MINISTRY OF TRANSPORT

RAILWAY ACCIDENTS

REPORT ON THE ACCIDENT
which occurred on
21st January 1960
near
SETTLE
in the
LONDON MIDLAND REGION
BRITISH RAILWAYS

LONDON: HER MAJESTY'S STATIONERY OFFICE
1960
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MINISTRY OF TRANSPORT,
BERKELEY SQUARE HOUSE,
LONDON, W.1.
19th April 1960.

SIR,

I have the honour to report for the information of the Minister of Transport, in accordance with the Order dated 22nd January, the result of my Inquiry into the accident which occurred at about 1.48 a.m. on 21st January 1960 near Settle on the former Midland Railway route between England and Scotland in the London Midland Region, British Railways.

The trains involved were the 9.5 p.m. Up 8-coach express passenger train from Glasgow (St. Enoch) to London (St. Pancras) hauled by the Britannia Class 7P locomotive No. 70052, and the 10.40 p.m. Down H. Class 20-vehicle freight train from Leeds to Carlisle hauled by a Class 5 MT locomotive.

The driver had stopped the express at Garsdale, 20 miles from the scene of the accident, to examine the engine which had developed a serious "knock", but as he could find nothing wrong he had decided to continue the journey at reduced speed to Hellifield, 5 miles on the London side of Settle, where there was a locomotive depot. The knocking continued, and while the express was approaching Settle at about 45 m.p.h., part of the right hand motion assembly came adrift, struck the ballast and threw up stones and sparks. The driver on seeing this made a full brake application, but the motion assembly, comprising the piston rod, cross head and connecting rod still attached to the driving wheel, was driven deep into the formation and overturned into the trailing position. The cross head then struck the opposite line and damaged it to such an extent that the freight train travelling at about 25 m.p.h. was derailed towards the 6 ft. space between the tracks. The front of the freight engine tore out the sides of the first three coaches of the express, broke windows and scored the sides of the other five vehicles. The two trains came to rest with their rear vehicles overlapping as shown by the accompanying drawing. Examination of the express engine showed that the two bottom right hand slide bars had fallen off, thus allowing the piston rod, cross head and connecting rod to come adrift.

I regret to report that five of the 75 passengers in the express lost their lives and 8 were injured. The guard of the freight train was also injured. Emergency measures were taken very promptly. The fireman of the freight train reached the signal box three quarters of a mile away at 1.56 a.m. and the signalman immediately sent the "Obstruction Danger" signals, after which he asked the Inspector at Hellifield to call Doctors, Ambulances, Police and Fire Services. The first ambulance arrived on the scene at 2.5 a.m. followed five minutes later by a doctor. Other rescue workers were equally prompt, and in spite of the very inclement weather all the injured were on their way to Skipton Hospital by 2.45 a.m. The remaining passengers stayed in the express until 4.0 a.m. when they were taken by ambulances to Settle Station where they boarded a relief train which departed at 5.19 a.m.

Breakdown cranes from Carlisle and Leeds and breakdown vans from Hellifield arrived during the morning and the derailed and damaged stock was removed by 12.40 p.m. Part of the Down line had been demolished but the repairs were completed and both lines were restored to traffic at 4.15 p.m. after a stoppage of 14½ hours. During this period trains were diverted over the Western route and buses conveyed passengers between Horton and Hellifield.

It was a dark night and a blizzard with winds of gale force was sweeping the area; snow covered the formation to a depth of several inches.

I. General Description

The "Midland" route from Scotland

1. The "Midland" route from Scotland runs from Glasgow, St. Enoch, 414½ miles from St. Pancras, through Kilmarnock (390 miles) and Dumfries (331 miles) to Carlisle (308 miles) and thence almost due south as shown by Fig. 1 of the accompanying drawing. All the mile posts south of Carlisle are measured from St. Pancras, and hence the mileages are given from there. The profile of the line from Carlisle to Settle Junction is shown by Fig. 2. On leaving Carlisle the line begins to rise immediately and except for a few short lengths of falling gradient it continues rising steadily as far as Ormside (275 miles) where the 15 miles ascent to the moors begins; the ruling gradient on this section is 1 in 100. The summit is reached at Aisgill (260 miles) and thereafter the line runs through Garsdale (256½ miles) and across the moors for 10 miles to Blea Moor Tunnel (250 miles). From there it descends, also on a ruling gradient of 1 in 100, for 15 miles through Settle (236½ miles) to Settle Junction (235 miles). Other places on this route to which reference is made are Hellifield (231½ miles) where there is a small locomotive depot and Leeds (195 miles).

The site of the accident

2. The accident occurred a few yards south of M.P. 237, three quarters of a mile north of Settle station signal box, and the positions where the two trains came to rest are shown by Fig. 3. The line is on a 20 ft. high embankment and it is falling towards Settle Station at 1 in 100. The Up and Down tracks are on curves of 60 chains radius, which are right and left-handed respectively.

Both tracks are laid with 109 lbs. F.B. rails resting on cast iron base plates held by elastic spikes to wooden sleepers. The spikes are placed two on the inside and one on the outside of the rail in accordance with the railways' standard practice. The super elevation of the Up line, on which speeds of up to 80 m.p.h. are permissible, is 4¼ ins., but on the ascending Down line, on which speeds seldom exceed 45 m.p.h., the super elevation is 2 ins. The Down line was re-laid on 7th June 1959 and the stone ballast was thoroughly consolidated with a tamping machine. A cross section at the point of derailment is shown by Fig. 6.

The freight train

3. The freight train comprised 20 freight wagons of various types and a 20-ton brake van and it was hauled by a 2-6-0 Class 5 MT locomotive with left hand drive. The weight of the engine and its 6-wheeled tender in working order was 108 tons, and the approximate weight of the vehicles was 440 tons giving a total weight of the train of approximately 548 tons. The overall length of the train was 230 yards.

The express train

4. The express train comprised 8 corridor coaches marshalled from the front as follows: —

Type of vehicle	*Position of corridor in direction of travel*
Brake van with four 2nd Class compartments at the front end.	Left side
2nd Class coach	Right side
2nd Class coach	Left side
1st and 2nd Class coach	Right side
2nd Class sleeper	Left side
1st Class sleeper	Right side
1st Class sleeper	Left side
Brake Van	No corridor

The coaches were of modern construction – all steel bodies on steel underframes – and they were fitted with Buckeye couplings. Their total weight was 286½ tons and the Britannia engine, which is described in Section III, weighed 148½ tons in working order giving a total weight of the train of 435 tons. The overall length was 197 yards. The steam brake was in use on the engine and the vacuum brake with D.A. valves on the coaches. The total braking force was 311 tons, equivalent to 71½% of the total weight.

II. The Damage To The Trains

The freight train

5. The engine and the first eight vehicles of the freight train were derailed to the right. The most significant damage was to the pony truck wheels of the engine. They were found to be 1⅛ ins. tight to gauge at one point and 1¼ ins. wide immediately opposite. The axle was bent and the right hand wheel had "toed in". There were fairly heavy bruises on the right hand wheel flange at the widest point where it had been in contact with the main engine frame which was scored. The pony truck centre casting was broken, the

pivot pin was bent, and the truck frame was distorted downwards on the right hand side. None of the other engine or tender tyres had any visible marks or bruises.

There was other damage to fittings and undergear, especially on the right hand side where the framing was bent upwards, the cylinder casing was ripped open and the vertical ribs were broken away. The cylinder steam chest drain cock was broken and the sand ejectors were damaged. Pieces of the door and window framings from the sides of the express coaches were found wrapped round the front end of the framing.

6. The freight vehicles sustained comparatively little damage. A number of axle guards were bent, mainly due to buffer locking of the four leading vehicles. The bodies of three of the wagons had superficial damage, but the whole of the damage to the freight train was due to the vehicles becoming derailed and there was no evidence of any of them having come in contact with the passenger train.

The express train

7. Particulars of the damage to the Britannia engine are given in paragraph 16. This resulted from the right hand slide bar bolts falling out followed by the two bottom bars, thus allowing so much play in the piston rod and cross head that eventually the piston rod fractured and the motion assembly came adrift. The damage to the rest of the train was caused by contact with the framing of the derailed freight engine. It was confined to the right hand sides of the coaches, in their direction of travel.

8. The side of the leading coach was ripped off from the second passenger compartment to the rear of the brake compartment. The front end of the next coach was torn away as well as a length of side panelling and the remainder of the side panelling up to the centre corridor door was badly bent. The side panels of the first five compartments of the third coach were torn out, and as the corridor was on the opposite side the interiors of the compartments were also damaged; it was in this part of the train that most of the casualties occurred. The damage to the rear of the train was not so severe though the side panels of each of the remaining five vehicles were badly dented and scored in places. Four doors were pulled off their hinges and a number of door handles were broken. A large number of fixed or sliding lights were broken throughout the train.

III. The Britannia Locomotive

General description

9. Locomotive No. 70052 is a British Railways standard Britannia Class 7 Pacific type engine weighing 148 tons 10 cwts. with its 6-wheeled tender loaded with 9 tons of coal and 4,725 gallons of water. It is driven from the left hand side and it is fitted with a speedometer mounted on the boiler plate on the same side. The leading dimensions are shown by Fig. 5. The length over buffers is 68 ft. 9 ins. and the engine wheelbase is 35 ft. 9 ins. with a coupled wheelbase of 14 ft. 0 ins. The coupled wheels are 6 ft. 2 ins. in diameter.

