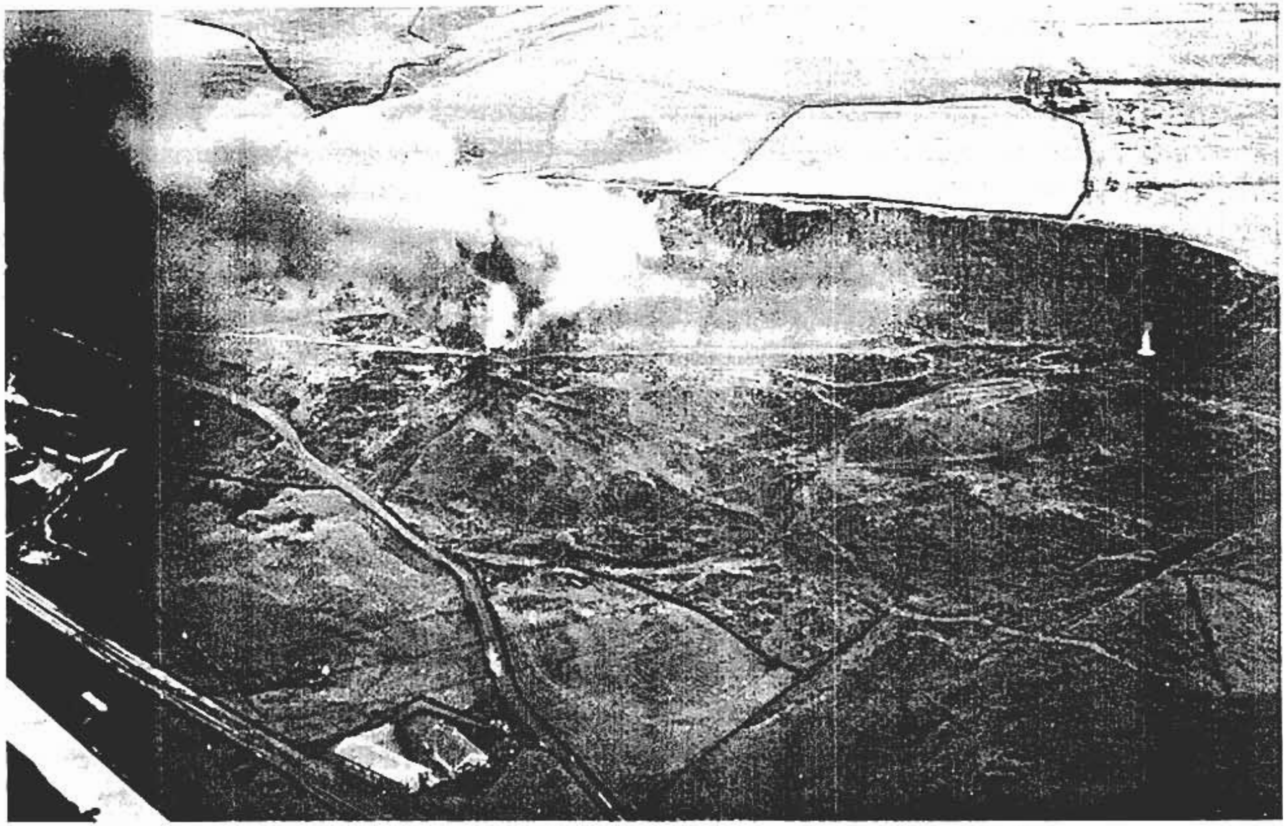
DEPARTMENT OF TRANSPORT

RAILWAY ACCIDENT

Report on the Derailment and Fire that occurred on 20th December 1984 at Summit Tunnel

IN THE
LONDON MIDLAND REGION
OF BRITISH RAILWAYS

LONDON: HER MAJESTY'S STATIONERY OFFICE



PHOTOGRAPH 1. Flames from Ventilation Shafts 8 and 9 at about 13.30 on 20th December 1984.
Photograph Courtesy of West Yorkshire Fire Service.

RAILWAY INSPECTORATE
DEPARTMENT OF TRANSPORT
2 MARSHAM STREET
LONDON SW1P 3EB
4th June 1986.

SIR,

I have the honour to report for the information of the Secretary of State, in accordance with the Direction dated 28th December 1984, the result of my Inquiry into the derailment and subsequent fire involving a freight train conveying loaded petrol tank wagons that occurred at about 05.50 on Thursday 20th December 1984 inside Summit Tunnel near Todmorden, in the London Midland Region of British Railways.

THE ACCIDENT

The train was 6M08, the 01.40 Haverton Hill (Teeside) to Glazebrook (Merseyside) freight train. It was hauled throughout its journey by Class 47 diesel-electric locomotive 47125. The train consisted of the locomotive and thirteen loaded bogie tank wagons conveying 835 tonnes of petroleum spirit. Its maximum permitted speed was 60 mile/h and it was air braked throughout.

The train left Haverton Hill about 10 minutes late but otherwise had a normal journey to Healey Mills where there was a change of crew. From Healey Mills the train ran normally until it entered Summit Tunnel (2885 yards) travelling southwards along the Up line at about 40 mile/h. Shortly afterwards it became derailed behind the third tank wagon, a coupling further down the train parted causing the automatic air brake pipe to rupture and the ensuing emergency application of the train's brake brought it to a stand about midway through the tunnel.

The leading axle of the fourth tank wagon was the first to become derailed. It was subsequently found to have suffered a catastrophic failure of its left leading axlebox roller bearing, resulting in the fracture of the axle journal. The damage caused to the track by this derailed wheelset quickly brought the following vehicles into derailment. The trailing wheelset was ripped from beneath the fifth vehicle and both bogies from beneath the sixth which turned onto its side and came to rest on the Down line. There was then a gap of about 60ft to the seventh vehicle, which remained upright as did the eighth and ninth, but all three were derailed all wheels. The tenth wagon lost its leading bogies and also fell onto its side on the Down line, the eleventh was derailed all wheels but remained upright. The leading bogie of the twelfth derailed but its trailing bogie and the thirteenth wagon remained on the track; these three bogies came to rest short of the point of the initial derailment.

Fire broke out almost at once and the train's crew rapidly evacuated the locomotive and made their way forward to escape from the tunnel; they quickly raised the alarm from a signal post telephone just outside the tunnel portal. The first fire appliances had arrived at each end of the tunnel by 06.16, a remarkable achievement in view of the remoteness of the site. Their crews at once set about assessing the situation and then tackled a number of small fires along the tunnel.

At 08.40, under the supervision of the Fire Brigade, the train's crew re-entered the tunnel and uncoupled the train between the third and fourth vehicle. They then withdrew the three leading tank wagons using the train's locomotive. After inspection this part of the train went forward to its destination.

In the early stages of the incident fires were burning at several places along the train; the Fire Brigades successfully extinguished a number of them and the incident seemed to be under control. At about 09.40, however, the fire developed rapidly and an immediate evacuation of all personnel from the tunnel was necessary. At 10.05 a 'Major Incident' situation was declared and residents were evacuated from the area. It was not until more than 24 hours later that fire brigade personnel were able to re-enter the tunnel when the environment was described as 'hostile' and there were still signs of fire. The situation was not considered to be under control until the evening of 24th December.

It was clear that little was to be gained from an early inspection of the aftermath of the incident. The first fire brigade parties to re-enter the tunnel reported daunting noises emanating, presumably, from contracting metal, brick and rock and so the tunnel was sealed off until 27th December.

Considerable problems faced the teams tasked with rehabilitating the line. Tank wagons had been badly damaged in the incident and the confines of the tunnel hampered the salvage crews as did the emergence of petroleum vapours from the ballast. The last vehicle was removed from the tunnel on 1st March 1985 and the line was re-opened to traffic on 19th August 1985.

The Train

1. The train was 6M08, the 01.40 Haverton Hill to Glazebrook petrol tanker train, the train's TOPS consist list indicated that it travelled in the following formation

Vehicle	*Number*	*Weight Tonnes*
Class 47 Locomotive	47125	117
Bogie Tank Wagon	BRT 84296	91
"	BRT 84294	91
"	BRT 84295	91
"	PR 82689	91
"	BRT 84313	91
"	PR 82703	91
"	PR 82691	91
"	BRT 84299	91
"	BRT 84298	91
"	BRT 84293	91
"	BRT 84311	91
"	BRT 84297	91
"	PR 82687	91
		Total 1300 Tonnes

Each rail tank contained 64.2 tonnes of petrol; 835 tonnes total. The length of the train and locomotive was 844 feet and the brake force was 736 tonnes.

2. The tank wagons were owned by Procor (UK) Ltd and were on hire to ICI Petrochemicals and Plastics Division. All of the wagons in the train were built by the Standard Railway Wagon Company Limited to carry Class B heavy oil traffic.

3. During 1984 all of the vehicles concerned were converted to carry Class A light oil products. The tank barrels were then freshly painted in dove grey and the solebars red to denote that the vehicles were carrying Class A products. A HAZCHEM label measuring about 700 × 400mm was applied to either side of each wagon bearing the UN Code No 1203 denoting petrol and the word 'petrol' appeared beneath the code number. The HAZCHEM label carried the action code 3 Y E. The figure 3 denotes that foam is the appropriate fire fighting agent, Y indicates that there is a danger of violent reaction or explosion and that breathing apparatus and protective clothing is required in event of fire and the E denotes that evacuation of people from the neighbourhood should be considered. The label also gave the name, address and telephone number of ICI, Eston Grange to contact in event of an emergency.

The Tunnel

4. Summit Tunnel is about 15 miles to the north of Manchester on the line to Leeds. The tracks run more or less south to north in the down direction over a 10 miles long section from Smithy Bridge passing through Littleborough, Summit Tunnel and Todmorden then turning north-east to Hebden Bridge.

5. Summit was the first trans-Pennine rail tunnel and was constructed during 1840–41 for the Manchester to Leeds Railway with George Stephenson as Engineer in Chief and T. Gooch as Site Engineer. It was driven through shales, gritstones, coal measures and broken ground.

6. The tunnel is double tracked and 2885 yards long and is located at the summit of the line. There is a continuous rising gradient of 1 in 182 from Tormorden to the north end portal, there are then 250 yards of level track followed by 1 in 330 continuously falling gradient towards Littleborough. The tunnel is straight except for a short length of curve at each end. It is built to a horseshoe profile with a height of 21'-5" and an average width of 23'. There are stone portals at either end. The brick lining varies between 5 to 10 rings depending on the geological conditions encountered during construction.

7. Fourteen construction shafts were originally provided, they vary in depth between 90 and 310 feet. Two shafts were subsequently blanked off leaving 12 for ventilation purposes at the time of the accident.

8. Because of the condition of the shale some 1800 yards of the tunnel is of invert construction. Just before it was first opened it suffered damage when the downward thrust of the side walls caused the blue shale

under the invert to heave for 80 yards between Shaft Nos. 2 and 3; Stephenson and Gooch inspected and agreed remedial work.

The Track

9. The track through the tunnel consisted of 113 lb/yard flat bottomed rail continuously welded and supported on softwood sleepers with limestone ballast. There was a drain in the six foot space with catchpits at regular intervals.

Signalling

10. Signalling through Summit Tunnel is of the Track Circuit Block type controlled from an Entrance/Exit panel at Preston Power Signal Box. Thus the lines through the tunnel are fully track circuited, protection at either end is afforded by way of four-aspect colour light automatic signals, PN.328 (Up) and PN.329 (Down) with emergency replacement switches.

11. To either side of the tunnel trains are worked on the Absolute Block system from Hebden Bridge (Eastern Region) and Smithy Bridge signal boxes respectively.

12. The West Yorkshire/Greater Manchester county boundary cuts the tunnel about midway.

13. The salient details of the site are shown in Figures 1, 1a, 2a and 2b at the back of this report. Details of the tank wagons are at Figure 4.

Site Inspection

14. On 27th December I entered the tunnel from the Todmorden end along with the first British Railways investigating team. As we progressed into the tunnel evidence of the extremely high temperatures that had occurred during the fire became more and more evident. The last tank wagon, the thirteenth in the train was just over 1000 yards inside the tunnel, it was little damaged and was reported at the time to contain some 30 tonnes of petrol (a total of 12 tonnes of hydrocarbons was later recovered). In this area the main signs of damage were a number of scorched sleepers. Further in the surface of the tunnel's brick lining was vitrified, the petrol tank barrels had collapsed and there was some melting of steelwork.

