# INTERSTATE COMMERCE COMMISSION

## REPORT OF THE DIRECTOR OF THE BUREAU OF SAFETY IN RE INVESTIGATION OF AN ACCIDENT WHICH OCCURRED ON THE PENNSYLVANIA RAILROAD NEAR DELAIR JUNCTION, N J, ON APRIL 8, 1926

SEPTEMBER 11, 1926

*To the Commission*

On April 8, 1926, there was a derailment of a passenger train on the Pennsylvania Railroad near Delair Junction, N J, which resulted in the death of 1 passenger and 2 employees, and the injury of 170 passengers and 1 employee The investigation of this accident was made in conjunction with the representatives of the New Jersey Board of Public Utility Commissioners

### LOCATION AND METHOD OF OPERATION

This accident occurred upon what is known as the Morris branch of the Camden terminal division, a single-track line extending between MB block station on the Trenton division, and DY block station, on the Atlantic division a distance of 0 76 mile, train movements being governed by interlocking signals The direction of this branch is north and south, and the accident occurred near its southern end where it connects with the tracks of the Atlantic division Approaching this point from the north there is a short tangent a curve to the right and then a curve of 12° 30′ to the left to the connection with the Atlantic division tracks The grade is 0 8 per cent ascending for southbound trains until the last-mentioned curve is reached and is then 2 per cent ascending

This track is laid with 100-pound rails which are 60 feet in length with the exception of one 30-foot rail on the high side of the curve, with an average of 32 treated ties to each 60-foot rail length The track is fully tie-plated, double-spiked on the inside and single-spiked on the outside, and is reinforced with six iron tie-rods for each 60-foot rail length is ballasted with cinders On the curve the gauge is maintained at 4 feet 9 inches and the superelevation at 3½ inches

The weather was clear at the time of the accident, which occurred at about 5 28 p m

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## DESCRIPTION

Southbound passenger train No. 1077 consisted of nine Pullman cars, hauled by engine 51, and was in charge of Conductor Faser and Engineman O'Connor. It passed MB block station at 5.27 p. m., about 12 minutes late, entered on the Morris branch, and was derailed about 1 minute later while traveling at a speed variously estimated by the employees to have been from 30 to 45 miles an hour.

The engine and first four cars were entirely derailed, the engine coming to rest on its right side on the outside of the curve about 120 feet beyond the point of derailment. The first car in the train, a steel-underframe car with a wooden superstructure sheathed with steel, had its superstructure nearly demolished. The second car was partly overturned, while the head end of the third car came to rest about opposite the head end of the engine; the superstructures of these two cars were considerably damaged. The employees killed were the engineman and fireman.

## SUMMARY OF EVIDENCE

Conductor Faser said he was riding in the fourth car of the train at the time of the accident and that the first knowledge he had of anything wrong was when the car gave a lurch at the time the derailment occurred. He did not think the speed was excessive, saying it was about 30 miles an hour and that it was necessary to run at that speed, considering the size of the train and type of engine, in order to reach the tracks of the Atlantic division without stalling. Conductor Faser did not make any examination of the track after the accident. Baggagemaster Lomberk estimated the speed to have been 30 or 35 miles an hour when passing MB block station, which he thought was about the usual speed, and he did not think this rate of speed was changed between that point and the point of derailment. The statements of Brakeman Sinisi brought out no additional facts of importance.

Operator Green, on duty at MB block station, said that trains usually observed the speed restriction of 30 miles an hour through the crossover leading from the Trenton division to the Morris branch, but he estimated the speed of train No. 1077 while making this movement to have been at least 45 miles an hour.