The steam brake operates on the coupled and tender wheels and the total brake power is 76.9 tons, equivalent to 51.7% of the weight.

The two outside cylinders of 20 ins. diameter and 28 ins. stroke develop a tractive effort of 32,150 lbs. at 85% of the boiler pressure of 250 lbs. per sq. in.

The motion assembly

10. The arrangement of the Walschaerts gear, slide bars, cross head and connecting rod is shown by Fig. 7. Those parts which came adrift are shown hatched in Fig. 5. The power from each cylinder is transmitted to the driving wheels through the connecting rod. This is attached at the big end to the crank pin of the coupled driving wheel and at the little end to the piston rod cross head, to which is fastened the union link connecting the cross head to the valve gear through the combination lever.

The cross head guide slides between the slide bars and produces an upward thrust of 3.84 tons on the top bar when the engine is starting with full steam pressure in fore gear. The downward thrust on the two bottom bars when coasting at 90 m.p.h. is 1.82 tons and this drops to 0.62 tons at 45 m.p.h., and 0.4 tons at 30 m.p.h.

11. The top slide bar is a steel bar 7½ ins. wide by 2½ ins. deep tapering in depth at the ends. It is 4 ft. 11¾ ins. long and it is held to the frame by bolts through a substantial central bracket giving support over a length of 1 ft. 11½ ins. The ends are free. The two bottom slide bars are each 2½ ins. wide by 3¼ ins. deep; they are parallel in width throughout and the same length as the top bar. They are fixed to the top bar by 1⅛ in. diameter steel bolts which pass through bronze packing pieces 2½ ins. wide by 1¼ ins. deep. The bolts are inserted from the bottom and are held by plain nuts with Whitworth threads. A ¼ in. diameter steel feather is inserted in a hole underneath the head of the bolt and this fits into a slot in the bolt hole to prevent the bolt from turning when it is tightened. A round steel split pin of ¼ in. diameter is used to hold the nut in position after it has been tightened. Details of this fastening are shown by Fig. 8.

12. The rear bolts can be tightened without difficulty, but, as will be seen from Photograph 3 and Fig. 7, the lagging of the steam chest directly above the top bar makes it difficult to tighten the front bolts, particularly the inner one for which a thin spanner must be used. It is also difficult to insert the split pin and to ensure that it is bearing hard against the top of the nut.

General history

13. The locomotive was built at Crewe in August 1954. Since then it has had one Light and two Heavy Intermediate repairs at Crewe. The last was a Heavy repair which was completed on 26th September 1959. The engine had run 286,600 miles altogether, and 17,500 miles since its last Heavy repair. It was based at Polmadie Motive Power Depot, Glasgow, and it had been given six "X" Day examinations since its last shopping at Crewe; the last examination was on 6th January, 1960.

Recent movements

14. The engine left its home depot, Polmadie, on the morning of 18th January after its daily examination, when the right hand front slide bar bolts were found loose and tightened. It worked the 7.0 a.m. passenger train from Glasgow (Central) to Carlisle with a Polmadie crew. It returned to Glasgow (St. Enoch) the following morning manned by Leeds enginemen and after its daily examination at Corkerhill Motive Power Depot it hauled the 4.0 p.m. Glasgow (St. Enoch) – St. Pancras express to Leeds manned by Corkerhill enginemen. The right hand front slide bars were again reported loose and they were tightened by a fitter at the Leeds (Holbeck) Depot. On 20th January the engine worked the 10.35 a.m. train from Leeds to Glasgow (St. Enoch) with Corkerhill enginemen. It received its daily examination at Corkerhill where nothing was found wrong with the slide bar bolts and it left there that night, hauling the express which was involved in the accident; Leeds enginemen were in charge.

Loose bolts

15. The slide bar bolts which eventually fell out and so allowed the two bottom slide bars to come adrift had been giving constant trouble. In addition to the two cases mentioned above the bolts had been reported loose on 14th January 1960 and 31st December 1959, and altogether these bolts had been reported loose nine times since the engine last came out of the shops. The bolts were tightened, but none was renewed. The left hand bolts did not give so much trouble; on one occasion, however, a front bolt was missing and the back bolts were very loose. The repairs to the engine the last time it was in Crewe Works during August/September 1959 included the grinding and re-fitting of the bottom slide bars and the re-setting of the top bars. There was no record to show whether or not the bolts had been renewed.

Damage to the engine

16. All the damage to the engine was confined to the right hand side. The two bottom slide bars of the motion assembly were missing, together with the four nuts and bolts and the two packing pieces which held these bars to the single top bar. The connecting rod with the cross head, the piston rod and part of the union link attached to it was lying in the trailing position with the big end still fastened to the driving wheel crank pin and the other end on the ballast.

The piston rod was badly bent and had fractured where it joined the piston head. The connecting rod was badly twisted and bent outwards, as shown by Photograph 1 which was taken in Hellifield Depot after the engine had been hauled there and the damaged parts re-assembled. With the engine standing on level track the maximum distance of the cross head gudgeon pin nut (the outermost part of the cross head assembly) from the inside of the rail was 4 ft. 8½ ins. at rail level. When towed at 4 m.p.h. on level track this distance varied between 4 ft. 6½ ins. and 4 ft. 8½ ins.

There was a heavy score mark on the top of the cross head, another on the big end cotter and a third on the connecting rod. All these marks were on the top side when the connecting rod was in the trailing position, but none of them had been caused by the parts coming in contact with each other.

The cross head was fractured at the gudgeon pin hole and the arm was broken away at the weld. The union link had broken about its mid point, one half remaining attached to the combination lever which was badly twisted, and the other half to the cross head assembly.

The right hand cylinder was discoloured from overheating and there was some longitudinal scoring and heavy ridging at the rear. The rear cover was knocked out and the piston head was severely bruised where it had come in contact with it.

The right hand leading coupling rod was bent downwards, approximately 1 ft. from the big end, and the joint pin and nut were bruised and cut by contact with the bottom flange of the connecting rod. Other parts of the motion were also damaged to a varying degree There were no visible marks or bruises on any of the engine or tender wheels.

The missing motion parts

17. An intensive search for the missing motion parts was made along the track from Carlisle to the scene of the accident and the following pieces were found: —

Mileage	*Part*
270 miles 1640 yards	One nut.
270 ,, 1640 ,,	One bolt with the split pin bent up.
270 ,, 15 ,,	One nut.
267 ,, 1560 ,,	Right hand bottom inner slide bar with the rear bolt jammed in the bolt hole.
264½ ,, (Birkett Tunnel)	Right hand front packing piece.
259¼ ,,	Right hand bottom outer slide bar.
259¼ ,,	One nut.
259¼ ,,	One bolt with the split pin sheared off.
259¼ ,,	Right hand rear packing piece.
237 ,,	SCENE OF THE ACCIDENT.

The positions where these parts were found are shown on Fig. 2. One bolt and nut are still missing.

Examination of the motion parts

18. The locomotive was sent to Crewe Works where the piston rod, slide bars, bolts and nuts were carefully examined.

(*a*) *The piston rod*

The piston rod had fractured where it entered the piston; it had bent sharply where it entered the cross head and was also bent over a distance of about 2 ft. near the piston end. The fractured face showed typical fatigue growth rings which exhibited some fibrous tearing at the ridges, indicating that the failure had been a rapid one. There were some minor marks on the surface of the rod, presumably where it had struck various other components, but none of these marks was deep enough to suggest that the rod had struck or fouled any wheels. Tests made from samples cut from an undamaged portion of the rod showed that it was up to specification in chemical analysis and tensile properties, but its resistance to the Izod impact test was lower than expected. This should not, however, be regarded as affecting the failure because the fracture showed evidence of rapid growth rather than sudden, brittle and complete failure. There seems little doubt that the piston rod broke on account of excessive vertical stresses produced by the irregular movement of the rod when the slide bars fell off and released the cross head assembly.

(*b*) *The slide bars*

The two bottom slide bars were bruised in places but these were consistent with their having struck parts of the engine when they fell on to the ballast. The bolt holes in the top and bottom bars were carefully measured; their diameters should have ranged between 1.125 ins. and 1.1275 ins. All, however, had worn beyond the maximum tolerances. The largest was the inside front hole in the top bar; its diameter was 98 thousandths of an inch greater than the high limit in the lateral direction at the bottom of the hole and 74 thousandths at the top. The respective longitudinal diameters were 49 and 37 thousandths above the maximum. Similarly the front hole of the inside bottom bar was enlarged by 60 thousandths in the lateral direction and 13 thousandths longitudinally. The other holes were not so badly worn, the next worse being the rear hole in the outside bottom bar where the excess ranged from 38 thousandths to 13 thousandths. The metal round the tops of the bolt holes in the top slide bar showed signs that the nuts had been working and the marksaround the two rear holes were more highly polished than those around the front, suggesting that the nuts on the rear bolts had been working more than the front ones.