15. Both tracks were badly damaged and distorted and there were breaks in the rails here and there. On one bogie a wheel had slipped from its seating on the axle as a result of being expanded by the heat of the fire and due to the bogie being on its side so that the axle was tilted towards the vertical and the expanded wheel had slid down it. None of the damage that I saw, however, was inconsistent with what one might have expected to have occurred when a train of heavy bogie tank wagons loaded with petroleum first derailed and then caught fire. When I arrived at the leading end of the fourth vehicle I noticed considerable damage to the six-foot side wheel tread of the leading axle consistent with it having run along the sleepers for some distance striking base plates. The cess side wheel, on this axle, was close to the tunnel wall but it was possible to see that the axle journal end and roller bearing axlebox were missing (Photograph 2). It was immediately apparent that the unloading of the cess side wheel that would have occurred when the journal failed and the consequent freedom of movement of the broken stub end of the axle within the bogie horn guides would have allowed the cess side wheel flange to attack and climb the rail and thus cause the initial derailment. The damage to the track caused by this wheelset would quickly have brought other wheels into derailment. We than searched back along the track amongst the tangled wreckage of the train and the piles of heat damaged brick from the tunnel lining that had spalled and in places was laying between two and three feet deep over the tunnel floor. In such circumstances we were extremely fortunate to come upon the missing axlebox complete with bearings and broken journal end laying by the tenth tanker which was on its side (Photograph 3).

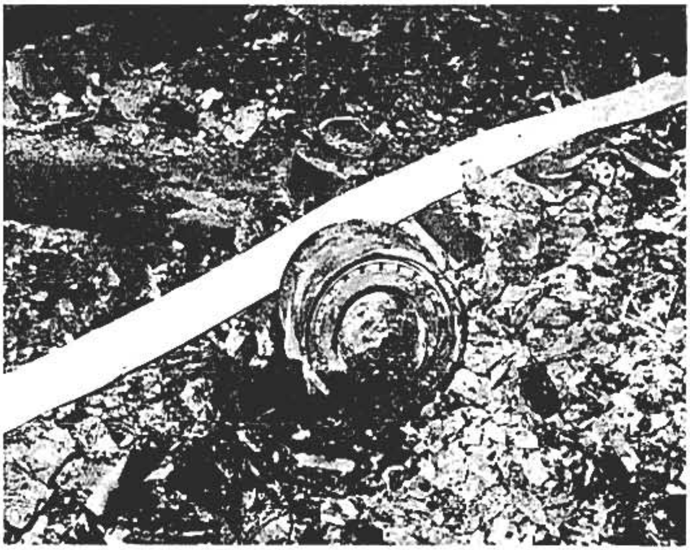
16. The leading bogie of the fourth tanker together with the axlebox and journal, which was positively established as belonging to the damaged wheelset, were subsequently removed from the tunnel and subjected to forensic examination at the British Railways Technical Centre at Derby.

EVIDENCE

As to the Running of the Train and the Derailment

17. *Rolling Stock Technician A. W. Davies* was on duty at Haverton Hill from 22.00 on the 19th December 1984 and he examined both sides of the thirteen tank wagons that formed 6M08. He said that his was simply a visual examination of the running gear and that he was quite satisfied, from what he saw, that the wagons were fit for traffic. There were no signs of any leakages of product. Mr Davies said that an external visual inspection of a roller bearing axlebox was unlikely to reveal anything unless it had previously become overheated to some extent when some discolouration or scorching might be apparent. He was able to confirm that a brake continuity test was carried out by the train's guard before 6M08 left Haverton Hill.

PHOTOGRAPH 2. View of Leading Axle of Tank Wagon No PR 82689, the 4th Vehicle in the Train showing the Stub End of the sheared Journal.
Photograph courtesy of British Railways.



PHOTOGRAPH 3. Axlebox and Broken Journal End from the 4th Tank Wagon found laying adjacent to the 10th Tank Wagon.
Photograph courtesy of British Railways.

18. *Driver S. Marshall* of Newton Heath, a man with some 25 years experience, was at the controls of locomotive No. 47125 when the accident occurred. *Guard F. Broadbent* and *Guards Inspector S. Smalley* were travelling in the locomotive's rear cab. Driver Marshall said he joined the train, along with the other two men, at Healey Mills and that the journey up to Summit Tunnel was normal in every respect. Approaching the tunnel the train's speed was about 40 mile/h, at the portal Marshall closed the controller knowing that the falling gradient through the tunnel would enable the train to maintain its speed. Shortly after entering the tunnel the locomotive began to shudder, he noted that the automatic air brake pipe pressure gauge was indicating zero, the brakes applied and the train came to a stand.

19. Driver Marshall got down from his locomotive and walked towards its rear where Guard Broadbent and Inspector Smalley had already alighted. The tunnel was full of fume and dust and then, suddenly, there was a 'whoosh' of flames back along the train and the three men decided to vacate the tunnel as quickly as possible. Guard Broadbent, who was the younger man, ran ahead to the signal post telephone at the Littleborough end of the tunnel, about a mile away from the scene of the accident, from where he contacted a signalman at Preston Power Signal Box to raise the alarm. Driver Marshall said that, in the heat of the moment, no attempt was made to apply a track circuit operating clip to the Down line but he and Guard Broadbent were carrying handlamps and would have attempted to warn any oncoming down train by waving their lamps had this become necessary.

20. *Guard Broadbent* corroborated the driver's evidence where he was able to do so. He also told me that because they relieved the train's original crew at Healey Mills, they were not required to carry out any inspection of it on joining and that they did not do so. However, from his TOPS train consist list he knew the train way carrying highly flammable petroleum products; Guard Broadbent had noted that the tankers were freshly painted dove grey with a red solebar which denoted that they contained Class A highly flammable products. He had also observed that an electric tail lamp was fitted; a paraffin tail lamp would have required the provision of a 30 ft barrier wagon at the rear of the train and Broadbent was advised to this effect on his TOPS print out. Throughout the journey he rode in the drivers seat in the rear cab, Guards Inspector Smalley sat on the other side. As the train was negotiating right handed curves along the route he was able to look back along it but in the darkness he saw nothing unusual at any time (the axlebox failure occurred to the opposite side of the train). A few miles before the tunnel the train passed over a 20 mile/h permanent speed restriction and Broadbent recalled checking that the train's speed was correctly reduced at this location. From there to the tunnel the gradient was rising and he noted that the train had accelerated to about 40 mile/h as it entered the tunnel. The train was about ¼ to ½ a mile into the tunnel when the locomotive began to shudder and then the air brake pipe gauge fell to zero, the brakes were applied and the train was brought to a stand in something less than its own length. Broadbent's first thought was that the driver had made an emergency stop but after the train had come to rest he and Inspector Smalley alighted on the six-foot side to be joined by the driver who said "I think we are on the floor." Broadbent began to walk back along the train examining it using his Bardic handlamp. He was alongside the third tank from the locomotive when flames suddenly erupted from the vicinity of the fifth or sixth vehicle; it seemed to him that a complete vehicle was going up in flames which filled the tunnel, the tank wagon concerned appeared to be on the Down track.

21. The three men then ran forward to escape from the tunnel and Broadbent reached Down signal No. PN 329 at the Littleborough portal ahead of the others to raise the alarm. He advised the signalman that the train was blocking both tracks, was on fire and that the emergency services were required.

22. After the Greater Manchester Fire Brigade team had arrived at the scene and assessed the situation, they asked Driver Marshall, Guard Broadbent and Inspector Smalley to re-enter the tunnel under their guidance and protection to remove the locomotive, the engine of which was still running, and the first three tank wagons which the firemen had determined were not derailed. Guard Broadbent said that, due to the derailment of the fourth tank wagon and to the Instanter coupler between it and the third vehicle being correctly in the short position, it was extremely difficult to perform the uncoupling operation. He had to ask Driver Marshall to ease back very carefully to release the coupler but without causing buffer locking between the third and the derailed, and therefore lower, fourth vehicle. Guards Inspector Smalley relayed Broadbent's instructions to the driver during the uncoupling operation. A fire just beyond the fourth vehicle was burning quite fiercely as they performed this task. The locomotive and three leading tankers were then drawn out of the tunnel and subsequently worked forward to their destination.

23. Until the accident happened *Guards Inspector Smalley* noticed nothing unusual about the journey. Although he was riding in the drivers assistant's seat and thus had a view back along the train's cess side during the journey he noticed no signs of sparking from the train at any time.

24. After the train had stopped and the fire began it was difficult to see very much towards the rear of the train because of the quantity of smoke and fumes but it was apparent that a derailment had occurred. At the time he did not know the nature of the product but before leaving the tunnel saw a sign on the side of one of the tanks saying 1270. On reaching the telephone after Guard Broadbent he advised the signalman that the train was carrying petroleum spirit. On this latter point he was, of course, correct but all the tankers were clearly labelled 1203. This error on Inspector Smalley's part may have been made in the heat of the moment or he may have made a slip of the tongue during the Inquiry proceedings but his error serves to illustrate one way in which later confusion as to the precise identity of the product may have arisen.

25. *Mr G. Fernyhough*, a relief signalmen, was on duty at Hebden Bridge signal box that morning. He told me that his signal box is the last to be passed by trains travelling towards Manchester before they enter Summit Tunnel some 7 miles to the south-west. The signal box stands in the cess of the Up line so that the signalman has a good view of the left-hand side of up trains as they approach. After Hebden Bridge the signals along the route are controlled from Preston Power Signal Box until Smithy Bridge signal box on the Greater Manchester side of the tunnel.

26. The petrol train passed his signal box at 05.37 and a few minutes later Mr Fernyhough was relieved at the end of his shift and before the accident occurred. He learned of the incident from a radio news broadcast as he was eating breakfast at home and at once realised that the train concerned must have been the last one to pass his box before he left. He could clearly recall observing the train as it approached but saw no signs of any sparking or flames, although if an axlebox had been smoking he might not have seen this in the darkness. He was a man of some 30 years experience as a signalman and had had occasion in the past to stop trains when he had seen signs of overheated bearings but on this occasion he saw nothing unusual.

27. *Signalman G. Harrison* was on duty at Preston Power Signal Box at the time of the accident and was responsible for the signalling over the section of line between Hebden Bridge and Smithy Bridge signal boxes. That morning everything was normal until the petrol train ran onto the section of line that includes Summit Tunnel. The diagram in his signal box indicates when a route is set and as a train travels along the route red lights appear to indicate its position. He observed the red light indication appear on his diagram as the train entered the tunnel and then, shortly afterwards, a warning note sounded on the panel that attracted his attention to another similar indication that had appeared on the Down line at the tunnel. Signalman Harrison knew that there should not have been any down train in the vicinity and he immediately checked with the signalman at Smithy Bridge that no down train had been despatched. At 05.57 Harrison sent the Obstruction Danger signal to Smithy Bridge. He noticed that automatic signal No. PN 329 had reverted to Danger thus giving immediate protection had a down train been approaching at the time. About 7 minutes later Guard Broadbent contacted him from PN. 329 signalpost telephone and told him what had occurred and that the fire services' assistance was required. The *Preston Power Signal Box Supervisor* was at once aware that the train concerned was carrying petrol from the TOPS information available in the signal box and *Mr A. Wise the Regional Operations Superintendent (North)* explained that the supervisor is provided with a geographical simplifier that gives details of telephone numbers for the appropriate emergency services for the place concerned together with details of the Ordnance Survey map reference for the location.

28. *Signalman A. Radnedge* was on duty at Smithy Bridge signal box that morning. He has two annunciators in his signal box that are operated by the train as it passes over treadles on the Up track, located near to the entrance to Summit Tunnel and operated at the same time that the train appears on his diagram, and at the tunnel exit on the Manchester side. These devices are provided to enable the signalman at Smithy Bridge to control the barriers at a level crossing by his signal box. After receiving the petrol train's description from Preston he heard the annunciator operate as the train entered the tunnel. But the signalman who was to relieve him and perform the next turn of duty had arrived, Radnedge then handed over the box to *Signalman Taylor* and left the signal box.

29. *Signalman B. W. Taylor* took over from Signalman Radnedge at Smithy Bridge signal box at 05.50 at about the time the accident occurred. He did not have time to realise that anything was amiss until he was advised of what had occurred from Preston Power Signal Box. He at once restored to Danger the Up line signals he had cleared for the passage of the petrol train. All his Down line signals were already at Danger and he completed his protection arrangments by placing detonators on the tracks.

30. *Mr B. W. Dinsdale*, a permanent way maintenance engineer, was called out to the incident and arrived at the Littleborough end of the tunnel at about 08.15 and then made his way to the Todmorden end of the tunnel by road. As he was doing so he observed a small amount of smoke issuing from No 8 ventilation shaft at about 08.30. He then entered the tunnel and came upon the train's thirteenth and rearmost vehicle which was not derailed, the twelfth tank wagon was upright and in line with the track but its leading bogie was

derailed. He positively identified the point of derailment as being midway under the twelfth wagon and that the derailment had occurred towards the tunnel wall or cess side. He then checked back along the track for signs of track deficiencies that might have caused the derailment but found that the track was sound. During his time in the tunnel there was a strong smell of petrol but he saw no signs of fire until he was ordered to evacuate the tunnel by the Fire Brigade. At that stage he saw flames in the vicinity of the tenth wagon. When I entered the tunnel on 27th December I had observed a broken rail under the thirteenth vehicle (Photograph 4) but he assured me that this break had not occurred at the time of his inspection and was the result of subsequent expansion and contraction of the rail during the fire. The complete length of track through the tunnel had been subjected to routine inspection by portable ultra-sonic equipment on the 16th December, only 4 days prior to the accident. This inspection did not reveal any inherent defect in the rail that had broken which confirms that it was the fire that caused the rail to break.