Operator Bauer, on duty at DY block station, said Operator Green reported train No. 1077 as passing MB block station and that he was watching for it as it approached. Just after it passed over a crossing known as De Rousse Avenue the head end of the engine seemed to dip downward while the rear end seemed to raise upward he at once began to summon assistance and did not observe the derailment of the balance of the train Operator Bauer thought train No 1077 had consumed about the usual running time from MB block station to the point of derailment and estimated its speed at the time of derailment to have been about 30 miles an hour

Section Foreman Sambucci, in charge of the section on which the accident occurred said that his attention was directed to the train by the way the engine was working steam, that he was watching the train when the accident occurred, and that the engine was the first to be derailed

Supervisor of Track Heyl said he reached the scene of the accident about 20 or 25 minutes after its occurrence and made an examination of the track before any of the equipment had been moved The first marks appeared on the outside of the high rail, but he was unable to say whether they were wheel marks or whether they had been made by something dragging, these were on the north side of the De Rousse Avenue crossing On the south side of the crossing he found a broken rail on the high side of the curve, this being the 30-foot rail, and from that point southward the track was quite badly torn up He found no marks on the ties or roadbed north of the broken rail with the exception of those previously mentioned, and these he succeeded in tracing to where the rear end of the second car came to rest The break in the 30-foot rail was located at a point 29½ feet south of the road crossing and 3 feet 10 inches from the leaving end of the rail There was also another break in this rail about 6 inches from its leaving end Mr Heyl also found that the next rail to the south on the high side of the curve had been broken in two places but these breaks apparently had been due to the occurrence of the accident and he said he thought the derailment occurred at the break in the 30-foot rail located 3 feet 10 inches from its leaving end

The commission's inspectors made a careful examination of the track at the point of accident and of the broken rails involved, and also carefully examined the engine and derailed cars The evidence as a whole indicated that the accident was due to a broken rail and an examination for the purpose of ascertaining the reason for the failure of the rail was made by Mr James E Howard, engineer physicist whose report immediately follows

## REPORT OF THE ENGINEER-PHYSICIST

The derailment of train No 1077, near Delair Junction N J , on April 8 1926 was due to a broken rail, the high rail of a 12½° curve The fracture which appeared to precipitate the derailment was at the leaving end of a 100-pound rail rolled by the Cambria Steel Co and branded "Cambria 100 lbs No 520 1902 IIIII"

There was a preexisting bolt-hole fracture in this end of the rail which separated the web, extending from the end of the rail to the second bolt hole. This fracture bifurcated between the first and second bolt holes, the branches of which extended obliquely upward and downward, respectively, and thus effected the complete fracture of the rail. This extension of the preexisting bolt-hole fracture in which the entire cross section of the rail was broken and a piece of the head detached, is believed to have been the immediate cause of the accident.

There were other fractures in this rail and in the next one beyond which were incident to the circumstances attending the derailment.

The continuity of the track was interrupted and a gap 6 inches long made by a fragment of the head of the rail being detached directly over the preexisting bolt-hole fracture. In the formation of this gap in the track it is believed that two trains were involved—extra No. 3740, which preceded No. 1077 nine minutes, and the derailed train. All the evidence available supports this explanation of the proximate cause of the accident. The character of the fracture was such that the electric-signal circuit was not affected by it, the bond wires spanning the gap.

Before entering upon a detailed description of the fractures displayed by the two rails involved in this accident reference will be made to events which transpired at the time of the derailment, as they were established by the testimony of witnesses.

The speed of the derailed train was the subject of early consideration. The conductor of the train and the operator of DY tower both estimated the speed at 30 miles per hour. The conductor noted the speed of his train shortly before the derailment, and the operator at DY tower noted its speed from a distance of about 700 feet. He was looking for the approach of the train, saw it enter upon the 12½° curve, and noted the peculiar behavior of the engine, its downward pitch, in the early stages of the derailment.

The position of the engine after the derailment leads to the inference that the train had not been moving at a high rate of speed. It came to rest 120 feet from the point of derailment. Even in this short distance it was in part impelled by the momentum of the train. The battering impulse which it received was shown by the buckled plates of the rear end of the tender. It was stated that a speed of about 30 miles per hour was necessary at times to avoid stalling the train on the curve. Apparently the engineman was maintaining substantially that rate of speed at the time of the derailment.

The Cambria rail displayed a composite fracture, 3 feet 10 inches from its leaving end. This fracture was examined by the supervisor of track, who arrived on the scene about 20 to 25 minutes after the accident occurred, and described it as new and bright.

The track structure of this curve was of superior construction. Excepting the bolt-hole fracture, it offered no explanation for the derailment. Bolt-hole fractures are progressive, the result of successive blows of the web of the rail against the shanks of the track bolts. High speeds intensify track stresses in general. Bolt-hole fractures are not specially influenced by them.

