DEPARTMENT OF TRANSPORT

RAILWAY ACCIDENT

Report on the Collision that occurred on 6th November 1985 at Copyhold Junction near Haywards Heath

IN THE
SOUTHERN REGION
BRITISH RAILWAYS

LONDON: HER MAJESTY'S STATIONERY OFFICE
1986

Railway Inspectorate
Department of Transport
2 Marsham Street
London, SW1P 3EB
15th October 1986

Sir,

I have the honour to report for the information of the Secretary of State for Transport, in accordance with the Direction dated 12th November 1985, the result of my Inquiry into the collision between two electric passenger trains at 01.55 on Wednesday 6th November 1985 at Copyhold Junction near Haywards Heath in the Southern Region of British Railways.

On a clear but windy night the 01.00 Victoria to Brighton electric multiple-unit passenger train, 2A18, consisting of four coaches and travelling in the Down direction, passed Signal T335X at Danger, ran through No. 1783 points on the Up line and collided head-on with the 01.35 Brighton to Victoria electric multiple-unit passenger train, 2A19. This train also consisted of four coaches and was travelling in the Up direction on the Up Main line prior to crossing to the Down Main line in the Up direction, reversibly signalled, via No. 1783 points. The collision caused considerable damage to both trains, but neither was derailed.

The emergency services were summoned immediately and, on arrival, began to convey the injured to hospital. In all 40 persons were injured of whom 39 attended hospital for treatment, but the majority only suffered minor injuries and were released after treatment. The guards of the two trains, together with 11 passengers, were detained in hospital, but I am glad to report that they had all been discharged before I commenced my formal Inquiry.

Following removal of the damaged coaches, the Up and Down Main lines were re-opened to traffic at 08.30 and 08.54 the same morning, following which trains ran under caution whilst the signalling was being fully tested. Normal working was resumed at 15.30 the same day.

Description

The Site

1. Copyhold Junction is approximately 1,600 yards north of Haywards Heath Station and 9,300 yards south of Balcombe Tunnel Junction. The line between the two junctions consists of two tracks, each junction enabling all trains to be routed from Up to Down line and vice versa. The south end of Copyhold Junction has additional crossovers to enable trains on the Up and Down Main lines to be diverted to the Up and Down Loop lines through Haywards Heath Station. The north end of Balcombe Tunnel Junction has additional switches and crossings to enable trains to be routed between the two lines south of the junction and the four lines leading to Three Bridges and the north. All lines are electrified on the conductor rail system at 750 volts DC. The maximum speed on the Up and Down lines in the Up and Down directions is 90 mile/h but the maximum permitted speed on the Up line in the Down direction and vice versa is limited to 75 mile/h. The maximum permitted speeds through the crossovers at both junctions is 20 mile/h. A track diagram is at Fig. 1 at the end of the report together with a location diagram at Fig. 2. The average gradient between Balcombe Tunnel Junction and Copyhold Junction is 1 in 264 falling, while the detailed gradient diagram on the approach to the site of the collision is at Fig. 4.

The Signalling

2. The signalling from Brighton to north of East Croydon on the Brighton-Victoria Main line is controlled from Three Bridges Signal Box. All signals in the Haywards Heath, Copyhold Junction and Balcombe Tunnel Junction area are four aspect colour light. Signalling in the Haywards Heath and Copyhold Junction area is controlled from the main signal box over a time division multiplex system through a relay room at Haywards Heath. Signalling in the Balcombe Tunnel Junction area is controlled directly from Three Bridges Signal Box.

3. An important feature of the signalling over the stretch of line between Balcombe Tunnel Junction and Copyhold Junction is the presence of reversible signalling on both lines. Thus at Balcombe Tunnel Junction trains travelling on the Down Main or Down Slow can be routed along the Up line provided that the line to Copyhold Junction is clear. Similarly an Up train approaching Copyhold Junction on the Up Main or Up Loop line can be routed onto the Down Main line in the Up direction. This facility, which also exists from south of Haywards Heath to Preston Park, is fully signalled to enable scheduled trains to be

reversibly signalled if this assists in the regulation and control of trains. Its main use, however, is during engineering works or following other emergencies such as the breakdown of trains. At the time of the accident the only booked trains using the reversible working between Balcombe Tunnel Junction and Copyhold Junction were the 01.00 from Victoria to Brighton and the 01.35 from Brighton to Victoria, the two trains involved in the head-on collision. The purpose of this working was to keep Victoria and Brighton drivers familiar with the reversibly signalled routes and the equipment in working order. A signalling diagram covering the area Balcombe Tunnel Junction-Haywards Heath is at Fig. 3 at the end of this Report.

The Trains

4. The 01.00 Victoria-Brighton passenger train, 2A18, consisted of one 4-car electric multiple-unit, No. 7390, of Class 421 (4CIG). The leading coach was a driving trailer composite, followed by a motor brake second, a trailer second and a driving trailer composite. The 01.35 Brighton-Victoria passenger train, 2A19, consisted of one 4-car electric multiple-unit, No. 7724, of Class 423 (4VEP). The leading coach was a driving trailer composite, followed by a trailer second, a motor brake second and driving trailer composite. Both units were of all steel construction built in 1971 and 1967 respectively. The coaches within each unit were permanently coupled with buckeye couplings. Both units were fitted with electro-pneumatic and Westinghouse air brakes, and had British Railways standard AWS. The overall lengths of the trains were 264ft 10in and 265ft 4½in respectively and their weights were 145.90 ton and 150.45 ton. The total brake force of each unit was approximately 88% of their tare weight.

Damage to the Trains

5. The damage to the two trains fell into two categories, that to the underframes and that to the interior of the coaches. The underframes suffered most damage at the ends of the coaches where the impact had buckled them. There was also much damage to the drawgear and centre casting housings on the motor coaches indicating the very heavy impact between the two trains. The damage to each coach of the trains may be summarised as follows:-

01.00 Victoria-Brighton — Unit 7390

4th Coach — 76811	Moderate bogie, underframe and interior fitting damage.
3rd Coach — 71058	Moderate body, interior and bogie damage, serious damage to underframe
2nd Coach — 62378	Moderate bogie damage, severe underframe damage, serious damage to body and interior fittings.
1st Coach — 76740	Severe bogie, underframe, body and interior damage.

01.35 Brighton-Victoria — Unit 7724

1st Coach — 76339	Serious bogie and severe underframe, body and interior damage.
2nd Coach — 70843	The 'B' end of this coach took much of the force of the impact. The underframe was distorted 24-30in downwards in contact with the bogie. The headstock, solebars and longitudinals, were all badly buckled. There was very severe body damage at the 'B' end of the coach and in 'K' compartment; there was severe interior damage throughout.
3rd Coach — 62185	Slight bogie damage, severe underframe damage, serious body and interior damage.
4th Coach — 76340	Serious underframe damage, moderate body and interior damage.

Damage to Signalling Equipment and Permanent Way

6. There was no damage to the permanent way, but the 'A' end of No. 1783 points was damaged by being run through by the Victoria-Brighton train when the points were set 'reverse' for the Brighton-Victoria train to travel from the Up Main line to the Down Main line in the Up direction. The closed switchblade was found slightly open and the clamp lock hook had been stretched by about an inch.

EVIDENCE

7. *Signalman M. F. J. Meade* booked on duty at Three Bridges Signal Box at 21.15 on 5th November 1985, controlling Panel 5 which covers the section of the railway from Balcombe Tunnel to south of Keymer Junction. He had no troubles concerning the signalling of any trains on his panel until 01.55 on 6th November. At 01.53 both the Victoria-Brighton train, 2A18, and the Brighton-Victoria train, 2A19, are time-tabled to arrive at Haywards Heath Station, but the former train was running two or three minutes late and, in order to avoid delay to the Up train, 2A19, he decided to give this train precedence in crossing at Copyhold Junction. Thus the route was set for the Down train, 2A18, from Balcombe Tunnel Junction over

the Up line in the Down, reversibly signalled, direction to Signal T335X at Danger. Meade said that he set the route for 2A19 from Haywards Heath along the Up Main to Junction Signal T332 and thence over the Up Main to the Down Main in the Up direction, reversibly signalled, via crossover No. 1783 when the train had passed Keymer Junction, but was well south of Haywards Heath. He explained that, as there was an engineer's possession of the Up Main line between Keymer Junction and Haywards Heath, he had routed 2A19 at Keymer on to the Down Main line, another reversibly signalled section, and thence into Haywards Heath Station Platform 3 via Signal T350X and Points 1792.

8. Meade said that when 2A18 was in the Balcombe area 2A19 had already reached Haywards Heath. He continued to watch the progress of both trains on his panel by means of the track circuit indications. He saw Track Circuit YG show occupied, indicating that 2A18 had passed Signal T335X at Danger and soon after 2A19 passed Signal T332. Thus the two trains were less than 1,000 yards apart, heading straight for each other. Points 1783 were in the 'reverse' position for the route already set for 2A19 and the next indication of the movement of the trains was when the points indicated 'out of correspondence', showing that they had been run through by 2A18. Finally, the only track circuit displaying 'occupied' was YE which indicated that a head-on collision had occurred or the two trains had come to a halt within the length of the one track circuit.

9. Meade said that at 02.00 he received a telephone call from Signal T331 from the Driver of 2A19 reporting that the two trains had collided head-on and requesting that the emergency services should be summoned immediately. He had already alerted *Regulator G. de Rosa* of the events leading up to the accident and the latter now took immediate action to summon the emergency services. The driver also asked for the traction current in the area of the accident to be isolated and Meade said that he immediately contacted Three Bridges Electrical Control to arrange the isolation which was granted between Redbridge Sub-Station and Folly Hill Sub-Station at 02.06. Meade said that, together with the signalmen on the adjacent panels, 4 and 6, the necessary action was taken to protect the scene of the accident. Emergency replacement switches were operated and reminder appliances were placed on panel buttons where appropriate.

