MINISTRY OF TRANSPORT & CIVIL AVIATION

RAILWAY ACCIDENTS

REPORT ON THE DERAILMENT which occurred on 7th March 1954 at NORTH QUEENSFERRY TUNNEL near the FORTH BRIDGE in the SCOTTISH REGION BRITISH RAILWAYS

LONDON : HER MAJESTY'S STATIONERY OFFICE

1954

SIXPENCE NET

MINISTRY OF TRANSPORT AND CIVIL AVIATION,
Berkeley Square House,
London, W.1.

23*rd June*, 1954.

SIR,

I have the honour to report for the information of the Minister of Transport and Civil Aviation, in accordance with the Order dated 11th March 1954, the result of my Inquiry into the derailment which occurred at about 10.50 p.m. on Sunday, 7th March 1954 at the entrance to the North Queensferry tunnel, near the Forth Bridge on the East Coast main line in the Scottish Region.

The 6.55 p.m. Up express passenger train from Aberdeen to King's Cross, comprising 13 bogie corridor coaches hauled by an A.4 Pacific type engine, was climbing the steep 1 in 70 gradient from Inverkeithing to the Forth Bridge when the engine began to slip in the North Queensferry tunnel. It stopped momentarily about 300 yards from the entrance and then ran backwards, with the result that the last three vehicles were derailed at the catch points just outside the tunnel.

The end of the last vehicle was forced across the Down Main at an angle of 45°, thus blocking both lines. The next coach, a brake third, was canted on to its side and came to rest on the edge of a high embankment, whilst the third vehicle from the rear, a third class sleeper, was derailed in the catch siding. Fortunately all the buckeye couplings remained connected and undoubtedly saved the brake third and probably the sleeping car from being precipitated down the embankment. Prompt steps were taken to rescue passengers from their perilous position and only one of them was slightly injured.

The signalman at Forth Bridge North had noticed that the train was an unusually long time in the section and had already taken steps to stop traffic in both directions before the fireman telephoned to him from the Down Intermediate Block Home signal and told him of the accident.

An assisting engine was obtained promptly and was coupled to the front of the train which left for Edinburgh at 12.5 a.m. with the 10 undamaged vehicles. Arrangements were made to divert trains to other routes, and a shuttle service was provided between Edinburgh and North Queensferry station. Buses were run between this station and Inverkeithing until normal train services were resumed. Single line working was introduced over the Down line between Forth Bridge North and Inverkeithing at 11.25 a.m. on Monday morning and normal working on both lines was resumed at 4.0 p.m. after an interval of 17 hours.

The weather was fine but there was a strong westerly wind blowing across the tracks.

THE TRAIN

1. The 13 coaches weighed 467 tons and were hauled by an A.4 class 4–6–2 type engine weighing 168 tons in working order. Thus the total weight of the train was 635 tons and its overall length was 303½ yards. The coach bodies were of composite construction on steel underframes. Buckeye couplings were in use throughout, with Pullman type gangways. The vacuum brake operated on the coupled and tender wheels of the engine and on all wheels of the coaches, giving a total brake power of 481 tons, equivalent to nearly 76% of the weight of the train.

THE ENGINE

2. Engine No. 60024 was built at Doncaster in 1936 and is stabled at Haymarket Motive Power Depot. At the time of the accident it had run 6,500 miles since completion of the last general repair at Doncaster on the 30th January, 1954.

The diameter of the coupled wheels is 6 feet 8 inches, and the engine is powered by three cylinders 18½ inches by 26 inches, giving a tractive effort of 35,455 lbs. at 85% of the boiler pressure of 250 lbs per sq. inch. The total weight of the engine and tender in working order is 167 tons 18 cwts. and with 66 tons on the coupled wheels, the adhesion factor is 4·18.

There are two independent sets of sanding gear. The dry sanders have hopper type boxes bolted to the main frames, one on each side, and sand is delivered through 1¼ inch pipes to the leading coupled wheels. The valves are of the fluted spindle type and are worked by a lever on the left side of the cab which operates a double wire mechanism. The capacity of each dry sand box is 6 buckets, sufficient for continuous use for 1¼ hours with the valve fully open. The wet steam sanders are of the usual type in which the sand is projected forcibly between the middle coupled wheels and the rail. There is no back sanding gear to the engine or tender.