The downward plunge of the engine of train No. 1077, witnessed by the operator at DY tower, is significant. It is taken to indicate the breaking down of an already weakened track. There were oblique marks across the heads of the adjacent rails at the 6-inch gap, with a battering effect on the receiving end of the second rail. These marks were distinct, but not deep. They were tangent to the curvature of the track, and were doubtless made before the driving wheels of the derailed engine reached the gap, fixing their formation upon the pony truck of the engine.

It is highly probable that train, extra 3740, which passed over the track nine minutes before train 1077, completed the fracture of the Cambria rail, but left the 6-inch piece of the head in place between the splice bars, and which was joggled out on the approach of the derailed train, thus precipitating the accident. In leaving the track the derailed train broke the Cambria rail 3 feet 10 inches from its leaving end and bent and broke the rail next beyond at its receiving end. Through this opening the train left the track, tearing up about 120 feet of it. With the exception of the bolt-hole fracture and its bifurcated extension, it is believed that all other fractures were secondary in their occurrence and incident to the circumstances attending the derailment.

The Cambria rail, a Bessemer rail, had the following chemical composition:

| | Carbon | Manganese | Silicon | Sulphur | Phosphorus |
|---|---|---|---|---|---|
| O location | 0.580 | 0.95 | 0.056 | 0.050 | 0.100 |
| M location | .545 | .94 | .056 | .047 | .092 |

A sulphur print showed uniform metal throughout its cross section. Its microstructure exhibited well-defined pearlite grains with boundaries of ferrite—normal structure for steel of its composition. This rail had a length of 30 feet. Other rails of the curve were 60 feet long each. The Cambria rail was cut to this shorter length to accommodate an insulated joint for signal purposes.

The next rail beyond the Cambria rail was rolled by the Pennsylvania Steel Co. in 1897, and was branded "96 P. S. Co. 97." This and other rails in the vicinity were relaid in 1921.

Figure No 2 shows the appearance of the leaving end of the Cambria rail and the receiving end of the P S Co rail A bolt-hole fracture had separated the metal of the web of the Cambria rail on each side of the first bolt hole This part of the fracture was of earlier origin It presented a darkened and somewhat battered surface The fracture bifurcated between the bolt holes with branches extending upward and downward respectively, thus completing the fracture of the rail The surfaces of these branches showed fresh breaks Their formation is attributed to the train which immediately preceded train No 1077

A fine crack will be noticed extending obliquely downward from the root of the bifurcated fracture to the second bolt hole This crack further indicated the existence of a fracture in the web prior to the present accident No force acting simultaneous with or subsequent to that which caused the bifurcated fracture can be conceived which would account for the presence of this fine crack

The 6-inch gap in the track is also indicated by Figure No 2 The fragment which filled the gap was not recovered Oblique marks, previously referred to, were shown on the heads of these two rails, in alignment with each other The receiving end of the P S Co rail was slightly battered These marks tangent to the curvature of the track, were doubtless made by the derailed train and prior to the general breaking up of the track The 6-inch missing fragment was doubtless knocked out or joggled out of its place just before the oblique marks on the heads of these rails were made

Figure No 3 illustrates a peculiar fracture which occurred 3 feet 10 inches from its leaving end A crescent-shaped piece was detached from the inner flange of the base followed by an oblique fracture, originating in the base which thence extended upward through the web and head This is the fracture which was described as new and bright by the supervisor of track

The crescent-shaped fracture in plan was parabolic, the vertex being at the fillet of the web and the base of the rail This base fracture had its origin at the fillet extending downward to the under-surface of the base The oblique fracture which extended from bottom to top of the rail, originated in the base about 1 inch from the vertex of the crescent-shaped fragment From its point of inception it traveled outwardly to the edge of the outer flange of the base, and also upwardly through the web and head In point of time this part of the composite fracture took place after the crescent-shaped break

This composite fracture as a whole is attributed to conditions which prevailed during the period of derailment of train No 1077 Normal track stresses are negligible factors in straining the inside fillet of the base, eliminating from consideration antecedent strains as having an influence on the formation of this crescent-shaped fracture. The oblique upward fracture through the balance of the cross section of the rail had its origin near the lower surface of the base and at the surface of the crescent-shaped fracture. This was a tension fracture, necessitating the prior formation of the crescent-shaped break to furnish opportunity for the locus of its nucleus.