10. I questioned Meade at length concerning his setting of routes as trains 2A18 and 2A19 approached the reversibly signalled section between Balcombe Tunnel Junction and Copyhold Junction to make absolutely sure that, despite all the approach locking and time delays built into the signalling, he had not altered the route that he had set in front of either train. This was particularly significant as I knew that I was to hear evidence from a leading railman at Haywards Heath that shortly before 2A19 arrived in the section he had noted on his train information VDU from Three Bridges that a Down train routed into Platform 2 had been changed to Platform 1. Meade vigorously denied that he had altered at any time the route he had set for either train and reiterated that he had set the route from Haywards Heath Platform 3 to Junction Signal T332 and thence through Crossover 1783 to the Down Main line in the Up direction all the way up to Balcombe Tunnel Junction well before 2A19 arrived at Haywards Heath Station. Even if this had not been the case and the route from Platform 3 had been altered with the train in the station, no conflicting route could have been set for at least three minutes without 2A18 on the Up line in the Down direction having passed Signal T335XRR showing 2 Yellows, T335XR showing 1 Yellow and T335X at Danger.

11. *Regulator G. de Rosa*, the regulator in charge of Three Bridges Signal Box on the night of the accident, confirmed that Signalman Meade had drawn his attention at about 01.55 to the fact that train 2A18 has passed Signal T335X at Danger and had run through Points 1783, set 'reverse', at the same time as train 2A19 had passed Signal T332 in the Up direction routed through Crossover 1783 onto the Down Main line in the Up direction. The first indication of the accident, which he saw for himself was Track Circuit YE occupied and the description of 2A19 shown on the Down line north of Crossover 1783. Track Circuit YE was the only one occupied, while the description of train 2A18 was still in the berth behind Signal T335X, indicating that the train had passed the signal at Danger. Both trains must have been within the length of Track Circuit YE which could only have resulted in a head-on collision or, if the drivers were extremely alert, the trains might have come to a stand short of actually colliding.

12. At 02.00 The Driver of 2A18 telephoned Meade from Signal T331, reporting that his train had collided head-on with 2A19 and requesting that the emergency services be summoned immediately. De Rosa alerted the emergency services using the special emergency number on the Waterloo exchange. He then alerted the various Railway Officers and Staff who would be involved in dealing with the accident. At 02.15 the Fire Brigade reported that they were on Copyhold Lane Bridge and were unable to sight the accident. In order to assist them to the site more accurately De Rosa gave them the grid reference of Signal T331 which he knew from the initial call from the driver of 2A18 was immediately adjacent to the scene of the accident. At 02.25 the driver reported again from the telephone at Signal T331 that train 2A19 had a large number of broken windows, jammed doors and suspected buckled underframes. The two front

coaches of train 2A18 were badly damaged and the train had split between the second and third coaches. There were injured passengers in both trains, including persons with fractured bones.

13. I asked De Rosa to summarise the Signal Box Instructions applying to signalling a train over the reversibly signalled lines controlled from Three Bridges Signal Box. He explained that, except where published in appropriate Operating Notices, reversible working could only be introduced during an emergency on the authority of the Regulator. As far as trains 2A18 and 2A19 were concerned, both were booked services on the reversible lines between Balcombe Tunnel Junction and Copyhold Junction. As there were booked services, no permission had to be given to the signalman to set up these routes.

14. *Driver P. C. Edwards* of the Up train said that he booked on duty at 01.05 and was well rested; the 01.35 Brighton to Victoria train was his first working that morning. He took over the train in Platform 4 at 01.20, carried out his train preparation, including a brake test in conjunction with the guard, and departed at 01.35 on receipt of his guard's bell signal. He was signalled on the Up Main line to Keymer, thence over the Down Main line to Haywards Heath due to an engineering possession and then back to the Up Main line, running into Platform 3.

15. After station duties at Haywards Heath he left with Signal T340 displaying a single Yellow aspect. As he proceeded round the curve towards Signal T332, protecting Copyhold Junction, he shut off the master controller and coasted, then switching back into series on sighting Signal T332 displaying a Double Yellow aspect with a position 4 Junction indicator, which changed to a Green aspect as he approached the signal. Mindful of the speed restriction over No. 1783 crossover, he at no stage took the controller beyond notch 2 and estimated that his speed was slightly above 20 mile/h. Edwards said that he first saw 2A18 approaching him as he passed Signal T332. At the same time the Up Main line Signal T326 changed from Red to Green, indicating that 2A18 had cleared the reversibly signalled section from Balcombe Tunnel Junction to Signal T335X. A moment later he saw the driver of 2A18 flashing his cab lights. He immediately made an emergency application of the train's brakes, released the Driver's Safety Device and then dived for cover on the floor of the cross passage between the cab and the passenger part of the coach.

16. After the collision, Edwards tried to get out of his cab, but the doors were jammed. He eventually got out, however, and made his way to Signal T331, going between the two trains, which had bounced apart as a result of the collision, and telephoned the signalman at Three Bridges to inform him of the collision and to request the emergency services be summoned immediately. Edwards also asked that the traction current in the area of the accident be isolated. He then went back to the heads of the two trains and talked to the driver of train 2A18 who was still unable to get out of his cab, also to Driver Pelling who had been travelling as a passenger in 2A18. They took the track-circuit operating clips and the short circuiting bars from both trains and applied them to both lines. Edwards also sent his guard back to protect the rear of his train, but the guard had been badly shaken up by the collision and Edwards was not certain whether he would be able to carry out his protection duties.

17. Edwards said that he then went back into his train, trying to assist the passengers and reassure them that the emergency services were on their way. In order to try to find the emergency services one member of the railway staff who had been travelling as a passenger walked northwards along the track to Copyhold Lane Bridge, while another member of the railway staff walked south to Wickham Lane Bridge. Eventually a police car was located and the emergency services were directed to the scene of the accident via Wickham Lane Bridge. After the emergency services had finally arrived, Edwards made his way along the track to Haywards Heath Station, looking for his guard. Having satisfied himself that his guard had been taken to hospital Edwards then allowed himself to be taken there.

18. Lastly, I questioned Edwards as to what experience he had had with 4 VEP sets skidding when he was braking on the Victoria-Brighton line. Having only been a driver from July 1984, he had had very little experience, but earlier in the week of the accident, when he had applied the brakes at Coulsdon South, the train started skidding and, when he applied power on pulling away from Merstham the wheels spun through lack of adhesion. When he found that the train was skidding he released the brakes to release the wheels and then applied the brakes again, this time with more effect. The weather at that time had been wettish and he thought the rails might have been greasy.

19. *Guard S. M. Nixon*, the guard of the Brighton-Victoria train, was able to offer very little useful evidence. He remembered working down as the guard of the 22.32 Victoria-Brighton train and changing platforms at Brighton to work train 2A19, the 01.35 Brighton-Victoria train. He could not remember making a brake test, nor could he remember leaving Brighton or any of the incidents leading up to the collision or after it. The first thing he remembered was waking up in Cuckfield Hospital, wondering what he was doing there.

20. *Driver E. B. Batchelor*, a driver since 1976, was the driver of the 01.00 Victoria to Brighton train, 2A18. After working the 23.15 Brighton to Victoria train he had gone to the Brighton end cab of the 4-car Class 421 unit which was to form the train 2A18 and had carried out a brake continuity test in conjunction with the guard: the test had been completely satisfactory. The journey had been entirely uneventful as far as Three Bridges where they lost a few minutes due to station duties.

21. After leaving Three Bridges the wheels lost adhesion for a short period, resulting in wheel spin, but he shut off power and then opened up again which successfully cleared it. He braked without difficulty approaching Balcombe Tunnel Junction before receiving the signal with the necessary route indication for him to cross from the Down line onto the Up line in the Down direction, whereupon he traversed the facing crossover at 20 mile/h. When his train was completely on the Up line he fully opened the controller and he ran without any wheel spin through Balcombe Tunnel and on to Balcombe Station where he closed the controller and commenced to coast at a speed of 65 mile/h.

22. Batchelor said that when he sighted the first signal on the reversible section of line, Signal T335XRR, which was showing a Double Yellow aspect, he started to brake, applying about 20 lb/sq in on the EP brake. He realised that the train's wheels had locked as his speedometer dropped to zero and so he released the brake until he could see that the wheels were revolving, whereupon he made a further application of the EP brake of about 20lb/sq in of air. He clearly remembered that the train was skidding when it was on the Ouse Viaduct and that as he came off it, he had freed the wheels by releasing the brakes and then again re-applied them using 20lb/sq in.

23. Batchelor said that he continued to apply and release the brakes, in the manner he had been taught to brake when encountering low adhesion, each time using 20 lb/sq in of air, resulting in the speedometer indicating zero which in turn showed that the train was skidding; after each release of the brakes the speedometer would recommence to register the speed, showing that the wheels were freely revolving. Signal T335XR, showing a Single Yellow aspect, was passed at 40–45 mile/h and Batchelor continued to use the 'brake and release' method in an attempt to control his train. He continued to do this as he approached Signal T335X at Red which he passed at about 20–25 mile/h, having cancelled his AWS as he approached the signal.

24. I questioned Batchelor about his continuation of the brake and release method after he passed Signal T335XR and approached Signal T335X, pointing out that he knew that the latter signal was approach controlled to ensure that Down trains on the Up line, did not cross to the Down line via Crossover No. 1784 in excess of 20 mile/h. I asked him whether he was not expecting that the signal would clear as he approached it and thus was not unduly alarmed at the fact that, using his method of braking, it was extremely doubtful if he was going to bring his train to a stand before Signal T335X. He assured me that he was endeavouring to bring the train to a halt before the signal, that at no time did he assume that it would clear to a proceed aspect as he approached it and that he considered that his method of 'brake and release' was the most effective in the condition of low adhesion. In his opinion, if he had made a full emergency application of the brakes as he passed Signal T335X and approached the Up train, 2A19, his train would have continued to skid into the other train.