31. *Permanent Way Section Supervisor D. Stott* arrived at the Littleborough end of the tunnel at 06.40 after having been called to the scene by Preston Power Signal Box to attend to a failure. On arrival he learned of what had happened but was asked by a member of the Fire Brigade the nature of the product being carried on the train. He contacted Preston Power Signal Box at once from the nearby signalpost telephone at PN 329 signal and was told that the product was petroleum spirit; he relayed the information to the fire officer within 2 or 3 minutes of being asked the question. He then went around to the Todmorden end from where, sometime after 07.00, he entered the tunnel accompanied by the Fire Brigade and observed a small fire on the sleepers under the twelfth or eleventh wagon but noticed no smell of petrol.

32. Mr Stott inspected the track for signs of the cause of the derailment and confirmed that the point of derailment was midway under the twelfth tank and that no track defect which could have caused the derailment could be found. Mr Stott made his examination whilst a small fire on the sleepers was burning only a few feet away. He then went to the Todmorden portal to report on his findings.

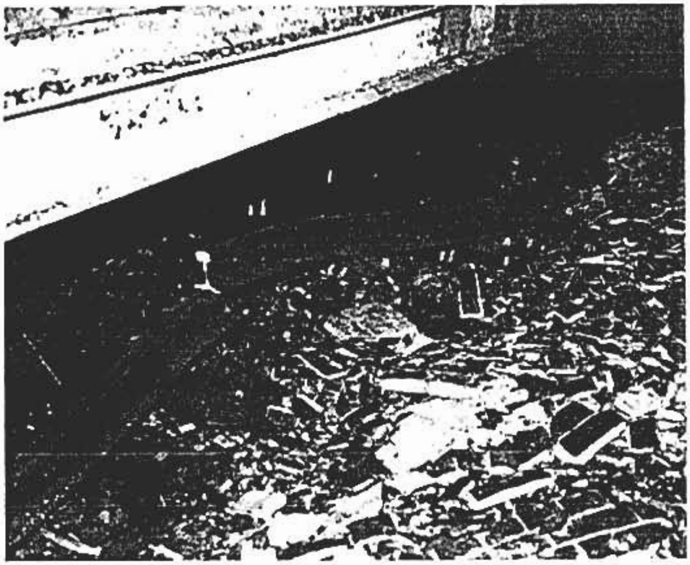
33. *Section Works Supervisor R. Clayton* was responsible for tunnel maintenance at Summit. One of the theories suggested in the early stages after the incident was that material had fallen or had been dropped down one of the ventilation shafts to cause the derailment. Mr Clayton said that grilles were provided at the top of all the shafts and that six of these had been renewed recently. The shafts project above the surrounding ground by between 12 and 30 feet. The original grilles were cast iron rings with a domed mesh of ⅜ inch diameter wire. Where grilles had been renewed redundant point rodding had been used; the grille mesh is about 1¼ inches. All grilles were fitted at the top of the vents. There was no evidence after the fire that any of the ventilation shafts had been tampered with.

34. *Area Rolling Stock Maintenance Engineer D. G. Reid* arrived on site at about 07.30 and was at the Littleborough end of the tunnel when the locomotive and leading 3 vehicles emerged. He examined these vehicles for defects but could not find anything amiss. He also checked load and contents labels and found these were all correct. At about 08.30 Mr Reid said he came upon the train's crew and a Fire Brigade officer discussing the contents of the tanks and it seemed to him than an element of doubt as to the precise nature of the product still existed. Having just checked the labels he was able to confirm that the product was 4-star petrol.

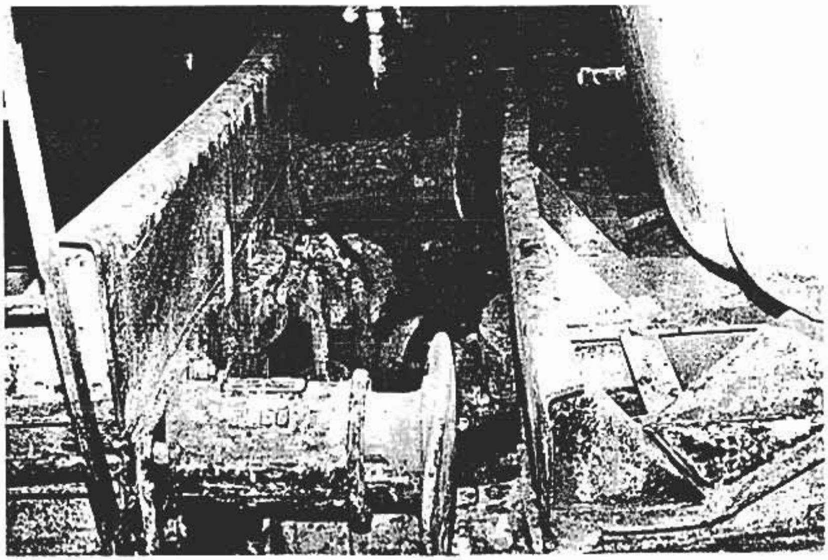
35. Mr Reid had also entered the tunnel on 27th December 1984 in the same party as myself and was able to corroborate my own findings regarding the defect on the leading axle of the fourth tanker and the position in which the axlebox and journal end were subsequently found at the tenth vehicle. There was no doubt in Mr Reid's mind that the failure of this journal end was the direct cause of the accident. The sudden unloading of the wheel concerned at the instant of failure would, he said, have caused it to climb the rail almost immediately so that derailment is likely to have followed directly after the journal failure. The journal and axlebox were found some two tank wagon lengths ahead of the point of derailment but this can easily be accounted for by the journal remaining momentarily in the horn guides after failure, its momentum (the train was travelling at 40 mile/h at the time) and by it being struck and carried forward by the fourth to ninth vehicles in the train which all overtook it before the train came to rest.

36. Mr Reid explained that the parting of the sixth and seventh vehicles leaving some 60 ft between them would have initiated an emergency brake application as the automatic air brake pipe ruptured. He considered that the bearing failure, subsequent derailment of the train and the distance the train travelled from the point of derailment was consistent with what might have been expected to happen in such circumstances.

37. Following a detailed examination of the vehicles there was no evidence of any of the tanks having been punctured during the derailment although some had broken pipework underneath that would have allowed any product that it contained to have escaped. It was difficult to assess what damage the two vehicles



PHOTOGRAPH 4. Break in Rail under 13th Tank Wagon found after the fire, note the spalled Brickwork.
Photograph courtesy of British Railways.



PHOTOGRAPH 5. The Buffer Override Protection Channels worked successfully.
Photograph courtesy of Mr D.G. Reid.

which were on their sides might have sustained prior to the fire. All the wagons were fitted with buffer override protection channels and these appeared to have prevented buffers from coming into contact with tank end shields except where tank wagons had overturned; no tank had been punctured by a buffer (Photograph 5).

As to the History of the Tank Wagons

38. *Mr B. Abbott the Director of Engineering, Procor (UK) Limited*, explained that his company were the owners of all the tank wagons in the train and were the largest private rail wagon fleet owners in Britain. Their total railway wagon ownership in February 1985, when I held my Inquiry, was 2,800 vehicles of various types including bogie and 4-wheeled tank wagons. The wagons concerned were maintained by Rail Car Services Limited, Procor and Rail Car Services being jointly owned companies of the United States of America based company, Marmon Corporation.

39. Mr Abbott explained that the petrol train had consisted of two types of tank wagons; nine of them carried the prefix letters BRT and the remainder, PR, before the wagon number. The BRT vehicles were manufactured in 1973 by the Standard Railway Wagon Company Limited for hire to Total Oil, they were purchased by Procor (UK) Ltd in 1974 but continued in Total Oil traffic covering some 110,000 miles in service. The PR vehicles were manufactured by the Standard Railway Wagon Company in 1968 also for hire to Total Oil. They were purchased by Procor (UK) Ltd in 1971 and up until 1984 had covered some 140,000 miles in service.

40. The PR vehicles were mounted on Davies and Lloyd three piece bogies; BRT vehicles had Gloucester Railway Carriage and Wagon GPS 25 primary suspension bogies. All of the vehicles were originally designed and constructed for the carriage of Class B heavy oil products. Commencing in February 1984, however, the wagons were brought into Procor's Horbury Works where they were converted for the carriage of Class A light oil products before being hired to ICI. Steam coils, external cladding and insulation were removed, new manlids and vent valves were fitted, outlet valves were reconditioned and gaskets and seals were replaced with those suitable for Class A products. Buffer override protection beams were added and the tanks were freshly painted in dove grey with red solebars; new HAZCHEM labels were applied. Conversion work was completed on Wagon No PR 82689 in July 1984; this was the vehicle on which the axlebox bearing and journal end failure occurred. This wagon then entered traffic and worked until, in the course of normal maintenance in November 1984, the wheelsets were found to require either wheel turning or replacement and the vehicle was despatched to the Gloucester Works of Rail Car Services for attention. On 4th December 1984 reconditioned wheelsets were taken from Rail Car Services stocks and fitted to the vehicle and on 10th December 1984 the wagon was returned to traffic. The wagon travelled light to Haverton Hill where it was loaded and departed for Glazebrook on the 18th December. It returned to Haverton Hill on the same day, was reloaded and departed for Glazebrook on 20th December in 6M08 and reached Summit Tunnel where the accident occurred.

41. The wheelset concerned was purchased by Procor (UK) Ltd from the British Steel Corporation on 18th February 1983. Ownership of the wheelset was transferred to Rail Car Services in January 1984 and, along with the 3 other wheelsets that were subsequently fitted to PR 82689, it saw no service until it was fitted to the wagon in December. The wheelset was not entirely new, consisting of new wheels and a new axle but reconditioned Timken bearings. During the fire the wagon identification plates were lost but the train consist list indicated that Wagon No PR 82689 was the fourth vehicle in the train. Moreover, the maintenance records of both Procor and Rail Car Services showed that the failed wheelset, which was positively identified by marks on the undamaged axle end, was fitted to PR 82689 in December 1984 as were the other axles on the wagon and thus there was no doubt regarding the identity of the vehicle.

42. The history of the axlebox bearings was not so clear. The right-hand side, undamaged, bearing was manufactured in 1969 and a similar identification mark was found on the failed bearing which was later confirmed to be of 1969 manufacture. It was not possible, from Procor's records, to determine the mileage run by individual bearings. Wagon mileages could be fairly accurately determined but wheelsets were changed as maintenance attention demanded and it was much more difficult to keep track of their service time; the removal and refitting of axlebox bearings to other wheelsets further complicated this.

43. I asked Mr Abbott whether axlebox bearings had a finite life and he stated that this matter was under consideration by the Joint Technical Committee whose membership consists of British Railways and Private Wagon Owners. He said that the axlebox failure rate of the Procor fleet was so low as to make it impossible for them to meaningfully quantify the problem and they looked to other fleet operators and to the bearing manufacturers themselves to provide advice on this aspect. At this stage, Procor had no definite proposals to change any of their procedures.

Examination of the Roller Bearing and Axle Journal

44. The axlebox bearing was manufactured by British Timken and the bearing and wheelset had been refurbished and assembled by the British Steel Corporation. It was agreed by all interested parties that British Railways should carry out the detailed examination of the fourth tanker's leading bogie and in particular the axlebox and broken journal. This work was undertaken by *the Fracture Mechanics Unit of the Research Division at the Railway Technical Centre at Derby.*

45. It was determined that the tank wagon concerned had re-entered service 10 days before the accident after being fitted with reconditioned wheelsets. In this time it had travelled about 640 miles, 172 of which were loaded.

46. The investigation concluded that the journal failure resulted from the seizure of the axlebox which was probably the result of its incorrect assembly or fitting on the journal. The investigation did not bring to light any need to revise bearing maintenance or assembly procedures but it served to illustrate that these procedures must be rigorously followed. Details of the findings are at Appendix A.

As to Bearing Failures on British Railways

47. *Mr I. Duncan, Head of Field Trials and Services of the Research Division, British Railways Board* told me that British Railways maintain a list of derailments that is classified in many ways. Mr Duncan said that in the period from 1st January 1981 to 31st December 1984 the total number of derailments of freight vehicles of all types that had either occurred on running lines or had occurred on adjacent sidings was 580, of which 350 occurred to vehicles whilst in a freight train on a running line. Twenty of these derailments involved bogie tank wagons and in 18 of these cases a bogie tank wagon was the first vehicle to derail. Of the 18 cases, over the 4 years under consideration, 3 were due to the mechanical failure of a journal. Out of the 580 cases there were a total of 13 roller bearing failures and 14 plain oil lubricated bearing failures. Mr Duncan produced figures at the Inquiry which indicated a bogie tank wagon roller bearing failure rate in any one year on British Railways of approximately 1 per 4 to 5 million bogie tank wagon miles run.

