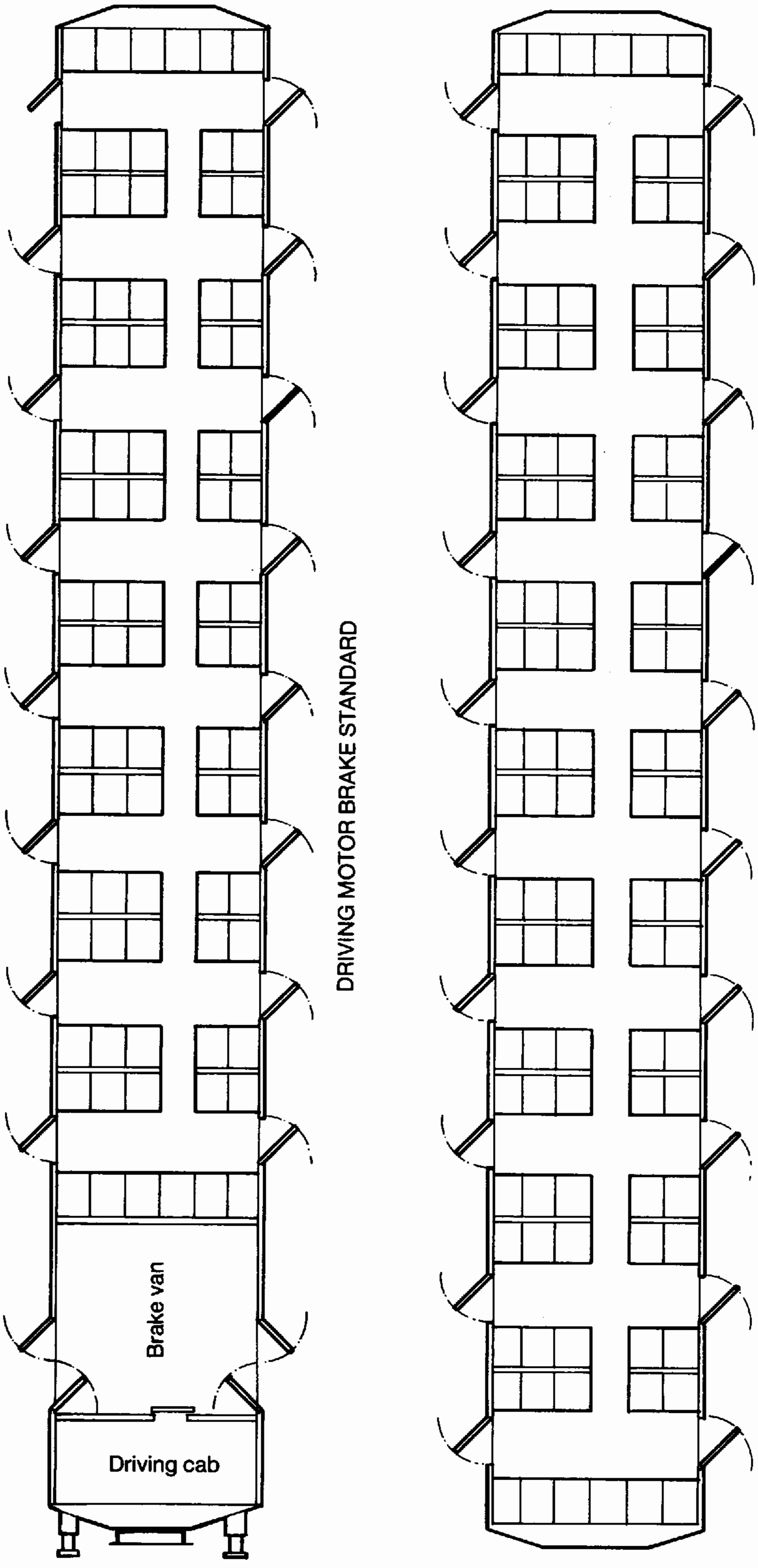

Figure 3 Seating arrangement of electrical multiple unit

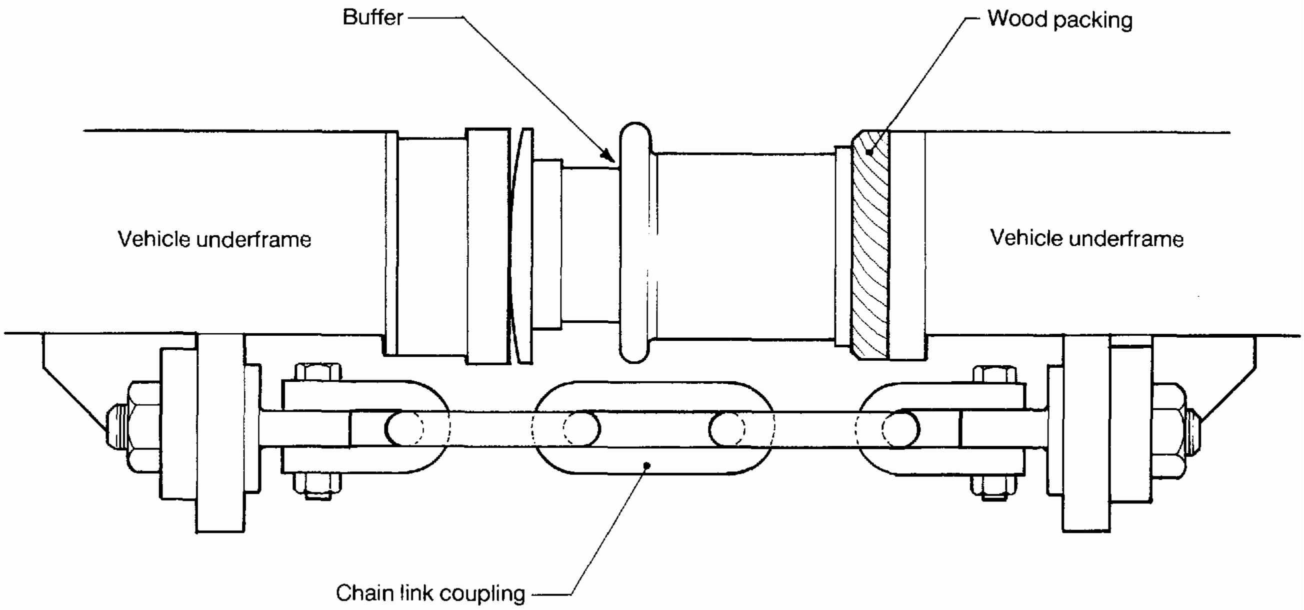

Figure 4 Centre buffer and coupling

leading vehicle. During EP braking the degree of application relates to the amount the handle is moved away from the release position and is self lapping.

The automatic brake operation

18 By moving the handle smartly through the quadrant of EP operation the lap position is reached without initiating the EP brake. With the handle in this position air is no longer supplied to the brake pipe. Further movement of the handle causes air pressure to be lost from the brake pipe in proportion to the length of time the handle is kept in this position. Restoring the handle to lap maintains the brake pipe at the new, lower pressure. The triple valves respond to the loss of air pressure and move to allow auxiliary reservoir air to expand into the brake cylinders in direct proportion to the brake pipe pressure reduction. Restoring the handle to release and running recharges the brake pipe, the triple valves move back allowing the auxiliary reservoirs to be recharged and the brake cylinders to release by venting to atmosphere.

The emergency brake

19 The fifth position of the driver's brake valve is the emergency brake position. Movement of the control handle through the other brake positions and into the emergency position causes a full application of both EP and automatic systems.

SUMMARY OF EVIDENCE HEARD IN PUBLIC

As to the events of the collision

20 *Mr I Giles* was a passenger on the train, having boarded at Grove Park. This was a familiar journey for him, he had travelled the route regularly for six years and taken this particular train for the past six months. He was in the second carriage, standing half way along the gangway between the seats, sideways to the direction of travel and facing the left window. Although there were usually seats available nearer the rear of the train he generally chose to stand in a forward carriage as this would permit a quicker exit from Cannon Street Station.

21 Mr Giles said the journey had passed as normal. He was sure that there had been no excessive speeds, no sudden or late braking and nothing which caused juddering or violent shaking or movement of the carriages. The approach to Cannon Street was unremarkable and, as was usual, the train had begun to slow down as it neared the station.

22 As it ran alongside platform 3, it seemed to Mr Giles that the train was freewheeling. He said it was usual to hear and feel the brakes being applied but on this occasion he did not, neither did he feel the train was under power. In response to a number of questions on this point, he was adamant that he did not detect braking after the carriage had passed the first quarter of

the platform. He did not, however, at this stage feel concerned and he was not aware of any alarm or panic amongst the other passengers. He had collected his possessions and was prepared to disembark. He was watching the platform as it went by and it then occurred to him that the train still seemed to be moving a little fast and did not appear to be slowing down. This was only moments before impact.

23 When the impact occurred, Mr Giles was thrown off his feet. He fell against a seat and struck his head against a luggage rack, sustaining bruising to the head, shoulder and leg. At the same moment, other passengers were being thrown about and it appeared that some seated passengers facing the direction of travel had been thrown forward against those seated opposite them. The lights had gone out, some light fixtures had fallen down and there was glass on the floor. Mr Giles could not say with certainty whether any of the carriage doors had already been opened on this occasion but said in his experience it was common practice for doors to be opened by passengers before the train stopped.

24 Mr Giles was asked if he could estimate the speed of the train on impact. He suggested that it would be about 10 to12 mile/h but did acknowledge there was a margin of error. It was difficult in the circumstances to be sure but he estimated the speed to be that of someone running at a fast jog.

25 *Mr A Knight* (a detective sergeant in the British Transport Police but travelling as a passenger) boarded the train at London Bridge. He was accompanied by Miss J Freeman and they entered the third or fourth carriage. No seats were available and they stood in the central gangway along with several other standing passengers. The journey from London Bridge was smooth and uneventful: nothing occurred to indicate anything might be amiss.

26 On the approach to Cannon Street, Mr Knight was aware the train was slowing down and, though engaged in conversation, he knew when they entered the station because the light was less under the station roof canopy. Other passengers were collecting their belongings and some stood up ready to leave the train but Mr Knight could not say whether any of the doors had been opened. Nothing in the passengers' behaviour suggested that anyone was alarmed in any way and neither Mr Knight nor his companion felt any cause for concern. He could not recollect any sound or sensation which indicated that brakes were being applied nor could he hear the sound of traction motors. He described the train's progress as coasting.

27 At the moment of impact, there was a very loud bang and Mr Knight was thrown to the floor, almost landing on his companion who also fell. The lights went out and there was shouting and screaming. Other passengers had been thrown and hurt, many receiving face and head injuries. Mr Knight received a whiplash injury to his neck. After a few minutes, during which he sought to comfort his distressed and shaken companion and ensure she was not seriously hurt, Mr Knight left the train in order to help other passengers trapped in carriages further back.

28 Mr Knight could not accurately judge the speed of the train when it struck the buffer but, based on his experience of many previous journeys into Cannon Street and his general impression at the time, he felt it must be between 5 and 10 mile/h.

29 *Mrs P M Webb*, a regular passenger on this route, was travelling with her husband from Petts Wood. They were seated near the front of the sixth carriage facing the direction of travel. After a routine journey, the train slowed down and, as it entered Cannon Street Station, Mrs Webb and her husband both stood up to prepare to disembark. She could recall no sensation that the brakes were being applied, nor did the train appear to be under power - it was coasting.

30 At this stage, she did not feel there was any reason for concern, nor apparently did other passengers. Suddenly there were three violent jerking sensations and Mrs Webb thought fleetingly that they were having a rough ride. Split seconds later the impact occurred. To what she thought was the sound of splintering wood and metal, the lights went out and the front of the carriage was pushed inwards. Severe damage was done to the front and roof of the carriage, and to the fittings and front seats. Mrs Webb and her husband were trapped by the legs between the seat they had been sitting on and the one in front. A passenger alongside them was thrown forward and his arm had been trapped. Mrs Webb could see that other passengers were in difficulties, most had their legs trapped. A few minutes later, she noticed electrical sparks arcing across the damaged roof and her husband shouted out that the power was still on. Shortly afterwards the flashes stopped.

31 The first rescuers to arrive were apparently workers from a nearby building site; they had torches with them. Between 10 to15 minutes after the impact the emergency services were there and arc lighting was set up. It seemed to Mrs Webb that this lighting was intermittent, occasionally going out or being obscured. She also heard talk about a shortage of equipment, specifically a screwdriver, and, on another occasion, apparent loss of an air supply for the power cutting tool. These incidents seemed to cause some delay in the rescue operation. While they were waiting to be released, Mrs Webb noticed someone taking a video of the scene. The photographer was in a uniform and she concluded it was a fire brigade officer. Later, someone

else, not in uniform, was taking flash photographs. Mrs Webb found this upsetting.

32 Mrs Webb and her husband appreciated that, because of the complexities of the rescue operation and the number of other people in greater need also trapped in the wreckage, it would be some time before everyone was released. She was eventually extricated from the train shortly before 11 00, about two hours after the collision.

33 *Miss H Croxford,* who travelled this route every day, boarded at Grove Park. She was in the sixth carriage and, from London Bridge onwards, was seated at the front of the carriage with her back to the direction of travel. Before Cannon Street there was nothing untoward or unusual during the journey. She recalled the train braking as it approached London Bridge but not when it entered Cannon Street. She said that braking usually causes some jolting forward, and this is particularly noticeable when attempting to read a newspaper. Her impression at Cannon Street was that the train was free wheeling as it entered the station. While this caused no alarm initially, it did occur to her, half to three quarters of the way along the platform, that they were still going a little faster than usual.

34 Miss Croxford heard the crash and a loud screeching at the time of impact. The lights went out and she was pulled backwards into her seat which then seemed to disappear from beneath her. The seats facing her came forward and trapped her legs and she had to duck to avoid a luggage rack which broke free and flew towards her. She shortly discovered that her feet appeared to have gone through the floor and her right foot was down on the ground. A number of other passengers were also trapped. Miss Croxford saw no sparks herself but heard other passengers referring to their concern that the power had not been turned off. She did however see someone on the platform taking photographs and someone using a video camera. This was shortly after the accident and they may or may not have been associated with the rescue services. Miss Croxford was eventually freed, approximately two and a quarter hours after the collision.

35 *Leading Railman W Batchelor* was on duty at Cannon Street at the time of the accident. He was about a third of the way along platform 3 as he watched the train enter the station. It seemed to be approaching and running along the platform at normal speed. Mr Batchelor estimated this to be 5 mile/h or very slightly faster. He heard no sound of braking nor of the traction motors. Many of the doors were being opened as passengers prepared to alight.

36 The fifth carriage had come alongside him when he heard a loud bang and the train came to an abrupt halt. The nearest carriages, which were the fifth and sixth from the front, reared about a foot into the air and fell back onto the track. The ends of these coaches had become entangled and there was a lot of screaming. Some people fell from the open doorways onto the platform.

37 Mr Batchelor briefly checked the rear of the train, he could make no progress towards the front and then quickly made a 999 call for ambulance and fire services. This was at 08 46 or 08 47. He did not speak to the driver but the train guard, who had alighted, asked him what had happened. Mr Batchelor then crossed platforms 4 and 5 to ensure the control point was aware of what had happened and that full emergency services were required.

38 *Leading Railman D Hamlin* was on duty in the kiosk by the ticket barrier at the buffer stop end of platform 3. When he heard the train, he glanced up and saw it enter the station approaching him almost head-on along platform 3. His view at this stage was somewhat restricted by pillars and workmen's hoardings on the platform but the approach seemed quite normal. He briefly completed some paperwork and then stood up and looked again at the train. By this time it was about one coach length from the buffers, the doors were open and passengers were ready to alight. He thought the train was still travelling quite fast and estimated the speed at 10 to15 mile/h. He realised it wasn't going to stop in time.

39 Within seconds the train hit the buffers, there was a loud bang but Mr Hamlin heard no sound of brakes - neither screeching nor the hiss of air release. People were screaming and he was a bit shocked but went to help passengers from the front carriages. Some of his colleagues were trying to open the doors of the leading brake van. This was made difficult by the pressure of passengers behind inward opening doors.

40 *Mr S P Kingsford,* a clerical officer employed by British Railways at Cannon Street Station at the time of the accident, was at the window in the control point which is a raised structure located between platforms 4 and 5. It is approximately 15 feet above platform level and overlooks the buffer stop end of the platforms. He tended to keep an eye on the trains arriving at platform 3 because it was the narrowest of the platforms and could become congested if there were a lot of passengers.

41 He saw the train when it was about 30 yards from the buffers. As he did so, he thought it was travelling faster than he would normally expect and that it was not going to stop in time. In normal circumstances, Mr Kingsford estimates that trains at this point are moving at 3 to 5 mile/h. But on this occasion, he judged the speed to be between 10 to 15 mile/h and the train did not appear to be slowing down. This opinion was based

on his 10 years' experience of observing trains arriving every day at this and other platforms at Cannon Street.

42 He noticed that there was no squeal of brakes and no hiss of an air release though it is usually possible for him to hear this. Some carriage doors were already open when the train hit the buffers though Mr Kingsford did not see if any passengers fell out at the moment of impact. The train came to a dead stop and did not rebound from the buffers. Mr Kingsford alerted his colleague to what had happened and then telephoned the emergency services.

43 *Mr M Fresco* believed he was the first member of the press on the scene, having arrived at Cannon Street just after 09 00. There were injured people on the forecourt. He used his camera there but was refused access to platform 3. He saw no other photographers about but said that a freelance photographer, who had travelled on the train, may have taken some photographs. He also understood that a Daily Express helicopter with a paramedic team on board was in the vicinity. He believed that when they went into the damaged carriages, photographs may have been obtained for the Daily Express.

As to the actions of the emergency services

44 *Mr M Coffey*, a Deputy Assistant Chief Officer in the London Fire Brigade, was the principal uniformed officer responsible for operations in the London North area. He had had 20 years' experience with the Brigade, mostly in an operational capacity. He confirmed that the first call to the Brigade was received at 08 50. Emergency rescue units were ordered to Cannon Street and the first of these arrived at 08 53. First-aid equipment was taken to the platform and, after a preliminary assessment, a search and rescue operation was mounted. Additional rescue vehicles and equipment were called for, these arrived within minutes and Major Incident Procedure was initiated at 09 06.