25. As he approached the other train he flashed his cab lights two or three times as a warning to the driver of 2A19. At the moment of impact the wheels of his train were locked and he recalled being thrown against his desk and then receiving a blow in his back. After the collision he turned the master switch to off and took the key out. He was unable to join Driver Edwards on the ground as his driver's doors were jammed, but the latter, having ascertained that he was not injured, took his short-circuiting bar, track-circuit clips and detonators, applying the first to the Up line and the second to the Down line. He then managed to open the communicating door to the train and made his way back to the rear cab to apply the handbrake. En route he tried to reassure the passengers, a number of whom were injured.

26. *Guard P. D. Norton* worked 2A18, the 01.00 Victoria-Brighton train. He said that he had an uneventful journey as far as Three Bridges where they lost a few minutes due to the time taken to unload parcels and papers. The train started normally from Three Bridges and he then particularly remembered going through Balcombe Tunnel as the wall nearest to the train was the righthand one, indicating that they were travelling on the Up line in the Down direction, using the reversible signalling. Norton was unable to estimate the speed they were travelling when they emerged from the tunnel. He was certain, however, that the train was not travelling excessively fast and, in his opinion, it was travelling at the normal speed when going on that stretch of reversibly-signalled line.

27. Norton said he was unable to remember anything from when the train emerged from Balcombe Tunnel until after the collision when he regained consciousness and found himself in one of the passenger coaches together with four or five passengers. A young lady was comforting him he said "because I was in a state of shock and didn't know where I was".

28. *Leading Railman A. P. Woodrup* was on duty at Haywards Heath Station on the night of the accident. His office was on the Down Island Platform, facing Platform No. 2, and to assist him in his platform duties he was provided with a visual display unit (VDU) showing the movement of trains in the Haywards Heath area. He noted from the VDU that the 01.35 from Brighton was travelling Up the Down line from Wivelsfield and was being routed into No. 3 Platform. He also noted at that time that the VDU first showed the Down train, 2A18, signalled into the Up Main Platform, denoted by a figure 2 on the VDU at the end of the platform. This then changed to a figure 1, indicating Patform No. 1, and then the platform indications for the Down train disappeared completely.

29. Woodrup then went over to Platform No. 3 to carry out the platform duties with train 2A19. These duties were entirely uneventful and he estimated that he was only away from his office for about three minutes. When he looked again at his VDU it seemed as though the two trains were side by side. At about 02.00 he was asked by the signalman at Three Bridges to go to Copyhold Junction on foot to investigate whether or not there had been a collision. He at once set off along the Down cess to investigate and en route met the guard protecting the rear of the Up train; he was very dazed. Woodrup told him to sit at the side of the track as it was obvious that he was in no state to continue with his duties. He carried on to the trains, found a guard who had been travelling as a passenger and requested him to go back and complete protection of the Up train. He went through both trains and, finding a considerable number of passengers either injured or suffering from shock, he enlisted uninjured passengers to help carry out first aid.

30. Woodrup said that he then telephoned the signalman at Three Bridges from Signal T326 to inform him of the details of the collision. He then continued on to Copyhold Lane Bridge where he had seen blue flashing lights. Arriving at the bridge, he found no vehicles, but soon afterwards a police car arrived and he informed the officer in charge that there was a considerable number of injuries and explained the location of the two trains, whereupon it was decided to use Wickham Lane bridge for the emergency services to evacuate the casualties. Woodrup then moved back to the trains, helping to remove the passengers and then helping with the removal of the trains.

31. *Driver A. G. Pelling* said that he was travelling as a passenger on 2A18, returning to his depot at Brighton. He had been a driver since 1960 and had been stationed virtually all the time at Brighton. Thus he was a very experienced driver with a comprehensive knowledge of the London-Brighton line. Describing his journey from Gatwick to Copyhold Junction, he said it was quite normal with no excessive speeds, nor any sharp braking until they were approaching Copyhold Junction: he was aware that the train was travelling down the reversibly signalled Up line. He did not notice the train passing through Balcombe Station or over the Ouse Viaduct, as he was talking to his guard, but he was aware that the train was skidding as it approached Copyhold Junction.

32. Pelling said that he was sitting over a bogie and thus was aware of the wheels skidding and then of the sound of the brakes being released. He could not say how many times the driver applied the brakes, the wheels skidded and then the brakes were released before being re-applied, but he was expecting that the skidding would cause wheel flats if it continued and he was waiting for them to develop. He was absolutely certain that each time the brakes were applied the wheels skidded, for the sound of the wheels on the rails when skidding was unmistakable.

33. When the collision occurred, Pelling was thrown to the floor but, after he had recovered from his fall, he tried to get down on to the track to discover what had happened. The doors in his coach were jammed but he managed to open one in the next coach and then went forward to the head of the train where he talked to both the train drivers, Edwards and Batchelor. The former was concerned about the protection of his train and Pelling and his guard agreed that they would ensure that this was carried out. When they had finished protecting the train they returned to the drivers where Pelling answered the adjacent signalpost telephone and was informed that the emergency services were on their way.

34. Pelling also asked the drivers whether the short-circuiting bars had been applied to give local protection against the re-energisation of the conductor rails. Only one had been put down and so he immediately obtained a second and applied it to the other line, thus ensuring that both Up and Down Main lines were protected electrically.

35. I asked Pelling about the weather on the night of the collision to which he replied "Just damp, damp and misty". Finally, in answer to more questions, he agreed that there were a number of areas on the Southern Region where, particularly with heavy freight trains, you tend to get wheel spin on the rising gradients and brakes locking with the wheels skidding on the falling gradients: Balcombe Station was one of those bad areas.

36. *Guard H. K. Watson* had accompanied Pelling from Gatwick and confirmed the evidence the latter had given. He too telephoned the signalman at Three Bridges to ensure that all the necessary protection had been given, and then went to Copyhold Lane bridge to locate the emergency services where, after about five minutes, the police arrived, announcing that Wickham Lane bridge would be used for the evacuation of casualties.

37. Watson said that he could not comment on train 2A18 skidding as it approached Copyhold Junction, although he was aware that the driver was applying and releasing his brakes. He was unable to estimate the train's speed as it proceeded towards the scene of the accident but was certain that it was not excessive and that it gradually dropped until at the collision he estimated the speed to be 10–20 mile/h.

38. *Mr G. R. Taylor, the Regional Traction Inspector, Waterloo,* said that he had examined the condition of the running rails on the Up line from the Ouse Viaduct to the point of collision on the morning following the accident. The rails at the southern end of the viaduct had some black deposits on their heads, but the deposits were intermittent. From the 35 mile, 36 chain, point the railheads were black until 36 mile, 05 chain, then not as black to 36 mile, 15 chain, and finally solidly black from there to the point of the collision at 36 mile, 72 chain. Where the railheads were black there were many trees on the line side which had shed their leaves. Skid marks could be seen at irregular intervals from 36 mile, 25 chain, to the point of collision. In contrast, the railheads on the Down line were clean and bright with no black deposits.

39. Mr Taylor said that he observed the passage of the first two trains on the Up line in the Up direction after the line was re-opened to traffic. Both experienced bad wheel spin over the section of line he had examined, thus confirming the low adhesion on that stretch of line.

40. Mr Taylor explained in detail the method of braking taught to drivers on the Southern Region with trains with clasp brakes as fitted to those involved in the collision. The normal method is to move the brake valve from the No. 1 position towards the full application position, No. 2, to the point the driver requires for stopping his train. If, when applying the brake, the wheels lock and therefore skid on the rails, drivers are instructed to return the brake valve to the 'release' position until the wheels start to revolve again and then to re-apply the brake. If further skids occur, the driver is instructed to repeat the 'release and re-apply' procedure until the train is brought to a stand.

41. Mr Taylor also explained how a driver recognised when his train was skidding. The speedometer only indicated what the wheels were doing on the driving trailer at the head of the train, but a driver would normally hear a hissing noise and also notice a lower volume of noise in general because the noise from the wheels running on the rails ceases. If it was only the front coach that was skidding, the driver would experience 'bumping and boring' from the rear coaches. The other important thing to note was that when a driver released the brakes when skidding took place, it took several seconds — sometimes four or five — for the brakes to finally release. Mr Taylor had also noticed that the wheels did not necessarily start revolving immediately. He also experienced delays of three or four seconds before the wheels started to revolve.

42. Finally, Mr Taylor confirmed that, having heard his evidence, he considered that Driver Batchelor had braked in accordance with the current instructions on the Southern Region in attempting to overcome the poor rail adhesion and bring his train to a halt before Signal T335X at Danger.

43. *Mr K. W. Parsons, Depot Engineer, Stewarts Lane,* said that he had been called out to attend the accident and had arrived at the site at 03.10. He examined the leading cab of each train and found nothing out of order. He then examined the wheels of both units and found the tyres slightly warm when touched. On examining the site, he found that the two trains had come to rest approximately 10 metres apart, the Brighton train being approximately 3 metres from the point of impact which could be determined from the position of glass from a broken observation light at the front of that train. The London train was approximately 7 metres back from the point of impact.

Mr Parsons then examined the Up line as far as Copyhold Lane Bridge to look for skid marks from the London train. He noted black deposits on the heads of the rails which he assumed were from the crushing of fallen leaves. He found skid-marks of a sort from the bridge to the point of the collision, but in many places the locked wheels had not penetrated onto the metal of the rail heads but had skidded on the black deposit, tending to scratch its surface. It was extremely difficult to determine the skid-marks accurately apart from those places where the wheels had penetrated the deposit and thus the skidding was between two steel surfaces.

44. *Mr P. R. King, Senior Engineering Assistant, RM & EE, Southern Region,* had examined the London-Brighton train 2A18, paying particular attention to the tread and flange damage to the tyres. There

was sufficient tread damage to show that most wheels had skidded sufficiently to produce wheel flats of 10-50mm over more or less the tread width. Whilst not particularly pronounced, there was a definite trend to larger flats towards the rear of the train, suggesting that the contamination of the railheads had been at least partially removed by the sliding of the wheels at the front of the train.