As to the Role of the Consignor in the Safe Transport of Dangerous Goods

48. *Mr A. Halfpenny, Safety Officer, Imperial Chemical Industries, Teeside*, told me that his company moves about 140,000 tonnes of petrol per year by rail between Teeside and Merseyside and they consider that rail transport is the safest way of moving the product. Worldwide the company moves several millions of tonnes of potentially dangerous products between countries and plants within those countries and therefore they have enormous experience in the safe transport of dangerous materials. In Britain a total of about 750,000 tonnes of dangerous products are transported annually by ICI.

49. Mr Halfpenny explained that his company takes an active interest in the safe transport of its products by rail and other means. In the case of the vehicles involved at Summit Tunnel they had ensured that these were correctly marked using HAZCHEM labels of a suitable type and they had also taken a positive interest in the refurbishing of the wagons by Procor for this traffic, they had, in fact, specified the fitting of the buffer override protection beams. ICI had also closely discussed the type of valves fitted to the wagons and their capability with the manufacturer and also the tank metallurgy and the final finish applied. The HAZCHEM labels, which were supplied to Procor by ICI, were all in good order and clearly legible.

50. Mr Halfpenny thought that the minor spills of product that were seen to be burning at several locations in the tunnel by different witnesses during the early stages of the fire was likely to have resulted from impact of derailed tanks with the tunnel walls and subsequent damage that this was likely to have inflicted on the tank barrels and seams. The manlids on the twelfth and thirteenth tank wagons were found to be very securely closed indeed after the incident; presumably their excessive tightness resulted from heat distortion. ICI Ltd was called in to support the Fire Brigade and Police through the CHEMSAFE procedure and their nearest (Huddersfield) team attended at an early stage; the Teeside team arrived on site at lunch time on the first day and stayed until the problem was cleared. In addition to the direct hazard caused by the conflagration there was also the possibility of leaking petrol contaminating water courses and ICI assisted in monitoring this. After the fire and before work could commence to remove the damaged vehicles from the tunnel it was necessary to empty the two rearmost vehicles of petroleum spirit and an ICI Teeside team carried out this work and declared the tanks safe. *Mr Holmes, the Rail Services Manager, ICI*, stated that loss of the undertank pipework on some of the vehicles during the derailment would have resulted in some minor leaks of product; in such circumstances and when a tank had come to rest on its side he was uncertain as to the integrity of the bottom valve before the tee branch and some leakage may have occurred from it. Mr Abbott of Procor expressed the view that the manlid was less likely to have been a source of leak than the tank barrel itself and even on the severely damaged tanks these lids appeared to be intact.

As to the Automatic Detection of Overheated Axlebox Bearings

51. *Mr E. Crosby, Works and Signalling Officer, British Railways London Midland Region*, said that in areas of multiple aspect signalling hot axlebox detectors are normally provided at about 30 mile intervals. In view of the fact that signal boxes existed within 10 miles of one another and to either side of the tunnel no automatic hot axlebox detection equipment was provided there.

As to the Involvement of the Emergency Services

The Police

52. *Chief Superintendent T. Davey, Divisional Commander of the West Yorkshire Police at Halifax* said that his force first became aware of the incident at 06.19 and some officers were on site at 06.38; he learned of the incident at 06.59. From the outset the police were aware that the accident had occurred in Summit Tunnel and that the train was on fire. There were conflicting reports as to whether the product was petrol and/or gas oil. Chief Superintendent Davey took command of the police activity at the incident at 07.30 from the Control Room at Sowerby Bridge Police Station and it was not confirmed that the product concerned was petrol until 08.16. From the outset evacuation of nearby property was considered but by 09.23 he was advised that things were under control. At 09.40 his control learned that 'a fireball was coming out of the tunnel' and they were asked to evacuate nearby houses. Within 21 minutes, by 10.01, 71 houses and an engineering works had been evacuated. The area was then extended and 5 more houses were evacuated by 10.09. The Ambulance Service, the Fire Service, the Social Services and the British Transport Police assisted in this operation.

53. Approximately 140 people lived in the evacuated premises and about 60 persons were employed in the engineering works and a temporary reception centre was set up for them in the nearby Walsden School. Most of the residents were accommodated overnight by friends, others stayed at temporary accommodation provided by Calderdale Metropolitan District Council. The evacuation was lifted at 13.00 on Friday 21st December, the following day. In addition some roads in the area were closed to traffic; the road between Walsden and Littleborough was finally re-opened at 15.50 on 22nd December. Throughout the incident the Emergency Services received excellent support from the Salvation Army, Todmorden Rotary Club and Todmorden Cricket Club who allowed their cricket square to be used to land a helicopter. There was also excellent support from the Officers and Staff of Calderdale District Metropolitan Council.

54. The police had investigated the source of the confusion concerning the product with the Fire Brigade but had no conclusive information as to how the confusion originated.

55. *Inspector S. Ingrams of the British Transport Police, Manchester* attended at the Todmorden end of the tunnel by 07.30 and assisted with securing the site and evacuating people from their homes. The greatest problem with the evacuation was due to there being a small number of infirm or bed-ridden people who required ambulance assistance to move them to a safe place. Ambulances had attended the site in case of injuries to persons involved in the accident and these were quickly made available to assist in the evacuation. He remained on site until 21.30 that day but had occasion to visit periodically over the next 3 weeks during which time British Transport police officers were stationed in a main control unit at the Todmorden end of the tunnel and in a vehicle at the Littleborough end, each of which was equipped with radios and telephones. The officers manning these units patrolled the tunnel portals and the ventilation shafts over this period. *Sergeant M. Morris, British Transport Police* arrived on site at the Littleborough end of the tunnel at 07.20 and liaised with the emergency services. At 09.40 he learned over his radio, whilst he was on the track at about 100 yards from the tunnel mouth, that an explosion in the tunnel was imminent and he cleared railway personnel from the area and then assisted the Greater Manchester Police with the evacuation of residents from the nearby houses.

The Fire Services

56. *Mr D. Howarth, Deputy Chief Fire Officer, West Yorkshire Fire Services* said that the initial call for assistance was received by the Greater Manchester Fire Service Control at 06.08 and was relayed to the West Yorkshire Fire Service Control at 06.13. Three pumping appliances and one foam tender were sent to each end of the tunnel arriving at 06.16 (Greater Manchester Brigade) at the Littleborough end and at 06.22 (West Yorkshire Brigade) at the Todmorden end. This immediate high level of attendance is in itself an indication of the early appreciation of the potential risk. At 06.34 a Control Unit was mobilised to the site.

57. On arrival at the scene the firemen entered the tunnel from either end to assess the situation. This meant walking in a distance of about a mile from the Manchester end and about 1000 yards from the West Yorkshire end. These distances over difficult ground in the dark were a considerable hindrance to assessing the situation and to co-ordinating the operation but by 07.04 both brigades had seen the need to request further assistance. By then it was known that there was a derailed train conveying petroleum spirit and that it

was on fire. The HAZCHEM markings on tankers at the West Yorkshire end had identified the product as petrol but at some time during the early stages of the fire the possibility of gas oil forming part of the load arose. The source of this uncertainty was not identified but the problem was soon resolved.

58. From the Manchester end the first action was to remove the locomotive and first three tankers from the tunnel. Their next plan was to attack the fire by lowering equipment down No. 8 ventilation shaft but this effort was frustrated by the rapid development of the fire. One problem particularly affecting the Manchester end of the tunnel was the fire risk and pollution problems caused by petroleum spirit entering drains and water courses. The train had come to rest where the gradient was falling toward the Manchester end of the tunnel which had a bearing on the later decision to evacuate members of the public.

59. At the West Yorkshire end the distance into the tunnel was not so great and the gradient was favourable. A fire fighting attack was set up using a cooling jet and a foam blanket. The Divisional Commander who took charge of the incident described the fire as 'a lazy fire being fed by petroleum spirit leaking from derailed tank cars'. The fire fighters progressed until they had extinguished visible fire around the rearmost seven rail tankers (Photograph 6).

60. At about 09.45 whilst the West Yorkshire Assistant Chief Fire Officer and the Divisional Commander were doing an on the spot check of the fire fighting operations in the tunnel the fire developed rapidly causing the immediate and urgent evacuation of the fire fighters from the tunnel. The officer in charge considered that the fire developed from the sixth vehicle that was lying on its side and the fire's rapid development was clearly due to the ignition of quantities of petroleum spirit and vapours that had leaked in this area. The fire was described as rolling along at roof level; this rapidly developing fire vented up Shaft No. 9 directly above the train and to a lesser extent up Shaft Nos. 8 and 10. If this had not occurred Deputy Chief Fire Officer Howarth considered that it might have prevented the safe escape of his fire fighters.

61. A 'Major Incident' was declared at 10.05 (Photograph 7) and Mr Howarth took charge in person at 10.30. His assessment of the situation at that time was that the fire would be prolonged and was potentially dangerous. A policy of containment was decided upon and this was firmly enforced. The command and co-ordination of the fire incident was conducted from the West Yorkshire Fire Service control unit that was by then located at the Todmorden end of the tunnel.

62. The fire could not be tackled along the tunnel and so it was decided to introduce High Expansion Foam down Shaft No. 7; this task was undertaken by the Greater Manchester Fire Services. The West Yorkshire crews attacked the fire using water down Shaft No. 11 and then advanced to No. 10. At about 12.30 fierce flames were issuing from ventilation Shaft No. 9 and from Shaft No. 8; heat and heavy smoke was coming from Shaft No. 10; at the peak of the fire the column of flame issuing from Shaft No. 9 was about 150 metres high (Photograph 1). The fire fighters had considerable difficulty in raising water to the site from the canal in the valley bottom from where it was plentifully available. One of the problems was the manhandling of pumping equipment on the steep slopes above the tunnel.

63. By 09.00 on 21st December there was no external sign of the fire and a controlled re-entry into the tunnel commenced at 10.30, the crews returning at 14.00 to report that they had reached Shaft No. 9, that some fire was still evident and the area was extremely hot. They also reported inexplicable noises in and around the train due no doubt to the contraction of the train and tunnel as cooling began. No further entry into the tunnel was made that day but the cooling operation continued. From 22nd December a number of controlled entries were made up to the foam plug at the bottom of Shaft No. 7 and at 18.38 on 24th December the 'stop' message was sent from the tunnel (meaning that the situation was under control).

64. The Fire Brigade continued to monitor the tunnel until 27th December when a full inspection of the incident was conducted by BR and other parties. The Fire Brigade presence was maintained until 3rd January 1985 when the incident was handed over to British Railways but they continued to assist until 17th January when they withdrew on the understanding that they would respond to any request from British Railways.

65. Because of the potential problems with fires and accidents in tunnels and the logistics of assembling men and equipment and difficulties in establishing communications which are vital for a successful operational command the West Yorkshire Fire Service had carried out operational pre-planning visits to Summit Tunnel in conjunction with British Railways and the Greater Manchester Fire Service. The information gained from these visits was recorded on a 'risk card' and the last visit of this nature had been made on 26th November 1984. Thus the tunnel was well known to the men at Todmorden, the nearest fire station, and to their senior officers based at Halifax.

PHOTOGRAPH 6. Fire Fighters at Tank Wagon No 10 and beyond in the Early Stages of the Fire.
Photograph courtesy of West Yorkshire Fire Service.

PHOTOGRAPH 7. Flames from Ventilation Shafts 8 and 9 at about 10.00 on 20th December 1984.
Photograph courtesy of West Yorkshire Fire Services.

66. I have no doubt that the accident was due to the failure of the axlebox bearing and axle end journal of the leading axle of the fourth tank wagon in the train. The derailed axle caused the disintegration of the track and subsequent derailment of other vehicles. The train was travelling at about 40 mile/h at the time and in tunnel, thus it was almost inevitable that the dispersion of energy necessary to bring it to rest would inflict sufficient damage on some of the tanks and their associated pipework to cause leaks. These leaks were ignited and the fire followed. The probable sources of ignition are discussed in depth in the Summit Tunnel Fire Report produced by the Health and Safety Executive; this is referred to in more detail later at the end of the Discussion section of this Report.

67. I am certain that the train crew had no opportunity to detect the impending accident and were in no way responsible for what occurred. They raised the alarm promptly and then later courageously re-entered the tunnel to remove the locomotive and leading three vehicles. This almost certainly saved these vehicles from destruction and probably reduced the petroleum spirit to be consumed in the fire by almost 25%. The only comment I would make on their actions concerns their failure to apply a track circuit operating clip to the Down line before they left the scene initially. However, following closely on the derailment, the initial ignition of the petrol in the confines of the tunnel must have been a daunting experience. The derailed tankers had, in fact, already shorted the track circuit on the Down line; thus applying the clip would not have better protected it, although the men were not to know this at the time.