(*c*) *The bolt found at* 270 *miles* 1640 *yards*

The shank of this bolt was almost entirely covered with a hard adherent layer of dark brown rust which had been subjected to pressure and therefore was very compact. The diameter which should have been between 1.125 ins. and 1.1275 ins. was 1.13 ins. for the first 2½ ins. from the head then there was a ridge and thereafter the diameter was only 1.08 ins. There was no steel feather in the ¼ in. diameter hole under the head and the hole contained dirt.

The thread was considerably flattened between 1¼ ins. and 2 ins. from the end of the bolt. The projecting ends of the split pin had been bent up and thread marks could be seen distinctly where the nut had cut into it when it came off. The face of the bolt head was considerably defaced by chisel marks. The metal from which it was made was found to be slightly softer than was to be expected.

(d) The bolt found at M.P. 259¼

The shank was heavily pitted and covered with dark brown compact rust except where it had been in contact with the slide bar and the slide bar packing piece. These parts were partly bright and partly pitted. As this brightness appeared all round the bolt, it suggested that the bolt had been rotating. There were two ridges running round the shank at distances of 1¼ ins. and 2½ ins. from the head and the diameters of the three portions were 1.12 ins. nearest to the head, 1.10 ins. in the middle and 1.09 ins. nearest to the thread. There was no feather in the ¼ in. diameter hole under the head.

The thread was considerably flattened on two sides. The projecting ends of the split pin had been sheared off and the face of the head was slightly defaced with chisel marks. The metal on this bolt was also slightly softer than was to be expected.

(e) The nuts

The nuts found at 270 miles 1,640 yards and 270 miles 15 yards showed marks on the thread which indicated that they had run over the split pins in the bolts. Their under side faces were polished where they had been working against the slide bars. The nut found at M.P. 259¼ was polished on its top face as well as on the bottom face, indicating that it had been turning against the split pin and also working against the slide bar. This suggests that there was some play between the nut and the split pin before the latter gave way.

The working of all the nuts against the slide bars suggests that the steel feathers in the three bolts were either missing or were so worn that the bolts were turning in the holes.

The test of the speedometer

19. The speedometer equipment was tested and found to be in good order and there were no defects. The following table shows the speeds obtained during this test, together with the figures obtained when the speedometer was tested prior to leaving Crewe Works on 2nd September, 1959 following the Heavy repairs to the locomotives: —

Standard reading m.p.h.	Reading on 2.9.59. m.p.h.	Present reading m.p.h.
95.2	97	98.5
80	82	82
71.5	72.5	73
60	61	61.5
40	41	41.2
20	20	20.2

Estimated braking distances

20. The estimated braking distances of an 8-coach train hauled by a Britannia engine on a falling gradient of 1 in 100 are: —

60 m.p.h.	710 yards
50 ,,	480 ,,
40 ,,	300 ,,
30 ,,	170 ,,
20 ,,	80 ,,
10 ,,	30 ,,

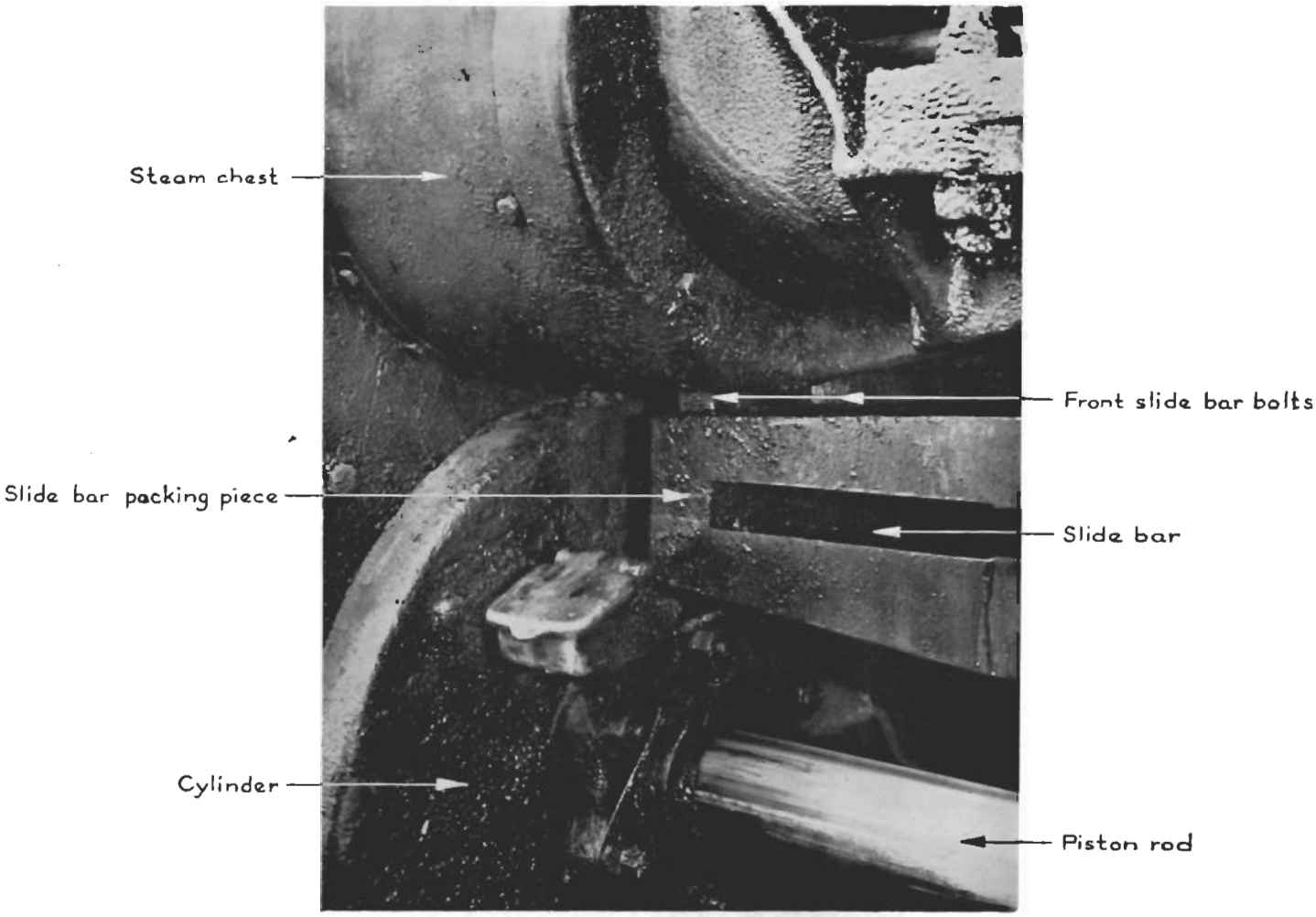
The failure of the right hand motion assembly

21. From a detailed examination of the parts of the motion which were recovered from the track, there is little doubt that the bolt which fell off first near M.P. 271, almost 34 miles from the scene of the accident, was the front inside bolt; its nut was found close by. The enlargement of the bolt hole and the condition of this bolt, covered as it was with a layer of compacted rust and worn at the end where it passed through the top slide bar, giving a play of ⅛ in. suggests that it had been working in the bolt hole for a considerable time. As the steel feather next to the head was missing and the head was defaced by chisel marks it seems clear that the bolt must have been loose in the hole for some time and that a chisel was used to hold it whilst it was tightened with a spanner; there were corresponding marks around the base of the front hole in the inside slide bar. In these circumstances it would be difficult to ensure that the bolt was properly tight.

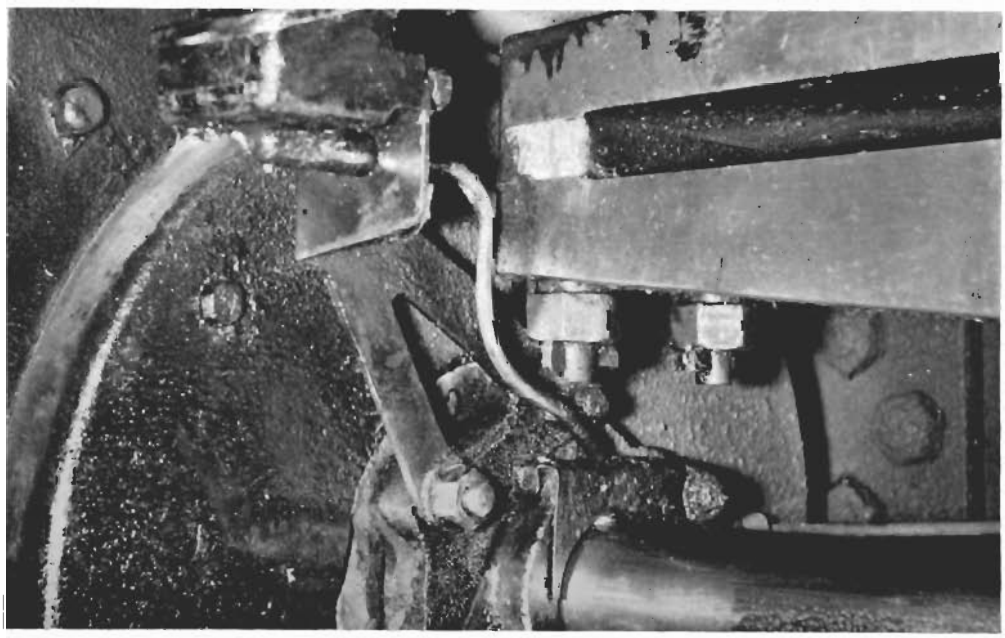
The loss of this bolt led to the loosening of the whole of the right hand slide bar assembly. The rear inside nut fell off next about a mile further on, but as the inside bottom slide bar gradually dropped down the rear bolt was bent and became jammed, thus holding up the bar for a further two miles. By this time

Photograph 1. The Britannia locomotive showing the displaced motion assembly.