45. No wheels showed heavy tearing of the tread surface, but there was damage to the flanges showing heavy metal-to-metal contact for a short period with bluing indicating local heating. These 'flange burns' were mainly about half way up the flange on the right hand side and there were 'vee scars' on the left hand side. Mr King examined the backs of the tyres and noted a slight scrape between 10 and 15mm long and a maximum of 3 mm wide where the flange radii blended into the back of the tyres. These marks were consistent with the train having run through a set of points, the left hand flanges having to push the open switch blade towards the curved stock rail whilst the right hand flanges had passed between the closed blade and the straight stock rail. The flats on the wheels were in line with these marks, indicating that the wheels were not rotating as they had 'trailed' the switch blades.

46. Mr King also carried out tests to the brakes of train 2A18. Everything was within normal operating limits apart from one brake cylinder which had been damaged in the accident. Tests on the train AWS equipment were also satisfactory.

47. Finally, Mr King stressed that, in his opinion, only one flat on each tyre had been made by the skidding prior to the collision and these were in line with the damage to the flanges. He was certain that the flats were caused when trailing the points at Copyhold Junction.

48. *Senior Rolling Stock Inspector P. Kersey* had examined the two trains after the accident. He said that the damage in the main had occurred to the underframes and to the interior of the coaches. The underframe damage was mainly 'drooped' ends, namely the ends of the headstocks being driven down, together with damage to the drawgear housing, and also the centre casting housing. There was also a limited amount of damage to the bogies, mainly in the torsion bars and the dampers.

49. The interior damage was particularly severe at the partitions, much more than he would have expected in an accident of this nature. Only 5 pieces of glass were broken, but a very considerable number of doors were damaged and/or jammed. About 24 side doors on both trains were jammed solid and a considerable number of corridor or cross doors at the ends of coaches were either very hard to operate or jammed in the half-open position: a number of the swing doors were also jammed due to the distortion of the flooring.

50. Mr Kersey confirmed that the second coach of train 2A19 had suffered more serious damage than any other one, but pointed out that this was not unique. In a recent rear-end collision at Battersea Park the second coach had also been the one most severely damaged. He was unable to explain, however, why this should have been.

51. *Mr P. J. Coulson, Assistant Area Signal Engineer, Brighton*, said that when he arrived at Three Bridges Signal Box after the accident, Mr D. A. Hotchkiss, the Signal Engineer (Projects), Southern Region, was already in the signal box in connection with the testing of certain new works unconnected with the accident. The latter supervised the establishment of the normal running of trains, with No. 1783 Points clamped 'normal' with 'normal' detection; the signals were temporarily approach controlled. By 14.24 on the day of the accident, No. 1783 points had been repaired, the clamp locks and associated equipment replaced and tested, and handed back to the operating staff.

52. Mr Coulson was then able to carry out the essential route locking tests, that is to say he tested to establish that there was no route or signal to signal locking missing in the area of the accident. The method he used to carry this out was to simulate the running of a train along one route by dropping individual track circuits and then attempted to set conflicting routes. He did this for all combinations of routes from Signal T335X with those from Signal T332 and in the reverse directions.

53. Mr Coulson confirmed that, as a result of the tests he carried out, he was absolutely certain that the signalling from Balcombe Tunnel Junction to Haywards Heath was completely in order and could in no way have contributed to the accident. He also confirmed that all the wrong-direction rutes on the reversible section of line between Balcombe Tunnel and Copyhold Junctions had to be set manually and could not be programmed to be set by the automatic route-setting equipment. Finally, he confirmed that after a train, travelling on the Up line in the Down direction towards Copyhold Junction, had cleared the berth track circuit of Signal T335X there was a delay of 10 seconds before the Up signals on the reversible section of the Up line could return to Green.

54. *Mr L. H. Page, Area Signal Engineer, Brighton*, said that he was in Three Bridges Signal Box at the time of the collision, assisting Mr Hotchkiss in the testing of signalling alterations in the East Croydon area. Having arranged for various technical staff to make their way to the scene of the accident, he left for Copyhold Junction in a police car, arriving at the accident site just before 03.00, leaving Mr Hotchkiss and some supporting staff to check the signalling equipment in Three Bridges Signal Box. At Copyhold Junction he carried out an inspection of the on-site signalling equipment. No. 1784 A and B switches were fully 'Normal' and detected 'Normal', No. 1783B switch was fully 'Reverse'. No. 1783A switch was 'Reverse' but the closed switch blade was slightly open and showed signs of damage consistent with being run through. When the clamp-lock hook was changed later in the day, it was found to have been stretched by about 25mm. Signal T335X was displaying a Red aspect, the relays associated with this signal indicated that the signal was illuminated and showing a Red aspect, and the cables associated with the signal were tested and found to be in perfect condition. The AWS equipment associated with the signalling was found to be working correctly. Signal T335XR, which was displaying a Single Yellow aspect, and Signal T335XRR, which was displaying a Double Yellow aspect, were similarly tested and found to be in perfect condition. Mr Page said that the approach sighting of the three signals was:

T335XRR	313 yards
TSS5XR	176 yards (sighting reduced due to lineside trees)
T335X	1140 yards

55. Mr Page assured me that only Mr Hotchkiss and himself had been on the operating floor of the signal box on the night of the accident and they were some 15 yards from the part of the signalling panel controlling the Balcombe Tunnel-Copyhold Junction section of the line. Similarly no S&T staff were in the Three Bridges Relay Room immediatley prior to or at the time of the accident. Thus he was completely satisfied that no signalling equipment had been interfered with which could have had any effect on the accident.

56. *Mr R. F. Bonham-Carter, the Assistant Regional Civil Engineer, Southern Region*, explained the current policy regarding the trimming of lineside trees and bushes. The principal activity was to clear a strip of land 3 or 4 metres wide, next to the cess, to ground level to enable train drivers to have a clear view of signals, to make a safe walkway for people working on or adjacent to the track and also to reduce the number of leaves, falling close to and on the track. In some places there were large areas of trees and scrub reaching back to the railway boundary fence. There the principal activity was the identification and removal of trees that were rotten or potentially dangerous, to avoid them either falling on the track or on adjoining property. Where the falling of leaves on the track was particularly troublesome they tried to alleviate this by cutting down additional trees in the central belt referred to above, even large scale clearance in these areas did not necessarily solve the problem, however, as leaves, where the railway passed through large wooded areas, often then blew onto the line from trees outside railway property.

57. *Mr A. M. Bath, the Regional Operating Manager, Southern Region*, in answer to my questions about the action the Southern Region was taking to reduce wheel spin and skidding of trains due to lack of adhesion caused by leaves being crushed onto the heads of rails, said that he considered that the Region was in advance of other Regions in the application of 'Sandite' to rails to aid adhesion, but perhaps this was because they had more adhesion problems. There were seven trains specially equipped to lay 'Sandite' on the rail heads throughout the parts of the Region where they anticipated lack of adhesion during the leaf fall season. The Brighton line south of Redhill had not been such an area, as it had not previously been one where adhesion problems had been particularly bad. The lack of adhesion leading up to the accident at Copyhold Junction had, in his opinion, been caused by gales, wet weather and frosts which caused a particularly large number of leaves to fall at once.

58. Finally, *Mr T. O. Monkhouse, Regional Mechanical and Electrical Engineer, Southern Region*, briefly summarised the main efforts which had been made to overcome this problem of lack of adhesion due to crushed leaves on the heads of rails. Attempts had been made to burn the leaves off using a plasma torch, but that had not proved effective, neither had the use of jets of high-pressure water to break up the contaminant and wash it away. The most effective method so far discovered was that which was currently in use, 'Sandite', namely the laying of fine sand in an adhesive jelly, similar to that used for wallpapering a room, on the head of the rails which is then spread by the wheels of trains, giving an abrading effect between the wheels and the rails.

Tests and Discussion

59. Following my hearing evidence in public, I discussed the whole problem of low wheel to rail adhesion with the Director of Mechanical and Electrical Engineering, British Railways Board, who agreed

that an investigation should be carried out by a Committee consisting of technical Officers of the Railways Board (Mechanical Engineering and Research) and of the Southern Regional (Mechanical Engineering and Operations) to produce the necessary technical evidence which would confirm or refute the conclusion that Driver Batchelor could have avoided the collision had he made an emergency brake application at an appropriate point during his braking on the approach to Copyhold Junction and a survey of known past research, development and testing that had been carried out on rails with low adhesion. The report, for which I am extremely grateful, is reproduced, less the appendices, at Appendix 'A' to this Report. I shall comment in the following paragraphs on certain specific items arising out of the report and, in particular, from the tests carried out on electric multiple-units similar to those involved in the collision.

60. Adhesion levels between wheels and rails are highest on dry rails when a co-efficient of friction μ of 0.3 is typical and even in wet conditions μ of 0.2 is generally obtained. In the conditions leading to this accident, Driver Batchelor's evidence that the wheel slide occurred at a brake cylinder pressure of 20 psi indicates μ of less than 0.04. The use of the 'release and re-apply' braking technique, already referred to in this Report, assuming that the brakes were applied for 50% of the time, also indicates that a mean value of μ was probably 0.04. Lastly, an examination of the Copyhold Junction site, some 8–10 hours after the accident, revealed Up trains experiencing wheelspin, thus supporting the view that adhesion was at or about the minimum level to support traction, namely a μ of 0.04–0.05.

61. Despite the past research, development and test work which had been carried out on Southern Region and elsewhere, the Committee considered that it was necessary to carry out further tests on the Southern Region to examine train braking behaviour in artificially produced conditions as near as possible to those at Copyhold Junction. A Class 421 (4CIG) was fully instrumented to monitor its performance during braking both in normal and low adhesion conditions and a Class 455 disc braked unit was employed as a control unit. The tests, which were carried out on the Shepperton Branch over a period of some 5 weeks, were designed to test three things, full brake applications, 'release and re-apply' applications to correspond with those used during the course of the Copyhold collision and an alternative braking technique.

62. Full brake applications with the Class 421 unit on clean dry rail showed that virtually no wheel slide occurred from 89.8kph, the unit stopping in 438 metres, giving an average retardation of 7.24%g. With adhesion levels being artificially reduced by spraying the rail heads with a solution of general interior cleaner (G.I.C.), a further test was carried out with the Class 421 unit. Ten axles locked up and the wheel sets slid, while the rear five braked wheel sets did not suffer any wheel slide, thus indicating that, when they had passed over the test site, the adhesion level was sufficient to support the full braking force. From a speed of 90kph an average retardation of 6.2%g was obtained.