45 At 09 11, Mr Coffey was informed of the incident and he went at once to Cannon Street. On arrival, he was updated by the Brigade's Divisional Officer at the scene, informed about the emergency services liaison meeting and received confirmation that all traction power had been isolated at Cannon Street Station. At 09 43 he instructed the control unit to send for further equipment and personnel which were required for command and control duties. He then went to assess the situation at platform 3.

46 A number of people were being treated by ambulance and fire crews and all emergency services were involved in the rescue operations. The principal area for concern centred on the fifth and sixth badly damaged carriages, where between 10 and 18 people were still trapped. The rest of the train had been cleared of passengers and, in Mr Coffey's judgement, adequate resources and manpower were available at this stage. The resources included acrow props, lifting and cutting equipment, air cylinders and fuel for the engines of the hydraulic pumps and lighting generators. Additional staff and equipment were also on hand should they be needed. The complexities of the operation and the risks of aggravating injuries to people trapped within the confines of the crushed carriages were the factors which would cause delay. Mr Coffey judged that it would take 2 to 3 hours to release them. This information was conveyed to his senior officer when he assumed responsibility and to the joint services liaison meeting which Mr Coffey attended at 10 05.

47 The first of the people who had been trapped was released at about 11 00 and the last just after 12 noon - three and a quarter hours after the crash occurred. Some casualties were moved from the scene by air ambulance. At the subsequent liaison meeting held at 13 30 it was decided that the London Fire Brigade should cease operations. An appliance and crew would remain at the scene should further help be required and a Divisional Officer remained in charge when Mr Coffey left Cannon Street shortly after 14 00.

48 Mr J Oakden, Assistant Chief Ambulance Officer of the London Ambulance Service, was the first senior officer to arrive on the scene and was the designated incident officer until 10 30 when the Divisional Assistant Chief Officer took over.

49 The first call received by Central Ambulance Control was timed at 08 46. At 08 48, two ambulances were despatched to Cannon Street, the emergency control vehicle (ECV) and the training division were put on standby. Subsequent telephone calls indicated the seriousness of the incident and further ambulances and the ECV were sent. The first ambulance arrived on the scene at 08 52 and, as a consequence of the crews report, the full emergency plan was initiated and additional staff and vehicles were rapidly deployed. Three hospitals were involved. St Bartholomews, the designated hospital, was put on standby at 08 53 and, as a major accident had been declared, the Royal London Hospital was informed at 08 59 and Guys at 09 01. Throughout the period of the incident, a continual build up of ambulances, staff and other resources was maintained. These included the helicopter emergency ambulance, medical assistance from three doctors from BASICS (see paragraph 52), medical teams from the three hospitals, 24 ambulances, 44 officers and supplementary help from London Transport in the form of buses and drivers.

50 On arrival at the station, Mr Oakden found many passengers receiving medical attention on the station concourse. There were others on platform 3 and on the train, some seriously injured or unconscious. There

were also a number of passengers trapped in the damaged coaches. The ambulance service was deployed in three teams - one to assist on the main concourse, one to help evacuate the train and the third to deal with passengers who were still trapped. Dr Hines, a BASICS doctor, arrived at 09 15 and he became the site medical officer.

51 By 09 55, the majority of casualties had been removed to hospital. Ambulances took 53 to St Bartholomews, 11 to the Royal London and 12 to Guys. A further 189 with minor injuries, accompanied by ambulance service staff, were taken to hospital by London Transport and by other means. At 10 20, Central Ambulance Control were advised that no additional ambulances would be needed. Sufficient vehicles remained on site for the remaining passengers who were still trapped and staff were assisting in the rescue operations. At 10 50, the number of ambulances was reduced to six and the last casualty was released and taken to hospital at 12 20. The incident was closed at 12 33.

52 Mr Oakden explained that BASICS was a voluntary association who formed teams of doctors who would respond quickly to calls from the ambulance service. When asked about the advisability and implications of using London Transport buses to convey injured passengers from the scene he said that co-operation had been impressive and effective. With ambulance staff in attendance, a large number of people with lesser injuries had been quickly and efficiently moved to hospital. This minimised delay and congestion and gave ambulances and their crews immediate access to more serious and high priority casualties.

53 *Superintendent J W Utley*, of the British Transport Police, was the Sub-divisional Commander in South-East London, his area of responsibility included Cannon Street Station. The first report of the collision to reach the British Transport Police was received via the City of London Police at 08 45 and both forces despatched officers to the scene. The first constable arrived at 08 45; he was already on duty near Cannon Street. Within minutes he was joined by City and Transport Police and rescue operations were already under way when an inspector of the British Transport Police arrived at 08 55. He assessed the situation and immediately declared a Major Incident.

54 Control and rendezvous points were established, a casualty enquiry bureau set up and emergency services co-ordination meetings arranged. These meetings were attended by representatives from each of the services who exchanged briefings and agreed procedures and co-operative measures to be taken. City of London Police took responsibility for the outer cordon and casualty enquiries, British Transport Police dealt with the inner cordon and site of the accident. Seventy-six British Transport Police officers were at some stage involved during the operation and the casualty bureau handled 2093 enquiries. The final casualty had been removed and the fire and ambulance services had withdrawn just after 13 30.

55 A joint inspection of the scene of the accident and wreckage was made by British Transport Police and staff of HM Railway Inspectorate and British Railways. Superintendent Utley answered a number of questions about various aspects of the police activity. Although not present at Cannon Street on the day of the incident, he was able to assure the Inquiry that liaison and co-operation between the British Transport Police and the British Rail incident officer were excellent.

56 He said that the officers who were at the scene would have been aware of the recommendations of the Hidden Inquiry into the Clapham Junction accident. They would be aware, also, of the subsequently agreed procedures to be followed in the event of an accident to preserve and record vital information or evidence which could have a bearing on the cause. He could not be precise about how closely these procedures were followed but is clear that when the chief superintendent arrived at the scene at approximately 09 15, access to the driving cab was immediately restricted. It was not possible however to know whether anyone had access to the cab or had entered it prior to this and Superintendent Utley agreed that the earliest photographs taken at 09 35 would not necessarily exactly reflect the state of the cab or position of the controls immediately after the moment of impact.

57 Asked about photographers on the scene, he was unable to speak for the fire or ambulance services but confirmed that use of cameras by police officers would have been directly under the control of senior officers. He said that the news media would have been denied access in the circumstances. He was not aware of any unauthorised person attempting to take videos or photographs or being prevented from doing so. He said it was not standard police practice to test rail crews for the presence of drugs or alcohol in the aftermath of an accident, such as may happen after road accidents. The matter had been the subject of discussion but had not been progressed beyond that.

As to the driving of the train

58 *Mr P L Gloster*, a British Rail employee, had been a driver since 1974 with considerable experience driving trains of the type involved in the accident at Cannon Street. He was not there at the time of the incident but had driven a similar train into platform 3 a little earlier, at 08 24 on the same morning. He was asked to describe his approach and the way in which he had brought the train to a stop on that occasion.

59 He said the approach had been perfectly normal and, having braked as he neared the station, entered platform 3 at about 10 mile/h, the power was off and the train was slowing down. He experienced no difficulty or distractions and the buffer stop lights were visible. Halfway along the platform, now running at 5 to 6 mile/h, he applied the EP brakes again, then released them. The train slowed down further and a final light touch of the brakes brought it to a standstill about six feet from the buffers. This, he said, was an entirely typical approach but, as the train was heavily loaded, the speed was slightly less than would have been the case with fewer passengers.

60 Mr Gloster said that drivers familiar with Cannon Street and knowing the lighting was not particularly good, would allow for this and compensate for the rapid transition from daylight to relative gloom as the train entered the station. Mr Gloster said he had never experienced a failure of EP brakes but that if it ever did happen he would go straight into emergency. If this occurred when he was entering Cannon Street, he considers he could safely stop the train by this means. Asked about the possible risks of going into lap when applying the EP brakes, he said this could not happen if the speed of the train and brake applications were appropriate for entry to a terminus station. If however the brake valves were faulty, and this happened very rarely, he acknowledged that an overshoot into lap could occur when the train was travelling somewhat faster and a sharp application of the brakes was needed.

61 *Mr P R Bright*, a British Railways train driver for 18 months and previously a guard for 15 years, was seated in his driving cab at the country end of an eight-coach train on platform 2 at Cannon Street. He saw the Sevenoaks train approaching practically head-on as it came in towards platform 3, immediately alongside and to the right of Mr Bright's train. Just before it reached the beginning of the platform, he estimated the speed to be 10 to15 mile/h, it was slowing down and, as it passed his cab, he put the speed at 5 to 6 mile/h. He thought it might stop a little short. He recognised the driver, Mr Graham, who appeared calm and in control.
Mr Bright did not notice the sound of the traction motors, the train appeared to be coasting and he paid no further attention to it because he was preparing to take his own train out. He heard the bang and saw clouds of dust as he looked back along platform 2. He got out, ran down the platform and, accompanied by his guard, went round to platform 3. They saw Driver Graham standing holding his head. After asking him if he was alright, to which he replied "yes", he went to help the passengers.

62 During his 18 months as a driver, Mr Bright had brought trains into Cannon Street many times. He had experienced no difficulty in doing so although he considered the lighting in the station was not good. He agreed that the change from bright sunlight into the darkened station might affect some drivers. He also felt that passengers may have difficulties negotiating building materials etc which obstructed some of the ill-lit platforms, but he was emphatic that the lighting did not affect him personally.

63 Asked about the use of EP brakes, Mr Bright said that technique would obviously vary a little according to drivers' preferences, it would be affected by the loading of the train and the particular characteristics of the controls. He personally had never experienced a brake failure though on occasion he had dealt with slow brake responses by making a stronger application. While he could not recall any training or practice in handling a brake failure, should this happen he would go into emergency. He said also that if brake valves were loose, it was possible to inadvertently go into lap. Similarly, if they were too tight, pressure required to move the brake lever could result in an overshoot into lap. This had never happened to him and he said he would report brakes which were faulty to this degree.

64 At the time when the accident occurred it was common practice, Mr Bright explained, for drivers coming on duty to go directly to where their first train would be picked up. They would not necessarily go first to their home depot to sign on, rather they would telephone to confirm they had arrived on duty. Thus it was possible for a driver to start work without having been seen by anyone in authority. He said that this practice had ceased and drivers now go to their home depot to sign on before going to collect their train.

65 *Mr A K Cork* was the guard on the 07 58 train from Sevenoaks. He had joined the stabled train at Grove Park at the beginning of his shift but did not report his arrival to the train crew supervisor. His first action was to test the brakes and, though it is usual when doing so, for guard and driver to speak by telephone, they did not do so on this occasion. However, Mr Cork said he was satisfied with the brake test. The first journey out to Sevenoaks was uneventful and entirely routine. On arrival there, Mr Cork remained in the brake van which would be the fifth coach from the front of the train on the return trip. After a wait of about 12 minutes, the train set out for Cannon Street and again the journey was unremarkable. There were a lot of passengers as was usual at that time of the morning but the train was handled competently without excessive speeds, sharp braking or anything else untoward. Mr Cork was unaware that some passengers were in the forward brake van but said that people sometimes travelled in there when the train was crowded. The only accessible equipment was the brakes. If these had been touched, the guard and driver would have been aware of it and it could only have slowed down the train.

66 The final approach to Cannon Street was at the usual modest speed and, although he did not look at the

brake gauge, Mr Cork felt the train slowing down as it ran into platform 3. He recalled no sound of brakes or of the traction motors. He felt no cause for alarm, neither did he think anything might be amiss as he left his seat to take his usual position at the door of the brake van. When the impact occurred, Mr Cork was thrown violently against the forward wall and his collar bone was broken.

67 When he left the train he saw Driver Graham, who appeared to be in shock. Mr Cork reported to a supervisor on the platform and then to the train crew supervisor in the control room. Subsequently he was taken to hospital.

68 *Mr P E Green*, a recently qualified driver but who was familiar with the route into Cannon Street, had to go to London Bridge that morning and, as the train was crowded, he travelled, with Driver Graham's agreement, in the driving cab. He had joined the train at Orpington and the journey to London Bridge was routine, the train being driven just as Mr Green would have driven it. After London Bridge he decided to stay with Driver Graham and travel to Cannon Street and back as he was early for his appointment at London Bridge. He said that the speed remained under 20 mile/h and braking was not necessary to comply with the 20 mile/h and later the 15 mile/h speed limits on the approach to Cannon Street. Before they reached the station, the driver turned off the power and allowed the train to coast into platform 3. Partway down the platform, as they were coming alongside the stationary train on platform 2, Mr Green, as a courtesy, changed the blinds which indicated the train's destination. He made sure the lights inside the cabinet did not distract the driver. While doing so, he felt the train slowing in response to a very light application of the brakes. Mr Green was collecting his belongings and had just picked up his hand lamp when the driver exclaimed that he had lost power in the EP brakes.

69 What followed happened very quickly but Mr Green endeavoured to explain the sequence of events. He looked up in alarm at the driver. At that moment, he saw the red side of the digital clock on platform 3 pass the window and, beyond it, the control point. He realised they were near to the buffer end of the platform. He was aware that there were passengers immediately behind in the brake van and his first action was to step over to the connecting door and shout a warning to them to hold tight and get down. As he turned to the front, he saw that the power controller was in the Off position and the driver had dropped the dead man's handle (the driver's safety device). Although he did not have a clear view, he believed he also saw the brake lever in the emergency stop position. He said he heard the hiss of air brakes which could have been caused by either device or both but did not notice any immediate braking effect. In the next instant they hit the buffers and Mr Green was thrown against an equipment cabinet and then to the floor.

70 It was very dark in the cab as he got to his feet but he could make out the driver slightly crouched over the controls, holding his head and shaking. Mr Green located his lamp, switched it on and, after checking the driver was "OK", turned to the brake van where a first aider was attending to some passengers. Mr Green went to assist others who were on the floor and eventually, with the help of platform staff and police outside, got the door open and helped the passengers out onto the platform.

71 He had to restrain one angry passenger who was remonstrating with the driver. As Mr Green left the train, he was abused by other shocked or frightened passengers. He left Cannon Street and went to Liverpool Street Station from where he phoned his father who advised him to return to Cannon Street. This he did, where he made a statement to a train crew supervisor.

72 Questioned at length about the approach to Cannon Street, the events leading up to the moment of impact and the actions of the driver immediately before it, Mr Green said it happened quickly, he was very shaken and it was difficult, in retrospect, to be precise. But he said the information he had given was correct to the best of his recollection.

73 *Mr M Graham,* the driver of the 07 58 passenger train from Sevenoaks to Cannon Street Station, on legal advice declined to give evidence to my Inquiry.

74 *Mr G R Taylor*, Chief Traction and Train Crew Inspector for Southern Region, was responsible for the training of train crews, both footplate men and guards, and for maintaining their performance. He had been the chief inspector for 5 years, having been the assistant chief inspector for 2 years, and a traction inspector for the previous $17^1/_2$ years. Prior to that he was a driver for 13 years and a fireman for 9 years.

75 He outlined the training methods used for steam traction and explained how these had developed to the present procedures, where trainees attend a school. Although the training included the application of the emergency brake, it did not include a practical test application. On completion of the course at the training school there were 40 days' practical driving experience with a 'minder driver'. Following that, the trainees would be assessed and, if successful, allocated to a depot to learn the routes over which they would drive.

76 Mr Taylor considered that driving simulators would be advantageous, as they could simulate the effect of driving in various adverse weather conditions, and emergency brake applications could be made. He thought also that data recorders would be useful as they would enable traction inspectors to assess a driver's performance, both in the event of an accident and routinely when carrying out the bi-annual assessments of

drivers. In those assessments, the traction inspectors normally travel in the cab with the driver.

77 Mr Taylor explained that British Railway Traincrew Instruction 505 deals with booking-on duties, and sets out the driver's responsibilities to arrive in a fit condition, with relevant papers and equipment etc and to report to their supervisor. The supervisor's duties include assessment of traincrew for drink and drugs, and they had been given instructions on how to do this. In the event of the absence of a supervisor, drivers would report to the timekeeper. At certain unsupervised depots, drivers would sign a register and report by telephone to the supervisor at the parent depot. Traction inspectors make periodic visits to such depots to ensure that these procedures are being followed.

78 Mr Taylor had driven electric trains, of the type involved in the accident, into Cannon Street for many years. He described how the trains reacted at different approach speeds. If the train coasted, with the power off, towards the station at 20 mile/h, the line curvature and points caused drag, which would reduce the speed to 15 mile/h. If the approach was less than 20 mile/h, it might be necessary to put power on, in order to clear the points. Once the train had reached the end of the platform, it would coast the rest of the way as the track was level. He explained that the brakes on these trains were very effective at low speeds, and the best procedure was to apply the brakes to the highest pressure necessary, then gradually ease them off so that only a few (less than 10) lbs/sq in pressure remained. If the emergency brake was applied at that stage, brake pressure would increase to 50 lbs/sq in and the train would stop in about 10 feet.

As to events immediately following the accident

79 *Mr C D Kennedy* was the Area Traction Inspector responsible for monitoring train crews and their activities. He was in his office at London Bridge when, at about 08 45, he was informed by telephone of the accident. He reached Cannon Street at 09 05 and was instructed by a senior officer to check the driving cab of the damaged train. He said that he examined the driving controls and established that the brake handle was in the full emergency position and the power controller was in the Off position with the driver's safety device (DSD) released. The needles on the duplex gauge were both at zero, the brake cylinder gauge showed 50 psi and the three indicator lights (for EP brake, traction current and dynamo) were all out.