Photograph 2. The Down track at point of derailment.



Photograph 3. Front end of slide bar assembly before modification



Photograph 4. Front end of slide bar assembly after modification

the excessive vibration would have loosened the nuts on the outer slide bar, and since the front packing piece fell off in Birkett Tunnel (M.P. 264½) the front outside bolt must also have fallen off in the vicinity, though it has not been found.

The outer slide bar eventually fell off at M.P. 259¼, and I have no doubt that the bolt and nut found in the vicinity came from the rear end of this bar. After this the vibration set up between the loose cross head and the top slide bar would have caused the serious knocking heard by the driver when he eased the regulator after passing the summit at Aisgill. He stopped the train at Garsdale for examination of the engine, but noticed nothing wrong.

22. On leaving Garsdale the engine was in a dangerous condition because the loss of both slide bars removed the support from the right hand cross head which was no longer held in its proper alignment. By keeping the regulator slightly open the driver reduced the knock because the steam pressure from the cylinder pushed the cross head against the top bar, but whenever the driver eased the regulator the cross head dropped away on account of its weight and the inertia of the connecting rod. Severe vertical bending stresses were applied to the piston rod which eventually fractured as the train approached M.P. 237. This failure was followed by the fracture of the union link which allowed the whole assembly to come adrift. The connecting rod, cross head and piston rod then dropped on to the ballast leaving the combination lever twisted outwards and still attached to the valve spindle cross head and with the remainder of the union link hanging from it.

When the motion assembly came adrift the connecting rod which was facing forwards lanced the cross head into the ballast. When the engine came to rest the connecting rod was found to be twisted and bent outwards in a trailing position, as shown by Photograph 1. In order to get into this position the connecting rod must have driven the cross head deep into the ballast and then "somersaulted". As the connecting rod, which is 10 ft. 8 ins. long between the big and little end centres, was bent outwards for about 4 ft., the cross head would have been driven to a depth of about 6 ft. below rail level during the overturning movement as shown by Fig. 6. It could not have turned upwards because if it had done so it would have torn away the return crank–expansion link assembly. It is remarkable that the engine was not derailed by the thrust from the connecting rod as it forced the cross head so deeply in the formation.

IV. The Damage To The Track And The Cause Of The Derailment

The damage to the track

23. The first mark made by the displaced motion assembly was on a sleeper of the Up track, 195 yards from the presumed point of derailment of the freight train as shown by Fig. 3. This was followed by more marks on the Up track sleepers and some on the Down track sleepers. The ballast was deeply disturbed some 35 yards from the first mark and 40 yards further on there was a deep hole in the six foot space. Mr. Blackburn, the District Motive Power Superintendent, who was one of the first officers to arrive on the scene, thought that this hole was at least 2 ft. below formation level; he was sure that the connecting rod somersaulted there and in doing so pushed the Down track towards the cess and made a kink of about 5 ins. A Hallade curve monument with a steel bar projecting from its centre was badly damaged at this point, and it is probable that the score marks on the cross head and small end of the connecting rod were caused by their striking this monument in the course of overturning.

Sleepers were marked and the ballast was disturbed in places from this point onwards to where the derailed freight engine stopped; after this the track was badly damaged for the next 67 yards by the derailment of the freight train. From the presumed point of derailment to within a coach length of where the express engine eventually stopped, the ballast in the 6 ft. space was disturbed for lengths of about 4 ft. at regular intervals of just over six yards corresponding closely to one revolution of the engine driving wheel. These marks no doubt were made by the cross head and were probably due to the change in velocity and angularity of the cross head relative to the ground during each revolution.

24. At the presumed point of derailment the right hand rail of the Down track (in its direction of running) was pushed outwards, as shown by Fig. 4 and Photograph 2. The cut in this rail which can be seen in the photograph was made after the accident to facilitate its removal. At point B where the rail was cut and which was 16 ft. 6 ins. from rail joint A, the inside bottom flange of the outer rail was bent downwards and flattened for a length of 18 ins. The rail was badly kinked and the inside bottom flange had undoubtedly been subjected to intense pressure by some object pressing against it. It will be noted that this rail was pushed out until it nearly reached the Up track. The fishplates at joint A were bent and those at joint C, the next one ahead, had come apart when the fishbolts sheared. The head of the facing rail at this joint was slightly battered but there were no marks on any of the rails to suggest that wheels had mounted them. The engine and the six following vehicles, however, were derailed with their right hand wheels in the 6 ft. space.

The cause of the derailment

25. Owing to the very inclement weather, with heavy snow falling continuously, and the need to get the vehicles removed and the track repaired, an accurate survey of the damaged line was not made. One cannot, therefore, be positive as to the exact cause of the derailment of the freight train. It seems clear from the marks on the tracks and ballast that the connecting rod still continued to thrash about after it overturned, and the cross head was driven hard into the ballast during each revolution of the wheel. Measurements taken on level track showed that the maximum distance of the cross head gudgeon pin nut (the extreme part of the displaced assembly) from the inside of the rail was 4 ft. 8½ ins. The Up line was, however, canted 4¾ ins. towards the Downline, and allowing for this and the speed and motion of the express engine, the cross head might well have been striking the ballast up to 5 ft. from the inside of the Up rail. In this position it would have struck the outside ends of the Down track sleepers as illustrated by Fig. 6. It might have struck the sides of a passing train, but it could not reach the rail and so derail a wheel.

I believe that as the freight engine was about to pass the express, the cross head caught some of the Down line sleepers, dislodged or broke the outside spikes and pulled the right hand rail outwards at point B. The freight engine was working heavily up the gradient with its right hand wheels bearing hard against this rail. Thus on reaching the kink in the right hand rail the leading pony wheels dropped off on to the bottom flange of the rail and burst open the track. The line had been re-laid recently with new sleepers and fastenings and it offered strong resistance. The severe buckling of the pony truck wheel and the flattening of the inside bottom flange of the right hand rail was clear evidence of the extreme pressure which was exerted. This pressure was so great that when the track gave way its parting was violent; a number of the outside elastic spikes were sheared, the fishplates at joint A were bent and the fish bolts at joint C were fractured. As will be seen in Photograph 2 the right hand rail was thrown out as far as the 6 ft. rail of the Up track – much further than the path taken up by the derailed wheels of the freight train. Having burst open joint C, the right hand engine wheels and those of the next six vehicles passed through the gap into the 6 ft. space without mounting any of the rails.

V. The Running Of The Express

26. The booked and actual times of the express are given in the following table. The actual times are taken from signal box bookings.

Mileage from St. Pancras	Place	Booked times Time p.m.	Av. speed	Actual times Time p.m.	Av. speed
414.5	Glasgow (St. Enoch)	dep. 9.5		9.5	
390.25	Kilmarnock	arr. 9.40	41.6	9.40	41.6
		dep. 9.48		9.48	
331.25	Dumfries	arr. 11.0	49.2	11.2	47.9
		dep. 11.6		11.8	
316.5	Annan	arr. 11.24	49.2	11.26	49.2
		dep. 11.30		11.32	
308	Carlisle	arr. 11.54	21.2	11.56	21.2
		a.m.		a.m.	
		dep. 12.1		12.3	
292.6	Lazonby	pass 12.22	44	12.24	44.0
277.2	Appleby West	pass 12.42	46.2	12.44	46.2
259.7	Aisgill S.B.	pass 1.10	37.5	1.10	40.4
256.7	Garsdale Stn.	arr.		1.16	30.0
		dep.		1.20	
253.3	Dent Stn. S.B.	pass		1.25	40.8
251.5	Dent Head S.B.	pass		1.27	54.0
248.5	Blea Moor S.B.	pass 1.22	56.0	1.31	45.0
247.2	Ribblehead Stn.	pass		1.32½	52.0
244.9	Selside S.B.	pass		1.36	39.4
242.5	Horton Stn.	pass		1.39	48.0
240.9	Helwith Bridge S.B.	pass		1.41	48.0
238.3	Stainforth Sidings	pass		1.45	39.0
237	Site of accident	arr.		1.48	26.0
234.5	Settle Junction	pass 1.35	64.6		

The average speed of the express from the stop at Garsdale Station to the site of the accident was 42.2 m.p.h.