The sanders are not usually operated simultaneously because the steam from the wet sanders is apt to blow away the dry sand. There is little to choose between the efficiency of the two types, some drivers preferring one and some the other method of sanding.

The driver has a seat on the left-hand side of the cab from which he can look ahead either through the spectacle or the open side window. He can also work all his controls, including the steam and dry sanding gear, without leaving his seat. The regulator handle is on the driver's right and it is pulled backwards to open; the valve is of the single-beat poppet type. The reversing screw is mounted on a vertical axis and is also on the driver's right in front of his seat. The handle is turned in an anti-clockwise direction to put the engine into forward gear and 10½ turns are required to move it from full fore gear to the mid position.

The Site

3. The main lines from the North of Scotland via Perth and Dundee join at Inverkeithing whence they climb continuously, except for a short length of level track, on a steep gradient of 1 in 70 for over two miles to the Forth Bridge. There are two double-line tunnels in the section, Inverkeithing 386 yards long, just south of the junction, and North Queensferry 569 yards in length, about half a mile from the bridge.

The incline is curved for most of the way. On the northern approach to the Queensferry Tunnel there is a long 40 chains radius left hand curve which begins on an embankment 1,433 yards from the tunnel mouth. This bank is followed by a short rock cutting after which there is a 40 feet high embankment 267 yards long leading up to another short rock cutting at the north portal. The left hand curve ends 110 yards inside the tunnel and it is followed immediately by a right hand curve of 61 chains radius.

4. The Block sections in the Up direction are Inverkeithing Central to Inverkeithing South and Inverkeithing South to Forth Bridge North, but on the day of the accident the Inverkeithing South box was switched out. There are Up and Down Intermediate Block Home signals about half way up the incline, and the Up I.B. Home is 480 yards north of the Queensferry Tunnel northern portal. Both lines are fully track circuited between Inverkeithing Central and Forth Bridge North.

5. Owing to the steep gradient, catch points have been provided in the Up Main about ¾ mile from Inverkeithing and also at the north portal of the Queensferry Tunnel. The latter points are of the usual self-acting double switch type and the toes of the switches are only 2 feet outside the tunnel. The catch siding extends for 103 feet from the switches to the buffer stops on the edge of the 40 feet high embankment.

6. The tunnel is comparatively dry though water leaks through in several places and at the one ventilating shaft 293 yards from the north entrance. Traffic amounts to nearly 100 trains per day in each direction and hence the tunnel is constantly being filled with steam and smoke from Up train engines which are working heavily on the rising gradient.

7. The Up Main had been relaid on the day of the accident with 95 lbs bull headed material on ash ballast; the new work extended through the catch points and the tunnel for a distance of 640 yards. A speed restriction of 20 m.p.h. was in force and the C and T boards were in position; the restriction had been printed in the Weekly Notice as usual.

Marks of Derailment and Damage to the Track

8. The track was examined after the engine and the first 10 coaches had been drawn away. Only a narrow line of contact was showing on the head of the new rails where the wheels had been bearing and there were no burns such as might have been produced by heavy slipping. Two light sets of skid marks were found, however, 227 and 295 yards ahead of the catch points. There were no signs of sand on top of the rails nor could any be detected on the sleepers and ballast, but there were a lot of ashes lying about from the recent relaying which made it difficult to distinguish the presence of sand.

9. The switch blades of the catch points were undamaged though there was a slight mark on the stock rail edge of the right hand blade and both stretcher bars were bent. The switch anchors on the heels were marked where a pair of derailed wheels had hit them and thereafter a number of chairs were broken or marked on the cess side with corresponding wheel marks on the chairs and sleepers on the opposite side. Further marks were found in the vicinity of the crossing where a second set of wheels had been derailed on striking the end of the right-hand check rail. Beyond the crossing the track in the catch siding was destroyed and the buffer stops were demolished. Some 75 yards of the Up Main were also destroyed and a few sleepers in the Down Main had been hit by some swinging object, probably the coupling at the rear of the brake van which was pushed across that line.