80 As he turned from the driver's cab, Mr Kennedy saw a man he correctly took to be the driver, Mr Graham. He asked if he was alright and whether he wished to go to hospital. Mr Graham declined but agreed to make a statement. They went to a room in the control office where Mr Kennedy explained who he was and the procedure they would follow. He then took notes as Mr Graham related the events of the journey and the collision, including the sequence of signals from London Bridge to Cannon Street. The statement was read back to Mr Graham who agreed it was correct. Mr Kennedy returned to his office and typed up his notes, adding the signal numbers which Mr Graham did not know. A copy of the typed version was subsequently sent to Mr Graham. The same procedure was followed when statements were taken from two other drivers, Mr Green and Mr Bright, who were present when the collision occurred, but Mr Kennedy could not interview the guard, Mr Cork, as he had been taken to hospital.

81 Later, at about 10 45, Mr Kennedy was asked to return to Cannon Street to assist the police photographer in the driving cab. This he did and when he re-entered the cab he found about six other people, most of whom he did not know, already inside. He made no attempt to verify the position of the controls, his main concern being to ensure the necessary photographs were taken, particularly of the miniature circuit breakers in the equipment cupboard.

82 Mr Kennedy was asked about several points which arose from his account:

(a) Concerning the controls - Mr Kennedy said that on his first visit to the driver's cab the light was not good but quite sufficient for him to see the controls. While he did not take notes at the time he was positive that he had recalled the details accurately. On his second visit, the cab was too crowded for him to have checked the details again, in any event that was not his purpose, he was at this stage concerned with the photographs. He agreed that it was possible that someone in the crowded cabin could have inadvertently knocked a control lever to a different position. In retrospect, he agreed he should have made a written record of his findings on the first visit.

(b) Concerning security of the driver's cab - Mr Kennedy twice went into the cab, at 09 05 and again at about 10 50. On neither occasion was the cab sealed, nor was he aware of anyone, police or otherwise, who appeared to be restricting entry or checking the identity and purpose of people entering the cab. He had not seen the instruction setting out the procedures to be followed in the event of such an accident but has since seen a copy and said if he had been aware of them at the time, he would have been concerned at the apparent lack of control on access to the cab.

(c) Concerning the statements taken from witnesses - On three occasions, Mr Kennedy said he had asked if Mr Graham wished to go to hospital and he had declined. Initially Mr Graham appeared to be somewhat shocked but later said he was alright. Mr Kennedy acknowledged that he had no medical knowledge to enable him to judge whether a man was in shock but he stressed that the statement was made voluntarily. The interview was interrupted on two occasions when people came into the room. Unfortunately, the notes taken at the interviews had been destroyed, Mr Kennedy realised that they should have been retained as evidence. On reflection he regretted he had not arranged for Mr Graham to be accompanied back to his home depot.

83 *Mr E Morrison*, area chargeman for traction and rolling stock, was acting supervisor on the day in question. He was informed of the accident at 08 50 and arrived at platform 3 within 2 or 3 minutes. He first located the train crew and took details of their names, depots and the train service involved. He then went with the driver, Mr Graham, to the driving cab and asked him to confirm that he had not touched the controls since the moment of impact. Mr Graham said he had not and Mr Morrison then made a note of the positions of the driving controls. The equipment did not appear to have been damaged. The brake handle was in the emergency application position and the brake cylinder gauge showed 50 psi. The power controller was On in the weak field position, ie position 4. The reverser handle was in the Forward position, the DSD was in the Operative position and the key was still in the master controller. This was just after 09 00 and it took about $1^1/_2$ minutes to observe and record the information. Though the light was poor it was sufficient, Mr Morrison said, to see the controls clearly. He then left the cab and went to report the situation to his manager.

84 He returned to the cab about 12 minutes later and saw Mr Kennedy who was talking to the driver. He agreed to continue with the inspection as Mr Kennedy wished to leave and interview Driver Graham and other witnesses. Mr Morrison confirms that, at this stage, the controls were still as he had recorded them earlier. He left the cab to carry out an inspection of the train but first asked Mr Pinfold to re-check all the controls, auxiliary cupboard and fuses. Mr Morrison went to examine the other brake cylinder gauges, couplings and connections along the train. This was achieved with some difficulty as the platform was very crowded. The readings he took were as follows:

61585 - 50 psi	70444 - 50 psi	70443 - 50 psi
61584 - 47 psi	14046 - 40 psi	15308 - No reading
15031 - 50 psi	14061 - 38 psi	77526 - 42 psi
65341 - 40 psi		

So far as Mr Morrison could tell by observation, all couplings and electrical connections had been properly made.

85 Mr Morrison said he was not challenged on either occasion when he entered or left the driver's cab, neither was he accompanied by a police officer or other official when he did so. He said also that he had not been issued with a copy of the card describing the procedure to be followed when a serious accident occurs.

86 *Mr T W Pinfold* was the British Rail maintenance fitter based at Charing Cross, he had 26 years' experience with electrical and mechanical aspects of the rolling stock. He was informed about the accident at 09 00 and went to Cannon Street, arriving at 09 20. He went with Mr Morrison into the driving cab of the damaged train and checked the controls and miniature circuit breakers (MCBs) in the electrical cupboard. He observed that the 100-amp fuse was hanging out, apparently knocked out of position by the impact of the train hitting the buffers. The fuse had evidently knocked open the cupboard door. Seven of the MCBs had been tripped and there were a number of others, including the EP brake MCB, which had not been tripped. Mr Pinfold was present when the police photographer took a photographic record of the electrical cupboard. He expressed the opinion that the driving control levers could have moved as a result of the impact.

87 Mr Pinfold, along with Mr Morrison, carried out an inspection of the the electrical train line connections (jumpers) between the coaches. He did not touch these but, from visual inspection all appeared to be coupled normally. He also checked the position of the brake blocks and found they were all in contact with the wheels, which is what he would have expected to find when the brake gauges were registering 50 psi or thereabouts. It was not, however, possible to examine the jumpers or brake blocks where the worst damage had occurred and where the rescue operations were still in progress.

88 *Mr B J Morgan*, a qualified engineer, was the depot manager at the Orpington Traction Rolling Stock Depot. He arrived at Cannon Street at 09 20 and, accompanied by Police Inspector Connell and three other British Rail technical staff, went to inspect the damaged train on platform 3. He saw that the buffer stops were fully compressed and the first two carriages of the train were slightly distorted due to compression. Inspector Connell took photographs of the cab interior while Mr Morgan examined and noted the positions of the driving controls and the gauge readings. He then checked each other carriage, except the sixth (No 15308) which was inaccessible by reason of damage and the rescue work being undertaken.

89 He also visually checked the electrical train line connections between the carriages, other than those between the fifth and sixth, and these appeared to be in a satisfactory condition. A further inspection carried out

at 13 30 with Mr Sawer of HM Railway Inspectorate essentially confirmed the details noted previously but on this occasion the MCBs were also checked. In the leading driver's cab (No 61585), all MCBs had tripped except the EP brake, the passenger alarm and the AWS. In the fourth carriage (No 61584), the MCBs which had tripped were: the EP brake; the main lights; lighting and heating; route indicator; and the compressor control. Mr Morgan concluded that it was the force of the impact which had caused this number of MCBs to trip. In the lead cab of the second unit (the fifth carriage - No 14046) the main auxiliary and main compressor fuses were out of their holders and in the eighth carriage (No 14061) all MCBs and fuses were either set or in place.

90 Mr Morgan agreed that he could not comment on the state of the MCBs prior to the collision, nor on the integrity of the jumpers although from his visual inspection these appeared to be sound. The details of Mr Morgan's inspections are given in Table 1.

91 At 14 10 a further check (excluding the fifth and sixth carriages) established that all brake blocks were applied to the wheels. Finally, at 16 30, an examination of the track beneath the first unit of the train revealed no signs of skidding and no skid marks. This Mr Morgan said, led him to conclude that the brakes had not been fully applied as the wheels had not locked prior to the impact. However, he also said that he would not expect a skid if the train was travelling at slow speed.

92 At 21 00, he undertook a series of brake tests. The train carriages were moved into what would have been their normal position on the track. The tripped circuit breakers were re-set, a temporary extension train pipe was installed to by pass the damaged vehicle (No 14046) and the jumpers linking No 14046 and No 15308 to the rest of the train were dropped, isolating these carriages. Thus it was possible to test the automatic brake the full length of the train and to test the EP brake of the front four carriages from the leading driving cab, and the last four from the driving cab at the back of the train. All tests indicated that the braking systems were functioning normally and satisfactorily.

93 Mr Morgan was challenged on any conclusions he might have drawn from this, in that the tests could not be carried out on the entire train and did not therefore

Table 1 Findings from Mr Morgan's inspection of the train

Controls										
Carriage serial No	*1st 61585*	*2nd 70444*	*3rd 70443*	*4th 61584*	*5th 14046*	*6th 15308*	*7th 15031*	*8th 14061*	*9th 77526*	*10th 65341*
Master controller key (driver's key)	On			None	None			None	None	None
Master controller selector switch	On			Off	Off			Off	Off	Off
Director selector	Forward			Off	Off			Off	Off	Off
Power controller	Released in weak field position			Off	Off			Off	Off	Off
Brake handle	Emergency position			Release	Release			Release	Release	Release
Brake cylinder gauge (guard's brake gauge)	49 psi	48 psi	48 psi	50 psi	30 psi (29 psi)	No reading	48 psi	25 psi (25 psi)	34 psi	29 psi (29 psi)
AWS indicator	Yellow and black			Yellow and black	Yellow and black					
Air pressure gauge train pipe	0			0	0			0	0	0
Air pressure gauge main reservoir	0			0	0			0	0	0

prove conclusively that all brakes were fully operational prior to impact. His response was that they were functional as far as could be tested but he acknowledged that if a data recorder had been fitted to the train, this could possibly have produced evidence to show whether or not there was, in fact, any brake failure.

As to the signalling of the train

94 *Mr D E Sayers* was the signalman on duty in the London Bridge signal box and had charge of the section of line into Cannon Street. Prior to the accident, services were running smoothly and on time. He set the route for the train into platform 3 at Cannon Street, having been asked to arrange this though the train would normally have gone into platform 4. However, there was nothing unusual in this and there were no subsequent changes.

95 A telephone call was received from Cannon Street Control at 08 45 to say the train had hit the buffers at No 3 platform but no indication was given then of the seriousness. At 08 55, the electrical controller at Lewisham telephoned to say there were electrical difficulties on platforms 3 and 4 at Cannon Street and he had had to remove the traction power supplies from platforms 1 to 6. Mr Sayers continued to route trains into platforms 7 and 8 until 09 15 when it was requested all power be cut off. It was restored briefly to platforms 7 and 8 but taken off again at 09 35.

96 *Mr D M Lee* was the regulator, that is the supervisor, in charge of the London Bridge signal box. He confirmed the details and accuracy of the evidence given by Mr Sayers and that, until the accident, trains were running according to the timetable and without difficulties. He could only add that the traction power was finally removed from all of Cannon Street to permit access by the air ambulance.

As to the buffer stop and trackwork

97 *Mr C Rayner,* the area plant manager, South East, British Railways, was the engineer responsible for electrical and mechanical plant other than rolling stock at Cannon Street Station. This included buffer stops. He described the buffers at platform 3. They were hydro-pneumatic, having two-stage pistons which resisted the impact of a train by oil pressure. They had been in place for 20 years and possibly longer. The buffers were subjected to regular three-monthly maintenance checks to ensure that oil and air pressures were correct, that seals were intact and that the rams particularly were kept clean and serviceable. This work was carried out by British Rail maintenance fitters and overseen by an engineering supervisor who also carried out random test checks on the standard of maintenance. The buffers on platform 3 had been checked in December, the month before the accident, and Mr Rayner had no reason to have any doubt about their condition or serviceability. Hydraulic buffers had remained at Cannon Street because there was insufficient room to introduce friction buffers which were longer and would have required longer platforms.

98 He inspected the buffers at about 14 00 on the day of the accident. He noted that the train was hard against the buffers which had been compressed their full 24 inches (610 mm). The buffers were set in a concrete base which was not disturbed but a hardwood timber between the buffers and the concrete was compressed by 50 mm. After the train had been moved away, Mr Rayner was instructed to remove the buffers for tests and repair, which he did, having first taken measurements and photographs to record their condition and any damage sustained. The state of the buffers, he explained, was judged to be secondary to the cause of the accident. It was considered essential to remove, test, repair and replace the buffers as quickly as possible in order that platform 3 could be brought back into commission.

99 Asked about the buffers' design characteristics, Mr Rayner said that in the manufacturer's specification they were rated at 3300 inch tonnes which meant they should withstand the impact of a train of 450 tonnes, up to a speed of 4 mile/h. Mr Rayner acknowledged, however, that this had not been empirically tested, the manufacturer no longer had experts on these buffers and the relevant documentation had been destroyed. Further, some doubt had arisen as to whether the specification referred to the capacity of the buffers as a pair or to each buffer as a single entity. This, he agreed, would obviously have a significant effect on the actual capacity to withstand impact. He said that all the buffers at Cannon Street were of the same type and similar in age and condition. There had been occasions in the past when a train had hit them but never to Mr Rayner's knowledge with as much force as in this case. Previously, buffers had been compressed up to about half their 24-inch length and on no occasion had they been displaced or the timber crushed.

100 *Dr R L Cope* was the permanent-way engineer at British Railways Board and had previously been head of track research at the BR Technical Centre. Railway tracks and buffer stops were both within his area of expertise. He said that the primary purpose of buffers was to indicate the end of the line. But if the normal stopping and emergency procedures failed, buffers should also prevent the train from running beyond the end of the track and slow it down as gently as possible to minimise damage and risk of injury to passengers.

101 There were, he explained, a considerable variety of buffer stop types throughout the British Railways network, these included pneumatic, friction or sliding

buffers and other types. There was a Code of Practice which set out guidelines and recommended particular specifications to be met wherever possible. These were that buffers should be able to sustain the impact of a train of up to 450 tonnes, moving at up to 6 mile/h and bring it to a halt with a deceleration rate of no more than 15% g, (ie 0.15 of the rate of acceleration due to gravity). When this formula was adopted, it was known that the weight of trains would vary to some extent and that the speed of approach to a terminal station would not normally exceed 15 mile/h. As a general rule, a lighter train would be stopped more quickly by the buffers.

102 The requirements of the Code of Practice were met by sliding buffer stops which work by friction and these were the generally preferred type. If a train collided with them, they would slide backwards for a distance of up to 2440 mm, resistance being created and increased by a series of clamps on the rail behind the buffer. Deceleration would be achieved and controlled by the number and degree of tightness of the clamps. This did not guarantee, however, that there would be no damage to the buffers or train. Dr Cope explained that the buffers at Cannon Street, which were of the hydro-pneumatic type, were designed to stop a train in the shorter distance of 610 mm, and were intended to withstand an impact of up to 4 mile/h. However, deceleration would be about 30% which was judged to be the maximum tolerable and twice that recommended in the guidelines. This was the main objection to this type of buffer. On the other hand, he said, the main disadvantage of the friction buffers was the harder initial impact to overcome the static friction although the retardation thereafter is more uniform and controlled. Existing evidence indicated that a retardation rate of 15% did not generally lead to significant passenger injuries and he could only conclude that the rate had been considerably greater than 15% g in the Cannon Street collision.

103 Dr Cope was unable to say when the buffers at Cannon Street were to be changed, nor whether the platforms could be extended sufficiently to accommodate friction buffers. But he was aware than an alternative pneumatic type had already been selected to replace the existing ones and, from this, he concluded that the necessary extra space was not available.

104 Asked about sand drags, he said these were not appropriate for use in a terminal station but that automatic train protection (ATP), when available, may be suitable and could perhaps help prevent an accident like the one at Cannon Street.

105 *Mr R J Middleton* was the British Railways Area Civil Engineer for the South Eastern area. A professionally qualified civil engineer, his responsibilities include maintenance of all the tracks into Cannon Street Station. He examined the track at platform 3 on the afternoon of the accident. He found the rails were dry and there was no evidence of any grease on the head of the rail nor of any obstruction on the track. He found some skid marks on the rail head, 6 to 9 inches long, immediately behind the position where the train's wheels had come to rest, indicating that the wheels had locked and travelled that distance before stopping.

106 Mr Middleton described the gradient profile of the track into Cannon Street. The track is level as it leaves Borough Market Junction, then there is a fall of 1 in 150, followed by a slight rising incline of 1 in 369. The track then falls very gradually at 1 in 550 as it approaches the station. It levels off at the end of the platform ramp and is level along the full length of the platform to the buffer stops. The track was in very good condition and it was Mr Middleton's judgement that it made no contribution at all towards the accident.

As to the examination of the train

107 *Mr K G Hubbert* was a senior engineering assistant, based at King's Cross. Essentially, he was a brakes' engineer, having been involved in design modification, repair and maintenance of braking systems and equipment over the past 18 years. He had also undertaken a number of investigations into actual and alleged brake failures.

108 He was called to Cannon Street on the day of the accident and, when the train on platform 2 was moved away at about 14 30, he went down onto the track and made an inspection of the damaged train on platform 3. He noted and recorded a series of details relating to the train's braking system. Specifically, he checked the brake cylinder strokes which would indicate whether the piston was working, the amount of slack adjuster movement still available to compensate for further brake block wear, the amount of brake block wear left and the pressure remaining in the brake cylinders. He found nothing out of the ordinary and all the equipment was in good condition.

109 Mr Hubbert then personally carried out the functional brake tests described by Mr Morgan. The fifth carriage had been bypassed but the automatic brake test on the rest of the train was entirely satisfactory. After the MCBs were reset and the fifth and sixth carriages isolated, the EP brakes were tested on the front four and back four carriages. All the braking units functioned correctly.

110 Later, the train was moved and reassembled at Stewart's Lane Depot with its coaches in the same relative positions. The brake pipe and electrical connections were restored, thus permitting testing of the automatic brake along the whole of the train. The EP brakes in the first six carriages could be tested from the driver's cab and the last four carriages from the back of the train. All tests were repeated and a record kept of

the results. In all cases, brakes functioned to the standard required and Mr Hubbert described their condition and performance as very good. The automatic brake test was fully satisfactory. In the emergency brake tests, pressure rose from zero to 45 psi in 1.1 seconds at the front of the train and in 3.3 seconds in the tenth coach. This was normal and acceptable. The series of EP brake pressure applications of 15 psi, 30 psi and the full 50 psi brought about the desired result within 5 seconds, except on one occasion when it was 5.1 seconds in one carriage. Full details of the test results were available and Mr Hubbert said he found no problem or malfunction in any brake equipment. He accepted that he could not be categoric about the state of the brakes prior to the moment of impact but pointed out that there was subsequently no identifiable defect in them. He agreed that intermittent faults could sometimes occur and it was not always possible to reproduce them but said that this was less likely to occur with a mechanical than an electrical fault.