Trainmen

27. Driver F. Waites, who is stationed at the Holbeck Motive Power Depot, Leeds, was in charge of Britannia Engine No. 70052. He is 60 years of age and has been a driver for 18½ years. He said that on the morning before the accident he had worked the 2.57 a.m. train from Leeds to Glasgow (St. Enoch) where he signed off duty at 10.0 a.m. He spent the day resting in the railway hostel and booked on duty at 8.15 p.m. that evening. He took charge of the Britannia engine at 8.40 p.m. when it arrived at St. Enoch Station from Corkerhill Depot. He did not examine it at that stage. The train left on time with a pilot engine in front as far as Kilmarnock. The load – 8 coaches – was light and the engine was running well. On arrival at Dumfries, the next stop after Kilmarnock, Waites walked round the engine feeling all the axle and motion bearings and examining the corks in the lubricating holes. He found nothing wrong. The train left Dumfries two minutes late, and after a stop at Annan it was still two minutes late at Carlisle where the engine was watered and the fireman attended to the coal. Speed generally had not been high though it reached a maximum of 70 m.p.h. at times.

The train was still two minutes late on leaving Carlisle but with the light load and easy timing Waites had no difficulty in handling the engine and he thought that he passed Aisgill at the top of the long rising gradient on time at about 1.10 a.m. The maximum speed on this part of the journey was about 50 m.p.h. through Appleby.

On passing the summit at about 35 m.p.h. Waites notched up the reversing lever and then became aware of a "knock" which he thought came from a big end, though he could not tell at first on which side it had developed. He shut the regulator and reduced speed, but the knocking got worse so he opened the regulator slightly and kept the speed down by applying the brake. He decided to examine the engine at the first opportunity and stopped at Garsdale. The weather at this time was bad. It was very dark, the wind was blowing at gale force and it was snowing. Waites said that he got down on the left hand side and examined the bearings with the aid of a small electric hand torch. He could see very little, but he felt all the axle box and motion bearings, paying particular attention to the big end which he thought was the cause of the trouble. Having examined the left hand side he walked round the front of the engine and examined the right hand side. He looked at the cylinder cover, felt the cross head, the big end and all the other bearings, and he examined the corks of the lubricating holes. Having completed the examination as far as the tender, he returned and examined the right hand motion again because he thought by then that the trouble was on that side. He could find nothing wrong; the bearings were cool and he did not see anything missing.

28. Having failed to find anything wrong with the engine, Waites decided to proceed at slow speed to Hellifield, 25 miles further on, where there was a small motive power depot. He said that he travelled slowly keeping the regulator slightly open and applying the brake whenever speed increased. At first he said that the speed never exceeded 20 m.p.h. and that he checked it by the speedometer, but when I told him that according to signal box timings his average speed was 42 m.p.h. from Garsdale to the site of the accident he said that the speed never exceeded 30 m.p.h. Finally, when I pointed out that he had been running down a long falling gradient with the regulator partly open, he agreed that the speed could have been well over 30 m.p.h. though he had not noticed it. He explained that the knocking did not seem to get worse except when he eased the regulator and he thought that it came from a big end bearing; he decided that his best course was to go on to Hellifield and make another examination there.

29. Continuing his account of the journey, he said that after passing the Settle Distant signal he and his fireman noticed sparks flying from the right hand side of the engine and ballast was being thrown up against the cab. Waites immediately made a full brake application and as he passed the freight train on the other track he felt his engine shuddering. He had no recollection of any violent jolt before this.

As soon as the engine stopped he examined it and found the connecting rod in the trailing position with the piston rod and cross head still attached and lying on the ballast. He walked back along the train and realising that passengers were injured he asked the guard to get first aid and then protect the train. Meanwhile Waites returned and after telling his fireman to protect the freight train he made his way as quickly as he could to Settle signal box which he reached at about 2.0 a.m. By that time the signalman had heard of the accident from the staff of the freight train and had taken action. Waites reported to the Control and told them that ambulances, doctors and the Fire Brigade were wanted. A doctor arrived very shortly and took Waites to the scene of the accident where he returned to his engine, after persuading some passengers whom he met to return to the train and await assistance.

30. Fireman J. Chester, of the Britannia engine, generally confirmed his driver's evidence. He said that the engine was working well and he had no difficulty in maintaining steam. Speed up the bank towards Aisgill was between 45 and 50 m.p.h. After passing the summit the driver "notched up" and then he noticed the knocking sound on the right hand side. The engine was stopped at Garsdale where the driver examined it, and on returning to the footplate he told Chester that he could find nothing wrong but thought that the big end might be the cause of the trouble. He decided to go on to Hellifield. The weather was very bad with a high wind blowing and snow falling. Chester thought that the speed from

Garsdale onwards varied from 12 to 20 m.p.h. and when I pointed out to him that it must have been much higher he said that whenever the engine gathered speed the driver applied the brake and reduced it to 20 m.p.h. In fact he kept taking the brake on and off while keeping the regulator open the whole time.

On approaching the scene of the accident, Chester saw sparks flying from the front of the engine on the right hand side and the ballast was thrown up from the formation. He immediately told his driver who made a full brake application. Chester did not see the approaching freight train but he felt the engine shuddering badly directly after the brakes were applied. He got off the footplate as soon as the train stopped and he saw the displaced connecting rod lying in the trailing position. After this he protected the train and then returned to the engine.

31. Guard W. C. Bird, of the express, said that the train stopped for about three minutes at Garsdale and when his van eventually passed the signal box the signalman called out that the engine was knocking. The train's speed remained steady and Bird thought that it did not exceed 20 m.p.h. The driver was continually applying the brakes whenever the train gathered speed. Bird did not remember feeling any additional brake application just before the accident. After advising the passengers to remain in their compartments he went back three quarters of a mile to protect the train and on his return he went to the signal box.

32. Driver G. Stewart, who was in charge of the freight engine, said that the train passed through Settle Station about 45 minutes late. It was travelling at about 20 m.p.h., the regulator was fully open and the engine was working hard up the steep gradient. Shortly afterwards his fireman called out "I think we have struck something" and the engine started to lurch and rolled over towards the right. It shuddered and then stopped quickly, but Stewart did not feel any bumps or bangs such as might have been caused from running over an obstruction on the rail. The whole incident was over so quickly that he did not have time to close the regulator or apply the brake. He did not notice the train on the adjoining track because the cab was filled with steam from some connection which had given way. After the accident his fireman went back to protect the freight train while he met the guard of the express and asked him to protect his train. After this Stewart returned to his engine.

33. Fireman J. M. Graham of the freight train engine said that the train ran through Settle at about 20 m.p.h.; the engine was pulling well with the regulator fully open. About half a mile north of the station he was looking out of the right hand cab window when he saw the express approaching. Immediately afterwards he saw sparks directly in line with his engine and he threw himself across the footplate and shouted to his driver to look out. At the same time he heard a big bang, the engine lurched and rocked about and the cab was filled with steam. Immediately the train stopped Graham alighted and saw that the engine and about five vehicles were derailed. He went back to find the guard who was sitting beside the track bleeding badly, but as he was capable of walking he told him to make his way to the signal box to get first aid. Graham ran on ahead and on reaching the box he told the signalman to stop all trains and get ambulances and doctors because the express appeared to be badly damaged. He then collected a lamp and detonators and went back as far as the Distant signal to protect his train.

34. Goods Guard F. G. Atkinson of the freight train was unable to attend my Inquiry on account of his injuries, but in a written statement he confirmed that the freight train went through Settle in a normal manner and shortly afterwards it came to a violent halt. Atkinson was thrown across the cab and received injuries to his head and face. He got down with the object of protecting the train, but the fireman arrived and went on ahead to give the alarm.

Signalmen

35. Signalman E. Ashton, who was on duty in Garsdale box, said that he received "Train Entering Section" for the Up express at 1.11 a.m. and it arrived at 1.16 a.m. though it was not booked to stop. The engine was about 90 yards away but he was able to see through the falling snow that a man with a torch was walking round it. After a few minutes the train started again, and as the engine passed the box, which was on the Down side, Ashton saw the driver and fireman looking out as if they were trying to locate a loud knock which Ashton heard distinctly. He thought that they might have asked him to send a message to Hellifield for assistance, but neither said anything though he shouted to the driver "She is knocking badly". The train left at 1.20 a.m. and he received "Out of Section" at 1.26 a.m. from Dent Station. Normally express trains took only three minutes to cover this distance.

36. Signalman J. W. Wilson, who was in charge of Stainforth sidings box near Settle, said that he received "Train Entering Section" for the Up express at 1.41 a.m. and it passed at 1.45 a.m. travelling at about 30 m.p.h. The normal running time was about three minutes. He watched the train approach and noticed that the brakes were applied because sparks were coming from the wheels for the full length of the train. He did not notice anything wrong with the engine nor did he hear any knocking, but the windows of the signal box were closed on account of the weather.

He accepted the freight train on the Down line at 1.41 a.m. and he received "Train Entering Section" from Settle Station at 1.45 a.m. A few minutes later the Settle signalman telephoned to say that

the freight train had stopped in section and he enquired about the running of the Up express. Wilson received the "Obstruction Danger" signal at 1.56 a.m. and immediately protected the Up line by placing detonators on it.