68. Signalman Fernyhough at Hebden Bridge signal box was the last person to observe the passage of the train. He saw nothing wrong as it passed him yet some 7 miles later the axle had totally failed. The axlebox concerned was a grease lubricated roller bearing type. The quantity of grease in the bearing is quite small and, during failure, flames are either not present at all or are much less evident than with an oil lubricated bearing. I am therefore satisfied that in the darkness Signalman Fernyhough was most unlikely to have seen it.

69. Rolling Stock Technician Davies examined the train before it commenced its journey but I am sure that no indications of imminent failure of the axlebox were present for him to observe during his inspection.

70. The buffer override protection channels appeared to have worked well and to have prevented buffers from penetrating the adjacent tank ends. These devices have been specified by British Railways for all new tank wagons built since 1980. Retrospective fitting was specified only in respect of liquefied petroleum gas tank wagons. In this instance ICI had voluntarily specified their fitting when the wagons were refurbished.

DISCUSSION

Prevention of Axlebox Failure

71. There are two basic types of axlebox journal bearings. Plain solid bearings lubricated by oil and roller bearings most of which are lubricated by grease. Plain bearings are now declining in numbers and roller bearings are in the majority. In either case a bearing defect will almost always manifest itself by overheating which, if unchecked, usually results in the failure of the journal end with subsequent derailment of the vehicle and possibly other vehicles in the train. Fortunately axlebox bearing failures are very rare events and roller bearings are particularly reliable. However, when failures do occur the results, as at Summit, can be catastrophic.

72. Today whilst an increasing proportion of the railway is operated under Track Circuit Block Regulations from remote power signal boxes, roller bearing axleboxes predominate. Overheating of these axleboxes gives rise to minimal smoke emission and there are fewer personnel who are likely to observe this. This has led to the increased use of infra-red hot box detectors which sense and measure axlebox temperatures as the train passes. The measured temperatures are compared to ambient temperature and between the axleboxes across a wheelset. Unusually high or uneven temperatures are detected as a potential failure. The detector identifies the axle concerned and whether left or right side in direction of travel and alerts signalling staff automatically so that the train may be stopped promptly and the appropriate action taken. However, variations in design between vehicles can lead to the device's failure to sense an overheated axlebox on occasions. Conversely high temperatures in adjacent parts, perhaps caused by heavy braking, can lead to the false indication of an overheated axlebox; about 30% to 35% of all hot axlebox alarms on British Railways are subsequently confirmed.

73. Hot axlebox detectors have been in use on British Railways for the past 20 years and there are currently 193 detectors in power signalled areas. In such areas the recommended spacing of detectors is 25/30

miles. However, a large part of the petrol train's route was controlled from manual signal boxes where automatic detectors are not normally provided.

74. The petrol train involved at Summit had passed over two hot axlebox bearing detectors, the first at Lowgates near Northallerton and the second at Pilmoor which indicates to Tollerton signal box north of York on the East Coast Main Line. This latter detector is over 70 miles from the site of the accident so it is quite probable that no detectable overheating had occurred in the bearing at that time. The fourth tank wagon in the train had Davies and Lloyd three piece bogies in which the axleboxes are well exposed to the detector so that no problem with detection should have occurred.

75. Hot axlebox detection by infra-red equipment is well established in the USA where wagon fleets are very large by British standards as are the distances travelled. In August 1981 the National Transportation Safety Board conducted a survey into hot axlebox detection by means of infra-red equipment. They found that plain bearings were being superseded by roller bearings which were more reliable and that the number of accidents resulting from overheated axleboxes was declining; 178 in 1980 when some 76% of the freight car fleet was equipped with roller bearings and 77% of overheated axlebox bearings were detected by infra-red equipment. Despite being detected a small number of these overheated bearings were allowed to run forward until total failure and derailment occurred because the train crew or other railway personnel involved at the time were unable to identify the overheated bearing. This type of incident is not unknown on British Railways; on 11th May 1985 on the West Coast Main Line an Up freightliner train was stopped after a hot axlebox on the train was sensed by equipment at Brinklow but subsequent examination failed to identify any problem and the train proceeded. The journal collapsed at Watford and derailment occurred.

76. It is clear from this that the equipment is better able to detect hot axleboxes than the personnel who are likely to be on hand when the overheating occurs. Also, if any significant period of time elapses before more skilled or better equipped personnel reach the scene the offending axlebox may well have cooled. To keep the problem in perspective it must be said that in 1984 only 6 accidents resulted from defective axles on British Railways.

77. In the USA many railroads space their hot box detectors at 30 mile intervals and in addition on the approaches to bridges and tunnels. The National Transportation Safety Board's survey did not recommend any increase in the frequency of infra-red hot axlebox detector installations. They considered that proper training and control of staff who might be required to attend such incidents was essential and that it was necessary to devise a visible means on or near the bearing of alerting railway employees of the presence of an overheated bearing. These seem to be thoroughly sound recommendations and I would commend them to British Railways. A hot axlebox detector sited on the approach to Summit Tunnel might well have averted the accident.

THE ACCIDENT AS A MAJOR EMERGENCY INCIDENT

78. The accident happened at about 05.50, the alarm was raised at 06.08 and the Fire Brigade attended to either end of the tunnel within 10 minutes. The situation was quickly and correctly assessed and in the early stages the work of extinguishing a number of small fires in the tunnel proceeded normally. The train's crew were able to re-enter the tunnel under the supervision of the fire brigade personnel and the locomotive and three leading tank wagons were drawn clear. There was some confusion as to the identity of the product but from the outset it was known to be petrol. In his evidence Guards Inspector Smalley told me that he knew the product carried the HAZCHEM Code 1270. This denotes petroleum fuel and is used by the oil industry on road and rail tanks that carry a variety of petroleum based products to save the frequent changing of labels and the likely consequence of incorrect labelling. In fact the tanks were clearly marked with the UN Code 1203 denoting Motor Spirit—petrol. The train consist list was correct in this respect and all enquiries made on British Railways Traffic Control concerning the product were correctly advised. Also the wagon labels of the 3 tank wagons removed denoted 4-star petrol. I can only conclude that local misunderstandings may have occurred during the excitement of the incident due, perhaps, to persons inadvertently quoting incorrect UN numbers from memory as Mr Smalley did. The train was over 1000 yards from either tunnel entrance and it therefore took time to reach it and physically check the product involved and return with the information. However, I do not think that this aspect caused any problems during the incident and did not hamper, delay or give rise to any unnecessary danger to those involved. It was clear at all times that the product was highly flammable, was on fire and was present in very large quantities and was in the confines of a well ventilated tunnel.

79. After 09.40 when the fire went out of control the correct decision was taken to try to contain it and to evacuate nearby residents, some 170 persons in all, who might have been at risk. The evacuation was carried

out expeditiously and without significant incident. The situation was fully and efficiently supervised from beginning to end. No injuries to persons resulted and damage to property was confined to the tunnel and the train. I consider that all the Emergency Services involved in this incident are to be commended for the way in which it was handled and it is difficult to see how their performance could have been improved.

The Fire

80. I am indebted to Dr Alan Jones of the Health and Safety Executive's Fire Research Laboratory at Buxton who assisted me during my Inquiry and separately carried out a very thorough and detailed investigation into the course of the fire throughout its progress. His Report is available separately from the Health and Safety Executive. It discusses all aspects of the incident as a fire. The Report's main conclusions appear at the end of Appendix B. A summary of the fire damage and temperature observations are also given at Appendix B and Fig 2 at the back of this Report.

Consideration of Radioactive Materials Transport

81. The House of Commons First Report from the Environment Committee Session 1985–86 on Radioactive Waste at Recommendation 39 stated that "British Rail should reconsider the possibility of timetabling movements of radioactive material so that the remote chance of an accident involving inflammable materials in a tunnel can be made even more remote". This Recommendation almost certainly stemmed from the accident and fire at Summit.

82. Irradiated nuclear fuel flask trains are not scheduled to run through Summit Tunnel and therefore there was no possibility of a nuclear incident arising in the case of this accident. There is no doubt, however, that a prolonged fire in the confines of a tunnel would severely test an irradiated nuclear fuel flask and I fully endorse the Committee's recommendation that British Railways should avoid such coincidences of traffic by timetabling, so far as it is reasonably practicable to do so.

Recommendations

83. I recommend that:—

1. buffer override protection channels or similar protection be provided on all tank wagons that are designed to carry highly flammable products.

2. hot axlebox detectors be placed at strategic places such as on the approaches to long tunnels and bridges to help prevent incidents occurring in inaccessible places where other dangers might arise. There is a positive policy for the provision of these installations in full Track Circuit Block areas but for other routes such as the line through Summit Tunnel where only a short section was so controlled the situation is less clear. British Railways policy for the frequency of installations along these routes should be reviewed to ensure full account is being taken of the nature and volume of the traffic on the line and of the difficulty of detecting overheating roller bearing axleboxes by other means.

3. a means of readily identifying overheated axleboxes detected by automatic equipment be found and provided either on the bearings themselves or for the use of key staff as soon as practicable. It should be remembered that, particularly on traction units, there may be other bearings that can adversely affect the integrity of an axle. With higher speeds the consequences of such a failure could be more significant than at Summit were a passenger train to be involved. British Railways are currently evaluating more advanced analysis and reporting facilities which will provide a detailed print out of axlebox temperatures for each train. It remains to be seen whether this equipment will provide more accurate and reliable information to staff on the ground faced with identifying a potential bearing failure in what may be very difficult circumstances.

4. the importance of following bearing manufacturer's procedures for repair and assembly be re-affirmed to all staff throughout the railway industry who have a responsibility for this work.

5. British Railways examine the timetabling of highly flammable and radioactive traffic so as to avoid, so far as is reasonably practicable, the coincidence of this traffic in rail tunnels.

I have the honour to be,

Sir,

Your obedient Servant

D. A. Sawer

The Permanent Under Secretary of State
Department of Transport

Appendix A

Examination of the Roller Bearing and Axle Journal

Photograph 8 shows the axlebox with the broken journal inside and Photograph 9 the outer end of the bearing with the inspection plate removed to reveal the outboard bearing and locking cap. In both views displaced or misshapen rollers can be seen together with their damaged cages. A general arrangement drawing of the axlebox assembly mounted on the journal is at Fig 3 at the back of this report.

When the assembly was dismantled it was found that the nominally 150mm diameter journal varied from between 151mm in diameter where it was covered by the end cap to 92mm at the point of fracture. On the axle stub of the wheelset the bearing abutment ring still remained in position (Photograph 10). This was removed and the stub end sized beneath the abutment ring seat. Four measurements of the journal diameter were taken in this area, all were greater than the nominal 150mm and it was evident that the hot axle stub had received a blow causing the end to mushroom. The broken journal was offered to the stub and the dimension from the abutment ring seat to the axle end was taken. This was found to be 10mm greater than the nominal 208mm. From this information and examination of the fracture surface it was concluded that the failure was due to ductile shear fracture and that the reduction in diameter of the journal was due principally to tensile necking and not metal removal due to abrasive wear.

The wheels themselves showed no signs of flatting, indicating that they had continued to roll until derailment occurred. However, their surfaces became so damaged during derailment that accurate measurement of their diameter was not possible. That they were in comparatively new condition is evidenced in Photograph 10 where the last turning size groove can be clearly seen.

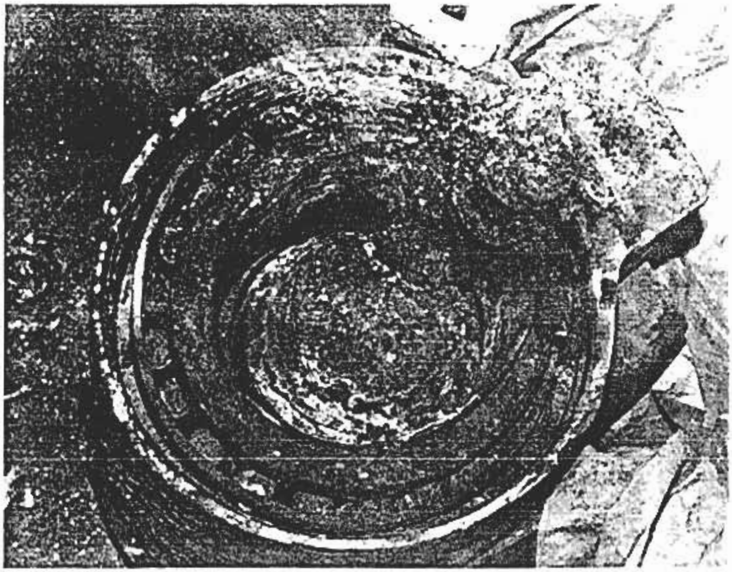
The inboard bearing had deep circumferential scour marks on the inner race (Photograph 11) indicating that the journal had been rotating within it. The outer ring of its cage had fractured and 8 arms had broken off the cage inner ring. All of the rollers were still present but, where the cage was fractured, they had skewed and become embedded in the flange of the inner race. A number of rollers had been fused to the inner race, the remainder were in comparatively good condition. The cage was subjected to detailed examination and fatigue cracks were found at the radii between some of its arms and the outer ring and at other arms to the inner ring. Examination of several cage arm fractures revealed they had failed by fatigue. The nature of the initiating cracks indicated that the arms had been subjected to high strains. The inside flange of the inner race was relatively undamaged but the outside flange was scoured. Contact between the circumference of the end faces of the rollers and the flange caused material from the flange to be plastically deformed into the groove between the track and the flange, or gouged out and deposited elsewhere. Flakes of material from the vicinity of the track were identified as bearing material by metallographic and X-ray analysis. Indentation marks were also found across the track of the inner race where the roller bearings had been pressed into the track after the bearing had become hot. None of these indentations were perpendicular to the flange indicating that all the rollers had skewed to varying degrees when the bearing finally seized.