111 *Mr S R Beck*, a chartered electrical engineer, was a senior engineering assistant based at King's Cross. He had been with British Rail for about 21 years and his responsibilities included the testing of rolling stock electrical equipment after an incident.

112 He had carried out an exhaustive series of tests on the train which had been involved in the accident at Cannon Street. These test were as follows:

(a) a check on the traction equipment of the leading and trailing units. This established that the train was not under power at the moment of impact;

(b) a check and test of each of the 27 separate wires in the train line electrical circuits which run throughout the train. Use was made of specially designed equipment which would locate breaks in any circuit, cross connections and other permanent or intermittent faults. No faults were found;

(c) a full physical examination of all visible wiring and of the 200 or so terminals associated with the EP brake on all ten vehicles. One minor fault was found, there were no other defects at all;

(d) a 'heat soak' test, consisting of energising the brake relays in the driver's cab for several hours to see if any heat generated in the coils affected their performance and thus that of the brake. After five hours, the brake worked normally;

(e) an examination of the electrical contacts in the driver's cab brake controller. No abnormal wear or sign of burning was found, the contacts were all in a satisfactory condition;

(f) a check on the wiring and traction control circuitry in the rear unit to see if there was any possibility that the power had not been shut off as the train came to the end of its journey. There was nothing to indicate that this could have occurred;

(g) the control jumper between the fifth and sixth carriages had been cut away to facilitate rescue operations. This equipment was carefully examined and, as the plug and socket were still together, a test meter was used and confirmed that all wires were correctly connected.

113 The minor fault in paragraph 112(b) concerned the positive electrical feed to the two brake relays located in a cabinet in the driving cab. A bolt on a terminal was not absolutely tight and, though the two electrical cable connections were relatively secure, it was possible to move them slightly by hand. Mr Beck emphasised that the electrical connection was not loose and that the spring washer exerted adequate pressure to ensure that the contact was in fact very good. There was no discolouration or any sign of burning or arcing and subsequent tests including a volt drop test, confirmed that it was functioning perfectly normally.

114 Asked about the implications of this, Mr Beck said that if the contact had been lost at any stage there would have been a loss of EP brake power throughout the train which would have been immediately noticeable. The terminal would also have shown signs of burning and arcing, yet there were none. Finally, both mechanical and electrical tests would certainly at some stage have indicated a fault but they had not done so. He said the terminal would have been scrutinised at the last six-monthly examination but this would have been a visual check and by no means as detailed as the inspection he had done. He could not say when it had last been tightened but if it had been correctly tightened, it could not have worked loose. He emphasised that it was not actually loose, it was simply not quite as tight as it might have been and had, nevertheless, made a very good contact.

115 In summary, he could find nothing in the electrical circuitry which could have caused a brake failure nor anything else which might have contributed towards the accident. Concerning this general conclusion, Mr Beck conceded that, because the circumstances of the journey could not be exactly reproduced, it was not possible to guarantee that no electrical fault had occurred during the journey. He accepted also that while all possible tests had been done, there remained the very remote possibility that an intermittent fault had gone undetected.

116 *Mr A C Baker*, Fleet Manager for South Eastern Division of Southern Region told me that the ten coach train consisted of three individual units capable of being operated in multiple. The EMU forming the front of the train consisted of four coaches built in 1960. The EMU in the

centre of the train also consisted of four coaches. The bodies and bogies of these were built between 1948 and 1953, but were mounted on underframes of older withdrawn coaches originally built between 1928 and 1948. Despite their age, Mr Baker was not aware of any incident in the past life of these coaches which would have affected their performance at the time of the accident. The EMU forming the rear of the train consisted of two coaches built in 1954.

117 EMUs are given a full electrical and mechanical service every six months, a daily safety inspection and an examination over a pit every three days. If faults are noticed at the inspections, or reported by the traincrews, they would be attended to appropriately. The maintenance periods and procedures are based on the experience of operating these particular trains since 1951 (and similar ones previously), the duties performed by the units and problems that have occurred over more than 40 years.

118 Mr Baker worked with my assistant, Mr Sawer, in planning the tests to be carried out on the train following the accident, and in assessing the results. He was of the opinion:

(a) that the tests were exhaustive;

(b) that there was no failure, full, partial or intermittent of the electro-pneumatic brake;

(c) that there was no failure, full, partial or intermittent of the auto brake;

(d) that there was no question of power being applied to any other part of the train.

119 *Mr K T Crofts* had, on behalf of the Director of Mechanical and Electrical Engineering, identified and recorded the damage caused to the rolling stock. He had produced a detailed report which was made available to the Inquiry. In his report he had assessed the factors which may have contributed to the structural damage caused to the rolling stock. Surface corrosion was found on some of the vehicle underframe members but he considered the level of corrosion was not sufficient to have had a detrimental effect on the performance of the underframes during the collision.

120 He had identified the main factors which could have contributed to the damage as:

(a) the speed of the train at the time of impact;

(b) the operational state of the traction and braking systems;

(c) the difference in ride height of the vehicles at the time of impact;

(d) vehicle pitching on impact;

(e) the inclination of the centre buffer due to local distortion of some vehicle headstocks.

121 The train speed would have determined the energy which was possessed by the vehicles (and the passengers). All of the energy would have been dissipated during the collision. The energy was absorbed by the compression of and damage to the buffer stops, compression of inter-vehicle buffers and couplers, structural deformation of the vehicles, and an increase in the potential energy of the overriding vehicle as it was lifted up relative to the overridden vehicle.

122 When Mr Crofts was preparing his report it was not clear whether the train was under power or being braked at the time of impact. If the train had been under power there would have been more damage caused for a given speed than if the train was coasting, since the traction system would be adding energy to the train during the collision. Hence, for the given amount of damage sustained during the collision the speed of the train, if under power, would be lower. Conversely, if the train was being braked at the time of impact then for the same amount of damage, the speed would be higher than the coasting speed.

123 Any variation in ride height between adjacent vehicles would have generated rotating moments during a collision under the influence of a longitudinal force to cause pitching of one vehicle relative to another. The ride height could have been affected by variation in the vertical alignment of the track and variation between vehicle underframe heights. Dissimilar passenger loading had been discounted on the basis that the vehicles were likely to have been similarly loaded.

124 The heights of the solebars of the vehicles were measured in the Stewart's Lane Depot on 10 and 11 January. These heights had been combined with the vertical alignment of the loaded track of platform 3 measured on 10 January. The results of this work alone did not give any conclusive indication as to why the damage occurred between the first and second vehicles and why the fifth vehicle overrode the sixth. The difference in height between the centre of gravity of the loaded vehicle and the centreline of the inter-vehicle buffers would have tended to cause the front of each vehicle to pitch downwards. Although this effect may not have been a major one, it would have contributed to the relative vertical movement which occurred between vehicles.

125 The most significant factor was the inclination of the buffer head caused by the local distortion of headstocks and the asymmetric collapse of the buffer's wooden mounting pads. Deformation of headstocks and the crushing of the wooden pads had occurred to varying degrees throughout the train. The crushing was most severe at the front of the second and sixth vehicles. At

both locations the pads had crushed more at the top than at the bottom resulting in the buffer on the front of these vehicles pointing up from the horizontal.

126 The effect of this was that the buffer would be likely to transmit the longitudinal impact force from the adjacent vehicle by means of a force along the inclined axis of the buffer. This in turn would generate a vertical resultant force on each vehicle at the interface. Hence, asymmetric collapse of the wooden pads and inclination of the buffers would generate forces which tend to lift one vehicle relative to the adjacent one, which is what occurred between the first and second vehicles and more seriously between the fifth and sixth.

127 *Mr J H Lewis,* from British Railways Research Department, had provided an estimate of the train impact speed included Mr Crofts' report. The estimate was based on calculating the energy absorption available through the various mechanisms and equating it with the kinetic energy of the train at the point of impact. The principal areas of energy absorption had been taken as the station buffers, the side buffers of the first vehicle, the central buffers along the length of the train, coupling resilience between units, structural deformation of vehicle Nos 61585 and 70444 where the vehicle ends buckled, structural deformation of vehicle Nos 14046 and 15308 (No 14046 overrode No 15308) and the increase in potential energy of overriding vehicles.

128 When Mr Lewis made his calculation it was uncertain whether the train was being braked or under full power at the time of impact. Therefore, both possibilities had been included in the calculations. The likely maximum and minimum values of energy absorption were summarised as follows:

Energy absorption	*Max (KJ)*	*Min (KJ)*
Station buffers	1795	1225
Side buffers of vehicle No 61585	50	30
Inter-vehicle buffers	260	200
Inter-unit couplings	40	30
Deformation of vehicle Nos 61585 and 70444	350	235
Deformation of vehicle Nos 14046 and 15308	1700	1020
Increased potential energy	215	215
	4410	2955

129 Experience from the analysis of previous accidents and instrumented static and dynamic tests showed that the above type of exercise underestimates the energy absorption by approximately 20% since it did not account for friction, elastic energy, structural damping and other losses. Increasing the above figures by 20% gave a maximum of 5290 KJ and a minimum of 3545 KJ. Mr Lewis had calculated the braking and power energies from train performance data as braking 18 600 KJ and power 700 KJ.

130 The likely impact velocities determined from the calculations were given as follows:

Condition	*Impact velocity (mile/h)* *Maximum*	*Minimum*
Full brake, no power	13.0	11.3
No brake, no power	11.2	9.1
No brake, full power	10.4	8.2

131 *Dr M G Pollard,* Engineering Services Manager in the Mechanical and Electrical Engineering Department, managed the specialist electrical and mechanical engineers and previously had spent 15 years in research working on vehicle dynamics and suspension. His work involved all aspects of traction and rolling stock design and development.

132 Dr Pollard explained that the front four-coach and rear two-coach EMUs involved were BR Mark I stock, designed to a substantial standard upon which the UIC standard was based. The UIC standard required that vehicles likely to be in collision with one another should be of comparative strengths, so that the damage would be shared among them and thereby minimised. However, the middle EMU was of an earlier design. The underframes, although old, were broadly similar to those used in Mark I coaches, but the bodies were not as strong, in that they lacked the substantial steel members at the end of the coach between the underframe and the roof. The coupling within the unit consisted of a single chain fixed to the underframes of adjacent coaches. As a result of the impact, the metal around the chain mounting tore and one coach overrode another. The resultant damage was greater in these coaches than in the stronger Mark I units. However, he did not consider it was necessary to operate trains so that they only comprised one type, or age, of stock.

133 Dr Pollard explained that as a result of the recommendations of Sir Anthony Hidden's Inquiry into the accident at Clapham Junction, BR had been researching measures that could prevent overriding. The measures under consideration included bar

couplers, couplers which do not disengage vertically, serrated surfaces on the ends of vehicles which in the event of a collision engage the surface on the adjacent vehicle locking them together, and energy absorbency built into the couplers and the vehicle ends. These devices would need to be easily replaceable. It was hard to fit anti-overriding devices retrospectively to existing stock as it was necessary to carry out massive modifications to the structures at the ends of the vehicles. In order for the device to work, the end of the vehicle had to be sufficiently strong to keep the device in a vertical plane, and for the end structures not to bend or go out of a vertical plane.

134 Mark III coaches currently under construction were designed to the current UIC standards, incorporating substantial proof loads and featured couplers which did not disengage. Coaches being specified to be built in four to five years time, would include such devices and should be capable of surviving a 15 mile/h impact with buffer stops without major structural damage. They would exceed the current UIC specification.

135 Dr Pollard told me that with the assistance of the Motor Industry Research Association, he had conducted research into coach interior design, which would enable BR to remove the most hazardous features from existing stock, and specify for new stock, interior designs which would minimise injury to passengers. New designs would feature intermediate partitions, larger radius edges on surfaces and padding on seat rails. Luggage rack design would be improved to hold only light luggage on overhead racks, with constrained storage provided for heavy items at floor level. Seats would need to be more securely fitted, using a metal frame. He explained that it would be possible to modify seats in existing vehicles, but it would involve a lot of work.

136 He was of the opinion that the slam doors on the train jammed because the structure was distorted. This would be unlikely to occur with sliding doors; even if the coach ends were deformed the doors would have remained intact and capable of being opened normally. Sliding doors also had other safety benefits, eg a reduction in accidents caused by passengers attempting to leave or join a train in motion.

As to the injuries to passengers

137 *Mr A W F Lettin*, Senior Consultant Orthopaedic Surgeon at St Bartholomew's Hospital, saw practically all of the casualties brought there from Cannon Street after the accident. His primary concern was to assess the nature and extent of the injuries and to send them for X-rays, surgery or other treatment as appropriate.

138 Of the people injured, 104 were brought to St Bartholomews, arriving in a steady stream between 09 15 and 12 20. Mr Lettin summarised the types of injuries as follows:

32	injuries to head or face, including four fractures of jaw or facial bones and three eye injuries;
11	neck injuries;
45	cuts, bruises, fractures to upper torso, back and arms, including three multiple rib fractures and others with collarbone or arm fractures;
2	back injuries;
14	lower limb injuries, including one leg fracture.
104	

Twenty patients were detained in hospital, of these, five were considered to be serious cases. It was understood that a number of seriously injured passengers were also taken to other hospitals.

139 The time of each arrival at St Bartholomews was recorded but no attempt was made to establish whereabouts on the train each person had been, nor whether they were seated or standing at the moment of impact. It was difficult, therefore, to attribute particular injuries to a specific cause. Nevertheless, Mr Lettin offered a view in general terms of the probable causes. He considered that:

(a) most cuts, bruises, fractures to head and upper body had been caused by impact: passengers falling against seats, fittings, walls; being hit by broken racks, fitments, luggage which had come loose; clash of heads as passengers fell against each other. Standing passengers would have been particularly vulnerable;

(b) crushing of chest or rib-cage would have occurred where passengers were standing in very crowded compartments. They would have been pressed against walls or fixed furniture and been crushed by the pressure of other people forced forward by the sharp deceleration;

(c) passengers who were trapped, seated or standing between seats mostly suffered injury to the lower limbs caused by distortion of the train structure and the collapse of floor or seats in the most severely damaged carriages;

(d) it was not possible to say whether anyone had suffered injury by falling from the train through a door which had been opened, but a number of people had sustained injuries which were not inconsistent with this;

(e) there were no instances of deep punctures such as could have been caused by sharp splinters of wood, metal or glass.

140 Mr Lettin agreed that unprotected wood or metal fixtures inside a train presented risks to passengers in the event of a collision and that frameworks with a degree of flexibility and protected by some form of padding would be preferable. He observed that in a very crowded compartment the risk of falling against structures might be reduced but that there would be an increased danger of being crushed. He felt that, as a general rule it would be safer if all passengers were seated and risk of injury would be reduced if it were a low-speed collision.

141 Asked about the removal of casualties to the hospital, Mr Lettin said the agreed policy in London was to do this at the earliest possible moment and treatment, other than emergency or life-saving, should not cause delay. Communications could be impaired and confusion could occur in the stressful conditions surrounding a major accident, even when adequate medical resources were at hand. However, he offered no criticism of the action taken or the speed with which the casualties were brought to St Bartholomews. There was a system, he said, for medical teams at the scene to indicate whether a particular patient had received medication or other treatment which the hospital staff should know about but this had not been necessary on this occasion.

As to the planning of train services

142 *Mr R Malins* was the London Regional Planning Manager, Network SouthEast. His responsibilities included provision and allocation of resources and devising the train service plan. Mr Malins said the primary intention was to provide a service with the capacity to meet the demand and transport passengers in reasonable comfort.

143 He explained how train service needs were established in order to match the supply as near as possible to the demand. A key to this was an annual series of passenger counts by which means it was possible to establish the number of passengers using particular routes, their starting and destination points, the time of travel and any trends or changes in travel patterns which appeared to be developing. This information, with additional surveys conducted as and when needed, enabled the planners to determine the size and frequency of trains required on each route at particular times of the day and to adjust existing services if this was necessary and practicable.

144 Mr Malins said the ideal was to enable passengers to be seated if their journey was to exceed 20 minutes. This was not, of course always possible but the aim was to provide a service which could do so and the capacity of a train was calculated at 110% of the seating available. This assumed one standing passenger for each ten seated as an average but there would obviously be instances where some trains would be more crowded than others. It did not take account of disruption or loss of services which may be caused by mechanical failures, staffing shortages, bad weather or other factors which could not be anticipated. Surveys, he said, would indicate past and probable future demand and the needs in broad terms of a particular service. This included the known peaks during the rush hours: 07 00 to 09 59 and 16 00 to 18 59. It was not possible however to anticipate local variations which would lead to overcrowding on one train and underuse on another.

145 In particular, regardless of the capacity of the train, there was nothing which would ensure the even distribution of passengers along the length of a train as some people may choose to stand despite the availability of seats in other coaches. This applied particularly to trains approaching Cannon Street, and in other terminal stations, where exits from the station were at the buffer stop end of the platforms. Passengers tended to crowd into the front coaches rather than occupy a seat further back simply because it enabled them to get through the barrier and away from the station more quickly.

146 If passengers chose to board a crowded train or enter a particularly crowded compartment, he did not consider it would be practicable to try to prevent this. Railway staff would sometimes advise passengers when another train was due shortly or that seating may be available elsewhere on the train but there would be no question of preventing a passenger from seeking to board where he or she chose.

As to the train crew arrangements

147 *Mr D W Langley,* a train crew supervisor for the past six years at Orpington Depot was on duty from 23 00 until 07 00 on the morning of the accident. He was asked to explain the procedures then in place for train crews reporting in and booking on for work.

