DEPARTMENT OF THE ENVIRONMENT

RAILWAY ACCIDENT

Report on the Derailment that occurred on 29th January 1975 near Oxford Station

IN THE

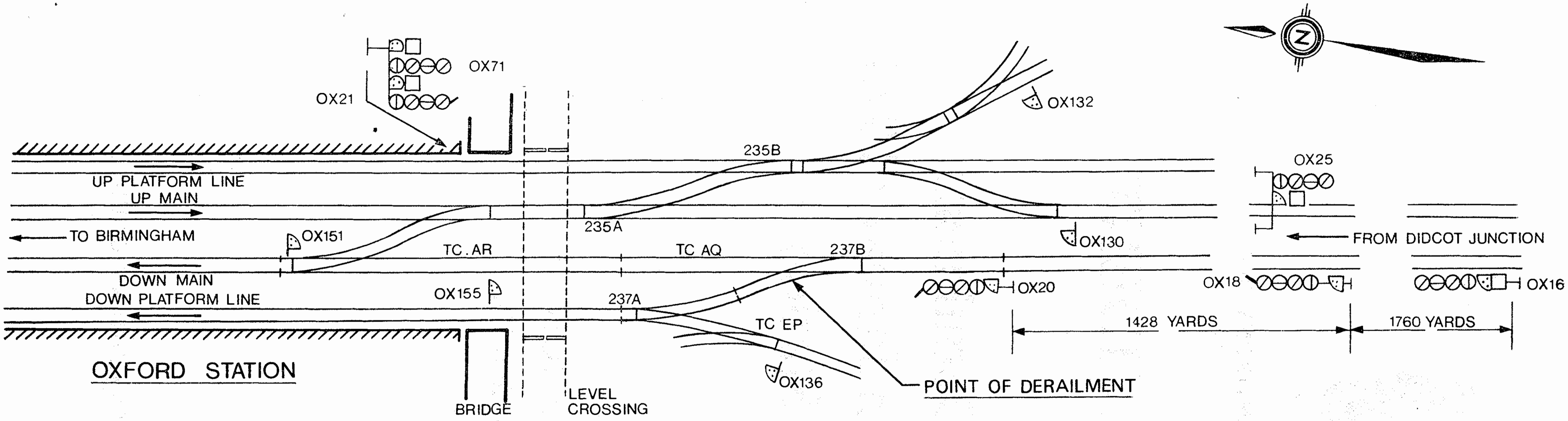
WESTERN REGION

BRITISH RAILWAYS

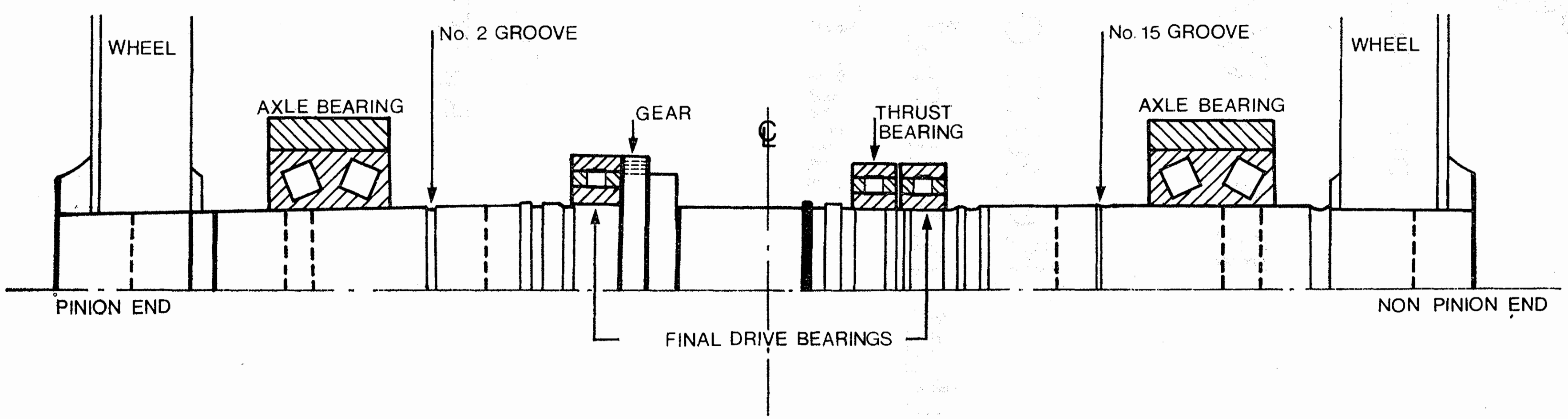
LONDON: HER MAJESTY'S STATIONERY OFFICE

35p net

DERAILMENT AT OXFORD (WESTERN REGION) ON 29th JANUARY 1975



SKETCH SHOWING POINT OF DERAILMENT AND SIGNALLING – NOT TO SCALE



SKETCH SHOWING HALF-SECTION OF CLASS 52 LOCOMOTIVE AXLE – NOT TO SCALE

GPH CARTO DO 752 DEC 1975

RAILWAY INSPECTORATE,
DEPARTMENT OF THE ENVIRONMENT,
2 MARSHAM STREET,
LONDON S.W.1.
29th December 1975.

SIR,

I have the honour to report for the information of the Secretary of State, in accordance with the Order dated 4th February 1975, the result of my Inquiry into the derailment of a passenger train that occurred at about 15.12 on Wednesday 29th January 1975 near Oxford Station in the Western Region of British Railways.

The accident happened as the 14.05 Paddington to Birmingham Class 1 passenger train, consisting of a Class 52 diesel-hydraulic locomotive and seven coaches, was travelling from the Down Main line to the Down Platform line on the approach to Oxford Station. Shortly after entering the turnout leading to the platform line, travelling at about 20 mile/h, the locomotive became derailed and was followed into derailment by the leading two coaches in the train. The train continued for some 80 yards before coming to a stand with the locomotive and all coaches upright and more or less in line. The derailment was caused by the sudden complete fracture of the locomotive's leading axle, which allowed the right-hand wheel to take the wrong side of the vee of the turnout crossing.

The lines were immediately protected by signals and the emergency services summoned. Police, Fire, and Ambulance services arrived within five minutes but were fortunately not required since no one had been injured. The passengers were detrained and escorted along the track to the station, where arrangements were made for those travelling to destinations beyond Oxford to continue by a special train, which left at 16.07.

The derailment blocked the Down Main and Down Platform lines and single-line working was instituted over the Up Main and Up Platform lines at 15.39. The work of re-railing the locomotive and coaches continued throughout the night and early hours of the next morning, being completed at 04.05. Following repair to the permanent way, the Down Main line and Down Platform line were reopened to traffic at 13.07 and 15.20 respectively on 30th January and full normal working was resumed at 17.05.