The outboard bearing was more severely damaged. A number of rollers were fused to the inner race as was the spacer plate, the cage was deformed and a number of arms broken. However, none of the cage arms had failed by fatigue. Smear marks indicated the journal had begun to rotate within the bearing. The rollers that were not fused to the inner race had a number of flats and material smeared onto their surfaces. The track of the inner race had been extensively damaged by the transfer of material from the track to the rollers. For this to occur, the rollers must have been rotating when the bearing had become hot.

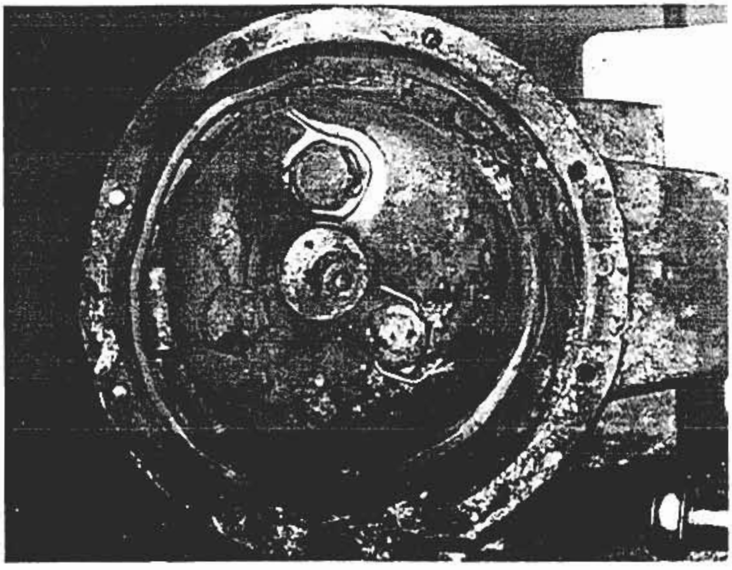
The bearings of the axlebox on the right hand side of the wheelset were examined and found to be in good order suggesting they were functioning correctly at the time of the derailment. No evidence of fatigue cracks were found on these bearings which were of similar age to those which had failed.

The locking cap bolts which can be seen in Photograph 9 were found to be fractured, the locking wire broken and the cap itself was friction welded onto the journal end. Sections through the parts of the bolts still in the journal end revealed that none of them had bottomed in their threads. Examination of the fracture surface showed they had failed by a ductile shear mechanism.

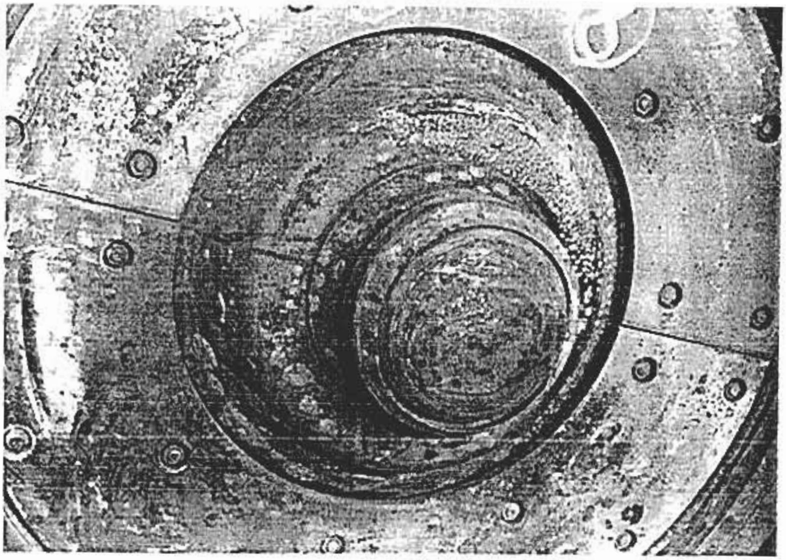
The inspection cover had a circular scour mark on the inside together with three hexagonal indentations that corresponded with the locking bolt heads. The edges of the bolt heads were evenly scoured suggesting that the bolts were being rotated and had therefore already sheared. The deep indentation on the outside of the plate almost certainly occurred when the plate impacted a solid object as the axlebox fell after it became detached.



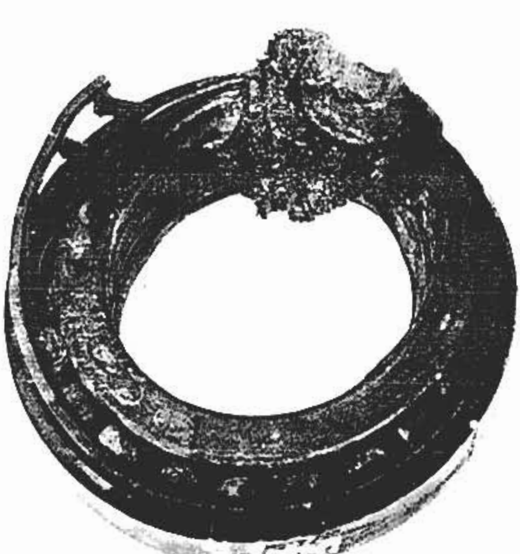
PHOTOGRAPH 8. Axlebox and Journal as removed from Summit Tunnel.
Photograph courtesy of British Railways.



PHOTOGRAPH 9. Axlebox with the Inspection Plate removed.
Photograph courtesy of British Railways.



PHOTOGRAPH 10. Fracture Face of Broken Journal. Abutment Ring is still attached.
Photograph courtesy of British Railways.



PHOTOGRAPH 11. Inboard Bearing showing the deposited metal and scour markes on the Inner Race.
Photograph courtesy of British Railways.

Samples taken from the journal and bearings were subjected to chemical analysis. The analyses showed that the axle conformed to Grade 1 material in British Railways Specification 109A for axle steels and the bearing components conformed to British Timken Specification ID20D.

To determine whether or not the bearings had contained the correct lubricant prior to the accident scrapings from the inside of all four axleboxes were analysed for lithium; the fire had destroyed all visible signs of grease in all of the bearings. The percentage lithium detected in both of the axleboxes from the leading axle was 0.01%; rather higher contents of 0.07 and 0.2% were found in the bearings of the trailing axle. The British Railways Specification for lithium grease requires a content of .35%. In view of these low lithium values experiments were conducted to determine the effect of high temperatures on a lithium based soap in a grease. These showed that the volatility of lithium is time and temperature dependent and that very little would remain if heated above 700°C for a sustained period of time. A very low lithium reading was therefore to be anticipated since metallographic examination of the failed journal indicated that parts of it had reached about 1200°C and inadequate lubrication of the bearings was not considered to have been a factor.

Metallographic examination also indicated that there was a temperature gradient along the journal with the maximum, 1200°C, occurring at the fracture. A full section longitudinal slice did not reveal the presence of any defects in the steel. Several surface initiated cracks were visible just below the fracture surface. These were small non-propagating shear cracks which formed in the necked material immediately prior to fracture. Examination of one of the inboard bearing rollers indicated that it had been heated to between 800 and 900°C and had subsequently cooled very slowly. Tests on a flatted but not fused roller from the outboard bearing showed it had not been heated above 720°C since the flats were formed. Microhardness measurements of the roller core and carburised surface layer were taken and heat treatment tests have shown that a tempering treatment of 8 hours at 670°C would be required to reduce the surface hardness to the level found.

The tests showed that the temperature of the journal when fracture occurred was about 1200°C. This temperature did not occur as a result of the fire because other tests clearly showed that the fire did not heat the axlebox above 670°C. During the fire the defective axlebox lay on the formation by No 10 tank wagon at the centre of the fire whereas the leading end of No 4 tank wagon was at the extremity of the fire.

Although both inboard and outboard bearings seized before the journal fractured, the type and extent of damage to each indicated that the modes of failure were different. The inboard bearing seized first causing the journal to rotate within its inner race. The heat generated by this action would have caused overheating and breakdown of lubricant within the axlebox resulting in the seizure of the outboard bearing. The extensive metal transfer between rollers and track, large flats on the rollers and the disintegration of the cage are typical of the sort of damage that would be expected.

The inboard bearing did not exhibit such extensive damage and seized before serious overheating occurred. The cage failed by fatigue, due to increased loading on the cage arms which was probably caused by excessive end play on the axlebox. Normally the loading on the cage is very small but excessive end play on the axlebox will increase the loading on the cage arms and, if sufficiently high, will cause fatigue cracks.

Excessive end play in a bearing that has recently been maintained, as this one had, could be the result of incorrect assembly or incorrect fitting of the axlebox on the journal.

The indications were that the fatigue cracks found on the cage were formed by low cycle fatigue. The reconditioned wheelset had travelled 640 miles after fitting to the point of failure which is equivalent to 170,000 load applications to each arm of the cage. This number of cycles is consistent with the view that fatigue crack initiation commenced after the fitting of the reconditioned wheelset.

The fracture of the journal was a direct result of bearing seizure which caused a massive temperature build up and a proportional decrease in the strength of the journal. The bearing failure was due to fatigue failure of the cage of the inboard bearing which was probably caused by excessive end play which could have been the result of incorrect assembly or fitting of the axlebox on the journal. The chemical compositions of axle and bearing components were within their appropriate specifications. The temperature of the journal in the necked region when failure occurred was about 1200°C and the maximum temperature to which a roller of the outboard bearing had been heated was about 670°C. This latter temperature could have been achieved either before or after the derailment.

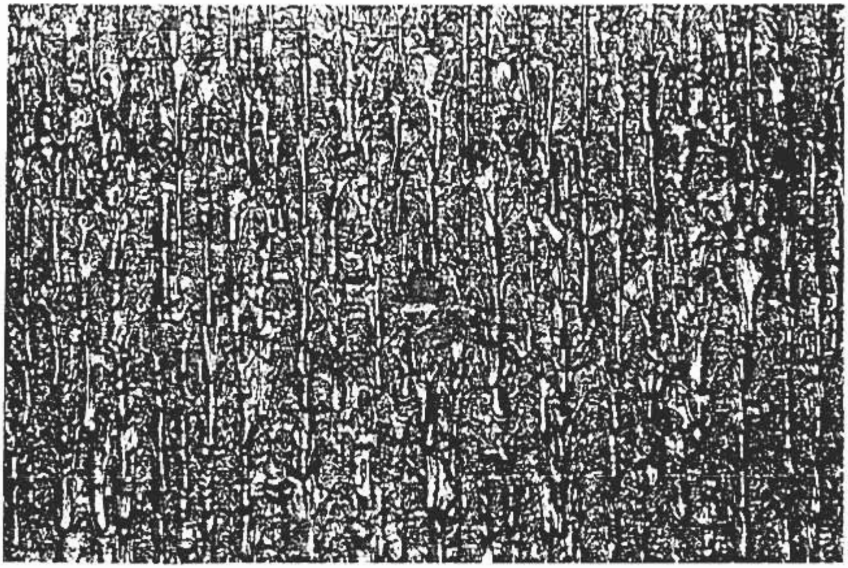
Fire Damage and Temperatures

Fire Damage

A detailed list is given below of the fire damage to both tunnel and train. The damage is listed with reference to the tunnel tablet numbers or marker plates and vehicle positions as shown in Fig 2. Included here are some additional observations made by the British Rail Fire Technology team on a visit to the tunnel on 9th January 1985.

It should be noted that two types of brick were used in the tunnel, a newer brick that tends to spall when heated and an older brick that tends to fuse.