148 He said the existing instructions required crew to report first to their home depot to confirm arrival and take note of any recent instructions concerning speed restrictions, routes or other information which affected the train services. Each member of the crew should be seen by the train crew supervisor before proceeding to join their train and this was what usually happened. However, drivers occasionally sought permission to go directly to the location or depot from which their shift was to start if this meant they would avoid an unnecessarily long journey or detour which might take several hours. In these circumstances, a driver would telephone the supervisor to get permission and would normally telephone again to confirm arrival at the designated depot in time for the start of their shift. Arrangements existed to ensure that late notices were

posted at all depots and drivers would see and be aware of them wherever they booked in. It did mean, however, that a driver could start work without being seen by their manager or supervisor.

149 This practice had been in existence for many years. The facility was not uncommon but it was allowed in a relatively small number of cases. At Orpington Depot for example there were 32 duties of which only three commenced at Grove Park or Cannon Street. There were 108 drivers on the strength and some of them, depending on where they lived, might ask to go there directly. Mr Langley understood that overall in Southern Region, 92% of drivers signed on under supervision even though 25% of depots were unsupervised. He said he considered it quite reasonable to allow drivers this facility as they were mature and responsible people who could be relied on to behave properly and carry out their duties conscientiously. He had never known anyone to report for work while under the influence of drugs or alcohol but said if he ever considered this to be the case, he would not allow the individual to start work.

150 Mr Langley said he knew Driver Graham reasonably well. He described him as always seeming smart, alert, conscientious and generally reliable. There had been a minor concern over his sickness record but there were no problems and nothing unusual about his work or behaviour. Mr Langley had never found Driver Graham to be incapable of or unfit for work.

151 At about 01 30 on the morning in question, he received a phone call from Graham who sought permission to go directly to Grove Park where his shift started at about 07 00. This was agreed but, in the absence of a subsequent call to confirm arrival, Mr Langley instructed a relief driver to go and cover the duty. This driver later telephoned to say that Driver Graham had in fact already arrived and was taking the train out. Mr Langley took no further action, he knew Graham sufficiently well and he had occasionally been allowed to go directly to Grove Park before.

As to training of drivers

152 *Mr E G Waite* was Training Manager and had previously been training assistant on electrical multiple units for British Railways. He was a qualified driving instructor, having also had considerable experience as a driver.

153 He outlined the process a trainee driver would have undergone until two to three years ago when the programme was changed:

- 5 weeks' training on rules;
- 3 weeks on the principles of route learning;
- 9 weeks' traction training, (practical);
- 7 weeks' revision.

154 The current training programme was different:

- As a pre-condition, prospective drivers must already have done 90 turns as a trainman, ie as guard, second man or driver's assistant. At least 40 of these turns must have been spent in the driver's cab, this would permit some preliminary understanding of the driver's responsibilities, signals, routes etc;
- 4 weeks' training on rules*;
- 4 weeks' traction training;
- 2 weeks' driving with instructor*;
- 8 weeks' driving with a qualified 'minder' driver;
- 2 weeks with the instructor*.

155 All training and progress was recorded by the trainee in their log book which was monitored and signed daily by the trainer. At the end of each stage marked * in the programme, the trainee took an examination to ensure full understanding and that they had reached the standard required. If unsuccessful, the trainee was allowed one further attempt, if they failed a second time they would be withdrawn from the training programme. The newly qualified driver then went to their own depot to learn the routes they were not familiar with. Their performance thereafter as a driver was monitored initially by the training school but principally by the local Traction Inspectorate.

156 Mr Waite explained the way in which trainees were taught to use the braking systems, how brakes should be applied in controlling the speed, stopping during the journey, approach and stopping at terminus stations and how and when the emergency brake should be used. He confirmed that training did not include practical exercises in the use of the emergency brake. Training outside the classroom was on trains actually in service and emergency applications would not therefore be practicable or desirable. However, full instructions were given and trainees were made fully aware of the circumstances in which emergency braking would be needed, eg if the EP brake failed, if there was a risk of running into a buffer or other obstacle, if there was a late signal change or if an obstruction or other danger was seen on the track. Drivers were clearly told to go into emergency in the event of EP brake failure. The consequences of doing this were explained as were the risks and implications of going into the lap position.

157 Although he had not taught Mr Graham and did not know him personally, Mr Waite was adamant that emergency braking procedure would have been covered in Mr Graham's training, whichever programme was current at the time he was being taught.

158 In response to questions, Mr Waite confirmed that there was no intermediate stage for trainees between learning the controls in a static vehicle and practical experience on a loaded train in service. He agreed that

ideally there should be an opportunity first to drive an empty train and if possible to practice emergency stopping procedure. He understood that driving simulators were being developed. If introduced, he felt these would also be of great value.

As to previous maintenance of the train

159 *Mr G P Johnson*, a qualified fitter based at Gillingham inspection shed, had on 18 December 1991, carried out some brake tests on unit No 5484: coach No 14061 which subsequently became the eighth carriage of the train involved in the Cannon Street accident. It had been reported that wheels were overheating and one of the 16 tyres on the coach had been moved out of position.

160 To try and establish if the brakes might have caused this, Mr Johnson tested the EP and automatic/ emergency braking systems to see if they were sticking, either on application or release. They appeared to operate correctly but he then stripped down the mechanical components of the brake unit on the coach to ensure there was no water or scale in the valves. He cleaned and reassembled them. He also checked the electrical connections and ensured all parts were clean and secure. He again tested each brake and was satisfied that they were functioning properly.

161 *Mr J Wyatt*, a fitter based at Slade Green, carried out the routine six-monthly examination of unit No 6227: coach Nos 77526 and 65341, on 19 November 1990. These became the ninth and tenth carriages of the train in the Cannon Street accident. As he deals with several coaches each day he did not specifically remember these particular vehicles but his records showed he had worked on them on that date. He had no recollection of there being anything amiss or unusual about them.

162 He said the normal procedure for these examinations was as described by Mr Johnson: brakes were tested for sticking, they were stripped down, cleaned, reassembled and tested again. This was followed by a further separate brake test. Approximately 10% of vehicles examined require some form of repair or adjustment. Straightforward jobs were done on the spot by the examining fitters but if heavy repairs are needed, the vehicle is retained at the depot until this is done.

163 *Mr J Bell*, another fitter based at Slade Green, had also worked on some of the units at Cannon Street: unit No 5484 in October and unit Nos 6227 and 5618 in November 1990. These were routine inspections and a standard procedure is carried out as described by the previous witnesses. In general, vehicles are remembered only if faults are found. Mr Bell had no particular recollection of these units nor that there was anything unusual about them.

164 Work records at Slade Green Depot show that *Mr P H Waghorn* worked on unit No 5618, which was the leading unit of the train, on 22 November 1990. His duties were brushing and cleaning electrical equipment and straightforward tasks like replacing light bulbs or changing contactor tips if this was needed. If he found anything else that appeared to be wrong or faulty, he would refer it to a skilled fitter to attend to the matter. The unit was one of many he had worked on and he could remember nothing of note about it. He said that if he had changed or replaced anything on this vehicle, it would be recorded on the work sheet which could be made available if required.

As to the medical examination of Mr Graham

165 During my Inquiry I heard evidence from *Dr A E Ormerod*, the British Railways Board's Regional Medical Adviser to the Southern Region, who had examined Mr Graham following the accident. As a result of that examination Dr Ormerod formed the opinion that Mr Graham was unfit for driving duties. A urine analysis for drugs abuse had found 50 nanograms per millilitre of cannabinoid products. Dr Ormerod said that he had sought advice and this indicated that it would have been relevant at the time of the accident.

FURTHER INVESTIGATIONS

Into the braking system of the train

166 Details of the testing of the braking system of the train were given during the public hearing of evidence and that evidence is summarised earlier in this report. As part of that testing the Research and Laboratory Services Division of the Health and Safety Executive undertook the electrical testing of the terminal of the busbar which links the contacts of the electro-pneumatic brake system application and holding contactors to the 70 V dc supply. (See paragraph 113).

167 Tests of the terminal were carried out with it in situ using a Gould 400 M sample/s 100 MHz storage oscilloscope. None of the tests undertaken indicated any loss of electrical continuity at the terminal, despite very hard blows to the panel supporting the contactors and the wires of the terminal being moved up and down.

168 The contactor assembly was removed from the train and taken to the Health and Safety Executive laboratory where further examination of the electrical terminal was made and the assembly dismantled. Examination of the surfaces showed no damage due to arcing. With the relatively high applied voltage (70 V) and current (4 A) involved if any loss of continuity had ever occurred, arcing would have resulted in burning of the surfaces with possible localised welding if the arcing was prolonged.

169 The Research and Laboratory Services Division concluded that:

(a) electrical tests did not indicate a poor electrical connection at the terminal;

(b) mechanical tests indicated that the setscrew securing the terminal had been tightened to a torque corresponding closely to a level obtained by tightening the setscrew tightly with the fingers;

(c) examination of the surfaces of the components of the terminal showed no evidence that arcing had occurred;

(d) taken together, conclusions a, b and c indicate that, although the terminal had not been fully tightened, it was sufficiently tight to provide electrical continuity at the voltage/current for which it was used.

Into the circumstances whereby traction power could be retained

170 I asked British Railways to provide me with an analysis of what fault conditions would need to exist for traction power to be retained during the braking of the train. This further information was produced for me by *Mr S R Beck*.

171 In order to obtain traction power in the forward direction it would be necessary to energise two of the train lines at the control voltage on all motor coaches throughout the train. Energisation of either one alone of the two train lines would not permit the traction equipment to function. Similarly the loss of either train line while the train was under power would result in an immediate loss of power.

172 The 70 V dc control feed is obtained from the motor generator and batteries of the leading motor coach through train line No 13 to the leading driving cab. It passes through the control selector switch and the main control circuit breaker to the driver's master controller. Contacts in this controller connect the 70 V dc feed to wire CS 2 whenever the master switch is in the on position.

173 Pairs of traction motors may be electrically connected in two different configurations, that is, in series or in parallel. When the power handle is moved to either the shunt or series position three contacts in series close and connect wire CS 2 to train line No 1 and another three contacts in series close and connect wire CS 2 to train line No 4.

174 The control feeds from the train lines drive the traction motors through contactor or camshaft equipment on the motor coaches. Unit Nos 5484 and 6227 had 1951 contactor equipment and unit No 5618 had 1957 camshaft equipment. For the traction motors to obtain power, multiple contacts have to be made; some through one train line, some by the other train line. The exact arrangements differ slightly depending on the type of equipment.

175 With the power handle in either the parallel or weak field position train lines Nos 1 and 3 are energised. Similarly, multiple contacts have to be made for the traction motors to obtain power. In any of the power controller positions the loss of either of the energised train lines will result in contacts opening and power being cut off from the traction motors.

176 Mr Beck informed me that for traction power to continue to be applied when the driver's power controller handle was moved to the Off position both of the train lines would have to remain energised. He identified the following circumstances which could cause this:

(a) all of the contacts on the power handle feeding the two train lines welded closed (in addition the master switch contacts would also have to be welded closed if that switch was put to the Off position);

(b) a spurious control voltage feed present on both of the train lines (this could originate from any vehicle in the train but would affect all five sets of traction equipment);

(c) a fault within individual traction equipment with contactors (four for 1951 type equipment and three for 1957 type equipment) being welded closed, electrically retained or physically jammed;

(d) interference with the controls in an intermediate driving cab.

177 Also, Mr Beck identified the fault conditions which would have to occur for power to be retained on the rear part of the train after power had been removed from the remainder of the train. They were:

(a) failure of an individual traction equipment (as in 176(c));

(b) a spurious feed to both train lines (as in paragraph 176(b) together with a break in the same lines between the rear of the train and the remainder of the train.

178 Mr Beck reaffirmed that all of the testing undertaken on the traction and braking systems of the train had found no evidence of the faults he had identified as being capable of maintaining an unintended application of power. In addition, with forward selected there is a pressure switch in the train line circuit which

prevents traction power being obtained when there is insufficient air pressure in the brake pipe to permit an application of the automatic brake. Also, it will cause the traction equipment to shut off if the brake pipe pressure falls below a pre-set level due to an emergency application of the brake.

Into the performance of the buffer stop

179 As the performance of the buffer stop was uncertain from the information British Railways had within their possession, I asked the Research and Laboratory Division of the Health and Safety Executive to devise a method of establishing the retardation provided by the buffer stops. In order to undertake these tests a buffer stop had to be removed from Cannon Street Station. That became possible during the late summer of 1991 when some of the station platforms were taken out of use for scheduled engineering works.

As to the number of passengers on the train

180 Following the accident, officers from the British Transport Police, through various measures, attempted to identify all the passengers who had been on the train when it arrived at Cannon Street Station. They also attempted to establish where on the train they had been travelling, whether they had been injured and, in general terms, the nature of any injuries.

181 The British Transport Police identified a total of 832 passengers who had been on the train. While some of the passengers were certain as to where on the train they were travelling others were less sure. Details of the distribution of passengers are given in Table 2. Maximum and minimum numbers of passengers in each coach have been quoted to make allowance for some passengers not being certain as to which coach they were travelling in.

182 Table 2 also shows the general nature and position of the injuries sustained. Many passengers suffered more than one injury and various combinations of injury are also given in the table. Again maximum and minimum figures are quoted because of the uncertainty as to which coach some of the injured were in.

183 I asked British Railways to conduct surveys to obtain information on how many passengers were standing in the individual coaches of trains arriving at Cannon Street Station during the Tuesday morning peak period. The first of these surveys was conducted on 5 February, 1991 but a second part of the survey could not be undertaken until 23 and 30 April because of disturbance caused to normal travel patterns by security disruptions. The results of these surveys are given in summary form in Table 3.

The effects of the collision on the passengers

184 In order to try to understand more fully the effect on the passengers of the rapid deceleration, which resulted from the collision, the Health and Safety Executive commissioned on my behalf *Frazer-Nash Consultancy Limited* to make a number of computer-based studies using dynamic modelling techniques. The work undertaken was in two stages.

185 Firstly, the generation of a mathematical model to predict the motion of the occupants of a railway carriage which is brought rapidly to rest as if in a rail crash. Secondly, comparison of the results of the modelling with data from the Cannon Street accident to identify and explain the various types of injury sustained.

186 The mathematical model employed the technique, DYNAMAN, to construct a three dimensional model using the dimensions of seats and luggage racks from the EPB group of vehicles. Three occupants were represented: seated, facing the direction of travel; seated, with back to the direction of travel; and standing in the gangway holding onto the luggage rack.

187 The dimensions of the three occupants (passengers) were based upon typical 5 foot 9 inch tall males weighing 170 pounds. The passengers do not react consciously to the impact, they are merely mathematical dummies. However, by locking or releasing joints in different cases it was possible to simulate a variety of extremes of human behaviour.

Two basic scenarios were considered:

(a) initial train speed of 5 mile/h;

(b) initial train speed of 15 mile/h;

In each case the train and its occupants were given the appropriate initial velocity. After a short period at this velocity the train (but not its occupants) was brought to rest in a distance of 1 m with uniform deceleration.

188 From the basic 5 mile/h impact scenario the length of time over which the significant events occurred (1.5 seconds) suggested that the passengers' reactions could have an effect. To assess the possible implications a further scenario was constructed, similar to the basic 5 mile/h impact scenario, but with the passengers braced for impact. Also, a further 15 mile/h scenario with two standing passengers was modelled.

189 In the basic 5 mile/h impact case the passenger seated facing the direction of travel slid forward in his seat with the top of his body tipping forward. His feet remained stationary on the floor until his heels left the floor as his upper body moved forward and then he crumpled into the gap between the seats with his head

Table 2 Passenger numbers, distribution and injuries

	Front guards brake		Coach No 1		Coach No 2		Coach No 3		Coach No 4		Coach No 5		Coach No 6		Coach No 7		Coach No 8		Coach No 9		Coach No 10		Rear van	
	Min	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Seats	-	-	82	82	102	102	102	102	82	82	82	82	102	102	102	102	82	82	102	102	84	84	-	-
Passengers	18	18	114	117	118	141	97	150	71	106	79	82	57	60	71	80	50	67	28	39	39	40	2	2
Deceased	-	-	-	-	1	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Total injured	18	18	99	101	99	109	84	131	63	94	75	78	40	43	42	46	17	18	11	12	18	19	2	2
Total hospital	14	14	54	55	48	59	37	51	25	32	40	41	23	23	17	17	-	-	-	-	1	1	1	1
Head (only)	8	8	23	23	33	40	20	35	13	22	13	15	3	4	10	10	3	3	3	3	4	4	1	1
with arm	-	-	3	4	3	5	2	6	3	5	1	1	-	-	-	-	-	-	-	-	1	1	-	-
with torso	1	1	9	9	5	5	3	3	5	5	6	6	1	1	-	-	-	-	-	-	-	-	-	-
with leg	1	1	10	10	11	12	3	8	4	8	5	5	2	2	2	2	-	-	-	-	-	-	-	-
whiplash	1	1	5	6	4	6	2	3	3	3	3	3	-	1	-	-	-	-	-	-	-	-	-	-
Arm (only)	3	3	-	-	1	1	3	5	1	2	1	1	2	2	3	3	2	2	-	-	3	3	-	-
with torso	-	-	-	-	-	-	2	2	1	1	1	1	-	-	-	-	-	-	1	1	-	-	-	-
with leg	-	-	2	2	2	2	2	2	1	1	3	3	-	-	-	-	-	-	-	-	-	-	-	-
whiplash	-	-	1	1	-	-	3	3	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Torso (only)	-	-	8	8	6	7	5	7	5	7	7	8	3	3	9	9	1	1	-	-	3	3	-	-
with leg	1	1	2	2	2	3	5	8	1	3	5	5	1	1	1	1	2	2	1	1	-	-	-	-
whiplash	-	-	2	2	1	1	-	-	1	1	1	1	-	-	4	4	-	-	-	-	-	-	-	-
Leg (only)	1	1	8	8	8	8	10	13	12	15	13	13	23	24	3	5	3	4	1	2	1	2	-	-
whiplash	-	-	-	-	3	4	2	3	2	2	2	2	1	1	1	1	-	-	-	-	-	-	-	-
Whiplash (only)	-	-	14	14	10	13	7	15	5	10	4	4	2	2	4	5	3	3	2	2	3	3	-	-
Cuts/bruises/other	11	11	10	10	9	10	13	16	5	8	10	10	-	-	3	3	3	3	1	1	1	1	-	-
Shock (only)	-	-	2	2	1	1	2	2	-	-	-	-	2	2	2	3	-	-	2	2	2	2	1	1