63. From the evidence from the Copyhold Junction Collision, it appeared that each wheel set had locked-up at some period during the braking. Thus additional G.I.C. spray points were provided to offset the cleaning effect of the locked-up leading wheels on the Class 421 unit, the tests with these revealed an average deceleration rate of 5.9%g from a speed of 90.1kph: during the braking all 15 braked axles locked-up (one axle was not braked to enable it to be used to measure the true speed).

Examination of Alternative Braking Technique

64. On the night of 17th/18th June 1986 a series of tests were carried out in simulated low adhesion conditions with the object of:-

(a) Attempting to repeat the braking method used by Driver Batchelor at Copyhold Junction.

(b) Applying alternative methods using both the EP and automatic air brakes to ascertain the most suitable braking method to be used in conditions of low adhesion.

Details of the results of the tests will be found in Section 9.3 of the Report at Appendix 'A'. From the results of the tests it was considered that the best method of controlled braking in conditions of low adhesion was a combination of a progressive increase in brake cylinder pressure followed, if necessary, by the release-progressive re-application method and that the brake should be left fully applied if the minimum distance for safe braking had been reached. This should result in the safe braking of a train together with minimising the production of flats on the wheels of the train.

Conclusions and Recommendations

65. The Report's conclusions and recommendations will be found in full in Sections 10 and 11 at Appendix 'A'. The most important conclusion is that, notwithstanding the low adhesion, train 2A18 could

have been prevented from colliding with train 2A19 had a different braking technique been used and not the 'release and re-apply' technique taught to, and used by, Southern Region multiple-unit drivers when low wheel/rail adhesion is encountered.

66. The report specifically recommends that the following guidance be given to the drivers referred to above:

> 'Under conditions of low adhesion, braking distances can be increased considerably. In these conditions, the initial application of the brake should give the minimum brake pressure and the pressure should be progressively increased until sufficient pressure is obtained consistent with stopping the train at the required point according to the distance available and the gradients prevailing.'
>
> 'If wheel slide occurs, the brake should be released and re-applied and, if wheel slide re-occurs, this should be repeated until it is considered that the safe braking distance to stop the train has been reached. At this point the brake should be applied with the maximum brake cylinder pressure considered necessary to stop the train at the point required and the brake should be left applied until the train is brought to a stand or to such a speed that the brake cylinder pressure can be reduced.'

SOUTHERN REGION LEAF SEASON TASK FORCE

67. In addition to the report referred to above, a Task Force was set up by the General Manager of the Southern Region with a remit to examine all the factors leading to the unacceptable quality of service caused by wheel slip during the leaf fall season with a view to reducing by at least 50% the number of trains involved and minutes lost compared with those recorded in 1983. Recommendations should be considered across all functional boundaries but must be capable of being introduced before the Autumn of 1986. The report of the Task Force is very wide ranging, but two items considered in it are, in my opinion, particularly important, namely the operation and equipment of 'Sandite' trains and the management of lineside vegetation.

68. During the 1985 leaf fall season seven 'Sandite' trains were used for a period of 9 weeks, treating some 300 sites throughout the Region, The limitation of resources, both of trains and train crews, meant that the treatment of sites was spread throughout the 24 hours regardless of the relationship of the train operating times to the reported needs. It is proposed that the number of 'Sandite' EMU should be increased to thirteen for the 1986 season and that priority should be given to their manning to ensure that the trains are run when the treatment is most effective, namely between 02.00 and 06.00 and, if possible, before the passage of the first service train. Similar priority arrangements should be arranged to cover the treatment of particularly bad sites before the evening peak services and, in addition, sites reported as bad by drivers during the day, or on the basis of weather conditions such as rain or drizzle. Known sites of bad adhesion are to be identified by the marking of sleepers in fluorescent orange paint and 'Sandite' trains are to be fitted with headlights with a spread angle and focus to highlight the sleeper markings. To assist in the maintenance of a speed of 20 mile/h, the most efficient for 'Sandite' laying, speed indicators will be fitted in all cabs of 'Sandite' trains, showing "too slow", "correct" or "too fast". A DEMU service unit is also to be provided for working as a 'Sandite' train over critical non-electrified routes and for providing a vehicle for further experiments in combating lack of adhesion.

69. The Director of Civil Engineering, British Railways Board, published "The Management of Lineside Vegetation — a guide of good practice" (Civil Engineering Department Handbook No 43) in 1985 and, although not specifically designed to deal with the bad leaf fall areas on the Southern Region, its recommendations are considered in general to meet those conditions, although the lack of dealing effectively with lineside vegetation in recent years raises the question whether budgeted resources and manpower are adequate to bring the condition of the lineside back to the condition required to meet the code of practice referred to above. It is estimated that an expenditure of an additional £500,000 per annum for 6 years would be required to carry out this task in areas where leaf fall is at present a significant problem on the Southern Region. It has been agreed that special tree clearance should be undertaken at six selected sites in 1986, followed by further sites in subsequent years based on the experience gained.

70. I have discussed the Southern Region policy on lineside vegetation management in detail with Mr F. S. Proctor, the Regional Civil Engineer, and am satisfied that, although there may have been certain shortcomings prior to the Copyhold accident, the action currently being taken on the whole will meet the requirements to reduce the leaf fall on the track. The main additional action being taken is as follows:–

(a) The provisions of more mechanised flails with a view to maintaining a clear cess strip on all linesides by flailing approximately once in every two years.

(b) The clearing from the lineside of scrub, saplings, shrubs and undesirable trees with heavy leaf fall. The last named include ash, horse chestnut, lime, poplar, sweet chestnut and, above all, sycamore that have grown rapidly in very large numbers since the mid-1960s. As already mentioned, six of the worst sites on the Southern Region, in addition to work in the Copyhold area, will be dealt with this year.

71. The clearance of the cess strip referred to in paragraph 65(a) above must be carried out effectively for both train and staff safety. Any method of clearing this strip will reduce the population of leaves growing and falling near the track. For increased effectiveness, however, stumps at or near ground level with potential for re-growth must be inhibited by the use of appropriate herbicides. In addition, the policy, where strips have been cleared by flail, is for a chain saw operator to tidy the new 'face' of the lineside vegetation where necessary. While the Board's advisors on vegetation management see no reason why the use of flails should worsen the leaf fall problem, if this or any other method of pruning does encourage increased re-growth, it is proposed to experiment with growth retardants to deal with this problem.

Conclusions and Recommendations

72. The immediate cause of this collision was the inability of Driver Batchelor to bring the Victoria-Brighton train, 2A18, to a halt at Signal T335X at Danger due to lack of adhesion between the wheels and the heads of the rails. Not only did he pass the signal at Danger at between 20–25 mile/h, he trailed Turnout No. 1783, set for the Brighton-Victoria train, 2A19, to travel from the Up Main to the Down Main in the Up direction and collided with the latter train while still travelling at an estimated speed of 15–20 mile/h at a point 521 yards beyond Signal T335X. The Brighton-Victoria train, Driver Edwards, having seen the Down train approaching with Driver Batchelor flashing his indicator lights, was at or nearly at a stand after an emergency application of the brakes had been made.

73. I am satisfied from all the evidence given that Driver Batchelor at no time travelled at an excessive speed between Balcombe Tunnel Junction and the point of collision. I am also satisfied that he applied the train's brakes in the normal manner when approaching Signal T335XRR displaying a Double Yellow aspect. His evidence regarding the wheels locking and the train skidding, resulting in him carrying out the release and re-braking procedure, as laid down by the Southern Region for braking in such conditions, is confirmed by Driver Pelling who was travelling as a passenger in the train and clearly heard the brakes being applied, the wheels skidding, the brakes being released and then being re-applied, several times. Thus I do not consider that Driver Batchelor can be blamed for the collision, although with hindsight it is for consideration whether, regardless of the driving techniques he had been taught, he would not have been wiser to have made a full emergency application of the brakes on passing Signal T335X at Danger rather than to continue applications and releases of the brakes whenever skidding commenced right up to the time of the collision. The results of the tests detailed in Appendix 'A' and referred to in paragraph 65 confirm that, notwithstanding the low adhesion, the collision could have been prevented had Driver Batchelor made a full emergency brake application as he approached Signal T335X.

74. The fundamental recommendation that clearly arises from this collision is that greater effort must be made to eliminate the areas of low adhesion which have become increasingly prevalent on the Southern Region of British Railways. I am glad to learn that the number of 'Sandite' trains is being increased from seven to thirteen this year and that priority is to be given to manning them to enable them to be used at the most effective times, namely between 02.00 and 06.00 and, in any event, before the passage of the first train in the morning.

75. Various methods of treatment of rails contaminated with crushed leaves causing low adhesion have been tried in the past, several of which are referred to in this Report. While I am assured that 'Sandite' is the most effective method of treatment used up to the present time, I strongly recommend that further research should be undertaken with a view to producing a more efficient treatment with a longer effective life between successive applications to the rails.

76. The most effective way to eliminate low adhesion from leaf fall is to prevent the falling of leaves on the line. The complete removal of trees, scrub and shrubs from all railways cuttings and embankments, however, is obviously impracticable and is also likely to encounter opposition from local residents on environmental grounds. The clearing from the lineside of trees with undesirably heavy leaf fall, particularly sycamores, will reduce the problem very appreciably, however, and I strongly recommend that the current programme referred to in paragraph 71 should be continued until heavy leaf fall trees have been eliminated.

From an environmental point of view, a properly afforested lineside with sturdy, stable, trees such as beech, oak, Scots pine and larch, together with the slow growing shrubs such as privet, holly, yew and hazel will make attractive features of the landscape as a whole. In addition, these trees will assist in the stabilisation of banks which in some areas is so essential for the stabilisation of the railway.