At the time of the accident the weather was dull and it was drizzling.

DESCRIPTION

The Site

1. The route from Paddington to Oxford follows the Western Region's Bristol and South Wales main line as far as Didcot East Junction, 53 miles from Paddington, at which point it branches to run almost due north to Oxford. Between Didcot Junction and Oxford, 63½ miles from Paddington, the railway is double track with connections to various works and sidings. On the immediate approach to Oxford Station the Up and Down lines are flanked to the east by a group of sidings and, about 140 yards before the station, a turnout leads from the Down Main line to the Down Platform line. Between this turnout and the south end of the platform there is a trailing connection to sidings on the Down side, and a level crossing.

2. The maximum permitted speed through Didcot East Junction onto the Oxford line is 70 mile/h. Thereafter the line speed is 90 mile/h until the 63 mile post is reached. A permanent speed restriction (to 30 mile/h at the time of the accident but later raised to 50 mile/h) then operates over the Down Main line as far as the 64 mile post. The Down Main to Down Platform line turnout is located within this restricted section at 63 miles 583 yards. The permitted speed through the turnout is 25 mile/h.

3. The line between Didcot Junction and Oxford is worked under the Track Circuit Block Regulations, with multiple-aspect colour-light signals. The greater part of the line is controlled from a modern power signal box at Oxford, which was commissioned in December 1973, the remainder being controlled from Reading Signal Box.

4. The drawing at the front of the report shows the layout of the lines on the approach to Oxford, including the signals, together with a sketch of the fractured axle.

The Track

5. The derailment occurred on the crossing of the facing turnout leading from the Down Main to the Down Platform line. The turnout forms part of a recently altered track layout at Oxford and was laid in October 1973. It is constructed to vertical design with D switches operated by a clamp lock mechanism and a 1 in 15 common crossing made as a unit in cast manganese steel. The whole turnout is laid on hardwood timbers. The track leading to the turnout is formed of continuous welded rail on concrete sleepers, except for a short closure length just before the turnout which is on wooden sleepers.