Table 3(a) Survey of passenger numbers on services into Cannon Street Station

Time at London Bridge	Seats available	At London Bridge: Passengers on train	At London Bridge: Standing passengers	At Cannon Street: Passengers on train	At Cannon Street: Standing passengers
07.04	554	-		187	
07.14	368	-		118	
07.23	736	498		520	
07.26	922	767		359	
07.29	736	592		468	
07.32	560	599	39	526	
07.34	468	568	100	397	
07.38	612	698	86	567	
07.42	736	883	147	654	
07.46	612	619	7	814	102
07.48	612	630	18	782	170
07.51	782	747		747	
07.52	922	710		753	
07.55	922	794		600	
07.57	666	656		656	
08.00	554	677	123	561	7
08.02	736	827	91	594	
08.05	736	743	7	564	
08.07	922	687		770	
08.09	736	761	25	682	
08.11	928	1091	163	1091	163
08.13	554	535		486	
08.15	922	809		837	
08.17	840	857	17	857	17
08.20	736	816	80	905	169
08.23	724	730	6	730	6
08.24	922	1029	107	788	
08.26	922	1021	99	805	
08.28	994	931		1057	63
08.31	928	1134	206	1134	206
08.32	922	1089	167	819	
08.34	736	783	47	991	255
08.36	840	993	153	993	153
08.37	922	1031	109	1053	131
08.40	922	951	29	810	
08.43	926	996	70	1114	188
08.46	926	992	66	848	
08.48	922	843		717	
08.51	928	1020	92	1020	92
08.52	736	927	191	761	
08.54	736	569		777	41
08.56	840	706		706	
08.57	736	848	112	683	
09.00	554	626	72	618	64
09.03	612	758	146	576	
09.03	666	683	17	683	17
09.07	736	973	237	655	
09.09	922	633		715	
09.11	666	634		634	
09.12	736	630		346	
09.14	736	461		457	
09.17	612	529		301	
09.19	560	390		347	
09.21	560	382		392	
09.24	736	500		261	
09.27	554	352		335	
09.29	736	400		209	
09.34	444	281		250	
09.37	736	-		24	
09.44	922	310		252	
09.49	280	224		126	

Table 3(b) Passenger survey: distribution along train

Train	*From*	*Time at London Bridge*	*Passengers standing in each coach* 1	2	3	4	5	6	7	8	9	10
2F63	07.28 Sevenoaks	08.22	120	175	80	58	76	41	8	13	-	-
2K09	07.46 Hayes	08.26	75	108	38	25	20	(1)	4	6	-	-
2B19	07.44 Dartford	08.31	85	142	65	47	36	(9)	(9)	(14)	(10)	(10)
2F59	08.02 Orpington	08.33	100	107	32	49	(3)	(7)	(3)	(20)	-	-
2A65	07.54 Dartford	08.37	70	80	49	52	30	8	4	(36)	(24)	(55)
2C25	08.00 Barnhurst	08.40	80	99	57	60	66	27	39	(7)	(16)	(52)
2F65	07.58 Sevenoaks	08.43	110	130	51	20	12	(10)	3	(29)	(19)	(38)
2K11	08.07 Hayes	08.46	85	105	54	39	22	(11)	(9)	(30)	(13)	(43)
2D69	07.52 Crayford	08.50	85	66	48	12	(30)	3	6	(14)	(36)	(43)
2A67	07.34 Gillingham	08.53	60	45	25	26	18	(40)	4	(22)	-	-
2F03	08.22 Orpington	08.56	45	40	(20)	0	(23)	(49)	(45)	(49)	-	-
2C29	08.20 Barnhurst	08.58	55	12	6	0	(31)	(31)	(15)	(35)	-	-
2D23	08.12 Crayford	09.00	(35)	0	(65)	0	(48)	(58)	(60)	(47)	(66)	0

Note Figures in brackets denote seats available

striking the knees of the other seated passengers (see Figure 5). Frazer Nash concluded from the fact that the passenger was still in contact with the seat after one second had elapsed that the passenger may have time to take evasive action. Thus, it was believed that the passenger may not fall in such an uncontrolled manner.

190 The passenger seated with his back to the direction of travel was relatively unaffected by the 5 mile/h impact. The standing passenger initially retained his hold on the luggage rack so that his arm straightened. Once the arm was fully straight the grip was broken and he collapsed onto the floor in the aisle.

191 In the 15 mile/h the passenger seated facing the direction of travel initially slid forward in his seat with his feet sliding across the floor until his feet and knees came into contact with the passenger opposite. The force generated by this contact was enough to pitch him head first into the chest of the other passenger. The passenger seated with his back to travel was pressed into his seat with his head and elbows hitting the seat back. His feet also slid along the floor until his legs came into contact with the front of the seat. He was then struck violently by the other passenger (see Figure 6).

192 Initially the standing passenger maintained his grip as his arm straightened. Eventually he fell sideways and continued to slide along the floor. In this particular case the passenger did not hit any of the seats during his fall. That would not necessarily have been the case if the passenger's starting position had been slightly different or there were other passengers or luggage in the aisle.

193 The 15 mile/h impact model was repeated with an increased value of friction between the passenger, seat and floor being used. As a result the passenger facing the direction of travel behaved slightly differently. His feet did not slide along the floor and his bottom stayed in contact with the seat longer, with his pelvis rotating forward more. This rotation caused his legs to open and so the contact with the other passenger was different.

194 With the standing passenger's knee joints rigid during a 5 mile/h impact, the model's behaviour was similar to the basic case but as his legs do not bend when he falls over, the way in which he fell and how he struck the seats was different. However, with a more open stance the standing passenger did not fall and no significant force was generated at his grip of the luggage rack.

Figure 5 Starting position for simulations shown in Figures 6 and 7

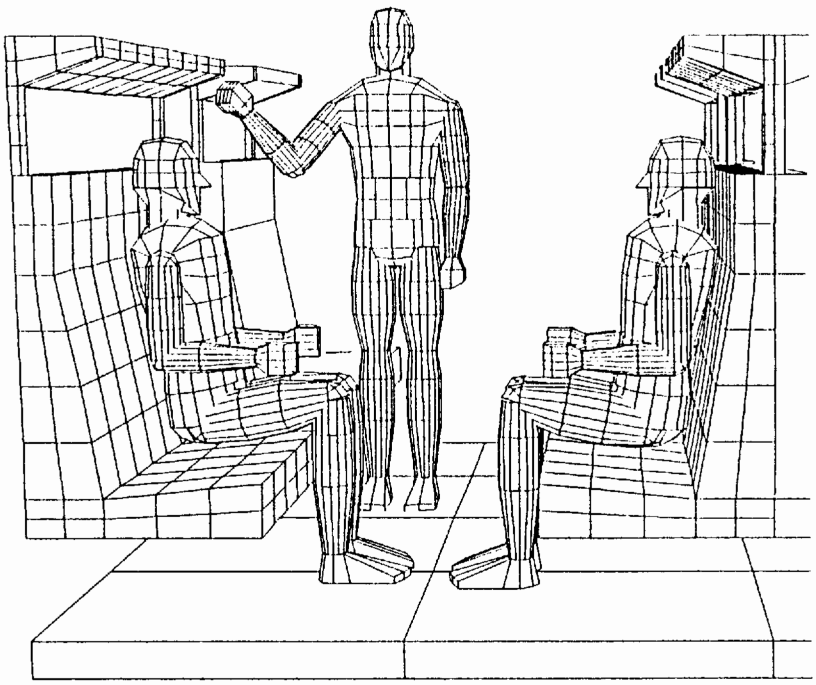

Figure 6 Five mile/h impact

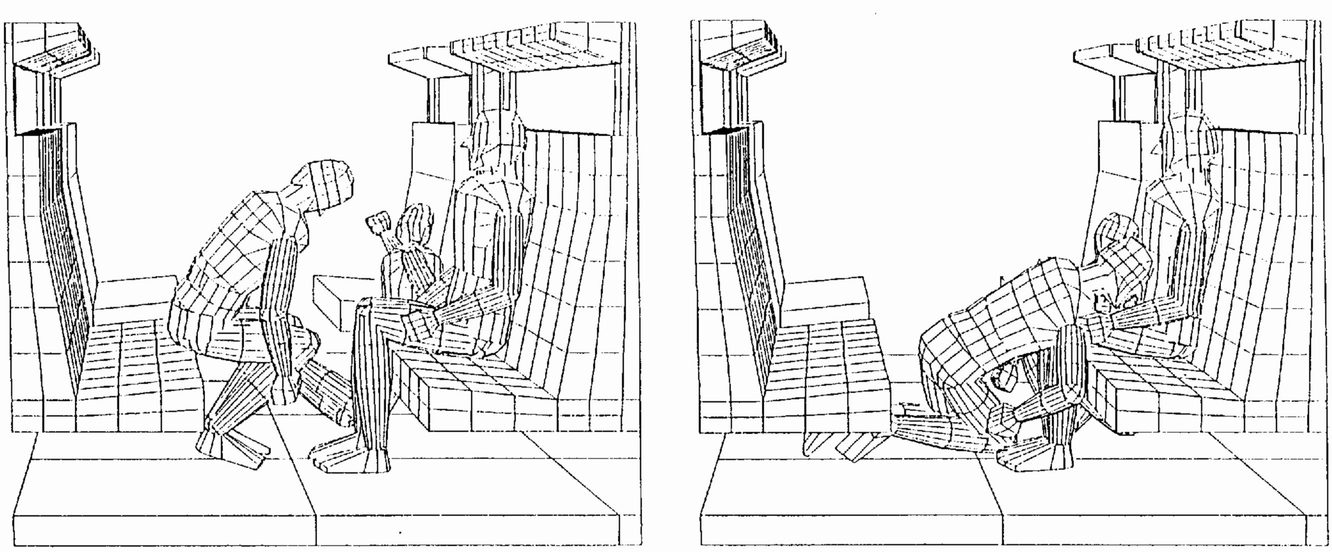

Figure 7 15 mile/h impact

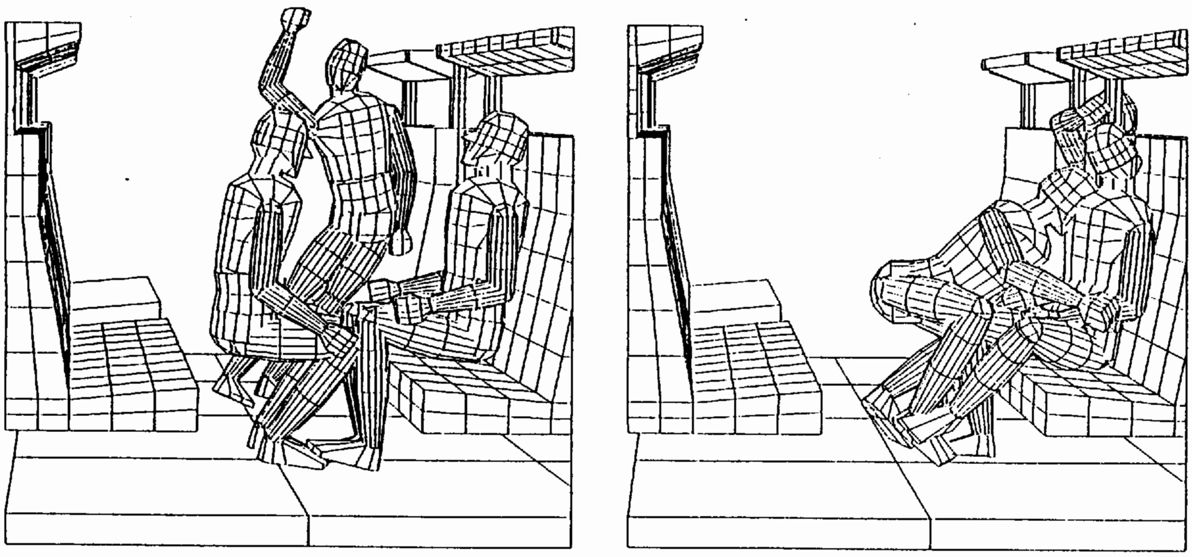

Figure 8 15 mile/h impact with two standing passengers

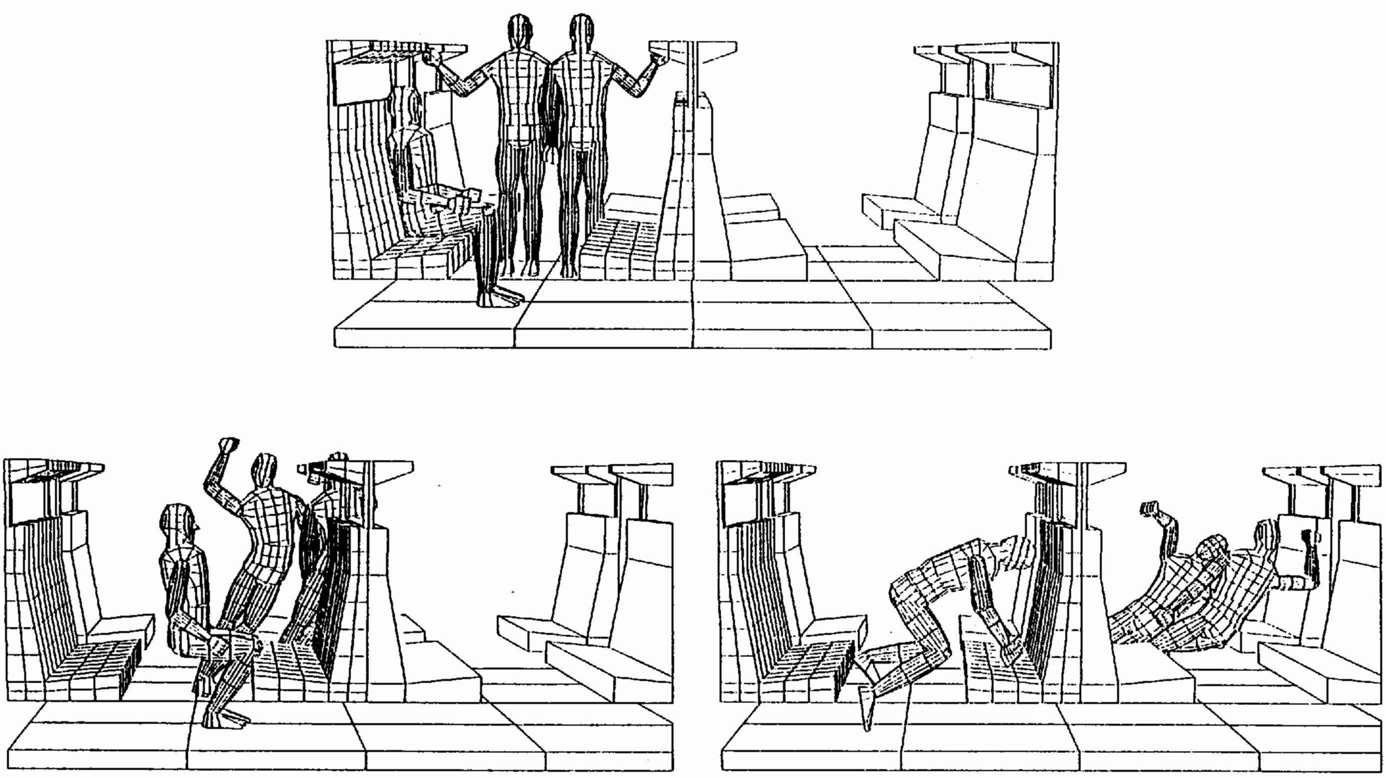

Table 4 Analysis of likely injuries predicted by computer simulations

	5 mph impact		15 mph impact	
Seated passenger (facing direction of travel)	*Chest* *Hands* *Head* *Knees*	bruising / rib or sternum fracture / lung contusion bruising / broken fingers facial injury bruising / broken kneecap	*Head* *Knee*	neck injury / facial injury bruising / broken kneecap / broken femur
Seated passenger (back to direction of travel)	*Knees* *Thighs*	bruising bruising	*Chest* *Knees*	bruising / rib or sternum fracture / lung contusion bruising / broken kneecap / broken femur
Standing passenger	*Arm* *Back* *Elbow* *Head* *Knees*	dislocated shoulder bruising / broken back bruising skull fracture / facial injury bruising / broken kneecap	*Arm* *Side* *Wrist*	dislocated shoulder arm or leg bruising / broken arm friction cuts or burns bruising / fracture

195 To investigate the interactions of multiple standing passengers a further 15 mile/h impact scenario was analysed in which one of the seated passengers was replaced by a second standing passenger. The behaviour of the original standing passenger was similar to that in the basic scenario except that when he fell he landed on the second standing passenger. The second standing passenger retained his grip on the luggage rack for some time until his arm was pulled straight across his chest. However, at that point there still had been no contact between the two standing passengers (see Figures 7 and 8). It appeared that during the initial stages of the impact there would be little interaction between standing passengers as they would be moving at the same speed. Later the situation for some would be made worse as others fell on them and better for others as their fall would be broken.

196 From the work undertaken Frazer-Nash Consultancy concluded that if the train was travelling very slowly (say 5 mile/h) there was a good chance that passengers would not be injured if they have prior warning of impending impact or react quickly. If this was not the case then standing passengers might be at a greater risk. This was because they were more likely to lose their balance and fall in an uncontrolled way.

197 If the train was travelling faster (say 15 mile/h) then it might make little difference whether other passengers were standing or sitting. This was because neither group would be expected to be able to prevent themselves from being thrown around uncontrollably. All passengers would then be exposed to a number of potentially injurious impacts.

198 In all cases the actual injuries sustained would depend on whether the passenger hit something hard or sharp or was hit by something hard, sharp or heavy. Owing to the chaotic nature of the event, luck would have a large part to play in the type and severity of the actual injuries. Frazer-Nash Consultancy's analysis of the likely injuries caused to the passengers is given in Table 4. The work undertaken did not include any injuries, which are known to occur, from being struck by dislodged luggage. The technique used could also be used for modelling the motion of luggage caused by the impact.