77. The flailing of the lineside strips, again as referred to in paragraphs 70 and 71, is recommended, provided that it is carried out sufficiently frequently and effectively, and chain saws used to tidy up wherever necessary. I also recommend that trials should be carried out using the latest design of heavy agricultural hedge cutters as opposed to flails as, in my opinion, these are just as effective and provide a neater finish.

78. The Southern Region accepts that the instructions given to drivers in the past were not as specific as they should have been when dealing with braking in conditions of very low adhesion. Following the Copyhold collision special instructions were included in drivers' training courses and I am assured that these instructions on low adhesion braking are being issued to all drivers in advance of the 1986 leaf fall season. I understand that the instructions are based on the recommendations made in the British Railways Board's Report and quoted in paragraph 66 and I fully support this decision. I am aware that the instructions will leave the driver to decide the moment at which to continue to 'release and re-apply' is no longer safe and that he must make a full brake application until he has come to a stand. The only safer method is to instruct the driver to make a full brake application as soon as his train starts to slide and to maintain it. This could be guaranteed to bring the train to a halt more rapidly than any other method but it would also result in so many flats being made on tyres that, by the end of of the leaf fall season, a high proportion of the EMU fleet would be out of service waiting for their tyres to be turned. This is obviously unacceptable.

79. Finally, while the results of the trials carried out by the British Railways Board using a Class 421 (4-CIG) unit with G.I.C. fluid to promote conditions of low adhesion are most valuable, there is no proof how accurately these represent the lack of adhesion caused by wet leaves. Thus the conclusions regarding the influence of braking practice may not be completley accurate and the recommendations made could be incorrect. I recommend, therefore, that further tests be carried out this autumn during the height of the leaf fall season, under conditions as similar as possible to those at the time of the accident, to confirm the validity of the tests carried out with G.I.C., as detailed in Appendix 'A'.

I have the honour to be,

Sir,

Your obedient Servant,

P. M. OLVER
Major

THE PERMANENT UNDER SECRETARY OF STATE,
DEPARTMENT OF TRANSPORT.

APPENDIX 'A'

BRITISH RAILWAYS BOARD

REPORT

BRAKING UNDER LOW ADHESION CONDITIONS RELATING TO THE COLLISION WHICH OCCURRED AT COPYHOLD JUNCTION ON WEDNESDAY 6 NOVEMBER 1985.

CONTENTS
(Less Appendices)

1. *SUMMARY*

1.1 It is acknowledged that at the time of the collision at Copyhold Junction on 6 November 1985, low wheel to rail adhesion conditions were present.

1.2 It is considered that the collision would have been avoided if at an appropriate point during the braking stop, Driver Batchelor had made an emergency brake application.

1.3 To produce the technical evidence which would confirm or refute the statement in 1.2 above, a survey of known past research, development and test work has been conducted.

1.4 To support earlier work a series of tests have been undertaken to establish the behaviour of a cast iron block braked Class 421 Electric Multiple Unit on rails with low adhesion levels present.

1.5 Because, at the time of the tests, natural low adhesion from leaf fall was not available, it was necessary to artificially reproduce the low adhesion conditions required for the tests.

1.6 The results of the specially commissioned tests demonstrated that:–

a) In conditions of artificially produced low adhesion, an improvement in effective adhesion occurs when operating with all wheels locked up. However, the consequences to wheelset condition are serious, this is borne out in practical tests which utilised two techniques of driving.

b) When braking in conditions of low wheel/rail adhesion, the braking technique applied has a significant bearing upon the stopping distance, and particular techniques can now be recommended.

1.7 As a result of these tests, guidance to drivers is recommended, giving details of braking procedures which should be adopted in conditions of low adhesion.

1.8 Reference is made to previous reports recommending procedures for improving adhesion levels.

2. *REMIT*

The technical enquiry is concerned with the brake performance, braking technique, track conditions and other circumstances applicable to the 01.00 Victoria to Brighton train driven by Driver E. B. Batchelor on Wednesday 6th November 1985.

The remit of the technical enquiry is as follows:–

a) Analysis of Railway Joint Enquiry and Public Enquiry reports appertaining to brake technique and braking performance of SR Class 421 EMU trains.

b) Explanation of the circumstances in a) above by a review of known experimental data and on-line tests as necessary under simulated and naturally occurring low adhesion conditions.

c) Analysis of data under b) and conclusions.

d) Recommendations.

2.1 *Commentary*

Two aspects regarding the remit are worthy of comment. Firstly that the Public Enquiry confirmed the evidence gathered at the Railway Joint Enquiry and that there is no conflict of evidence. The facts of the case are not in dispute and the circumstances leading up to the collision are established.

Secondly, with the tests being conducted in May/June, test running in conditions of naturally occurring low adhesion have not been possible. The report of this enquiry is thus based upon tests which have been carried out in artificially produced low adhesion.

3. *COMPOSITION OF THE TECHNICAL ENQUIRY TEAM*

N. Coyne (Chairman) Surburban Maintenance Engineer BRHQ*
T. A. Stubbs (Chairman) Surburban Maintenance Engineer BRHQ (From April 1986)
R. J. Gostling Head of Mechanical Engineering Research
T. G. Pearce Vehicle Dynamics Unit Research
D. B. Nicholas Brakes Engineer BRHQ

*Retired from BR during the period of the Technical Enquiry

K. Bence Traction & Rolling Stock Engineer SR
A. Hawes Rolling Stock Project Engineer SR
T. Adams Regional Operations Officer (West) SR
K. Gardner Traction & Train Crew Manager SR*
C. Marshall Traction & Train Crew Assistant SR

*Retired from BR during the period of the Technical Enquiry

4. *BACKGROUND*

At 01.55 on Wednesday 6 November 1985, the 01.00 Victoria to Brighton train (2A18) passed Copyhold Junction signal T335X at danger and collided head-on with the 01.35 Brighton to Victoria train (2A19).

Whilst running at about 65 mph, Driver E. B. Batchelor had applied the EP brake to 20 psi brake cylinder pressure on the approach to signal T335XRR and due to low wheel to rail adhesion prevailing at the time, wheelslide occurred on the unit. The driver then released the brake in order to prevent the slide continuing, and when this had been achieved, he re-applied the brake, once again to about 20 psi. Wheelslide occurred again almost at once, and again Driver Batchelor released the brake. This technique continued and at each partial brake application wheelslide occurred again. The unit thus continued, with the brake being successively applied and released, and passed signal T335XRR showing double yellow at 60–65 mph, signal T335XR showing yellow at about 45 mph and signal T335X showing red at 20–25 mph. The collision with 2A19 occurred approximately 520 yards beyond the red signal. The speed of impact was estimated at 15–20 mph. The emergency brake was not applied until just before impact.

Weather conditions during the days leading up to the incident were most conducive to wheelslide. On the night of Saturday/Sunday 2/3 November there was a severe frost and this caused the trees to shed unusually large quantities of leaves. From Monday night, 4 November 1985, onwards, damp atmospheric conditions prevailed. During this time, the leaves would be swept into the slipstream under each train and some would be trapped on the rails. This would progressively build up to form a continuous film, which when damp would reduce the level of adhesion.

The total distance between sighting Signal T335XRR and passing T335X is 2609 yards. Added to the distance of overrun (520 yards) this gives a braking distance of approximately 3,100 yards; this distance of travel brought about a reduction in speed from 60–65 mph to 15–20 mph. Under normal circumstances the train would have stopped from this speed within a maximum of 800 yards. The purpose of the technical enquiry is to explain the circumstances of the above collision as detailed in the Remit of the Team (See Item 2).

5. *FACTORS FOR CONSIDERATION*

5.1 *Braking behaviour in normal and low adhesion conditions*

The majority of multiple units operating on the Southern Region are designed with a maximum braking retardation rate in the range 9% to 11% g. This maximum braking rate is well in excess of the braking which would be required to comply with the signalling distances, this figure normally being about 4.5% g on the Southern Region. To maintain the maximum braking rate a value of μ (the co-efficient of friction) between wheel and rail needs to be in the region of 0.1 and for signalling distance purposes a value of 0.05 is used.

Adhesion levels are normally highest on dry rails when μ of 0.3 is typical, but even in wet conditions μ of 0.2 is obtained. Occasionally, combinations of contaminants and damp conditions contribute in producing μ levels below 0.1 and in exceptional circumstances figures as low as 0.03 occur.

Low adhesion in certain conditions has been a feature of railways operation for many years. With electric multiple-units fitted with block brakes operating on the wheel tread, all brakes on the train are applied or released virtually simultaneously under the operation of the driver's brake controller. In conditions of low adhesion one or more of the wheelsets in a train may lock-up and slide during braking and, if this occurs, wheel flats may be produced. If the wheel flats are severe, the train will need to be taken out of service and the wheel treads reprofiled.

If the driver of a train becomes aware that wheels on the train are sliding, one action he can take to limit the formation of wheel flats is to release the brake until wheels are once again rotating, and then re-apply the brake. This technique is taught to drivers, but it should be noted there are some limitations in this method. With most block braked Southern multiple units, all the brakes are released or re-applied simultaneously, even though not all the wheels may have been sliding. Secondly the stopping distance is extended due to the fact that for part of the time the train is running with brakes released.

Evidence has been produced to indicate that a wheel which is sliding does have some form of cleaning action on the rail head. If it is allowed to slide, the following wheels in the same train are likely to benefit from slightly higher adhesion levels as a result.

5.2 *Estimated level of adhesion at the time of the collision*

Without the advantage of measuring apparatus being available at the time of the collision, the actual level of μ relating to this incident cannot be established with certainty. However, some guidance can be obtained by considering the evidence available.

The driver's evidence that wheelslide occurred at a brake cylinder pressure of 20 psi indicates that μ of less than 0.04 was present, 20 psi being about 40% of a normal full brake application.

From the evidence of the enquiry, the use of the apply/release braking technique, the braking distance and speeds at the time of the incident are not in dispute. Calculations to establish a mean value of μ assuming that the brake was applied for 50% of the time, indicate that a figure of 0.04 was probable.