There was a specimen sawed out near the base of the rail for microscopic examination. Normal structure was shown in the metal. There was a minute slag streak in the vicinity of the fracture, not a matter of uncommon occurrence, nor appreciably influencing its formation. The rail was burnt with a torch close by this composite fracture in clearing the track for traffic.

Figure No. 4 is an end view of the composite fracture, showing part of the surface of the crescent-shaped break and the surface of the oblique fracture. The nucleus of the latter is indicated by a star on the cut.

Strain gauge measurements were made on the intact rail near the composite fracture to ascertain whether internal strains of exceptional magnitude were present or in any manner accountable for this fracture. The stresses corresponding to the measured strains were 9,000 and 10,200 pounds per square inch compression in the flanges of the base and 5,400 pounds per square inch tension along the middle of the width of the base. The total range in plus and minus directions was therefore 15,000 pounds per square inch, not an excessive range in cooling strains.

Figure No. 5 shows the base of the Cambria rail, near its leaving end, as it appeared after pickling in hot hydrochloric acid. Longitudinal surface seams were revealed by the pickling bath. They were of shallow depth and practically effaced by abrasive action where the rail rested on a tie plate. Surface seams in the base lead to the formation of crescent-shaped fragments, the origins of which are at the seams. Such fractures commonly extend along the seams for a distance before deflecting toward the edges of the flanges of the rails.

The difference in the manner of formation of an ordinary crescent-shaped fracture and that part of the composite fracture exhibited by the Cambria rail, 3 feet 10 inches from its leaving end, will be recognized. The ordinary fracture of this type has its origin at the lower side of the base, and induced by a longitudinal seam which it generally follows for a few inches, the seam being easily recognized. The crescent-shaped fracture of the Cambria rail had its origin in the fillet on the upper side of the base. Surface seams are not found in the fillets of a rail, and none was present in the Cambria rail. A microscopic slag streak was found in the vicinity of the fracture, but clearly had no relation to its formation. Minute slag globules have been found in large numbers in different parts of an ingot, which in the fabrication of the rails are drawn out into acicular seams. They have a relation to split heads.

A semicircular notch will be noted in one corner of the base of the rail illustrated by Figure No. 5. This represents a drilled hole, one-quarter inch diameter, near the edge of the flange, apparently intended to receive a bond wire for signal purposes. It chanced that this section for pickling was sawed off midway this drilled hole.

A drilled hole near the edge of the flange is a menace to the integrity of the rail. A fractured rail came to notice, caused by the presence of a drilled hole in the edge of the flange, a counterpart of the hole here illustrated. It so chanced that the rail, one of 85 pounds section, fractured before the eye of an observer. The fracture appeared to happen under the last car and last truck of the train. Danger lurks in such rails.

The P. S. Co. rail next beyond the Cambria rail exhibited two fractures each starting in the base at the edge of the inside flange, also a third fracture which started at the top of the head. This rail was turned bottom side up during the period of the derailment, doubtless accounting for these two types of rupture. It was bent inward to a sharp degree of curvature, and a part of the inside flange of the base sheared off and bent still further inward. This rail was jammed under the fourth car of the train and cut apart with a torch to permit its removal.

In conclusion it is believed that the derailment of train No. 1077 was caused by a gap in the track, in the high rail of a 12½° curve, the gap resulting from a preexisting bolt-hole fracture, which therefore was the primary cause of the accident.

## SUMMARY

Two rails were fractured at the time of the derailment of train No. 1077, each of which displayed features of unusual character. A careful investigation was made to determine whether the physical properties of the rails were responsible for the display of those features and therefore the immediate cause of the accident, or whether they represented secondary effects, incident to conditions attending the derailment, the latter apparently being the case.

The Cambria rail, at its leaving end, had a preexisting bolt-hole fracture, which early in the investigation seemed to be the primary cause of the accident. The final summation of all available evidence confirmed the early inference. The peculiar composite fracture exhibited by the Cambria rail was not the result of unusual physical properties but attributable to stresses received during the period of derailment. The P. S. Co. rail was overturned and fractured in a different manner than would occur under normal track stresses.