37. Signalman A. Bullock, of Settle Station box, said that he received "Train Entering Section" for the Down freight train at 1.42 a.m. and it passed the box at 1.46 a.m. The engine was pulling well and the speed was at least 30 m.p.h. He received "Train Entering Section" for the Up express at 1.45 a.m., and at 1.48 a.m. he noticed its headlights and realised that the express had stopped some way up the line. He also saw the tail lights of the Down freight which did not disappear as usual. Bullock could not understand what had happened, so he telephoned to the Stainforth signalman who told him that the express had passed, but it was not travelling as fast as usual. At 1.56 a.m. the fireman of the freight train arrived and told him to stop traffic on both roads because his train had hit the express. Bullock sent "Obstruction Danger", contacted Control and asked Hellifield South box to call ambulances, doctors, Fire Services, etc. Assistance arrived very quickly and a doctor came to the box and attended to the guard to whom Bullock had given first aid a few minutes earlier.

38. None of the signalmen in the other boxes between Garsdale and Settle Station noticed anything wrong with the running of the express nor did they hear any knocking.

Other witnesses

39. Shed Master M. Cowley, who was in charge of the Hellifield Motive Power Depot, said that he arrived at the scene of the accident about 4.0 a.m. He examined the Britannia engine and saw that the right hand piston rod had broken away from the piston but it was still attached through the cross head to the connecting rod The whole assembly was lying in the trailing position with the piston and cross head on the ballast. The connecting rod was twisted and the piston rod was bent as shown by Photograph 1 which was taken in Hellifield Depot after the engine had been hauled there and the displaced motion had been re-assembled. The right hand back cylinder cover was broken and the two bottom slide bars were missing. The right hand return crank arm and the rod connecting it to the expansion link were still in position.

After inspecting the engine Mr. Cowley examined the rest of the train and decided that it and the engine could be moved together so as to allow breakdown cranes to get in position for lifting the derailed vehicles of the freight train. The displaced motion of the express engine was therefore dismantled, but it was replaced as soon as the engine reached Hellifield. Mr. Cowley also examined the freight engine after it had been removed; he gauged the pony wheels and found them to be 1½ ins. out of true (later checked and found to be 1¼ ins.). There were marks on the wheels as if they had struck some object.

The Down track at the site of the derailment was badly damaged, and Mr. Cowley thought that some object, probably the connecting rod, had hit the ends of the sleepers and pulled the track out of gauge. There were marks in the ballast of the 6 ft. way where some heavy object had been hitting it and there was one particularly deep hole some yards on the Carlisle side of the derailment. At this point the track had been pushed inwards.

40. Examining Fitter G. A. Neil, of Polmadie Motive Power Depot, whom I saw at Glasgow, said that on the night of the 17/18th January he examined Britannia Engine No. 70052 and found the right hand inside front slide bar bolt was loose and he made out a repair card. He explained that he tested the bolts for tightness by tapping them with a hammer and he had no difficulty in picking out a loose one though it was difficult to test the front inside bolt.

41. Fitter J. Aitkenhead, of Polmadie Motive Power Depot, whom I also saw at Glasgow, said that on the morning of 18th January he was instructed to tighten the right hand front slide bar bolts of Britannia Engine No. 70052. He found the outside bolt was tight but the inside bolt was about half a turn loose. He used a thin spanner to tighten it but he did not replace the split pin, which he said was in good condition.

42. Examining Fitter C. Warriner, of Holbeck Motive Power Depot, said that he examined Britannia Engine No. 70052 when it arrived in the depot on the night of 19/20th January. He found the right hand inside front slide bar bolt was loose and there was a slight gap between the packing piece and the bottom bar. The outside front bolt and both rear bolts appeared to be tight when he tapped them with a hammer which was the normal method of testing. He made out a repair card for this and other minor defects. He said that the slide bar bolts of Britannia engines sometimes worked loose and that trouble was almost always confined to the front bolts. He explained that they were difficult to reach on account of the cylinder lagging and a thin spanner had to be used to tighten the inner one, and this was not satisfactory. He agreed that the bolt found at 270 miles 1640 yards had been working in the hole and should have been renewed.

43. Fitter E. J. Sadler, of Holbeck Motive Power Depot, said that on the morning of 20th January he attended to Britannia Engine No. 70052. Amongst other items requiring his attention were the right hand front slide bar bolts. The inside one was loose and the bottom bar had dropped about 1/64th in. He tightened the bolt with a thin spanner and he used a 4 lbs. hammer to tap it. He put the spanner on three times and moved the nut about one third of a turn. He did not renew the split pin and he agreed that as he had tightened the nut by 1/64th in. the split pin could no longer be bearing against the head

of the nut. He also agreed that it was difficult to tighten the inside front bolt which was hard to reach. He did not attend to the rear bolts.

44. Examining Fitter H. A. Wallach, of Corkerhill Depot, whom I saw at Glasgow, stated that he examined Britannia Engine No. 70052 on the evening of 20th January and found no faults to report as the engine was, according to him, in perfect mechanical condition.

45. Permanent Way Inspector J. W. Walton gave evidence about the condition of the track which is described in paragraphs 23 and 24, and about the finding of the missing motion parts, details of which are given in paragraph 17. This information was also based on additional checks made by the District Officers because at one time there was some doubt about the actual places where the individual pieces were found.

Conclusions, Remarks and Recommendations

46. The circumstances of this accident were remarkable. It was initiated by the failure of the motion of a modern express engine which led eventually to part of the motion assembly coming adrift and causing the derailment of the engine and leading vehicles of a freight train on an adjoining line. The engine of that train struck and ripped open the sides of the coaches of the express and caused serious casualties to the passengers.

The failure arose from a slide bar of the Britannia engine falling off some 30 miles from the scene of the accident, followed by a second one, 8 miles further on. The "knocking" of the motion assembly produced by the loss of these bars was heard by the driver who stopped at Garsdale, 2 miles further on, to examine the engine. He did not notice the loss and having failed to locate the trouble he decided to continue the journey. Consequently the engine ran in this dangerous condition for 20 miles before the right hand piston rod, cross head and connecting rod came adrift. The train was travelling at about 45 m.p.h. and the displaced motion assembly was driven deep into the formation, so much so that it penetrated to a depth of about 6 ft. below rail level and then "somersaulted" into the trailing position as shown by Photograph 1. This occurred on an embankment where the formation was comparatively soft; otherwise the violent thrust must surely have derailed the express engine possibly with even more serious consequences. Considering the force needed to twist the connecting rod during its overturning it is indeed remarkable that the engine stayed on the track. Finally the derailment of the freight train was most unusual and resulted from the displaced cross head pulling so hard against a newly laid track that it displaced one rail sufficiently for the leading wheels of the freight engine to drop into the four-foot space. These wheels exerted such a heavy and immediate pressure on the track that it was burst open violently for a rail length and thus allowed the engines and leading vehicles of the freight train to veer towards the opposite line.

47. The failure of the right hand motion assembly of the Britannia locomotive was undoubtedly initiated by the loosening of the right hand front inside slide bar bolt as explained in paragraph 21. This bolt had been found loose at Polmadie Depot, Glasgow, on the night of 17/18th January and again at Holbeck Depot, Leeds, on the night of 19/20th January. On each occasion it had been tightened but the split pin had not been taken out and replaced nor had a washer been inserted under the nut to bring it properly in contact with the split pin. On two other recent occasions, namely on 14th January 1960 and 31st December 1959 the front bolts had also been loose and had been tightened. Altogether the right hand bolts had been reported loose nine times and the left hand bolts once since the engine returned to service on 26th September 1959 after receiving a heavy overhaul at Crewe Works. There is no record, however, of any of the bolts having been changed though the two right hand front bolts which were recovered were so badly worn that they should not have been allowed to continue in service.

The right hand motion of this engine was in a potentially dangerous condition when the engine left Glasgow on its last journey and this was due to insufficient attention having been paid to the tightening of the front slide bar bolts which were not easy to reach and were difficult to tighten. I do not, however, propose to make particular reference to the individual staff concerned for the reasons given later in this report.

48. In considering the failure of Driver Waites to notice the loss of the slide bars at Garsdale, allowance must be made for the weather. The conditions under which he examined his engine could hardly have been worse – it was dark and a blizzard with winds of gale force was sweeping the area. It is understandable, therefore, that he failed to notice the missing slide bars, especially as his attention was concentrated primarily on looking for a hot bearing which is a usual cause of engines' knocking. In view of these circumstances I do not criticise him for this.

49. Having failed to find anything wrong at Garsdale, Waites decided to continue the journey to Hellifield where there is a Motive Power Depot. In view of the late hour of the night, the inclement weather and the exposed position of the train, this decision was a reasonable one but Waites should have

sent a message to the Shedmaster advising him of the trouble and he should have travelled very cautiously. Although both Waites and his fireman said at first that the speed never exceeded 20 m.p.h. the timings of the express as taken from the signal box bookings show that the average speed from Garsdale to the scene of the accident was over 42 m.p.h. Signal box bookings may vary by about one minute either way, but after making full allowance for this, the average is still over 39 m.p.h. Furthermore, the train travelled for about 460 yards from the place where the displaced motion first struck the ballast, and after allowing time for the drivers' reaction to the emergency I estimate that the speed at that moment was about 45 m.p.h. based on the braking distance given in paragraph 20.