During an examination of the Copyhold Junction site, some 8 to 10 hours after the incident, trains leaving Haywards Heath over the Up line were observed experiencing wheelspin whilst accelerating. This indicates that the adhesion was at or about the level needed to support traction. A theoretical consideration of the traction characteristics for the units indicates that a μ of 0.05 would be required for acceleration purposes at this location.

Measurements of adhesion caused by leaf film and in damp conditions indicate a typical adhesion level down to a μ of 0.03. It therefore seems likely that the value of μ prevailing at Copyhold Junction at the time of the collision was in the range of 0.03 to 0.04.

5.3 *Effect of braking technique on stopping distance*

As described in 5.1, brake control with Southern Region block braked electric multiple-units causes application and release of all the brakes on the train virtually simultaneously. In service braking, if the level of prevailing adhesion will not sustain the braking demanded, wheelslide will occur. Small variations in μ, in the brake force or in the axle load may well cause some wheels to slide and not others.

The braking technique used will depend upon the situation of the train at the time. To minimise the creation of wheel flats, release of the brake will certainly be effective, but will also lead to an extension of the stopping distance. The latter may not be important, as in most cases the driver will be braking at less than the maximum possible rate, and in places where he anticipates lowered adhesion should in any case be aplying the brake sooner than normal.

If no extended stopping distance is available to the driver, an increased, even full or emergency brake application may well be needed. This is likely to cause more of the wheels in the train to start to slide. This fact itself will cause stopping distance to be greater than on dry rail, but may well reduce the stopping distance compared with the apply/release technique.

One purpose of this technical enquiry is to assess the improvement likely if an alternative braking technique is used in conditions of low adhesion, instead of the apply/release technique.

5.4 *Measures to improve adhesion levels*

Areas which persistently suffer from low adhesion in the leaf fall season are reasonably well identified.

The difficulties which arise and details of causes and solutions have been investigated by BR and two reports are particularly relevant. These are:–

a) A. O. Gilchrist. Signal Station Overruns — The Influence of Braking Systems dated February 1984.

b) BR Southern Region. Regional Leaf Season Task Force Report to Production Management Group Ref 82.3.2 (DI) dated 20.3.86.

Consideration is being given to the recommendations of the above reports with a view to applying effective remedies to low adhesion from leaf fall. The Adhesion Improvement Group is a joint committee comprising representatives from the Directors of Research, Mechanical & Electrical Engineering, Operations and Civil Engineering. The report of this Group is being finalised at present. The Southern Region is taking steps to improve the treatment on low adhesion areas and much of the work involved will be implemented before Autumn 1986.

With specific reference to tree clearance, the BR Director of Civil Engineering issued Handbook No. 43 Code of Practice for Management of Lineside Vegetation in 1985. The methods detailed in this handbook have not been fully implemented, principally due to a lack of resources.

6. *EXAMINATION AND REVIEW OF EXISTING EXPERIMENTAL DATA*

An extensive survey of known past research, development and test work has been undertaken during which the following sources have been exhaustively searched.

BR Board Test Work
BR Research & Development Division Reports
Office de Recherches et d'Essais de l'Union International des Chemins de fer (ORE)

The most extensive survey of adhesion and braking related matters is contained in ORE Committee B164 Report 1, September 1985. From this study it has been possible to find some evidence which relates to vehicle performance on leaf affected track. This however is not directly related to the vehicle involved in the Copyhold incident but does serve to illustrate how two other railway administrations have sought to investigate braking performance under extremely low adhesion. The ORE Committee B164 have in their programme of work made an allowance to study adhesion values that can be used in different train/vehicle braking conditions. It is unanimously acknowledged that dead leaves accompanied by humidity results in the lowest adhesion values.

Tests with artificially produced low adhesion carried out in conjunction with other work in 1981 and 1982 indicated that some improvement in retardation rates can result from braking cast iron tread braked multiple units with wheels locked.

In view of the foregoing, it was considered necessary to commission further testing on BR Southern Region to examine train braking behaviour in conditions related to the Copyhold Junction collision.

7. *PROPOSALS FOR TEST WORK*

In view of the limited experimental evidence to hand, it was decided to commission further test work. The tests would set out to determine the behaviour of a Class 421 multiple unit during braking in conditions of low adhesion. It was recognised that ideally it would be preferable to use low adhesion conditions created by genuine leaf fall. However, these conditions cannot be created except during a particular brief seasonal period, and then not with consistency or certainty.

It was, therefore, necessary to carry out the new tests with artificially produced low wheel to rail adhesion. Full instrumentation was provided to record the prevailing adhesion levels by two separate means, and to record retardation obtained by two separate means. In addition, speed traces were taken of each wheelset in the two test units so that after the tests fully documented evidence would be available regarding behaviour in low adhesion conditions — albeit artificially induced low adhesion.

A Class 421 unit was fully instrumented to monitor the performance during braking in both 'normal' and low adhesion conditions.

During the tests a Class 455 disk braked unit was also employed as a control unit. This was fitted with special high sensitivity WSP equipment and the function of running this unit was two fold.

a) To help to condition the railhead by providing controlled slip braking over the test site.

b) To provide a monitor of the prevailing adhesion by means of recording the possible retardation during test stops.

Both units were equipped with tanks, pipes and spray nozzles to apply adhesion — lowering fluid, the spraying taking place from the rear of the trains as they passed over the test site. Additional tanks and spraying equipment were also used on the Class 421 unit to give a further adhesion lowering effect.

8. *TEST ARRANGEMENTS*

The detailed test arrangement were as follows:-

8.1 *Test Sites*

Test sites on the SR Shepperton branch were selected as these had been used in the past for braking trials and the pattern of traffic on the line enabled intensive testing to be carried out at night. The locations used were:—

Kempton Park Station — Down line from 16 miles 20ch for the artificially reduced adhesion conditions.

Fulwell — Up line at 14 miles 20ch for the normal adhesion conditions.

8.2 *Special Trains and Equipment*

a) Class 421, Unit No. 7402, fitted with General Interior Cleaner (G.I.C.) laying equipment, axle speed monitoring equipment, brake performance monitoring equipment and retardation recording instruments.

b) Class 455, Unit No. 5918, equipped with G.I.C. laying equipment, special WSP equipment, brake performance monitoring equipment and retardation recording instruments.

c) Portable tribometer trolley for use at the Kempton Park site, at which ambient temperature and relative humidity will also be measured.

8.3 *Test Procedure*

8.3.1 Both the Class 455 Unit, 5918, and the Class 421 Unit, 7402, ran Strawberry Hill–Shepperton and return, laying G.I.C. on the Kempton Park test site. Unit 5918 whilst laying G.I.C. on the Kempton Park test site made Step 3 stops from 90 kph and was used to monitor the prevailing adhesion.

8.3.2 The tribometer trolley recorded adhesion levels at appropriate intervals at the Kempton Park test site.

8.3.3 Ambient temperature and relative humidity were recorded at the Kempton Park test site.

8.3.4 Passes over the Kempton Park test site were repeated until the Class 455 unit recorded successive braking performances of 3 to 4%g corrected brake efficiency.

8.3.5 Once low adhesion conditions were established, Unit 7402 made test stops from 90 kph on the Kempton Park site WITHOUT laying G.I.C. solution.

8.3.6 Low adhesion conditions were obtained on a number of nights spread out over 5 weeks of testing. The braking with Unit 7402 was divided into three main stages, namely full brake applications, simulation of braking technique to correspond with that used at the Copyhold Junction incident and trial of an alternative braking technique. In all tests the key parameters were recorded.

9. *EXAMINATION OF TEST RESULTS*

9.1 *Introduction*

Tests which were carried out on the night of 5/6 June 1986 illustrate the braking performance of the Class 421 unit when subject to a full brake application. The trials covering varying braking techniques were carried out on the 17/18 June 1986.

9.2 *Full Brake Applications*

For reference purposes the Class 421 unit was braked on clean, dry rail at Fulwell: virtually no wheelslide occurred. From 89.8 kph, the unit stopped in 438 metres, giving on average braking efficiency of 7.24%g.

At the Kempton Park site, adhesion levels were steadily reduced with both units laying G.I.C. as described in Section 8. At 04.17, a test stop with the Class 455 unit gave an average retardation of 3.63%g. At 04.25, the Class 421 unit made a test stop and 10 axles experienced lock-up. From a speed of 90 kph, an average retardation of 6.26%g was obtained.

This demonstrates that the 10 sliding wheelsets had some beneficial effect on the prevailing adhesion level. The rear five braked wheelsets did not suffer any wheelslide and this indicates that when these passed over the site, the adhesion level was sufficient to support the full braking force.

The next test was a stop made at 04.44 by the Class 455 unit. This unit was fitted with special WSP equipment and the effects of the WSP activity on the braked wheelsets was clearly seen in the individual axle speed traces. The average retardation recorded on this stop was 3.89%g.

From evidence relating to the Copyhold Junction collision, it would appear that each wheelset had locked-up at some time during the braking period. In view of this, it was considered that a brake test should be conducted with all braked wheelsets locked-up. To achieve this, it was necessary to increase the number of spray points for the G.I.C. on the Class 421 unit, the additional laying taking place midway along the unit. The results of this test indicated an average deceleration rate of 5.9%g from a speed of 90.1 kph. During the stop, all 15 braked axles locked-up.

9.3 *Alternative Braking Techniques*

On the night of 17/18 June 1986, a series of tests were carried out in simulated low adhesion conditions with two objectives:–

a) Attempt to repeat the reported braking method used by Driver Batchelor at Copyhold Junction.

b) To apply alternative methods using both the EP and automatic brake. To ascertain the most suitable to be used in natural conditions of low adhesion.

As with the tests on 5/6 June 1986, adhesion was lowered using G.I.C. solution and prior to the first test run of the Class 421 unit, an average retardation of 3.75%g was obtained by the Class 455 unit. Consistently low adhesion levels were maintained throughout the night, the recorded figures on the Class 455 unit being between 3.3%g and 3.7%g.

There were six relevant test runs with the Class 421 unit.

The first run used the EP brake apply/release method throughout. This was an attempt to simulate the technique used in the Copyhold Junction incident.