199 From the modelling it appeared that the risk of injury increased with the greater speed of impact and the consequential greater value of deceleration. The 5 mile/h impact giving 0.25 g and the 15 mile/h impact 2.25 g; a nine-fold increase in the forward force on the passenger for a three-fold increase in speed. The rate of change of deceleration (jerk) at the moment of impact was also likely to be important as it would tend to lead to passengers losing their grip on hand holds.

Into the effects of cannabis

200 Following the evidence given by Dr A Omerod I sought expert evidence from *Professor I Hindmarch* of the Human Psychopharmacology Research Unit of the Robens Institute of Health and Safety which is part of the University of Surrey.

201 Professor Hindmarch informed me that it had been well established, and with the confidence of contemporary research, that cannabis in its various

forms (herbal, resin and oil) can have a profound effect on human psychological and psychomotor states. Manual dexterity tasks and speed of response have been shown to be impaired following cannabis use. Both over and underestimation of distance and discrepancy in the estimation of time are significantly impaired. Certain tests of memory and cognitive function have also been shown to be impaired by cannabis use when compared with non-user control tests.

202 Cannabis has been shown to impair motor vehicle driving and driving related skills and to be especially associated with low-speed collisions and accidents associated with lapses of attention. (This is somewhat in contrast to alcohol where high-speed passing accidents are heavily featured.)

203 The individual's personality and psychological state can modify the effects of cannabis in much the same way as the administration of alcohol has different effects on different individuals. Research has demonstrated that individuals exposed to what they believe is cannabis have shown many of the behavioural changes of people who have actually used it.

204 If the accounts from earlier investigations are added to the most recent scientific evidence a picture emerges of cannabis as an illusionogenic substance, that is, a drug which modifies perceptual processes in all sensory modalities without necessarily giving rise to hallucinations. The characteristic features noted from large scale surveys of populations in North Africa and India, among whom the use of cannabis is widespread, characterise the cannabis user as without motivation, somewhat introverted and reflective, and in a completely timeless state.

205 It is probably the disruption of the sense of time and reality that is the common report from both scientific and anecdotal accounts of cannabis use. Such disturbance of the central nervous system reactive processes is certainly the reason why the edge is taken from human performance.

206 Professor Hindmarch is of the opinion that even the smallest amount of cannabis and/or its metabolites, which can be detected in the body, can be readily associated with some change in the integrity of the performance of the tasks of every day living. Not only are critical stimuli in the environment unheeded, but the motor and behavioural response to such stimuli is retarded and delayed.

207 *Dr E G Lucas*, a Senior Employment Medical Adviser from the Health and Safety Executive, gave me advice on the clinical effects of cannabis. He explained that, clinically, cannabis exerts a wide spectrum of effects on the mental state from the less severe such as euphoria, impaired hand eye co-ordination, sense of time, reaction time and cognitive function paradoxically associated with a subjective feeling of its enhancement, paranoid thoughts, depersonalisation (feeling of unreality), derealisation (unreality of surroundings), through to a toxic psychosis. The latter is characterised by the sudden onset of confusion, emotional liability, lack of insight and judgement, hallucinations and delusions.

208 It should be noted that the severity of the effects would vary between individuals. The effects may be modified by the user developing a tolerance. The effects are generally dose-related but occasionally may be idiosyncratic. Also the effects may persist for days or weeks after the final dose. Urinalysis can identify cannabis metabolites for up to 28 days following its administration.

209 I discussed with *Dr G Smith*, the Chief Medical Officer for the British Railways Board, the drug screening arrangements introduced on 5 August 1991 for all new entrants. It was decided to restrict the screening to those people who would already be required to have a medical examination, as that encompassed all safety-related grades of employees. In addition it had been decided to implement screening for drug use on internal promotion as well as transfer from non- safety to safety-related grades, with a view to widening the screening process to include promotion and transfer within safety-related grades in due course.

210 'For cause testing' was already being undertaken at management request and when there appeared to be good reason for doing so. These tests required the consent of the individual. A requirement for staff to submit to unannounced (random) testing had also been included in new contracts of employment but it would be many years before this condition applied to the majority of staff.

211 Dr Smith confirmed that it was the British Railways Board policy that employees voluntarily seeking help with an alcohol or drug related problem would be assisted with counselling and rehabilitation. Information, leaflets, posters and visual aids, including a new video on alcohol and drug awareness entitled *The morning after*, are regularly produced and updated to draw the attention of all rail staff to the risks associated with alcohol and drugs. The new Code of Practice also described the symptoms and signs of alcohol and drug abuse which managers and supervisors should look out for.

212 The British Railways Board Rule Book states that: "An employee must not report for duty under the influence of intoxicating liquor or any drug which might impair the proper performance of his/her duty." It is the aim of the Board's initiatives to identify those with problems as early as possible and to assist their recovery in every way possible.

Into the age of the rolling stock

213 Following the accident there was considerable speculation as to the age of some parts of the rolling stock. I am grateful to *Mr L Mack* who provided from historical data he had built up over a number of years a detailed history of the vehicles of the train. In particular, he concentrated on unit No 5484; the second four-car unit of train.

214 The first coach of the second unit (the fifth coach of the train) No 14046, was built on an underframe which dated from 1934 as part of Southern Railway electric driving motor brake coach No 9854. At that time, the underframe supported a body rebuilt from a London and South Western Railway (L&SWR) coach dating from 1895 and which had already been rebuilt once. Coach No 9854 was marshalled in a three-car suburban unit.

215 It was withdrawn from service in 1951. The underframe was re-used with a new steel body and returned to service in 1953 as coach No 14046 as part of the 4EPB unit No 5023. That unit was in a collision with a locomotive in 1958. Coach No 14046 was at the rear of the train and survived the collision and was transferred into unit No 5031 which subsequently became unit No 5484 on face-lifting in around 1986.

216 The second coach in unit No 5484 (the sixth in the train) was built on an underframe dating from 1928 when it was equipped with an ex-L&SWR body, built in 1902, and formed part of a two-coach trailer set. It was transferred into a 4-SUB unit in 1943 and was withdrawn from passenger service in 1954. The underframe was re-used and re-introduced with a new body as part of a 4EPB unit in 1955.

217 The third coach (the seventh in the train) started life in 1948 as an all-new coach in a SUB unit. It was rewired and formed into unit No 5031 in 1953. The other driving coach, No 14061, had an underframe dating from 1927 when it was introduced with a body converted from South Eastern and Chatham Railway coaches from 1892 and 1896. It was withdrawn in 1951 and re-introduced with a new body in 1953.

DISCUSSION OF EVIDENCE

218 The refusal of Mr Graham to give evidence to my Inquiry was unhelpful in that it denied me first-hand evidence as to his actions immediately before the collision. Therefore, I have had no alternative but to attempt to assess what his actions must have been on the basis of the evidence of others and the results of the technical investigation. I comment further on this matter in paragraphs 285 to 287.

219 Although Mr Graham chose not to give evidence to my Inquiry, those representing him were present throughout the public hearing of evidence and were able to ask questions of the other witnesses. In this questioning witnesses were asked if they were completely certain about such matters as the speed of the train before the impact with the buffer stops or if some unknown fault on the train may have remained undetected.

220 In assessing the evidence I have had to make judgements on much evidence, which, if not conflicting, is not completely consistent. In forming my opinion as to what occurred and as to why it happened, I have had to do so on the best balance of the evidence available. Of course, in many of the matters I have had to consider it is not possible to have total and absolute proof. Therefore, in reaching my conclusion I have had to make my judgement on what is reasonably probable.

The speed of impact

221 The eyewitness evidence as to the speed of the train when it struck the buffer stops varies considerably. That is to be expected because the unaided human judgement of speed is very subjective, especially in cases when the train was viewed only briefly or from an acute angle and when the accurate estimation of speed is difficult.

222 The evidence is that the train did not approach the station at an excessively high speed or at a speed above the permanent speed restrictions. Mr Knight travelling on the train estimated the train to be moving at between 5 mile/h and 10 mile/h. Mr Batchelor on the platform estimated the speed as 5 mile/h or slightly faster. Mr Hamlin at the end of the platform put the speed higher at 10 to 15 mile/h.

223 I believe the best eyewitness evidence available was from two witnesses who related the speed of the train to other movements. Mr Giles, a passenger on the train, estimated the speed to be between 10 and 12 mile/h and related it to someone running at a fast jog. Mr Kingsford, who from the elevated control point had a better view of the approaching train than some of the other witnesses, estimated the speed of impact to be 10 to 15 mile/h.

224 The calculations made by Mr Crofts and Mr Lewis gave the speed of impact as 9.1 to 11.2 mile/h for a train being neither braked nor powered. This calculation included the assumed retardation provided by the hydraulic buffer stops. The subsequent testing of the buffer stop was not sufficiently complete at the time I was preparing this report for the results to be included. However, early indications are that the calculations of impact velocity are reasonable.

The condition of the track

225 Mr Middleton gave evidence that the rails were dry and in good condition. There was no contamination of the rail heads by oil or grease throughout the length of the platform. I was able to confirm this for myself on the day of the accident. The possibility of a brake application being adversely affected by contamination of the rails can be discounted.

The braking system of the train

226 The visual examination of the brakes of the train after the accident described by Mr Morrison (paragraphs 83 to 85) indicated the brakes had been applied immediately before or during the course of the impact. The brake application could have been made by the driver or caused by the damage to the fifth and sixth coaches.

227 There was conflicting evidence from Mr Morgan (paragraph 91) and Mr Middleton (paragraph 105) as to whether there were signs of skid marks on the rails caused by a brake application. What is clear from the evidence is that there were no signs of prolonged heavy braking.

228 Starting with the tests undertaken at Cannon Street Station, before the damaged fifth and sixth coaches were separated, a series of progressively more detailed tests were carried out on the braking system of the train. Although undertaken in the main part by British Railways the test programme was overseen by Mr Sawer on my behalf and individual tests witnessed, as appropriate. No deficiencies were found to explain Mr Graham's alleged claim that the brakes had failed.

229 One of the aspects I considered was the possibility that a fault could have existed which would have caused power to be applied to the motors of the coaches at the rear of the train. If this had occurred it would have reduced the efficiency of the brake application and possibly, to some extent, accounted for the severe damage towards the centre of the train. However, there is no evidence that power was being applied to the rear of the train.

Examination of the driving cab

230 Of those railway staff who examined the driving cab immediately after the accident Mr Kennedy undertook the examination in so superficial a way that I found his evidence of little value. I consider that Mr Morrison undertook his examination properly. While the possibility of someone else having entered the driving cab and moving the controls cannot be completely discounted, I am inclined to accept that the controls were in the positions described by Mr Morrison.

231 However, I am not inclined to place too much significance on the position of the controls after the accident. If the driver was holding them or thrown against them when the impact occurred they are likely to have moved. Therefore, whether the power controller was in the weak field position or not immediately after the collision is not conclusive as to the way in which Mr Graham was driving the train.

Mr Graham's driving of the train

232 Although Mr Green travelled in the driving cab with Mr Graham from London Bridge Station to Cannon Street Station he appears not to have observed Mr Graham's actions particularly closely. From his evidence it does not appear that Mr Graham's behaviour was in any way abnormal. Certainly, it did not cause Mr Green any concern.

233 Until the final moments of the journey to Cannon Street Station, Mr Graham's handling of the train appears to have been perfectly proper. Indeed, he stopped the train at and started the train away from the stations on the journey in a way which was neither the cause of comment or concern. Mr Bright in the driving cab of the train at platform 2 saw the approach of the other train to the start of the platform and saw nothing unusual in the speed at which the train was being driven into the station.

234 Earlier Mr Gloster had driven another train into Cannon Street Station and successfully stopped at platform 3. Mr Graham was an experienced driver (he was appointed as a driver in June 1988) and there are no reasons why he should have had any greater difficulty than Mr Gloster in stopping at platform 3. For Mr Graham to have so completely misjudged his braking if he was fully attending to his duties would seem to be improbable.

235 Mr Taylor expressed the opinion, based on his vast experience, that if a train was started away from London Bridge Station in a normal manner and then traction power was shut off for the 20 mile/h speed restriction between London Bridge and Cannon Street Station but no brake application was subsequently made, it would continue to coast towards the buffer stops at about 15 mile/h.

236 Assuming Mr Graham, for whatever reason, had allowed his attention to wander and not made a brake application at the appropriate place then the likely outcome suggested by the evidence given by Mr Taylor would appear to correspond to what actually occurred. The evidence as to the exact point at which Mr Graham attempted to apply the brakes is not precise enough for any firm conclusions to be drawn from it.

237 If Mr Graham had allowed his attention to wander as the train entered the station or on the approaches to the station, it is likely that at the last minute he would have

made a belated attempt to apply the brakes. Also, having left the braking too late, it is conceivable he should believe the brakes had failed.

238 If Mr Graham in making his brake application, instead of applying the EP brake firmly had moved the brake further into the lap position, then there would have been no brake application and the train would have continued to coast. However, this would appear too elementary a mistake for an experienced driver to make. Had he done so, it seems very unlikely that he would not have realised his mistake in time to recover from it.

239 The advice given to me by Professor Hindmarch, that the effects of cannabis include (a) distortion of timescales and (b) the failure to respond to external warning stimuli until the situation was perceived to be extreme, indicates some degree of similarity between these effects and the reactions of the driver. It may be significant that the effects of cannabis can occur sometime after the use of the drug. The medical evidence indicates that Mr Graham had at some time used cannabis. However, I have no evidence as to when he had used cannabis and as to whether or not it was a factor in Mr Graham's actions.

The lighting levels in the station

240 The temporary lighting provided during the construction work was not to the standard of the proposed permanent installation. In his evidence to me Driver Gloster, who had earlier driven another train into platform 3, commented on the adequacy of the temporary lighting (paragraph 60). While this temporary lighting was not as good as it might have been, there was no suggestion that the lighting levels were so poor as to create undue difficulties for train drivers. I have no evidence to suggest that Mr Graham experienced particular difficulties in this respect.

The risk to standing passengers

241 Following the accident there was considerable speculation as to whether those passengers who were standing on the train were exposed to an unacceptably higher risk of injury than those who were seated. Mr Lettin expressed the opinion that standing passengers were exposed to a higher risk taking issue with medical opinion expressed to the investigation into the Clapham Junction accident.

242 The circumstances and the consequences of the two accidents were very different. At Clapham Junction the collision resulted in some of the coaches virtually being destroyed. Therefore, the passengers travelling in them were unlikely to escape serious injury and whether they were standing or seated was of less importance. At Cannon Street, with the exception of the fifth and sixth coaches, the damage to the train was not as great. If the vehicle body virtually remains intact then injuries will be caused by the passengers being thrown about as the train stops suddenly.

243 Mr Lettin was able to confirm that many of the passengers he treated had injuries which could have been sustained by standing passengers. However, he had not actually checked with the injured as to how their injuries had been caused. The number of injured passengers exceeded the number of passengers who were standing although the numbers standing may have been swollen by those passengers who had risen from their seats as the train entered the station.

244 One of the remits of the work undertaken by the Frazer-Nash Consultancy was to try to compare the behaviour of standing and seated passengers. I recognise that the computer modelling technique used is not developed sufficiently to give a completely accurate representation of human behaviour. In particular, the models have no reactive response and, for example, do not attempt to recover their balance. Therefore, the computer model tends to predict the more extreme reactions.

245 Nevertheless, I accept the basic theory developed from the work that in a low-speed accident standing passengers are likely to suffer more than seated passengers. At a higher speed both seated and standing passengers will suffer similar level of injuries. This too would account for the differences in medical opinion between the Clapham and Cannon Street accidents. The former collision occurred at approximately 35 mile/h.

CONCLUSIONS

As to the cause of the accident

246 From the evidence available to me I can find no defect in either the braking or traction system, either permanent or intermittent, which would have prevented brakes from operating effectively. Therefore, I must conclude that Mr Graham failed to make the proper brake application and that by his omission he was responsible for the accident. I am unable to reach any firm conclusion as to the reasons for his error or as to whether Mr Graham's use of cannabis was the cause of his omission.

As to the part played by the age and construction of the rolling stock

247 Despite its age the rolling stock had been properly maintained and it did not contribute to the cause of the accident. Nevertheless, its now superseded design did result in more severe damage to the rolling stock and an increase both in the severity and number of injuries. In

particular, the overriding of the fifth and sixth coaches occurred because of the inadequacy of the single buffer coupling and the lack of structural strength in the coach bodies.

The number of passengers on the train

248 Claims that overcrowding of British Railways trains is unsafe are frequently made especially after accidents have occurred. I do not consider the number of passengers on a train will be the direct cause of an accident to the train. However, the more people there are on a train, which is involved in an accident, the more people there are at risk of injury. The large number of passengers injured in this accident was due, in part though not solely, to the number of passengers standing in the front coaches of the train. Undoubtedly, many of the passengers had risen in preparation for alighting.

REMARKS AND RECOMMENDATIONS

Prevention of similar accidents

249 Prevention of buffer stop collisions and if that is not completely possible, reducing the consequences of such collisions, cannot be achieved by any single measure. The measures required will include both improving the skill of the driver and physical provisions. Clearly, space at terminal stations is limited and it is not always physically possible to provide long overruns beyond the intended stopping point.

250 The driver of the train has to manage the approach speed and judge the brake application and the final stopping point. This operation requires skill but also proper concentration. If an error is made the period of time available to the driver to rectify the situation is extremely limited. However, the only response needed should be for the driver to make a harder or emergency brake application. *I recommend* that the British Railways Board should review the training given to drivers on the control of a train into a terminal platform and enhance the supervision of drivers' performance of this part of their duties.

251 I gained the impression that drivers are permitted to enter terminal platforms at too high a speed. The excess speed is only marginal, and may aid the efficient working of the railway, but it significantly reduces the chances of a driver being able to take the action necessary to recover from an error of judgement and avoid the collision. A similar situation would arise if the overspeed arose from physical factors.