The Train

6. The train consisted of Class 52 diesel-hydraulic locomotive No. 1023 'Western Fusilier' and seven standard BR Mk 1 coaches fitted with buck-eye couplers and gangwayed throughout. Its overall length, including the locomotive, was 531 ft 6 in and its total weight 353 tons. Class 52 locomotives are mounted on two six-wheel inside frame bogies. The drive to each bogie is via a Voith Hydraulic transmission incorporating 3 torque convertors, all axles being driven. Wheel diameter is 3 ft 7 in and the locomotive weighs 109 tons.

The Course of the Derailment and Damage Caused

7. Examination of the track and the train soon after the accident established that the right-hand leading wheel of the locomotive had passed along the wrong side of the turnout crossing nose and had been diverted along the left-hand rail of the Down Main line. This had caused the centre and trailing right-hand wheels of the bogie to climb the crossing and derail between the lines. The left-hand wheels had passed along the correct side of the check rail, causing pressure marks and damage as the right-hand wheels were forcibly diverted to the right. Due to the divergence of the track the left-hand wheels of the leading bogie had then been drawn across to the right-hand rail of the Down Platform line beyond the turnout. This rail was pulled off its fastenings and spread wide to gauge, and the Down Main line was displaced en masse. The leading bogie of the locomotive came to a stand just short of the level crossing at the London end of Oxford Station having run derailed some 80 yards. Behind it, the leading two coaches in the train had derailed where the Down Platform line had spread wide to gauge. The remaining coaches were not derailed. The train remained properly coupled and upright.

8. During re-railing it was found that the locomotive's leading axle was broken. Apart from this there was only superficial damage to the train: brake gear on the leading bogie of the locomotive was damaged, an air reservoir and associated air pipes were displaced, and the wheels of the two derailed coaches were bruised. On the track, 90 sleepers and 36 crossing timbers were broken, 64 base plates were smashed, and 8 lengths of rail and the trailing end of the set of points in the Down Platform line were damaged.

Axles Fitted to Class 52 Locomotives

9. The Class 52 diesel-hydraulic locomotives were first introduced on British Railways in 1961. The original drawings and specifications for the locomotives' axles were prepared by BR at Swindon in 1959 and were based on the design of similar axles already in service on the German Federal Railway: the design was also very similar to that of axles fitted to the Class 42 and 43 diesel-hydraulic locomotives already in service on the Western Region of British Railways. The axles were manufactured at either Swindon or Crewe Works.

10. A feature of the design of all these axles was the inclusion of a number of stress-relieving grooves at changes in section. In the latter part of 1963 an axle failure occurred on a Class 43 locomotive. Investigation showed that a fatigue fracture had developed in the No. 12 stress-relieving groove, and that this had been caused by a wrongly profiled groove with an unsatisfactory surface finish. As a consequence, a number of Class 52 axles were stripped for special examination and were found to have similar faults in the No. 11 and 12 stress-relieving grooves. Arrangements were therefore made for the axles of all classes of diesel-hydraulic locomotive to be stripped for special examination of these grooves. As well as further evidence of incorrect profiling of the suspect grooves, some grooves were found to have corrosion pits developing at the bottom. In order to re-profile the grooves and remove any traces of corrosion a reduction up to a maximum of 1 mm in the groove diameter was authorised. On re-assembly all the grooves were packed with grease.

11. During the course of these special checks a further fracture in the No. 11 groove of a Class 42 axle was found. As a result, a limited form of depot ultrasonic axle testing was introduced in January 1964 for all classes of diesel-hydraulic locomotive having this type of axle. This involved testing the axle in the area of the No. 11 and 12 grooves only.

12. In May 1964 a new drawing for Class 52 axles was introduced. This incorporated a redesigned form of stress-relieving groove which had been developed to reduce stress concentration in the axle. The steel specification was also improved. Since May 1964 all replacement Class 52 axles have been manufactured to this drawing and specification.

13. In February 1965 the axle of a Class 52 locomotive failed in the hitherto unsuspected No. 5 groove and ultrasonic testing was extended to cover the area of this further groove. By 1966, although no further failures had occurred, the Chief Mechanical & Electrical Engineer decided that improved depot testing was necessary and, in early 1967, an approved procedure for ultrasonic testing of the whole series of grooves throughout each axle was introduced.

14. By the end of 1973 all the axles of early Swindon or Crewe manufacture had been replaced, leaving in service only later Swindon-manufactured axles having a correct groove profile and improved surface finish, and axles newly manufactured to the modified design and steel specification.

15. When full ultrasonic axle testing was first introduced for Class 52 locomotives, in early 1967, the tests were carried out at 3-monthly intervals. After a trial period this interval was extended to 6 months in the case of axles of the modified design. More frequent testing was specified for any axle found to be in any way suspect during the routine 3 or 6-monthly test. At the time of the accident at Oxford, this pattern of testing was still in force.