Position and Condition of the Damaged Stock

10. The last three coaches of the train came to rest outside the tunnel as already described. The rear bogie of the last vehicle, the brakevan, remained derailed astride the Up Main but the rear end projected over the Down Main and the front end was thrust out to the edge of the embankment. The next coach, the brake third, was lying practically on its side overhanging the bank and was held suspended in this precarious position by the buckeye couplings at either end. The next coach, the third class sleeper, was derailed all wheels and it was resting with the rear end on the edge of the embankment which was widened at this place in order to accommodate the siding.

11. The three derailed coaches suffered remarkably little damage except for the bogies and some of the undergear. The rear near side buffer of the last vehicle was broken off when it hit the buffer stops of the catch siding, and the underframe and body of the adjoining brake third were slightly damaged.

Report

Signalmen's evidence.

12. Signalman D. Johnston of Inverkeithing Central box said that the express was accepted by Forth Bridge North at 10.33 p.m. and it passed his box at 10.42 p.m. running 19 minutes late. It was travelling under clear signals at about 25 m.p.h., having just passed through a permanent speed restriction from the East Junction. Johnston did not receive the "Train out of Section" signal but at 10.55 p.m. he received "Obstruction Danger" from Forth Bridge North. The signalman there also telephoned to him about the same time.

13. Signalman G. Speedie of Forth Bridge North said he received "Train Entering Section" for the express at 10.43 p.m. and cleared all signals for it. He saw the track circuits on his diagram light up when the train passed the Up I.B. Home and two or three minutes later he went to the cabin window to see the train pass. It did not arrive and since it had been an excessively long time in section he telephoned to Inverkeithing Central and advised the signalman there to stop all traffic. At 10.55 p.m. the fireman of the express telephoned from the Down I.B. Home to tell him of the derailment and Speedie promptly sent "Obstruction Danger".

Trainmen's evidence.

14. Driver S. Storie had been appointed to that grade in 1925, after 14 years' service, and for the last five years he had been in the top link in Haymarket Shed. On the night of the accident he took charge of the express engine as soon as it had backed on to the train at Dundee. The engine had already been prepared, and Storie was quite satisfied with its condition and performance because he had driven it before and it had only recently come from the Doncaster shops after an overhaul. He was told that the load behind the tender was 13 coaches weighing 467 tons. This represented an overload of 17 tons above the 450 tons maximum loading for that type of engine on that route, but Storie said he was not in the least worried since he had had no difficulty on previous occasions in hauling such loads with an A.4 engine.

The engine was steaming well and the vacuum gauge was showing 21 inches in the reservoir. He did not experience any difficulty in starting from Dundee, though the engine slipped a little as usual and he applied the dry sanders. The next stop was at Leuchars, where he also used the dry sand and after that came Cupar, where he had to reverse before starting, again with a little slipping.

The train passed through Inverkeithing at 20 m.p.h. under clear signals and then Storie opened the regulator fully with the reverser at 25% cut-off. He applied dry sand as soon as the engine entered the first tunnel and he kept the sand running for the rest of the climb. Speed increased at first to a maximum of about 30 m.p.h. and then began to fall gradually as he did not alter the cut-off in view of the restriction ahead. The I.B. signals were off and he saw the C and T boards clearly as he approached Queensferry Tunnel at about 25 m.p.h. with the speed still dropping. On entering the tunnel, the wheels began to pick up so he partially closed the regulator and altered the reverser to 30%. This was not effective and he had to close and re-open the regulator constantly so as to check the slipping, which went on practically the whole time. To quote his own words "It was just slight to start with and she never regained her feet. It was not one of the dancing slips but just catching and slipping, and catching and slipping".

The speed continued to drop but Storie did not realise that the train had stopped and was running backwards until he felt a bang, which he thought was the rear coach hitting the catch siding buffer stops. He immediately closed the regulator, applied the brake and turned off the sanders. His fireman picked up a hand lamp and went back to find out what had happened. Storie explained that the tunnel was full of smoke and he had no indication of the direction in which he was running since he could not see the side nor touch it when he put out his hand.

15. About an hour after the accident the relief engine arrived and was coupled in front. The three derailed vehicles had been detached by then, and a few minutes later the train left for Edinburgh with the 10 undamaged coaches. Storie used the dry sand and also opened the cylinder cocks, but again the engine slipped a little on starting.