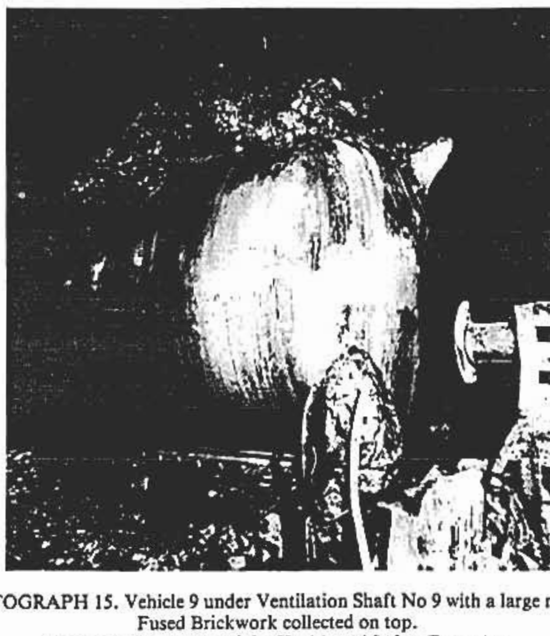
Marker Plate 100	The brickwork in this region was relatively unaffected. The sleepers had burned through.
Vehicle 4	The tank barrel had collapsed completely and in places there were indications that the metal had melted.
Marker Plate 101	Much of the brickwork had a black glass-like deposit which appeared to have flowed down the walls. Where a different type of brickwork had been used spalling of the walls was evident. A sample of the glass-like deposit was removed for analysis (Photograph 12).
Vehicle 5	The barrel had collapsed completely and in places there was evidence that melting had taken place. The walkways had distorted and in some places had melted (Photograph 13). A photograph was taken of the pressure relief valve system and dip hatch on the top of the tank (Photograph 14).
Marker Plate 103	There were glass-like deposits on the walls of the tunnel (Photograph 12) and much of the limestone ballast in this region had calcined. The sleepers were destroyed and a short length of rail had melted.
Marker Plate 104	There was spalling of the brickwork in this region and the concrete trough at track level had become friable. The sleepers were burned away.
Vehicle 6	The vehicle was on its side with the barrel only partly collapsed. Some parts of the barrel had melted at the ends. The rubbing pads between the barrel and the underframe were still intact though brittle. There was calcined limestone at track level.
Marker Plate 105	There was no vehicle in this area. The brickwork was little damaged but the sleepers were destroyed.
Marker Plate 106	The brickwork was spalled on both sides of the tunnel and there were soot deposits on some areas of the soffit.
Vehicle 7	The barrel of the vehicle had partly collapsed and some melting had occurred along the top. The walkways were distorted.
Marker Plate 108	There were glassy deposits on the walls of the tunnel and the brickwork of the soffit was badly spalled. The sleepers were destroyed.
Vehicle 8	Like Vehicle 7 the barrel had partly collapsed and some melting had occurred on top. The walkways were also distorted.
Vehicle 9	The barrel of this vehicle was beneath Shaft No 9 and a large mass of fused brickwork had collected on top of the barrel. Although the barrel had partly collapsed it still retained its general shape (Photograph 15).
Marker Plate 110	Two rings of brickwork had spalled in the soffit. Sleepers were destroyed.



PHOTOGRAPH 12. Melted Brickwork where it had flowed down the Tunnel Walls.
Photograph courtesy of Mr D.G. Reid.

PHOTOGRAPH 13. Vehicle 5, showing melted parts of the Barrel.
Photograph courtesy of the Health and Safety Executive.

PHOTOGRAPH 14. Top of Vehicle 5 showing the Dip Hatch and the remains of the Pressure Relief Valve system.
Photograph courtesy of the Health and Safety Executive.



PHOTOGRAPH 15. Vehicle 9 under Ventilation Shaft No 9 with a large mass of Fused Brickwork collected on top.
Photograph courtesy of the Health and Safety Executive.

Marker Plate 111	The brickwork had spalled over the soffit with at least one ring missing in places. The remaining brickwork had a glass-like deposit. The concrete trough at track level had degraded and sleepers had burned away.
Vehicle 10	This vehicle was on its side and was considerably damaged. The barrel appeared to have burst along its length (Photograph 16) and there was some evidence that melting had taken place. A red deposit was observed on the brake mechanism.
Vehicle 11	This vehicle was in fair condition although there was some little distortion of the barrel and walkways.
Marker Plate 112	There was some spalling of brickwork on the walls of the tunnel and also glass-like deposits on the non-spalled brickwork. Sleepers were destroyed.
Vehicle 12	This vehicle was in fair condition with only minor signs of distortion.
Marker Plate 113	Some brickwork in the soffit and on the walls had spalled. The sleepers were destroyed.
Vehicle 13	This vehicle was in fair condition although the top of the barrel was slightly flattened and the chassis was slightly distorted.
Marker Plate 115	There was some spalling over the soffit of the tunnel and charring of some of the sleepers.
Ventilation Shafts 8 and 9	A visual examination of Shaft 9 revealed that the iron retaining ring at the base of the shaft was still in place. The brickwork had glass-like deposits at the base of the shaft and at the top although the brickwork in the middle seemed relatively unaffected. Similar glass like deposits were evident at the top of shaft 8. In a region within 20m of the top of Shaft 9 (but not 8) small hollow metal spheres were found amongst debris that had apparently been swept up the shaft with the exhaust gases (Photograph 17).

Fire Temperatures

From an analysis of samples taken in and around the incident site and a knowledge of the properties of materials in the tunnel it is possible to get an indication of temperatures attained in the fire.

Analysis of the glass-like deposit from the region of Marker Plate 101 revealed that the major metallic components were silicon and aluminium. The carbon content was less than 0.1%. The sample was mainly amorphous with traces of quartz and cristobolite. These results are consistent with the identification of the sample as fused brick with little or no inclusion of carbon. Melting points were in the region of 1300°C.

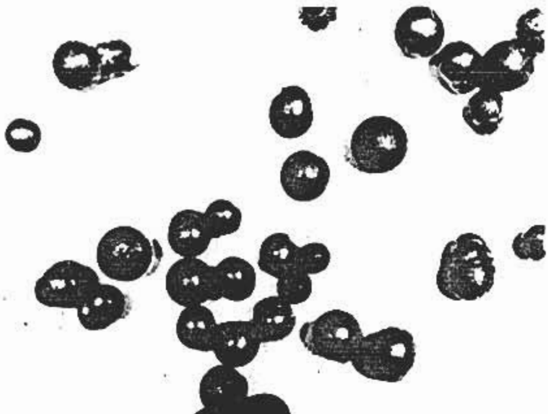
The calcined limestone found in the region of Marker Plate 103 and Vehicle 6 indicates a temperature of at least 900°C at these points.

The melting of the mild steel on the barrels of Vehicles 4–8 and 10 is indicative of temperatures of ~1530°C.

Analysis of samples by British Railways Scientific Services Team showed fused brick samples with melting points in the region of 1250°C. The analysis of the rubbing pad on Vehicle 6 revealed an asbestos component that had converted to the Forsterite and Protenstatite forms indicating a temperature in excess of 1050°C. The red deposit on the brakes of Vehicle 10 was shown to be iron oxide with a large inclusion of carbon and the damage to the concrete cable trough suggested exposure to temperatures of 600–900°C. The results reported by British Rail are summarised in Table 1 and Figure 2.

The results obtained above indicate that there was no uniform temperature attained during the fire. A mean temperature in the region of 1300°C is indicated with temperatures higher at the roof than at ground level but local areas of the fire reached much higher temperatures. A temperature of 1530°C was clearly attained at the top of some of the barrels and a ground temperature of 1400°C was attained in the region of the melted rail.

PHOTOGRAPH 16. Vehicle 10 which had burst along its length.
Photograph courtesy of the Health and Safety Executive.



PHOTOGRAPH 17. Metal Spheres found on the surface in the vicinity of Shaft 9. (The largest sphere is about 7mm dia.)
Photograph courtesy of the Health and Safety Executive.

TABLE 1

Results of Examination of Samples taken by British Railways Scientific Services

Material	*Location*	*Melting Point (°C)*
Fused Brick	M. Plate 109	1250–1280
Fused Brick	M. Plate 108	1250–1280
Glassy Material	M. Plate 103	1040
Metal Walkway	Vehicle 5	1520–1540
Rail Steel	M. Plate 102	1400
Rubbing Pad	Vehicle 10	1050
Concrete trough	throughout	600–900

Conclusions of the Health and Safety Executives Fire Report

1. The fire most probably started at the time of the derailment due to ignition of petrol vapour by frictional heating. The hot axle on Vehicle 4 and the hot journal end and axlebox unit near Vehicle 10 were also probably sources of ignition.

2. The sudden emission of fire that led to the evacuation of the tunnel was most probably caused by ignition of petrol ejected from the tank by the sudden opening of the pressure relief valves on Vehicle 6.

3. The temperature profile in the tunnel during the fire was very non-uniform. A mean temperature of 1300°C is indicated but temperatures in excess of 1530°C were attained in places.

4. At the height of the fire, the flow of exhaust gases up the vent shafts probably exceeded 50 ms^{-1} and radiation levels of up to 200 kWm^{-2} are indicated from the flames from the ventilation shafts.

5. In general, the pressure relief valves on the rail tank wagons operated satisfactorily during the fire and the petrol vented as expected. One tank burst along its length probably as a result of being engulfed in a particularly hot region of the fire.

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ACCIDENT THAT OCCURRED AT 05.50 ON 20th DECEMBER 1984 AT SUMMIT TUNNEL

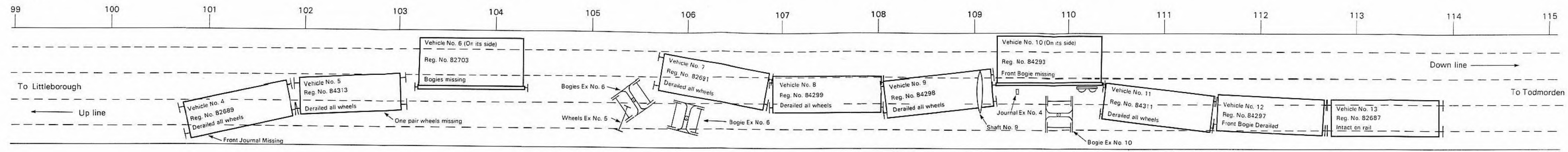

Fig. 1
DERAILMENT PLAN
(Not to scale)

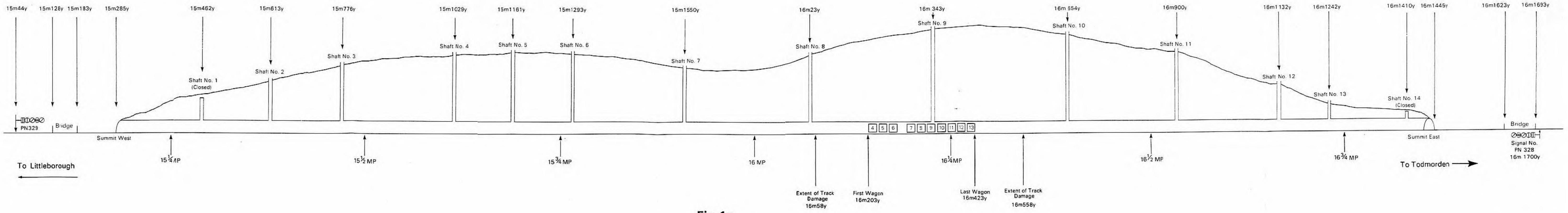

Fig. 1a
TUNNEL DIAGRAM
(Not to scale)

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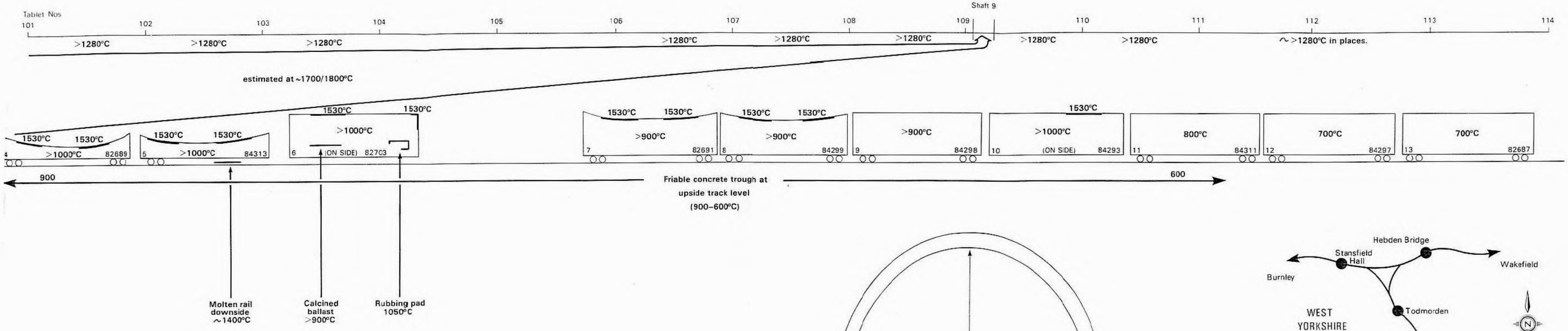
ELEVATION: WITH PROBABLE TEMPERATURE RANGES DURING HEIGHT OF FIRE