Evidence

16. The driver of the train was *Driver F. G. Harris*, stationed at Old Oak Common. He was an experienced driver and was very familiar with the Class 52 locomotives, having driven them since shortly after they had been introduced in 1961. On the day of the accident he booked on at Old Oak Common at 12.55 and went with his secondman to prepare locomotive 1023, which was at the Depot and which was to haul the 14.05 Paddington to Birmingham train. His preparation included a general look round the locomotive,

including the brake blocks and springs, and everything appeared to be in order. The only outstanding item in the report book related to a missing windscreen wiper on the secondman's side. On completion of the preparation, Harris drove the locomotive to Paddington where it was coupled to the train. The locomotive handled normally during the trip between Old Oak Common and Paddington.

17. Before leaving Paddington, Harris and his secondman were joined in the leading cab by another Old Oak Common driver who was learning the route. The train left on time, with Harris driving, and thereafter speed was increased to about 60 mile/h passing Old Oak, to 80 mile/h approaching Southall, and then to the train's maximum permitted speed of 90 mile/h. Signals were clear as far as Reading, which was the first stop, and everything appeared quite normal. At Reading, a second route-learning driver joined the locomotive and the secondman moved to the rear cab. Approaching Didcot East Junction, signals were at Caution and the junction was traversed at between 55 and 60 mile/h. Thereafter signals were generally clear as far as the approach to Oxford and Harris drove at normal speed.

18. Nearing Oxford, Signal OX 16 was showing double yellow, OX 18 single yellow, and OX 20 red. Harris reduced speed to about 20 mile/h, using the combined air-vacuum brake valve, and as he approached Signal OX 20 it cleared to single yellow with the junction indicator for the Down Platform line illuminated. He allowed the train to continue at about 20 mile/h and was just remarking to the two route-learning drivers that the permissible speed of the turnout was 25 mile/h when, without warning, the locomotive appeared to drop and bump along the ballast. He at once made an emergency application of the brake and the train stopped.

19. Driver Harris was certain that there had been no indication of anything wrong before the sudden derailment. The whole run had been uneventful and the locomotive had handled perfectly. After the derailment he had noticed a smell of hot oil in the cab but did not think that this had been present before the train came to a stand.

20. The driver's evidence was confirmed by his secondman, *Secondman G. M. Hehir*, and by the two route-learning drivers. Hehir was sitting in the rear cab, on the left-hand side in the direction of travel, as the train entered the turnout leading to the Down Platform line at Oxford. Very soon after the locomotive had started to take the turnout he felt a sudden sharp movement towards his right, that is towards the platform side, followed immediately by another movement the other way. After the train came to a stand he assisted in protecting the train. Both the route-learning drivers had glanced at the speedometer as the train approached the turnout and both confirmed that it was reading about 20 mile/h. One of the drivers had also observed that the turnout points were set correctly for the move from the Down Main to the Down Platform line.

21. *Signalman A. G. Walker* was operating the panel in Oxford Signal Box at the time of the accident and had been on duty since 14.00. At the time he started duty the Tokenless Block on the Bicester line was out of action and pilot working was in progress: other than this, all the signalling controlled from the box was working normally. Shortly before the 14.05 from Paddington was due he routed a Southampton to Coatbridge freightliner train from the Down Main line through the Down Platform line and experienced no difficulty in setting this route. After the freightliner train had passed he cleared the route and then reset it for the Paddington train. He confirmed that as the passenger train approached Signal OX 20 this would have cleared to a single yellow with the junction indicator illuminated since Signal OX 72, at the Banbury end of the Down Platform line, was at Danger at the time. Within seconds of the train passing Signal OX 20 Walker saw track circuits AQ and EP show occupied and the indications for points 237 and 235 flashing 'out of correspondence'. This was quickly followed by a telephone call reporting the derailment and Walker thereupon sent the 'Obstruction Danger' signal to Reading, replaced all necessary signals to danger, and called for the emergency services.

22. One of the first people to arrive at the site of the derailment was *Traction Inspector D. S. Fendley*. He went directly to the locomotive cab, where he spoke to the three drivers and examined the controls, gauges, and AWS indicator. He then went to examine the track. The facing switch (blades of the turnout 237B) were undamaged and were fully closed and set for the route to the Down Platform line. The nose of the manganese crossing, however, had an obviously new score mark on the fillet and other marks suggesting that a wheel had struck the nose and been deflected so as to run along the left-hand rail of the Down Main line. Mr. Fendley next went back several hundred yards along the track in the Didcot direction to see if there was any obstruction on the line or sign of earlier damage but found nothing. On returning to the locomotive he noted the damaged condition of the leading bogie and wheels but could not see anything obviously wrong.