252 It is essential that the final speed of approach of the train towards the intended stopping point is limited to the maximum speed which the buffer stop will absorb without the impact causing serious or widespread injury to the passengers. While today, and possibly for some years to come, the responsibility for the control of the train's approach speed must rest with the driver, I understand the facility to enable the speed of approach to be monitored and for the driver's actions to be overridden if the speed is too high, can be included in the automatic train protection (ATP) signalling systems currently being evaluated by the British Railways Board. *I recommend* that this facility should be included in the ATP system chosen and installed as quickly as is reasonably practicable. Also *I recommend* that the priority for installation should take account of the density of traffic into the various terminal stations.

253 Despite the above measures the risk, albeit reduced, of a train overshooting and colliding with a buffer stop will remain. In addition to indicating the end of the line the buffer stop has to fulfil two other purposes depending on the circumstances. Firstly, it must cushion the low-speed impact of a train which slightly overshoots the intended stopping place. Secondly, it needs to prevent a train out of control from continuing on beyond the end of the track.

254 The second requirement, which will prevent, for example, a train smashing its way across a station concourse, can be met by providing a separate structure designed to resist the violent impact involved. The probability of such an accident is extremely low but inevitably some casualties will occur. I believe the collision speed involved placed the Cannon Street accident into this second category of accident.

255 The design of the Cannon Street buffer stops clearly met the second requirement, but at the speed of impact involved, they were not particularly effective in meeting the cushioning requirement. In designing a buffer stop to meet the first requirement the technical factors such as space available, type and weight of train, etc, need to be taken into account but the leading decisions which have to be made are the impact speed and the rate of retardation which is required to minimise injury to passengers.

256 During the course of my Inquiry I was invited to recommend that modern sliding buffer stops would provide a better buffer stop than existing hydraulic types. Others asked me to recommend that efficient hydraulic buffer stops should become the standard. The existing hydraulic buffer stops at Cannon Street have a number of disadvantages: their performance is uncertain; the retardation provided does not meet today's requirements; they are difficult to maintain; and because of their age spare parts are not available.

257 However, simple sliding buffer stops may in themselves not provide the complete answer. Because they rely on mechanical friction to generate the retardation required, they can be designed to provide a

smoothly increasing level of retardation once the sliding movement has started. Before movement of the buffer stop does commence, the higher static friction has to be overcome and it is this initial jerk which creates the risk of injury. The mechanism also requires a considerable distance which may not be available.

258 Therefore, the best solution appears to be a combination of both hydraulic and sliding buffer stops. In this way a smooth initial retardation can be provided with the sliding buffer stop. The introduction of new rolling stock without side buffers requires buffer stops which will engage the centre automatic coupler; the traditional design of hydraulic buffers needs to be modified to allow for this.

259 I understand that the director of civil engineering for the British Railways Board is currently reviewing the design standard for buffer stops. *I recommend* that this work should incorporate the factors referred to above and be completed as quickly as possible. I suggest that the maximum retardation should not exceed 15% g (compared with 12% g commonly provided as the emergency brake retardation). Also *I recommend* that the British Railways Board should install new or modify existing designs of buffer stops on passenger lines to meet the new standard and that the work should be undertaken taking into account the density of traffic.

Standing passengers

260 Although I do not believe there are any safety grounds for prohibiting passengers from standing on a train, indeed many metro and suburban railway systems worldwide are designed and operated on the basis that many of the passengers will stand, care needs to be exercised in the way standing passengers are conveyed.

261 There already exist, under an understanding between HM Government and the British Railways Board, maximum loading targets of 110% of the seating capacity for journeys and that no passenger should stand for more than 20 minutes except by choice. This target does not include occasional exceptional loading which may occur, which appears to be employed to cover crush loading. Clearly, the British Railways Board and its individual passenger businesses need to continually and routinely monitor the number of passengers using their trains. It is only by doing so that the Board will be able to ensure that the loading targets are not routinely exceeded.

262 I do recognise that it is not practicable to run a railway system which is capable of an infinitely flexible response to the fluctuating demands upon it. However, it is reasonable to expect the British Railways Board to recognise developing trends and to instigate action before the overcrowding becomes prolonged or excessive. From the evidence available to me, the majority of the services into Cannon Street Station, are not usually overcrowded in the sense that the whole train is overloaded.

263 Examination of Tables 3a and 3b shows the distribution of passengers between the various coaches on the trains surveyed. With a free choice many passengers will choose to travel in the front coaches even if this means having to stand. The reasons for doing so will differ between individuals but the prime reason appears to be the desire of the passengers to leave the train quickly on its arrival at the terminal station.

264 This is particularly evident with services into Cannon Street Station as many of the passengers in the front part of the train board it at London Bridge Station for the last short part of the journey. Many passengers are prepared to stand for this portion of the journey for the advantage obtained by being at the front of the train. This situation is not helped by the platforms at London Bridge Station, which are used by the services continuing through to Cannon Street Station, having the access to them adjacent to the front of the train.

265 *I recommend* that the British Railways Board should examine what measures, both on-board trains and at stations, can be introduced to distribute passengers more evenly along the train. I anticipate that these measures will include providing better advice to intending passengers of the available space on trains, arranging access points to platforms away from the front of trains and making arrangements at terminal stations, particularly where ticket examination takes place, to remove the perceived advantage to those at the front of the train.

266 Having accepted that some passengers travelling on the train will be standing, then the design of the train must make adequate provision for those passengers. I deal with this in paragraph 272 to 274.

The age of the rolling stock

267 As stated in paragraph 247, I do not believe that the age of the rolling stock played a part in the causation of the accident. Providing it is properly maintained rolling stock does not become unsafe and likely to cause an accident merely because it is old. However, the age of the rolling stock was a factor in the extent of injuries suffered by some of the passengers and also in the number of the passengers injured.

268 The age of the rolling stock was a factor because the designs to which it was built are now seen to be deficient by modern standards. The weaknesses of

the design may be summarised as follows:

(a) in a collision, the centre buffer and coupling arrangement is more likely to allow overriding of one vehicle over another than other arrangements;

(b) the lack of structural strength in the body of the coach (in this respect the 'Southern Railway' design of bodies is worse than the 'British Railway' design);

(c) the interior fittings and seating of the coach;

(d) the numerous slam doors.

269 I deal with the interior design of the coaches in paragraphs 272 to 274. The other weaknesses in the design of this particular rolling stock are such that, in my opinion, they are not capable of being rectified by modification to the existing rolling stock. Modern rolling stock is designed with the floor, body-sides and roof forming a strong structural tube, which gives a vehicle with considerable crash resistance.

270 Modern rolling stock is also equipped with various forms of sliding doors which have to be released by a member of the train crew. Such doors provide a number of safety advantages but in relation to the Cannon Street accident would have prevented passengers from opening doors before the train came to a complete stand.

271 The decision to replace this old rolling stock by new rolling stock built to a modern design has already been made. *I recommend* that the withdrawal of the class 415 electric multiple units and their replacement by the new 'Networker' units should proceed as quickly as possible and without further delay. In addition *I recommend* that the first priority should be to withdraw the 'Southern Railway' designed vehicles.

The interior design of rolling stock

272 It has been recognised for many years that collisions with buffer stops are likely to cause a disportionately high number of injuries to the passengers on the train. Undoubtedly this is due to many of the passengers preparing to alight and being caught unawares and off balance when the impact occurs. Fortunately the level of injury sustained is normally minor. Nevertheless, careful interior design can reduce the consequences of a minor collision.

273 I have in paragraphs 260 to 265 already acknowledged that it would not be realistic or necessary to ban standing passengers from railway trains. However, the interior design of the train must provide adequate hand holds. Greater care is required in the design to avoid hard or sharp edges which will cause injury. Equally, further consideration needs to be given to the way in which luggage is contained.

274 It has been suggested on a number of occasions that the provision of seat belts would contribute to the prevention of injury and that the provision and use of seat belts on trains should be compulsory. I do not believe that the provision of seat belts is a practicable solution.

The provision of on-train data recorders

275 I have previously recommended that on-train data recorders should be provided*. Clearly, had an on-train data recorder been fitted to the train involved in this accident my task would have been made much simpler. The recorder would have provided information about the actions of the driver as well as the operation of the train's braking and traction systems. Therefore, I repeat that *previous recommendation* that all new builds of locomotives and multiple-units should be equipped with such recorders and that existing ones should be retrospectively fitted if it is practicable to do so. It may be appropriate to use a simpler recorder for existing rolling stock.

276 The British Railways Board are already considering the provision of black-box incident recorders. In July 1988, the Director of Network SouthEast decided that multi-function data recorders would be fitted to all new builds of rolling stock for the Network, with retrospective fitting of the equipment to the more modern stock. A full specification was prepared in October 1988 listing all the essential as well as desirable functions required to be recorded. It would be of the overwriting type with a capacity of eight hours or 1600 km recording.

277 These on-train data recorders will not only provide invaluable help in accident investigation but also many advantages in normal operation and management. The purpose of an on-train data recorder is to provide a full record of the operation of the train over a designated period. Therefore, it will provide a discipline to drivers and their driving technique and provide a record of any malfunction, irregularity or incident. The British Railways Board have already started evaluating designs of on-train data recorders. This evaluation should be completed as quickly as possible and an installation programme produced and commenced.

Alcohol and drugs

278 Regardless of whether the use of cannabis was a factor in this accident, the use of alcohol or drugs by

* Report on the collision that occurred on 4 March 1989 at Purley, HMSO ISBN 0 11 550996 8

railway employees is unacceptable. The consumption of alcohol or the use of drugs is against the British Railway Board's rules and is subject to their disciplinary procedure. Although for railway staff to be under the influence of alcohol is illegal, there is no equivalent law in relation to drugs. Neither is there any statutory provision for testing of employees for drugs or alcohol after an incident. I believe this situation is unsatisfactory.

279 Therefore, *I recommend* that legislation should be introduced making it an offence for railway employees with safety responsibilities to be impaired by the consumption of alcohol or drugs. I do not believe this legislation should apply to just train drivers but to all those whose duties involve the safe operation or maintenance of the railway.

280 Also, *I recommend* that legislation should be introduced to permit the testing of employees involved in a safety related incident. I consider that a police officer and not railway management should be empowered to require these tests. I believe the recommended changes in legislation will not only provide a control which will enhance safety but will provide protection from unjustified suspicion to any member of staff involved in an incident. (Note: The Transport and Works Act, 1992, contains provisions dealing with these matters.)

281 *I endorse* the action being taken by the British Railways Board's medical services both in respect of pre-employment medicals and, perhaps even more importantly, providing help to existing employees who may have either a drugs or alcohol problem. *I recommend* that the British Railways Board should develop a management culture which enables employees with problems to seek and obtain assistance without endangering the safety of the railway.

Arrangements for train crew booking on

282 During my Inquiry I learnt of the widespread arrangements which still exist on the Southern Region for train crew to start duty at some location other than at their home depot. Of particular concern to me is the arrangement whereby train crew can, and are allowed, to take up their duties without being seen by a supervisor. The risks associated with such arrangements have been long recognised following accidents elsewhere and the British Railways Board were to phase out unsupervised booking on.

283 The fact that such arrangements still remain on the Southern Region may to some extent be explained by the fact that many members of staff live considerable distances away from the depot to which they are allocated. The social factors which cause this are beyond the control or even influence of the British Railways Board. I accept that to expect train crew to significantly extend the time taken travelling from home to work would be unreasonable.

284 Although I have no reason to believe that it played any significant part in this accident, I was concerned to hear that at a number of locations drivers were able to book on for duty unsupervised. While I can understand some of the reasons for this situation continuing to exist, despite previous undertakings by the British Railways Board not to allow such booking on, it is undesirable for a number of reasons. *I recommend* that the British Railways Board should review the need for this practice to continue. I consider that the British Railways Board must make the necessary arrangements to ensure that a supervisor is present at all locations where train crew start duty and that the train crew must report to that supervisor. I recognise that for efficiency the supervisor may have to be multi-disciplinary.

The refusal of Mr Graham to give evidence

285 Mr Graham was advised not to give evidence by his lawyers because they were concerned that if he was to do so he could provide information which could subsequently be used against him in any prosecution. Although there had been no indication that a prosecution of Mr Graham was being considered, his lawyers were concerned that no immunity had been granted against any future possibility of a prosecution of Mr Graham.

286 I was specifically requested by Mr J Cartledge, on behalf of the Central Transport Consultative Committee and the London Regional Passengers Committee, to: "consider, in concert with the Government, what changes in the law (if any) may now be necessary to ensure that relevant evidence is not withheld by any witness at inquiries or Investigations conducted under the Regulation of Railways Act 1871."

287 The matter is complex and it is not an easy one for me to deal with. Clearly, as I have commented on earlier, the absence of direct evidence from the driver did make my assessment of the available evidence more difficult. Regrettably it does appear to be coming an almost automatic response of those representing some grades of railway employees to advise witnesses not to give evidence unless an immunity from prosecution is given.

288 As an inspector appointed under the Regulation of Railways Act, 1871, to hold an Inquiry, I had the powers available to me to insist on the attendance of Mr Graham to answer such questions as I chose to put to him. Although for him to refuse to answer my questions is an offence in law it is unrealistic to assume I could compel him to answer my questions. Nor would it be proper that I should be able to do so.

289 Any inspector appointed to conduct an inquiry (or an investigation) under the railway legislation is very clearly aware of the need to conduct the inquiry in a way that is in accordance with natural justice and will not prejudice the position of any individual giving evidence.

290 The purpose of the inquiry is to establish what happened and endeavour to identify measures which will prevent it happening again. Although the Inspector's task is not made easier if evidence is withheld it does not make the task impossible. Therefore, I do not regard it as being in the wider public interest that some form of immunity should automatically be given.

291 Despite the difficulties that this withholding of evidence may sometimes create, I consider an inquiry held under the Regulations of Railways Act, 1871, still remains an effective way of conducting an investigation of a railway accident. In particular it meets the expectation that the investigation should be conducted, for the most part, in public. Accordingly, I have no recommendations to make on this matter.

The costs of attending the Inquiry

292 Following the public hearing of evidence, I was requested by the lawyers representing many of the injured passengers to make a recommendation for costs for their representation at my Inquiry. My attention was drawn to the reimbursement of costs incurred during the formal investigation of the Clapham accident.

293 Inspectors appointed to hold an inquiry or undertake a formal investigation have no powers under the Regulation of Railways Act, 1871, to direct that any person's legal costs be paid. I am informed that the Department of Transport's payment of costs for the Clapham accident investigation did not imply any change to the Department's general approach for the less formal and more frequent inquiries held by inspecting officers of railways that legal expenses are not paid.

294 On the basis of this I feel that I am unable to make the recommendation requested for the payment of legal expenses.

Protection of the evidence

295 During the Inquiry criticism was made of the failure of police officers to secure the driving cab of the train immediately upon arrival at the scene. While an earlier securing of the driving cab would have been helpful, I do not believe it would have resulted in any more evidence being available to me. On arriving at the scene the first police officers must have been confronted with hundreds of members of the public, many of them with injuries, and quite properly their initial actions concentrated on dealing with them.

296 What was not acceptable was the way the railway supervisor who examined the driving cab and subsequently interviewed Mr Graham at Cannon Street Station undertook those duties. The examination was superficial and the interview conducted and recorded in a way which was both unprofessional and showed little regard for Mr Graham's welfare. The typed versions of the alleged statement were not signed by Mr Graham who was referred to in the third person, consequently they do not constitute a statement as such but rather a report of the accounts given by the individuals concerned. Mr Kennedy said that this had been the way such statements had been handled previously. He confirmed that on previous occasions, the witnesses had had the opportunity to amend any part they wished and each agreed the accuracy before the report was typed.

297 Before the date of the accident, the British Railways Board issued instructions which if they had been applied should have avoided what happened in this case. Clearly, not all of those who find themselves involved in the initial investigation following an accident understand the instructions and appreciate their importance or purpose. Therefore, *I recommend* that the British Railways Board should take action to ensure that all staff are properly instructed and trained to discharge their responsibilities in an emergency.

The use of the emergency brake

298 During the Inquiry the question arose as to whether or not a driver would have the opportunity to make an emergency brake application or to regularly use the automatic airbrake instead of the EP brake. While use of the automatic airbrake in normal passenger train service is acceptable the use of a full emergency brake application would be undesirable. Nevertheless, the British Railways Board need to find a way in which a driver may gain experience in the use of the emergency brake. The use of driving simulators may assist with this. In the meantime *I recommend* that the British Railways Board should explore how drivers may have the opportunity to practice emergency brake applications.

Station lighting levels

299 I do not believe that the difficulties, which sudden changes in lighting levels can create, have been fully recognised. It is not just the illumination level provided over the platforms which is important. It is the transition from, say, bright sunlight outside the station into the artificially illuminated areas of the station. *I recommend* that the British Railways Board, together with those who are responsible for the design of the reconstructed stations, should give further consideration to this aspect.

300 Finally, I must comment that I share the concern expressed on behalf of some of the injured passengers regarding the use of cameras and video recorders. It is

perfectly proper that video recorders are used at the scene to preserve information for future analysis of the accident. It is through their use that improvements in rescue techniques can be identified and, possibly, lives saved in the future. However, to the passengers trapped in the wreckage it can add to their distress. Perhaps a word of re-assurance and explanation about what is happening would help. Care also needs to be exercised as to what is subsequently made available for public broadcast.

This publication is no longer available from HMSO

HSE
BOOKS

MAIL ORDER
HSE priced and free
publications available from:
HSE Books
PO Box 1999
Sudbury
Suffolk CO10 6FS
Tel: 0787 881165
Fax: 0787 313995

RETAIL
HSE priced publications
available from Dillons
Bookstores nationwide and
can also be ordered at any
branch of Ryman the Stationer
or Ryman Computer Store
(*see Yellow Pages or telephone*
071 434 3000 *for local details*)

PUBLIC ENQUIRY POINT
Health and safety enquiries:
HSE Information Centre
Broad Lane
Sheffield S3 7HQ
Tel: 0742 892345
Fax: 0742 892333

£8.00 net

EMPLOYMENT DEPARTMENT GROUP

ISBN 0-11-886303-7

9 780118 863032