The brake was applied using the normal maximum application. The speed at the commencement of braking was 91.4 kph. At between 20/30 psi brake cylinder pressure, the speedometer indicated that the wheels were sliding. The brake was released and when the speedometer indicated that the wheels were again turning the brake was re-applied. This was repeated throughout the length of the site and beyond. It was estimated that the stopping point was some 18 coach lengths beyond the termination of the trial site, the actual stopping distance being 882 metres and an average braking retardation of 3.72%g was obtained.

The second run used the same technique at the commencement of the braking, when the wheels picked up, this was repeated and on the third application the brake was left fully applied. The stopping distance was 914 metres and the average retardation was 3.55%g.

The third run used the same technique again, but less time was allowed on the release giving an earlier final application. The objective of the method used was to attempt to stop the train in the shortest distance and with the least risk of damage to the wheels. The stopping distance from 90.4 kph was 736 metres and the average retardation was 4.36%g.

The fourth run was under automatic brake conditions using a progressive and gradual increase in brake cylinder pressure. The first application was 5/10 psi brake cylinder pressure, this was held and then increased to 15 psi, held and then increased to 20 psi, at which point the wheels picked up. The brake was released and re-applied in the same manner when the wheels locked again. When the brake was released it took a considerable time for the wheels to rotate. The brake was then re-applied and the brake cylinder pressure indicated that the maximum would not be obtainable due to the characteristics of the automatic brake. As the end of the site was rapidly approaching an emergency brake application was made (this was expected). The train stopped some 14 to 15 coach lengths beyond the termination of the trial site. The stopping distance was 1,010 metres and the average braking retardation was 3.39%g.

Although the tests were restricted by the length of the conditioned track available, an assessment of the previous four runs indicated that there was insufficient control of braking on the first EP stop (Run 1) and the automatic brake stop (Run 4) and that the technique of apply and release followed by an application which is left applied gives a shorter stopping distance.

The fifth run used the reverse of the normal EP brake technique and employed a gradual and progressive increase in brake cylinder pressure. The brake was applied at 10 psi brake cylinder pressure and progressively increased by 5 psi stages until approximately 40 psi brake cylinder pressure was reached. When at that pressure, the speedometer indicated wheelslide, the brake was released and re-applied gradually. Only the one instance of wheelslide was noted. The train was brought to a stand some 8 coach lengths beyond the termination board of the test site, the actual stopping distance being 848 metres, with an average braking retardation of 3.79%g. The technique used was aimed at minimising the formation of wheel flats, and forms the basis of the recommended technique included in Section 11.1.

Finally a test run with a full brake application was made for reference purposes. The stopping distance from 91.3 kph was 571 metres, the average braking retardation being 5.74%g. 13 braked wheelsets locked-up and significant wheel flats were caused as a result.

Following the experience gained during the foregoing test runs, it is considered that the best method of controlled braking in conditions of low adhesion is a combination of a progressive increase in brake cylinder pressure followed, if necessary, by the release/progressive re-application method and that the brake should be left applied if the safe braking distance is reached. This would be consistent with minimising the production of wheel flats.

9.4 *Comparative Adhesion Data*

During the testing, the portable tribometer trolley was used at the Kempton Park site to directly measure the adhesion. The aim was to measure immediately before and after the Class 421 braking runs, so as to quantify the change in adhesion produced by the sliding wheels. While the measurements generally supported the results derived from the retardation rate of the train, the trolley had never before been used on track where G.I.C. had been employed to lower the adhesion.

It is not possible to directly relate the readings obtained from the trolley with those recorded by the train owing to the limited contact area of the tribometer wheel. However, on the night of 28/29 May 1986, when wheelslide was established on the leading two coaches of the Class 421 unit, readings from the tribometer trolley indicated a significant rise in adhesion resulting from the passage of the train.

10. *CONCLUSIONS*

10.1 At the time of the Copyhold Junction incident on 6 November 1985, a low level of wheel/rail adhesion was present on the Up (reversible) line, and although the co-efficient was not measured at the time, evidence gained elsewhere (refer to 5.2) indicates that μ was likely to have been in the range of 0.03 to 0.04.

10.2 The cause of the low adhesion on the line at the time can be attributed to leaf fall from the adjacent trees, and to the prevailing ambient conditions.

10.3 Tests in artificial conditions have suggested, notwithstanding the low adhesion, that the train 2A18 involved in the incident, could have been stopped prior to colliding with train 2A19, had a different braking technique been applied.

10.4 Traditionally the brake apply/release technique has been taught to and used by SR MU drivers, in the belief that this gives the optimum braking performance where a low level of wheel/rail adhesion is encountered.

Whilst this technique is still appropriate on stock without wheelslide protection equipment, guidance is required to clarify to drivers what action should be taken in bringing trains under control in conditions of very low adhesion.

11. *RECOMMENDATIONS*

11.1 Guidance be given to drivers of SR tread braked multiple-unit trains, when operating under low adhesion conditions, recommended wording being as follows:–

'Under conditions of low adhesion, braking distances can be increased considerably. In these conditions, it is recommended that the initial application of the brake should give the minimum brake cylinder pressure and that the pressure should be progressively increased until sufficient pressure is obtained consistent with stopping the train at the required point according to the distance available and the gradients prevailing.

'If wheelslide occurs the brake should be released and re-applied and if wheelslide re-occurs, this should be repeated until it is considered that the safe braking distance to stop the train had been reached. At this point the brake should be applied with the maximum brake cylinder pressure considered necessary to stop the train at the point required and the brake should be left applied until the train is brought to a stand or to such a speed that the brake cylinder pressure can be reduced.'

11.2 Increased action should be taken to combat the effects of leaf fall in lowering wheel/rail adhesion, taking note of the recommendations of earlier reports referred to in Section 5.4 of this report.

Attention is also drawn to the code of practice for the management of lineside vegetation published by the Director of Civil Engineering in the form of Handbook No. 43, 1985. It is recommended that the provisions of this handbook be worked to.

Printed for Her Majesty's Stationery Office by Bocardo Press Limited, Oxford 11/86 C7 Dd.240345.

First published 1986

ISBN 0 11 550803 1

COLLISION AT COPYHOLD JUNCTION, SOUTHERN REGION, 6th NOVEMBER 1985

FIG. 1. TRACK DIAGRAM SHOWING SITE OF COLLISION AND POSITIONS THAT TRAINS CAME TO REST

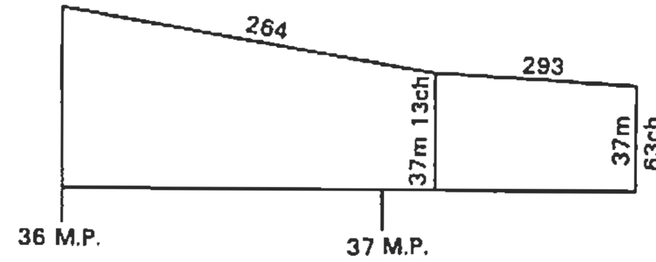

FIG. 4. GRADIENT DIAGRAM

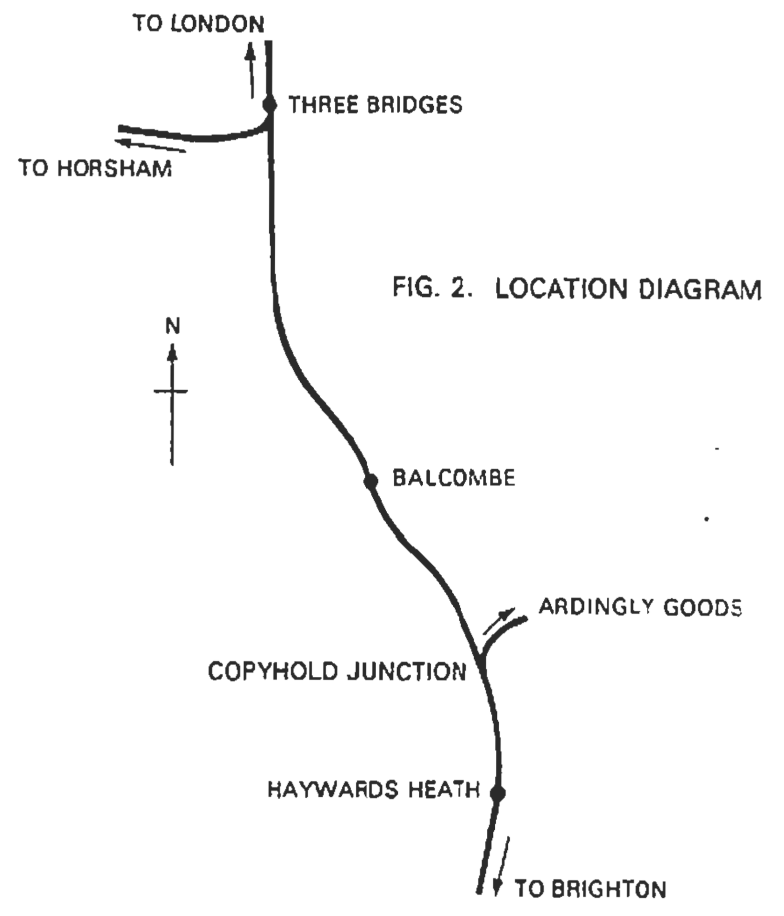

FIG. 2. LOCATION DIAGRAM

GENERAL NOTES:-

OVERLAPS 200 YARDS UNLESS OTHERWISE STATED
ALL MAIN SIGNALS HAVE A TELEPHONE
A.W.S MAGNETS SITUATED 200 YARDS IN REAR OF SIGNAL UNLESS OTHERWISE STATED

DISTANCE OF POINTS FROM HAYWARDS HEATH RELAY ROOM

1783	1784	1785	1786	1787	1789	1790	1791	1792	1794	1796	1797
1918 2000	1754 1892	1745	1577 1745	1745	530 593	461 525	8 102	6 109	35 163	137	176 278

FIG. 3. SIGNALLING DIAGRAM, BALCOMBE TUNNEL JUNCTION – HAYWARDS HEATH

Not to Scale