23. The damaged track was also examined immediately after the accident by *Signal Supervisor T. C. Mundy* who, like Mr. Fendley, was in the vicinity when the derailment occurred. He confirmed that 237B points were undamaged and correctly set. At 237A points the closed switch blade was in its correct position, but the open switch and stretcher bars were damaged as also was the left-hand clamp lock fitting. Various track cables carrying circuits to Points 237 and 235, and to track circuits AQ, AR, and EP, were severed. Mr. Mundy was present later the same evening when the cables were repaired and the points reconnected: all the signalling equipment functioned normally as soon as these repairs were made.

24. *The Divisional Civil Engineer, Reading, Mr. D. J. Harris*, told me that the track in question, including points 237A and B, had been patrolled on the morning of 29th January, the day of the accident, and everything had been in order. Immediately following the accident, permanent way staff had examined the track leading to the point of derailment without finding anything amiss. The condition and gauge of 237B points and

the turnout crossing had been checked and, apart from the marks on the crossing nose and subsequent signs of damage caused by the derailment, all was in order. Later, all the connections in the Down Main line between Didcot Junction and Oxford were examined but none had any unusual marks or signs of damage.

25. *Mr. A. Jones-Gerrard, the Divisional Locomotive Engineer, Reading*, arrived on the site at about 16.30. After a preliminary inspection of the locomotive and the track he took charge of the re-railing operations. Just after 17.00 his attention was drawn to an apparent distortion between the leading pair of wheels of the locomotive. The right-hand leading wheel was leaning inwards and almost touching the bogie frame at the top, whilst the left-hand wheel was leaning slightly outward. A wheel gauge showed that the tops of these two wheels could be as much as 3 inches less than the correct distance apart.

26. In order to minimise interference with traffic the actual re-railing did not start until 21.30. Shortly before midnight, the locomotive, which had been lifted and traversed sideways about 2 ft by hydraulic jacks, was lowered carefully back onto the track and it was found that all wheels engaged correctly, except the two leading ones each of which stood with its flange on the rail table. At this point the jacks were removed and the locomotive was moved slightly but the flanges of the leading wheels, instead of falling correctly into place, dropped to the outside of the rails. The front end was then again jacked up, high enough for an examination to be made underneath, and Mr. Jones-Gerrard was able to see that the leading axle was completely fractured at a point just to the inner side of the right-hand axle bearing.

27. *Mr. G. H. Passey, Locomotive Engineer of Western Region*, described the initial examination of the leading bogie of the locomotive on its arrival at Swindon Works. Signs of rubbing were found on the top flange of the left-hand side of the bogie frame consistent with the top of the left-hand leading wheel's having been in contact with the frame for some short time. There was no equivalent rubbing on the right-hand side of the frame. The leading axle was found to be fractured through the full section in the area known as the No. 2 groove, just inside the inner edge of the right-hand axle box. There was some damage to the fracture faces but it was apparent that most of the area bore the characteristic marks of a fatigue failure.

28. The failed axle was number W 2606, made by Messrs Steel, Peech and Tozer to BR Specification 109A in 1966, and subsequently machined in Swindon Works. It incorporated various modifications that had been made since the Class 52 locomotives were first introduced, and was to the latest standard design for fitting to these locomotives. It was first fitted to a locomotive in 1966 and during its life it had been fitted to a total of five different locomotives. At the time of fracture it had covered some 954,000 miles. Mr. Passey explained that axles to the latest design received non-destructive, ultrasonic, testing at six-monthly intervals: earlier, unmodified, axles are tested every three months. Any axle found to produce a test signal other than normal is reported to the Regional Metallurgist and specially investigated, if necessary being withdrawn from service.

29. Throughout its life, axle W 2606 had received regular non-destructive testing and had never given cause for suspicion as to its soundness. It had been ultrasonically tested in Swindon Works in September 1973, before it was fitted to locomotive 1023, and on that occasion was reported free from defect. Thereafter it received further ultrasonic testing at six-monthly intervals, in March 1974 and in October 1974, and on both these occasions was also reported clear. Its next scheduled examination would have been in April 1975. At the time of failure it had covered approximately 170,000 miles under locomotive 1023, and 32,000 miles since its last examination in October 1974.