There was a gap made in the track, 6 inches long, in consequence of a piece of the Cambria rail being detached at the bolt-hole fracture. This gap in the track was clearly responsible for the derailment, thus placing responsibility for the accident on the bolt-hole fracture.

Evidence presented led to the inference that the gap in the track was virtually caused by the train which preceded the derailed one. The ends of the rails between bond wires represent unprotected parts of the track, hence no warning signal was given of the dangerous condition of the track. It is understood that attention is being given the matter of bonding and it is expected that an improved method will be adopted which will practically eliminate the danger zone which commonly exists.

Respectfully submitted.

W. P. BORLAND, *Director.*

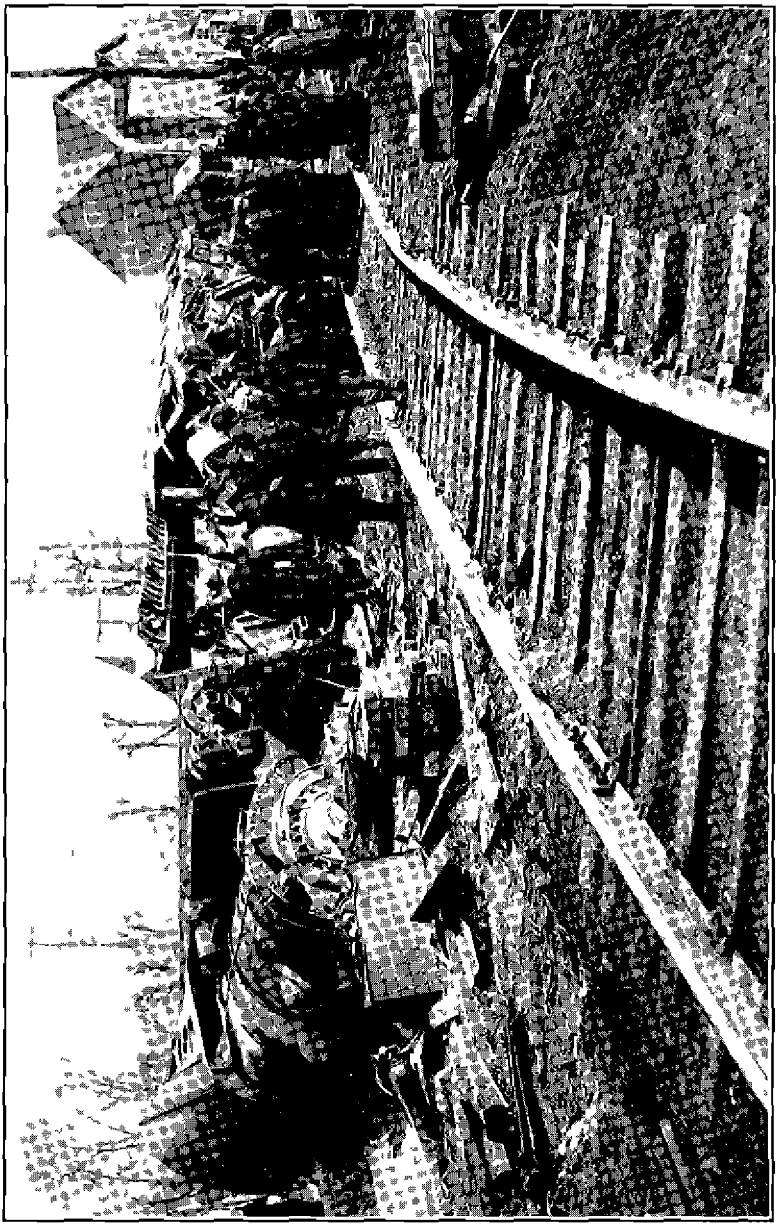

Fig. 1.—General view of scene of accident. Derailed engine, lying on its side, and forward cars of the train. Track with tie rods, tie plated, and double spiked, inside.