On arrival at the Haymarket Shed, Edinburgh, Storie checked the dry sanders and found they were working satisfactorily. He explained that the sanding lever was very stiff and he had to pull it with both hands in order to open it fully but he was confident that he had done this on all the occasions he needed to use it. He preferred dry sand to wet, particularly in tunnels.

16. Storie, in describing his previous experience, said he had come to a stand owing to slipping in a tunnel on one other occasion but he had never run backwards. He had also noticed that engines were apt to slip more easily on new rails than on old ones.

17. Passed Fireman J. Grieve, who was working with Driver Storie, said that the engine was steaming freely and he had little difficulty in keeping the boiler pressure at about 240 lbs per sq. inch. He personally tested the dry sanders before leaving Dundee and although the lever was stiff the sand flowed freely.

Grieve generally confirmed his driver's account of the journey. He thought the speed climbing the Forth Bridge incline reached about 30 m.p.h. but it had dropped to between 20 and 25 m.p.h. by the time they entered Queensferry Tunnel, where the engine was steaming very well with pressure still about 240 lbs per sq. inch. Once inside the tunnel the wheels began to slip and Grieve thought his driver tried to check this action by working the reverser. The engine continued to slip until he felt a bump. He also thought they must have run into the catch siding, though he did not notice any backwards movement in the dark and smoky atmosphere of the tunnel.

18. Grieve walked back to the north entrance, where the smoke had cleared by the time that he had reached it, and after speaking to the guard he ran back to the Down I.B. Home signal about ¼ mile away in order to telephone to the Forth Bridge signalman to stop all traffic. Grieve then returned through the tunnel and protected the Down line by placing three detonators at the south entrance, one some distance further on and another at the Forth Bridge signal box.

19. Independent evidence was given that the dry sanders were working properly both before the engine left Dundee and on its return to Haymarket Shed, where three buckets of sand were used to replenish the left-hand box and two to fill the right-hand one.

20. Goods Guard R. Willison, who was acting as passenger guard, joined the train at Dundee and travelled in the van at the rear. He tested the brake before leaving and found it was working satisfactorily, with 19 inches of vacuum in the train pipe. The train left at 9.14 p.m., 18 minutes late, and the journey was uneventful until they were climbing the Forth Bridge bank.

Willison was looking out through the closed window alongside the guard's cubicle, which was on the "six foot" side of the van and about 40 feet from its leading end. He did not notice anything unusual until the van entered the tunnel when the speed seemed to drop suddenly and Willison realised that the engine was slipping. He opened the window on the other side of the van and put out his hand to touch the tunnel wall so as to find out the direction in which they were moving. He could not reach it, however, and the tunnel was so full of smoke and steam he could not tell what was happening. He returned and opened the window on the other side and found he was in the open air, so he made his way to the cubicle with the intention of applying the brake, but before he could reach it he was thrown across the coach, presumably when it hit the buffer stops. Willison climbed out of the van and met the Sleeping Car Attendant, who was going to the assistance of the passengers, so he ran back to protect the train.

21. Sleeping Car Attendant G. Christie was in charge of the third-class sleeping car, which was derailed. He did not notice anything unusual until he felt the derailment. Although he was aware that the train had been climbing the incline, he did not realise it had stopped and was running backwards in the tunnel. He went back to the brake third and helped to rescue the passengers from the overturned coach. They opened the corridor doors which were uppermost, and the passengers walked along the side of the coach to the sleeping car which they entered through the broken gangway.

22. Driver W. Elder, who was in charge of the relief engine, said that he worked wrong line from Forth Bridge North and entered the tunnel smoke box leading. He used the dry sand as he came in so as to leave a sanded rail behind him for the return journey. The engine was coupled to the front of the express engine and had no difficulty in starting a few minutes later.

Elder stated that earlier on the day of the accident he had been in charge of a B.1 class engine, hauling a train of five coaches over the same route. He had no difficulty in climbing the gradient until he reached the Queensferry Tunnel. He reduced speed to 20 m.p.h. in order to comply with the restriction and the engine wheels began to slip a little on the new rail in the tunnel. He applied dry sand and managed to get through without stopping. Elder said that he also had experienced similar difficulty when travelling over new rails on gradients.