30. Describing testing arrangements for axles fitted to Class 52 locomotives Mr. Passey said that detailed instructions are given in a BR document, Ultrasonic Testing Procedure Chart No. 1, Sections 3 and 4. This describes the exact method to be adopted to ensure a satisfactory test of the whole axle, and makes particular reference to the axle's fifteen stress relief grooves, each of which requires special attention. The operators of the test equipment are specially trained for their work, and are issued with certificates of competency when they qualify. The test equipment itself is also subject to a daily check by the operator, and to regular checks by the BR Ultrasonic Equipment Maintenance Section.

31. The last ultrasonic examination of axle W 2606 before it fractured was carried out in Laira Depot, Plymouth, on 9th October 1974, by *Quality Control Inspector B. Wheldon*. Inspector Wheldon told me that he was one of a number of Ultrasonic Test Inspectors at Laira and that he was regularly employed on testing the axles of locomotives. His experience of the axles fitted to Class 52 locomotives went back to the introduction of the class in 1961–63, and he had been involved in ultrasonic testing of the axles ever since such testing was introduced in 1964. During his years as an Inspector he had attended a number of refresher training courses at the BR Ultrasonic Testing School at Derby, the last one being within the previous two years.

32. Concerning axle No. W 2606, Inspector Wheldon said that it had been tested by one of his colleagues, at Laira, on 20th March 1974 and the records showed that no fault or irregularity had been found on that occasion. The axle was therefore programmed for a normal 6-monthly check, and Mr. Wheldon had himself done the next test, on 9th October 1974. This test was done inside the shed at Laira, in dry conditions and at a comfortable working temperature. Mr. Wheldon assured me that he had carried out the test exactly as required by the Procedure Chart, including the correct calibration of the probes and the cleaning of the axle ends, and that he had been fully satisfied that the ultrasonic equipment was functioning properly throughout the test. He had found nothing whatsoever during the test to indicate that there might be any fault in the axle, and he had completed and signed the test form accordingly.

33. Mr. Wheldon confirmed that he had on previous occasions successfully detected cracks or flaws in axles during the course of his ultrasonic testing: he had had two cases during the past year, both involving Class 52 locomotive axles, in which he had detected an irregularity that had been confirmed as a crack on

further investigation. He also recalled a case where a suspect signal was observed on an axle, but had disappeared on re-test after the locomotive was moved. The signal had reappeared when the wheel was further rotated through 180 degrees. Subsequent tests had shown that this axle was in fact cracked. He believed that this phenomenon had been observed on other occasions.

34. Evidence was finally given by *Mr. Passey* on the immediate measures taken after the accident to check the Class 52 locomotive fleet. A special re-test of all axles in the fleet was put in hand, concentrating on the No. 2 groove, where the fracture on axle W 2606 had started, and on No. 15 groove, the corresponding groove at the other end of the axle. These re-tests were completed within four days. In addition, a complete re-check of all Class 52 axles was ordered, to be carried out at the next scheduled 'B' maintenance examination, this to be in addition to any tests carried out under the normal time-based testing programme. The 'B' examination is based on hours in service, and most locomotives would become due for this examination in something under four weeks. The testing procedure had also been altered so that each axle would be tested with the wheels in two positions, 180 degrees apart. This new procedure was being used during the special 'B' examination checks.

SUBSEQUENT INQUIRIES

Result of special check on all Class 52 locomotive axles

35. During the course of the special checks described in paragraph 34, that is the immediate check of the No. 2 and No. 15 grooves and the subsequent full testing of all axles in the Class 52 fleet, three axles were suspected of having some irregularity. They were each re-tested several times at short intervals and then removed from service for more detailed investigation. The results were as follows:

(a) *Locomotive* 1034. *Axle W* 2291. No sign of cracking. The suspect test signals were attributed to incorrectly profiled stress-relieving grooves: subsequent inquiries revealed that the ultrasonic test operator had been applying an increased control signal height in error on this occasion and this had shown up the incorrect groove profiling and led him to suspect the presence of a crack.

(b) *Locomotive* 1063. *Axle W* 1250. No sign of cracking. This axle was an unmodified type having a 'deep' re-profiled No. 15 groove. It was thought possible that the test operator had used the procedure chart for a modified axle, i.e. one with a shallower groove, and had interpreted the signal showing the greater depth as a crack.