Fig. 2

SPOT TEMPERATURES RELATE TO IDENTIFIABLE PHYSICAL DEGRADATION



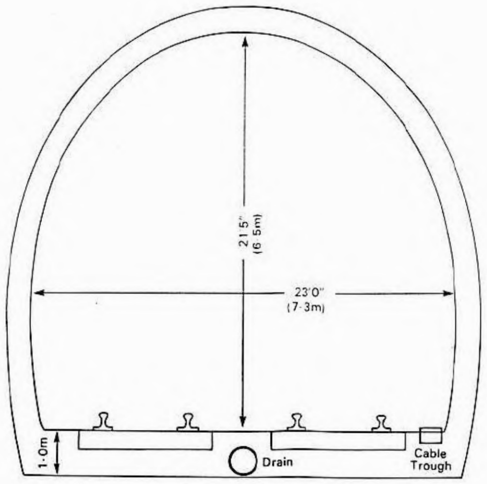


Fig. 2a Cross section of Tunnel

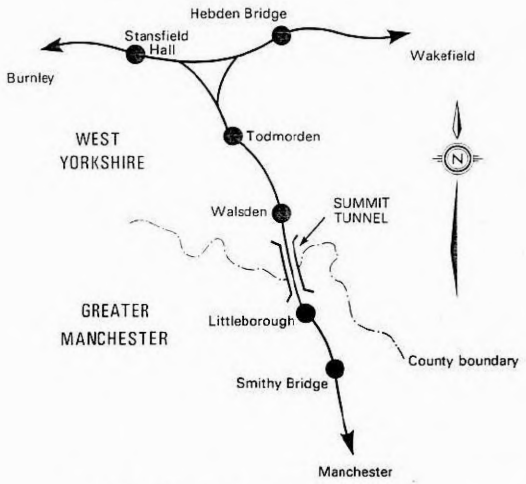


Fig. 2b Location Diagram

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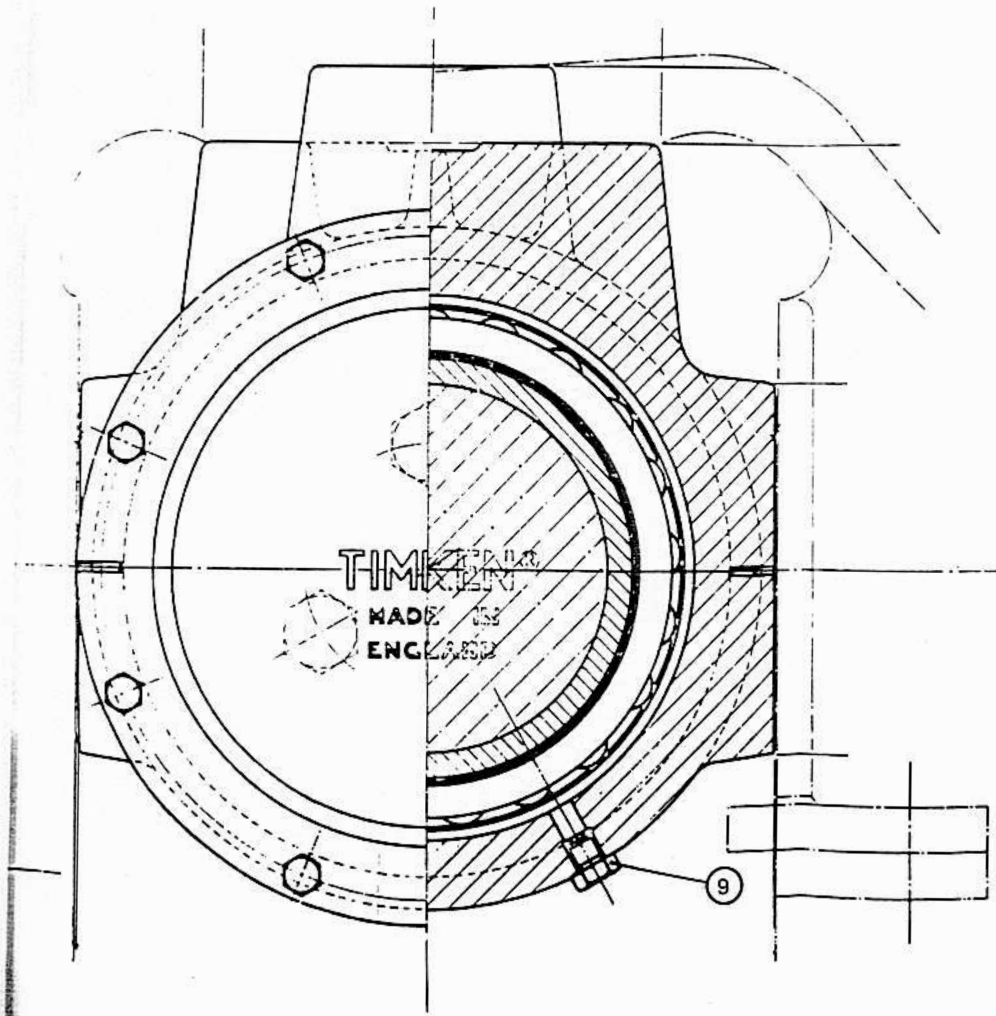
TIMKEN ROLLER BEARING AXLEBOX

1. Axlebox Body
2. Rear Enclosure
3. Abutment Piece
4. Flinger
5. Inspection Plate
6. Joint Washer
7. Cover Bolts
8. Washers
9. Grease Plug
10. Locking Cap
11. Bolts
12. Locking Wire



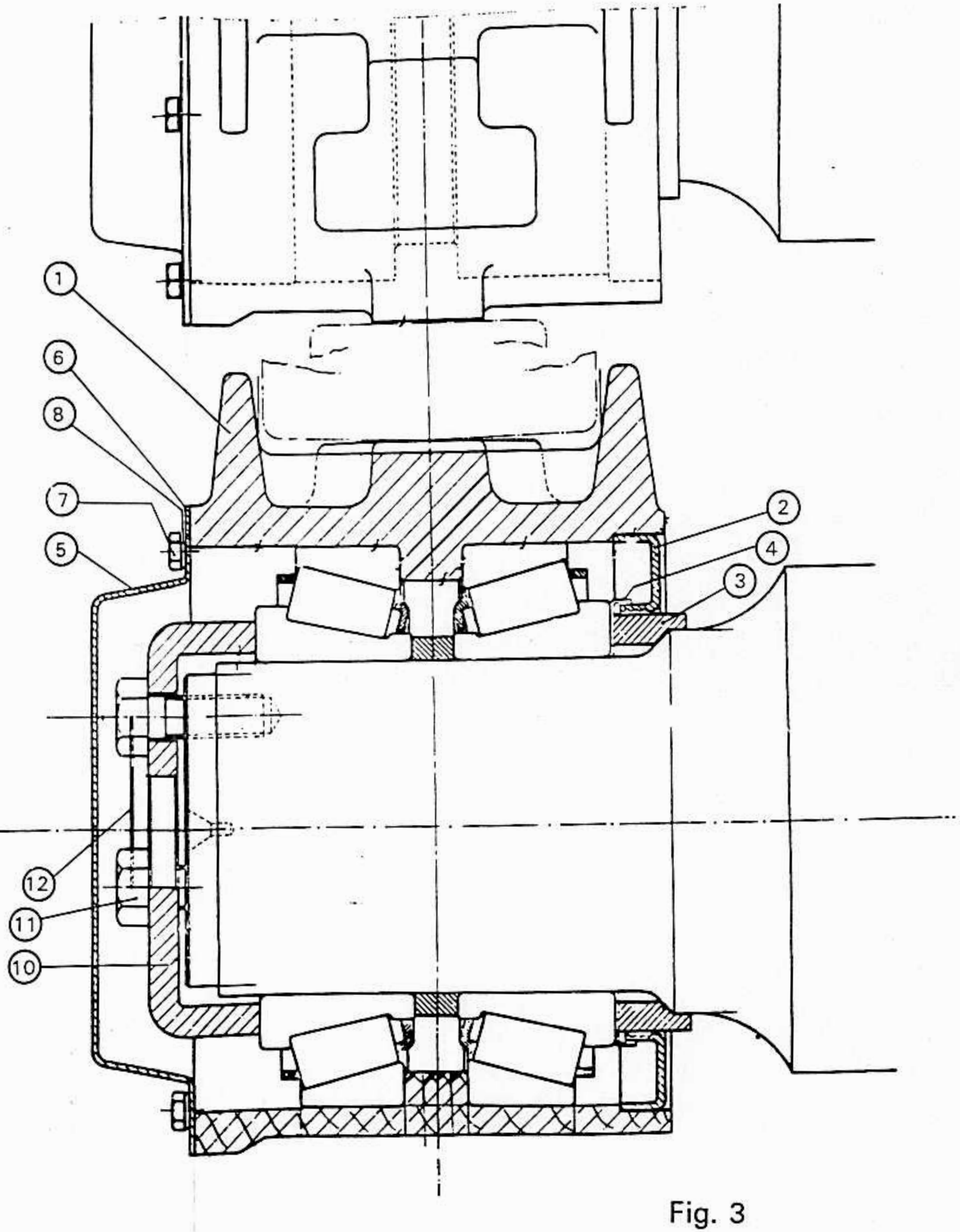
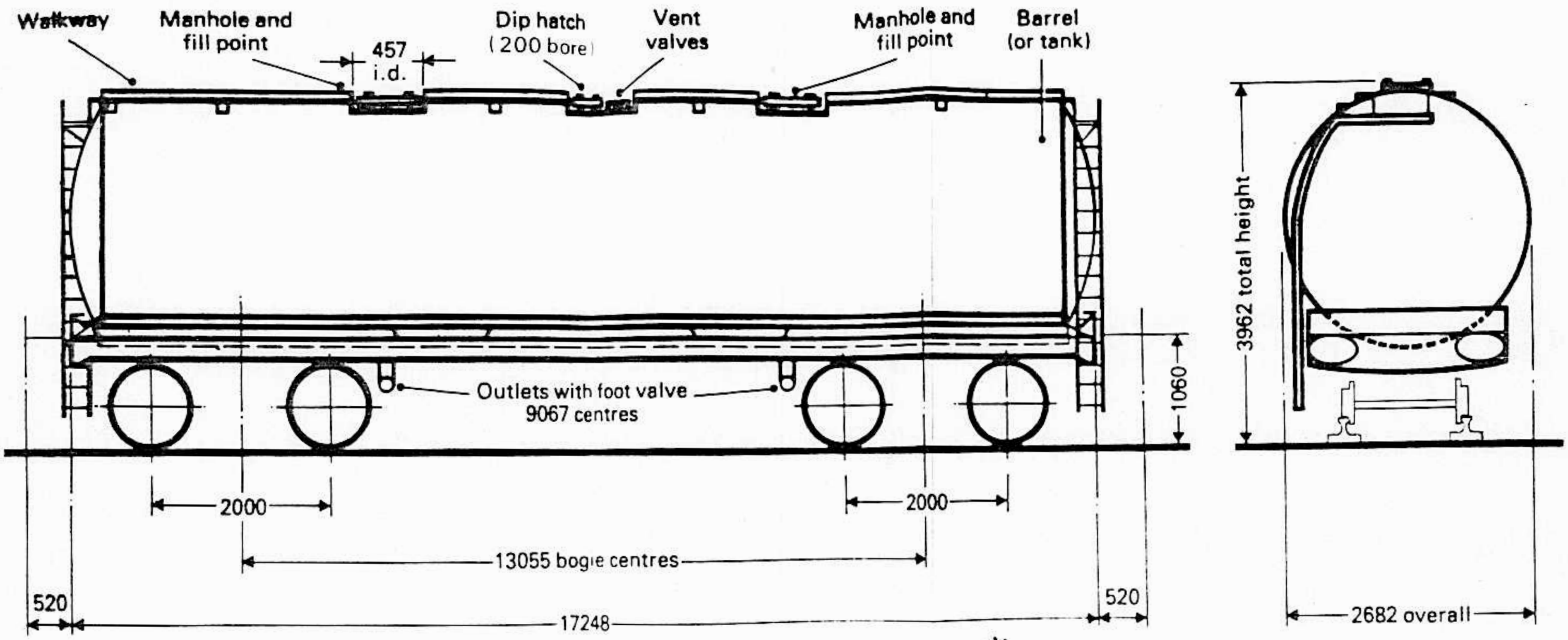


Fig. 3

RJ 3/2/0386



* All dimensions are in mm.

Tare weight - 26800 kg
Capacity - 64·2 tonnes
Barrel:- Bottom quadrant and ends - 10 mm Remainder - 6·4 mm Material - Commercial mild steel

Vent valves - 4 x 102 mm pre/vac
Vent valve settings:- Overpressure - 10 psi Vacuum - 5" water gauge

Bottom outlet foot valves:- B. D. Collins style 18 (102 mm)
Outlet tee branch valves:- Worcester ball valves (102 mm)
Wheels - 952 diameter
Journals - 150 diameter roller bearings

Fig: 4 - Rail tank wagon

RI 3/2/0386