Evidence of the Permanent Way staff.

23. Ganger J. Williamson, who was in charge of the length which included the Queensferry Tunnel said that he had been working on the relaying on the day of the accident, and he had unclamped the catch points after the ballast train had left. He tested these points by working them with the lever and found they operated satisfactorily, though at first they gaped a little when he let the points back slowly. He cleaned and oiled the slide chairs again and then the points closed fully.

24. Permanent Way Inspector B. D. Constable was ill on the day of the accident and did not resume duty until the following morning, when he arrived on the site at 8.28 a.m. He walked through the tunnel from the Forth Bridge end and noticed slight skid marks on both rails about 227 yards from the catch points. He did not notice any other marks, nor did he see any signs of sand either on the rails or the sleepers.

25. Chief Permanent Way Inspector J. Cameron arrived at the south entrance to the tunnel at about 1.35 a.m. He also examined the Up line but he did not notice any signs of sand, nor did he see any skid marks. On arrival at the catch points he found the switch blade on the six foot side was lying $\frac{1}{4}$ inch open and the two stretcher bars were bent. There was a slight rub on the switch blade and there were marks on the chairs and sleepers, as already described. The Chief Inspector came to the conclusion that as the train was running so slowly through the catch points, the spring had not driven the blade home hard against the stock rail. Thus when the train ran backwards the flanges of the leading wheels caught between the stock rails and the switch blades and so were derailed. The points probably received a jerk which caused the switch to close sufficiently for the other wheels to run correctly into the catch siding. The spring points were tested after the stretcher bars had been straightened and they then worked properly.

Inspector Cameron also confirmed that trains tended to slip more easily on new than on worn rails and he said that it was quite normal for new rails to be worn bright over a small width of the head until they had been run in.

Assistant District Motive Power Superintendent's evidence.

26. Mr. J. F. King, Assistant District Motive Power Superintendent at Thornton, arrived on the scene shortly after midnight. The centre vehicle of the three derailed coaches was in such a dangerous position that he decided to anchor it to the breakdown train engine on the Down line before attempting to uncouple the other ones. Some trouble was experienced in getting them separated as the vehicles were twisted and the couplings had to be cut with oxy-acetylene. As soon as this was done the outside vehicles were rerailed without difficulty.

The rest of the train had by now been drawn out of the tunnel so Mr. King decided to examine the Up line in order to search for evidence of slipping by the engine. He was surprised to see only a narrow line of contact showing on the outer edges of the rails; in some places it was only $\frac{3}{8}$ inch wide. He found no conclusive evidence of slipping, except at a point 295 yards from the catch points where he was able to

distinguish light marks on the outer edges of the rails, but there were no signs of burning and nothing to suggest that all six coupled wheels had been spinning at this place. As the overall length of the train was 303 yards, these marks must have been made just when the rear bogie of the last coach was over the catch points, though there was no definite evidence to show that the train had actually stopped at this critical moment. Mr. King said he did not notice any sand but in view of the amount of new ash ballast lying about he was not prepared to say that none had been used though he would have expected to see more traces of it if the dry sand had been applied full bore.

Mr. King then returned and tested the catch points; he found that by closing them slowly the points remained about 1 inch open. The stretcher bars had not, however, been straightened when he made this test.

Previous failures.

27. Examination of the operating records since the 1st January, 1952 showed that passenger, fish and freight trains had failed to negotiate the Forth Bridge incline on 30 occasions, as indicated below:—

Type of train	*Number of failures*	*Place of failure*		
		Inverkeithing Tunnel	*Up I.B. Home signal*	*North Queensferry Tunnel*
Passenger	3	1	–	2
Fish ..	1	–	1	–
Freight ..	26	3	13	10

In every case except one, where the freight engine vacuum brake had given trouble, an assisting engine was sent out from Inverkeithing. One of the passenger trains had been the 6.55 p.m. express from Aberdeen.

Train loads.

28. An analysis of the Sunday working of the 6.55 p.m. Aberdeen express since the beginning of the year up to the time of the accident showed that on every occasion the load was up to or in excess of the authorised maximum, the heaviest being 474 tons on the 7th February.