The engine had continued to knock after leaving Garsdale and it should have been clear to Driver Waites that something was seriously wrong. In these circumstances it was his duty to exercise extreme caution and he should have travelled very much slower than he did. He must, therefore, bear some measure of responsibility. He does not seem to have appreciated how quickly a powerful engine can gain speed with a light load on a steep falling gradient, and I believe that in his anxiety to reduce the knocking by keeping the regulator open he failed to keep his engine sufficiently in check with the brake. A test of the speedometer proved that it was registering to an accuracy of between 2 and 3 per cent and accordingly Waites could not have paid much attention to it.

50. The difficulty of keeping bolts tight on railway engines arises from the vibration produced by steel wheels running on steel rails and this is accentuated by wheel slip which often occurs on starting and sometimes on rising gradients when extra power is applied. The constant reversal of stresses in motion slide bars presents an even greater problem in keeping these bolts tight. These connections should, therefore, be designed to resist these vibrations and to be easily accessible for examination and tightening. The way in which the nut of the inside front slide bar bolt of the Britannia engine bent its split pin upwards and then cut a thread in it shows how severe are the forces applied to such connections once they become loose.

51. As previously mentioned, loose slide bar bolts had been a frequent occurrence on this Britannia engine. On nine occasions in less than four months the right hand bolts had been reported loose and on one occasion a left hand front bolt was found to be missing and the rear bolts very loose. This type of defect had not been confined to this engine but had been common to the Britannia class, although the numbers of incidents per engine had varied widely. Of even more significance have been the previous failures of Britannia engines from slide bars becoming displaced or falling off. Four have occurred in the last two years, but none had serious consequences.

52. These troubles have been due to the failure of the maintenance staff concerned to tighten these bolts properly when they were reported loose and to ensure that the split pins were always bearing correctly against the tops of the nuts, but, as can be seen from Fig. 7 and Photograph 3 the front bolts which were inserted from the bottom came so close to the steam chest lagging that the nuts were difficult to reach. Following the second of the four failures this difficulty was recognised, particular attention was paid to the examination of the bolts, and a new design was prepared for the front fastening. The bolts were reversed, the nuts were lengthened and the round split pins were replaced by substantial split cotters, as shown by Fig. 9 and Photograph 4. On 11th March 1959 all Regions were advised of the modification, and on 28th August 1959, following the fourth failure, the Chief Mechanical and Electrical Engineer of the London Midland Region issued orders that this alteration was to be carried out whenever Britannia engines in that Region were sent to the repair shops for periodical overhaul. Only four had been modified at the time of the accident. It is satisfactory to record, however, that all 55 engines of the Britannia class and 10 engines of Class 6 which have similar slide bar fastenings have now been modified.

The motion gear of the Class 5 and Class 9 engines is also of similar design, but examination of the engine repair cards show that they have not been prone to the same trouble. Nevertheless the Commission have issued orders that the front slide bar bolt assembly of all these engines shall be altered when they are next in shops for periodical overhaul.

53. In view of the vibration and stresses to which engine bolts are subjected, the provision of efficient locking devices is essential. I am informed that many locking nuts of various types have been tried, but none has been found satisfactory to stand up to these severe stresses. Consequently, reliance is placed on the use of substantial fastenings properly tightened and held from loosening by carefully fitted pins or cotters. It is most important, therefore, that these fastenings are easily accessible and I recommend that special attention be paid to this feature in the design of future locomotives of all types, both diesel and electric.

54. Difficulty in reaching such parts can lead to slack maintenance as has been exemplified by this accident and the investigations which have followed it. These have shown that the standard of maintenance of the motion of Britannia engines had not been satisfactory in a number of depots, and that failure to tighten bolts properly had not been confined to the depots under reference. I therefore recommend that the facts of this case be brought to the notice of all the Motive Power maintenance staff concerned and that special steps be taken to ensure that proper attention is paid to the security of fastenings on which so much of the safety of the engine depends.

55. It has been suggested that engines should carry a record of previous faults as an aid to drivers and maintenance staff. This is worthy of consideration but I doubt whether it is practicable. Steam engines constantly develop minor faults which are reported by drivers or are noted on the daily examination. These faults are recorded on cards prepared at the depots where the engines are examined and the faults put right, and the cards are then sent to the home depot. To carry on each engine a duplicate set of cards filled with a mass of information about defects of all kinds would, I believe, confuse rather than help drivers. The periodical examination of repair cards is the task of the home depot staff whose duty it is to draw attention to constantly recurring faults. In this case the trouble with the slide bar bolts of the Britannia Class engine was known and the remedy had been found, but prompt action had not been taken to apply it.

56. Finally, I would draw attention to a much more satisfactory feature. It is gratifying to record the speed and efficiency with which the emergency services, both railway and local, came into action in the early hours of the morning despite the adverse conditions. The train crew took prompt steps to advise the Settle Station signalman of the accident and he lost no time in calling for assistance. Despite snow-covered roads and a raging blizzard the response was most prompt and effective. The first ambulance reached the site less than 10 minutes after receiving the call for assistance. The first doctor arrived 5 minutes later; other rescue workers including Police and Fire Services, were soon on the scene, and all the injured passengers had received first aid and were on their way to hospital less than an hour after the accident. Later the uninjured passengers were given every assistance by the Settle Station staff. These excellent arrangements reflect the greatest credit on all concerned and demonstrate the close liaison which must have existed between the railway and the local authorities.

I have the honour to be,

Sir,

Your obedient Servant,

C. A. LANGLEY,

Brigadier.

The Secretary,

Ministry of Transport.

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LONDON MIDLAND REGION

ACCIDENT AT SETTLE

21st. JANUARY, 1960

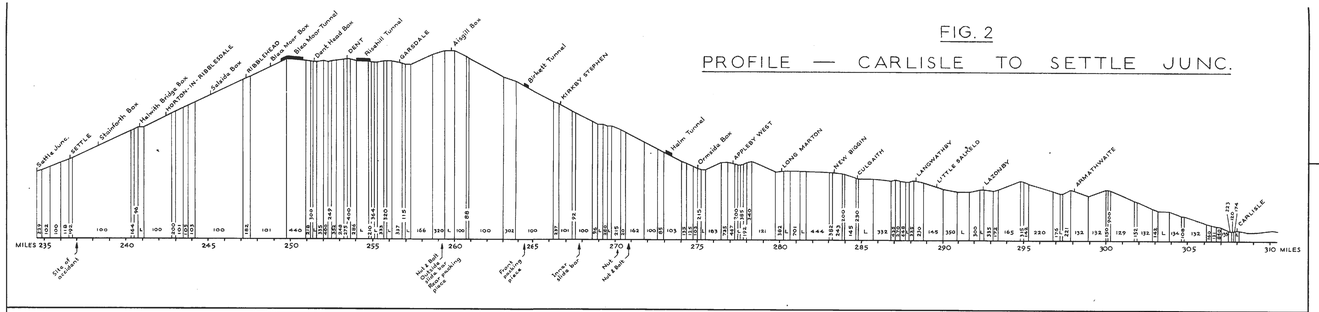


FIG. 2

PROFILE — CARLISLE TO SETTLE JUNC.