(c) *Locomotive* 1058. *Axle W* 1234. This axle was already subject to testing at monthly intervals, a suspect signal associated with the No. 11 groove having been reported in November 1974. This signal could not be reproduced at the tests carried out in December 1974 and January 1975, but it was again seen on 10th February 1975. It was still present when the axle was re-tested, as part of the complete check of all axles, on 28th February and the axle was removed from service. On stripping, a shallow crack in the No. 11 groove was confirmed, running intermittently all round the axle.

Investigation of fractured Axle W 2606 *at the BR Technical Centre, Derby*

36. Following its initial examination at Swindon Works, axle W 2606 was sent to Derby for detailed investigation. A material analysis of the axle steel showed that it was fully up to specification and attention was concentrated on the fracture surfaces. With fatigue failures, it is sometimes possible to make a realistic estimate of the rate of crack growth by counting the striation markings on the fracture face, which are a characteristic of this form of crack. On axle W 2606 it was clear that the fatigue crack had been growing from three separate initiation points on the periphery of No. 2 groove, but it was also clear that, although concentric 'beach' marks were visible, the battering together of the fracture surfaces immediately after failure had removed much of the fine striation marking. Examination using a Scanning Electron Microscope confirmed that much of the fracture surface was flattened and relatively featureless. It was not possible, therefore, to use this method to make an estimate of the minimum time that the crack had been growing prior to fracture.

37. The three initiation points were not associated with any observable irregularity in the groove. There was some slight discoloration in No. 2 groove, and in some of the others, but this was not judged to be significant: the discoloration did not amount to corrosion of the kind that had caused trouble in axles of the original design, as described in paragraph 10.

38. Although the battering after failure had removed much of the fracture face marking, it was considered that the degree of damage was consistent with the locomotive's having run only a matter of yards after complete fracture of the axle. This in turn was consistent with the degree of rubbing observed on the wheels and bogie frame.

39. Since the length of time during which the crack had been growing could not be estimated by physical examination, the Fracture Mechanics Section (Research & Development Division) attempted to investigate the rate of crack growth by calculation. The technique had been used successfully in the case of failed diesel multiple-unit axles, for which a measured range of service stresses was available. The calculation attempted to show the number of stress cycles which would be required to cause a crack in the No. 2 groove to grow from 0·5 mm to 10 mm. The first figure was chosen as the largest size that it would be reasonable to suppose could be missed during a properly conducted ultrasonic test, and the latter size since the time required for a crack to grow from 10 mm to complete failure would be only a small precentage of the total growth time.

40. Reliable use of this calculation technique depends on accurate knowledge of a number of factors, principally the stress history of the axle. In the case of axle W 2606 this was not known, and 'average' bending stresses had been used incorporating the nominal vertical wheel load plus a dynamic increment (assumed as 26 per cent) and a small (6 per cent) lateral component. Other assumptions involved the stress-concentration factor for the notch, the stress-intensity factor (K) for the crack, and the relationship between K and the crack-propagation rate.

41. The calculation indicated that the crack could have grown from 0·5 mm to 10 mm in a matter of a few weeks. This was an unexpected result, and various checks were at once made by the Fracture Mechanics Section to test the validity of the assumptions made. In particular, the method was checked against crack growth conditions in a wheel seat, for which there is a great deal of service experience indicating that cracks grow very slowly. In this case the results obtained by calculation were reasonably consistent with the observed facts.

42. The result of the calculations was discussed in detail with the Board's and Western Region's locomotive engineers. It was generally agreed that such a short period for the crack growth seemed unlikely in view of previous experience with other axles, although it was realised that much of this experience was with cracks starting from fretting in the wheelseat where crack propagation could be expected to be slower. The previous history of the Class 52, and similar, axles was discussed, and an attempt was made to see whether records of the crack depths at the time axles had been withdrawn from service, combined with the known intervals since last inspection, might tend to support the calculations. This did not prove possible since, in the small number of cases recorded, the cracks had been in the early stages of development when the axles were taken out of service, and the depths of crack had not always been measured.

43. It was concluded that the number and nature of the assumptions made in the calculations would leave a considerable margin for error and that, as a method, it did not form a satisfactory basis for setting inspection periods and should not be preferred to practical experience. Nevertheless, it was considered to be sufficiently accurate to have shown that cracks emanating from grooves will grow much faster than cracks in wheelseats. The calculation had *not* provided grounds for supposing that the ultrasonic examination carried out on the axle on 9th October 1974 had failed to find a discoverable crack.