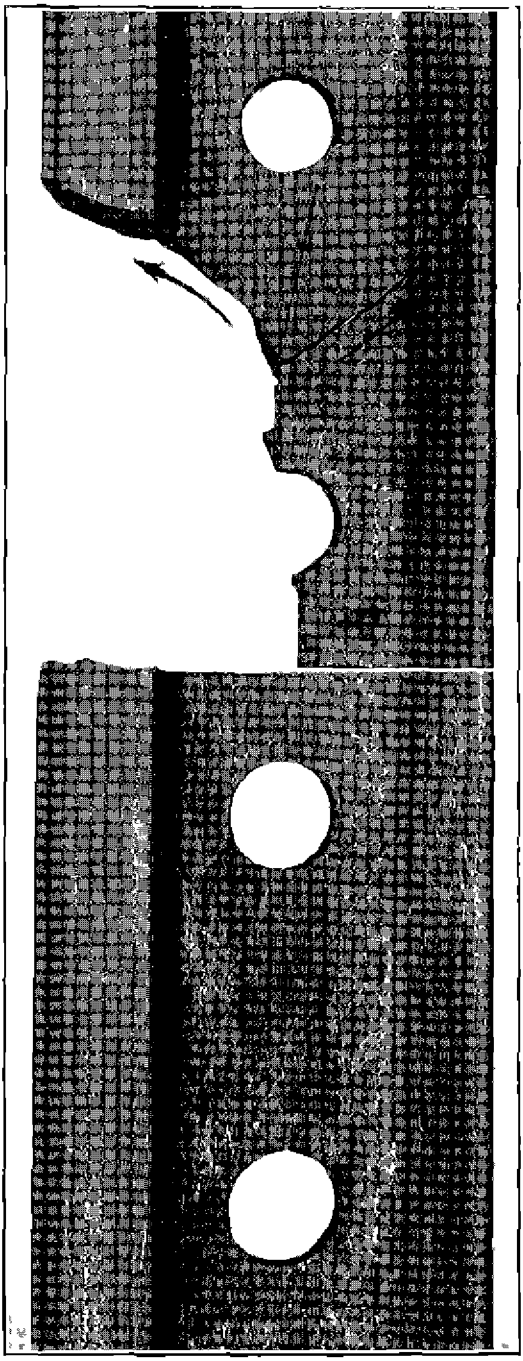

FIG 2.—Leaving end of Cambria 1905 rail showing preexisting bolt hole fracture with crack extending to second bolt hole. New fracture bifurcated separating head web and base. Missing fragment of head 6 inches long. Cut also shows receiving end of P S Co 1897 rail