SCALE: 8 FEET TO 1 INCH

FIG. 4

THE DOWN TRACK AT PLACE OF DERAILMENT

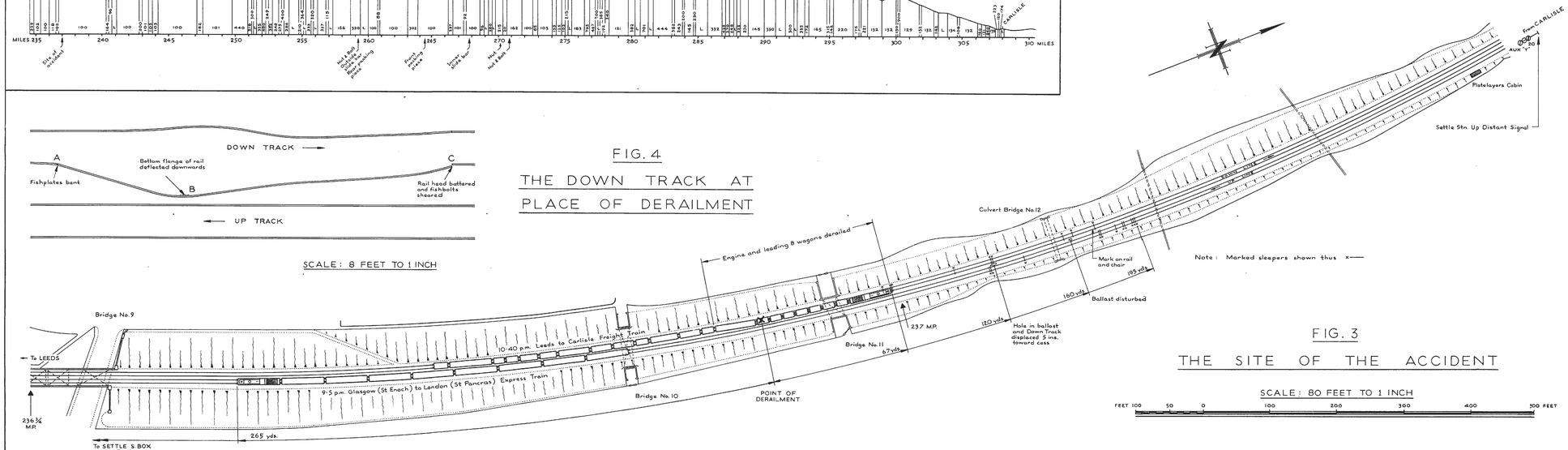


FIG. 3

THE SITE OF THE ACCIDENT

SCALE: 80 FEET TO 1 INCH

FEET 100 50 0 100 200 300 400 500 FEET

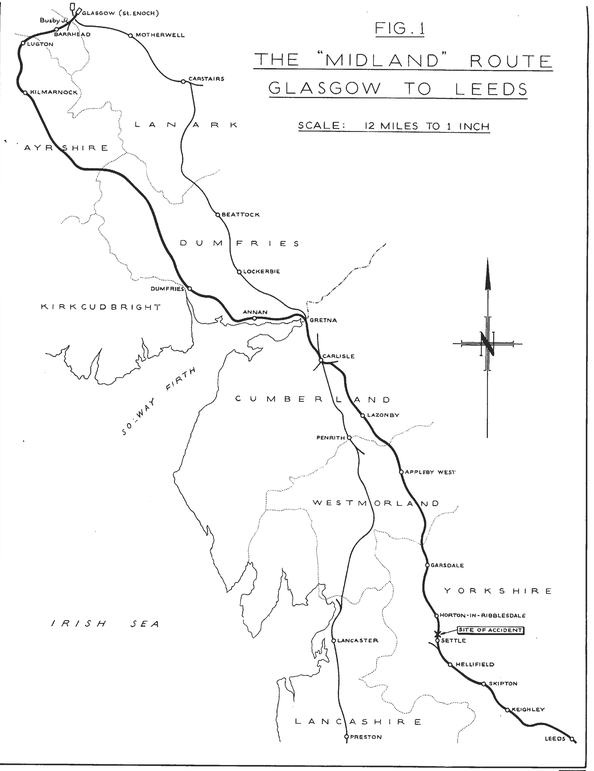


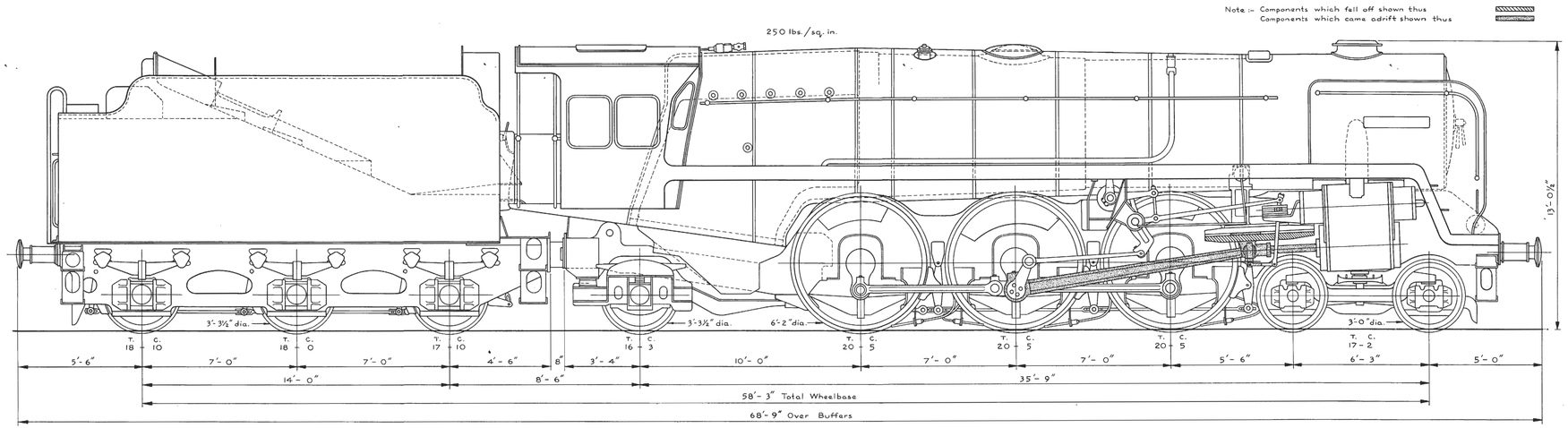
FIG. 1

THE "MIDLAND" ROUTE GLASGOW TO LEEDS

SCALE: 12 MILES TO 1 INCH

FIG. 5 ENGINE DIAGRAM — BRITANNIA CLASS 7 LOCOMOTIVE — No 70052

SCALE ⅜ INCH TO 1 FOOT



DESCRIPTION

Boiler	Barrel diameter (outside) 5'-9" increasing to 6'-5½"
Firebox	Outside firebox 7'-0" x 7'-9" to 7'-4" wide
Tubes	Large tubes 40, 5¼" outside dia. x 7 S.W.G. Small tubes 136, 2⅛" outside dia. x 11 S.W.G. Superheater elements, 1⅝" outside dia. x 9 S.W.G. } Length between tubeplates — 17'-0"
Heating Surfaces	Tubes 2264 Sq. Ft. Firebox 210 " " Superheater 677 " " } Total evaporative 2474 Sq. Ft.
Grate Area	42 " "

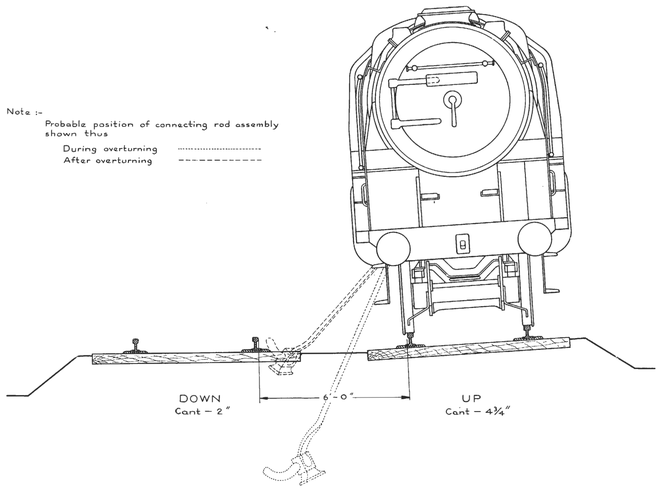
Cylinders	Two — 20" x 28"
Tractive effort	32,150 lbs.
Adhesion factor	4·23
Brake % Engine & Tender	51·7
Radius of minimum curve	6 chains (4½ chains dead slow)
Boiler Type	BR 1
Tender Type	BR 1 D

WEIGHTS

	Engine T. C. Q.	Tender T. C. Q.	Total T. C. Q.
Light	85 - 3 - 0	24 - 8 - 0	109 - 11 - 0
Loaded	94 - 0 - 0	54 - 10 - 0	148 - 10 - 0

Tender Capacity: Coal — 9 Tons; Water — 4,725 gals.

FIG. 6



END VIEW OF BRITANNIA LOCOMOTIVE ON THE TRACK AT THE SCENE OF THE ACCIDENT

SCALE: ⅜ INCH TO 1 FOOT

Valve spindle crosshead
Steam chest
Valve spindle
Radius rod
Top slide bar (one)
Rear slide bar bolt
Rear slide bar packing piece
Front slide bar bolt
Expansion link
2½"
2'-0"
3¼"
2'-9¼"
Connecting rod big end
2'-4"
Connecting rod
Piston crosshead
Bottom slide bar (two)
Front side bar packing piece
Cylinder
Gudgeon pin
3½"
Piston rod
Piston head
Combination lever
Connecting rod small end
Coupling rod - trailing
Return crank rod
Coupling rod - leading
Crosshead arm
Union link
Driving crank pin
10'-8"
Driving coupled wheel
6'-2" dia.
Leading coupled wheel
Trailing bogie wheel
3'-0" dia.
Leading bogie wheel

FIG. 7 BRITANNIA CLASS 7 LOCOMOTIVE No. 70052 — DETAIL OF RIGHT HAND MOTION

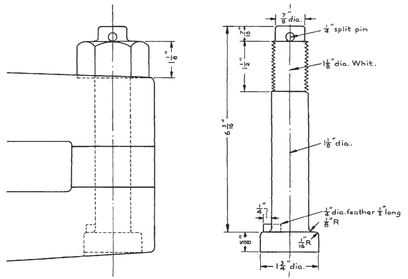


FIG. 8
FRONT SLIDE BAR BOLT BEFORE MODIFICATION

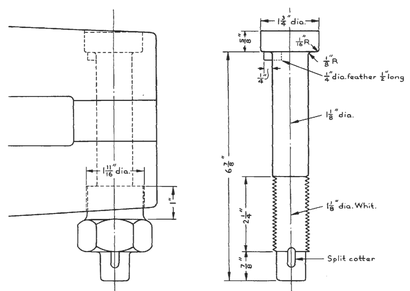


FIG. 9
FRONT SLIDE BAR BOLT AFTER MODIFICATION