Course of the Derailment

29. The absence of serious burns on the rails in the tunnel suggests that the train stopped only momentarily before running backwards. Although it is not possible to say exactly where this occurred, it seems likely that the second set of skid marks, some 295 yards from the tunnel mouth, fixed the furthest point reached by the train.

On this assumption, the derailment probably took the following course. The train stopped either as the last pair of wheels were over the catch point switches or else shortly after they had passed through them. In either case the blades failed to close fully and remained gaping, probably by about $\frac{1}{2}$ inch. Thus when the train began to run backwards the last pair of bogie wheels were derailed at the points and the rear coach veered towards the Up Main instead of following the catch siding. It hit the buffer stops a glancing blow and was thrown further across the main lines instead of running through the stops and toppling over the embankment, as it would have done if it had not been derailed. The next two coaches followed through the catch siding and were derailed beyond the crossing where the track had then been destroyed, but the buckeye couplings fortunately held and thus saved these vehicles also from falling down the embankment.

Conclusion

30. There is no doubt that the express stopped in the tunnel owing to the engine wheels slipping on the new rails and that it ran backwards through the catch siding as already described. I am satisfied that the engine was steaming well with the vacuum brake and sanding gear working properly and that in normal circumstances little difficulty should have been experienced. The load was, however, slightly more than the authorised maximum and the speed had been reduced to 20 m.p.h. on account of the restriction over the newly laid rails, which experience has shown are more liable to cause slipping than worn ones. The strong wind blowing across the track would also have slightly increased the train resistance round the curve.

Thus when the train entered the tunnel the engine, which was probably labouring by this time, began to slip intermittently; speed continued to drop till finally the train stopped altogether and began running backwards. I do not think in the circumstances that the driver can be blamed for mishandling the engine, nor for failing to notice the run-back, because it is well nigh impossible to sense the direction of movement from the footplate when travelling at low speed in an unlighted tunnel full of smoke and steam.

31. Guard Willison was unable to take action in sufficient time to prevent the derailment, although he realised the train was moving backwards as soon as his van came out of the tunnel. By this time it was already derailed at the catch points.

Remarks

32. The records show that in just over two years, 30 other trains including three passenger trains have failed to negotiate the steep Forth Bridge incline, also that one of the passenger trains was the 6.55 p.m. Aberdeen express. The incline, which is on curve for most of the way, is undoubtedly a difficult one and occasional failures may be expected, but in view of the number which have occurred it seems desirable to review engine loadings to ensure that they are not too heavy after taking all circumstances into consideration. In any case, the loading of the 6.55 p.m. Aberdeen express warrants particular examination in relation to the class of engine which may be expected to work it, in view of the number of times on which the loading has exceeded the authorised maximum.

33. Serious accidents due to trains stalling and running backwards in tunnels unbeknown to the drivers have occurred before, as for example, at King's Cross on 4th February 1945 and at Glasgow, Queen Street, on 12th October 1928. Lights have since been provided in both these tunnels as well as in some others on steep inclines and, provided they are spaced sufficiently close together, they can be of great assistance to a driver at a critical time. I understand that as a result of this accident a scheme is being prepared for lighting both the Inverkeithing and North Queensferry tunnels, but I recommend that the conditions in other tunnels on heavily worked inclines should also be reviewed with the object of providing lights should the circumstances warrant them.

34. The catch points at Queensferry Tunnel were so close to the north entrance that any run-back would result almost inevitably in a derailment at the buffer stops, because the guard would have little or no opportunity to make an emergency brake application before the train hit them. It seems that the catch points were placed there in order to give sufficient overlap beyond the Up I.B. Home signal, but the gradient is so steep and speeds so slow that this distance can be reduced considerably. There is a much better site near the other end of the 40 feet embankment where a longer catch siding with a substantial sand drag can be laid, and this should provide an efficient retarder for a break-away as well as giving a guard more time to act in the event of another run-back. The re-siting of the catch points has not yet been carried out but I have been informed that a scheme is being prepared and it is hoped that the work will be undertaken without delay.

I have the honour to be,
Sir,
Your obedient Servant,
C. A. LANGLEY,
Brigadier.

The Secretary,
Ministry of Transport and Civil Aviation.

11940 Wt.2740/3139 K8 7/54