The Test Instrument used at Laira Depot on 9th October 1974

44. The instrument used by Inspector Wheldon during his test of axle W 2606 on 9th October 1974 was Mark 2 Ultrasonascope No. C 506. All the test instruments at Laira are overhauled at regular intervals on a programme issued by the BR Ultrasonic Maintenance Section at Brighton. Instrument C 506 was passed as satisfactory after annual overhaul at Brighton on 2nd July 1974 and returned to Laira. In early November 1974 it was reported for 'low gain' and given a general check over at Brighton. This check showed that the instrument should have been capable of making a fully satisfactory axle test in October 1974.

CONCLUSION

45. The derailment was caused by the sudden complete fracture of the leading axle of the train's locomotive as it entered the facing connection leading from the Down Main line to the Down Platform line at Oxford. The failure of the axle caused the wheels to lean inwards at the top and this permitted the right-hand wheel to pass along the wrong side of the turnout nose, thus initiating the derailment. It is extremely unlikely that any indication of the impending failure would have been given to the crew of the locomotive: the train was being correctly handled and no blame whatsoever attaches to any member of its crew.

46. The axle failed due to extensive fatigue cracking initiated from points on the No. 2 stress-relieving groove. It has not proved possible to estimate with any accuracy the length of time during which the fatigue cracks might have been developing. A period of some 16 weeks had elapsed since the last occasion on which the axle was ultrasonically tested and, whilst practical experience would seem to indicate that such a rapid growth rate, from initiation to complete failure, is highly unlikely, theoretical calculations have suggested that the possibility cannot be entirely discounted.

47. The last ultrasonic examination of the axle before it failed was carried out by a very experienced Inspector, using an instrument in satisfactory condition. It is, in my view, most unlikely that such an experienced man would have failed to detect a significant crack had one existed. But it is not impossible. The full examination of the six axles of a Class 52 locomotive is a long and tedious process: each axle is examined from both ends, and each axle examination involves re-setting the probes for each of the grooves, checking the signal at each groove against the testing schedule. In these circumstances, a momentary distraction could lead to a signal being missed. There is also the possibility that, when Inspector Wheldon carried out his test, the axle position was such that his chances of finding a crack were minimised. There has been clear evidence since the accident that the signal given by a crack can be reduced when the crack is on the compressive side of the axle.

48. In view of all the evidence, some of it conflicting, I am inclined to the view that a crack most probably did exist at the time of the ultrasonic examination on 9th October 1974 but that, for some reason, it was not detected during the examination. This view cannot be proved. I am however quite sure that, if a developing crack was missed, this was not due to any lack of expertise or care on the part of Inspector Wheldon, who impressed me throughout the Inquiry as being a most conscientious and reliable man.

Remarks

49. The failure of axle W 2606, one of the modified designs produced for the Class 52 locomotives, and the results of the subsequent investigations have obvious implications for safety. I have discussed these implications with the responsible Railway Officers. They have assured me that the doubts raised as to the suitability of the previous frequency of ultrasonic testing apply to the Class 52 axles only, and that there are no grounds for thinking that the present frequency of testing is unsatisfactory in the case of any other axle. So far as the remaining Class 52 axles are concerned, the interval between testing was reduced soon after the accident at Oxford to 3 months in every case, with more frequent testing whenever the slightest suspicion is aroused as to an axle's condition. In addition, every test is now carried out with the axle in two positions approximately 180° apart. The Railway Officers feel that, having weighed the available evidence, both practical and theoretical, the 3 months frequency is adequate, and I support their view.

50. This particular axle problem will in any case disappear within the course of the next year. The Class 52 locomotives are being withdrawn and there should be none left in service after the end of 1976. As at 29th December 1975 there were only 34 of these locomotives still in service. The Class 42 and 43 locomotives have already all been withdrawn from service.

51. The investigation of the failed axle has served to highlight some gaps in knowledge. The threshold of crack detection by ultrasonic techniques is not known with any certainty and this has an important bearing on the selection of adequate test frequencies. It seems certain that the growth rates of cracks smaller than 0·5 mm are very much lower than that of larger cracks, and reliable detection of these small cracks would permit an increased time interval between tests. Again, the information and techniques available at present are such that any judgment based on theory alone is probably inferior to one based on practical experience. In an ideal situation, practical experience and theory should lead to a common conclusion. However, in the range in which it is valid, the theoretical treatment has shown that the groove position in an axle may be substantially more dangerous, in terms of fatigue, than the wheel seat. This has wider implications for axle design in general, and a programme of work to study crack growth in these situations is planned by the Research & Development Division at Derby for 1976. Any progress that can be made in this difficult field will make a real contribution to safety.

I have the honour to be,

Sir,

Your obedient Servant,

C. F. ROSE,

Major.

The Permanent Secretary,
Department of the Environment.

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