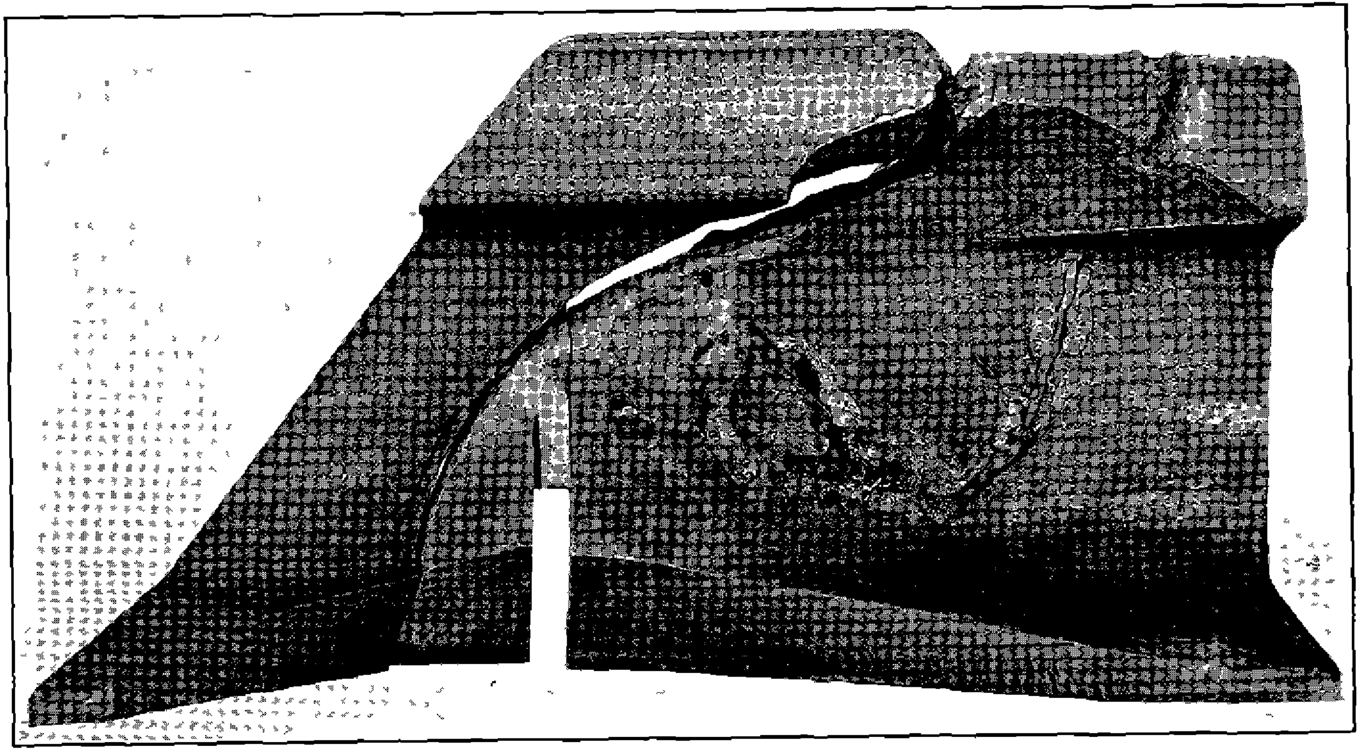

FIG 3.—Cambria 1903 rail Composite fracture 3 feet 10 inches from leaving end Crescent shaped fragment detached from inner flange of base Oblique fracture, originating in base, extending upward through web and head Rail burnt by torch after the accident Sample for microstructure taken from base

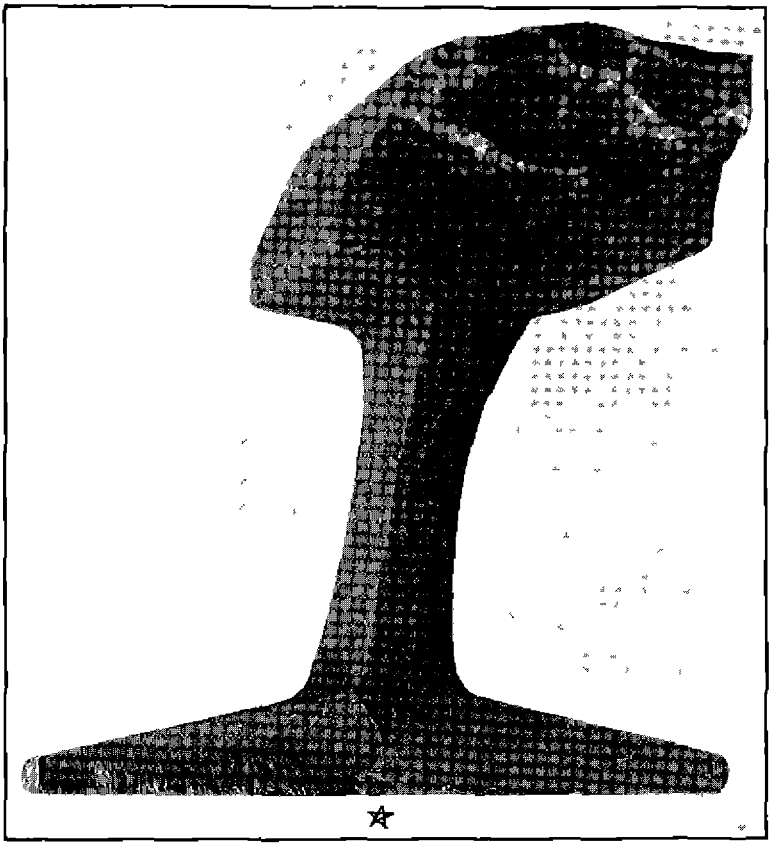

FIG. 4.—Cambria 1903 rail. End view of fractured surface 3 feet 10 inches from leaving end, showing part of crescent shaped fracture and surface of oblique fracture originating at middle of width of base, thence extending outward and upward, *completing the fracture of the rail*.

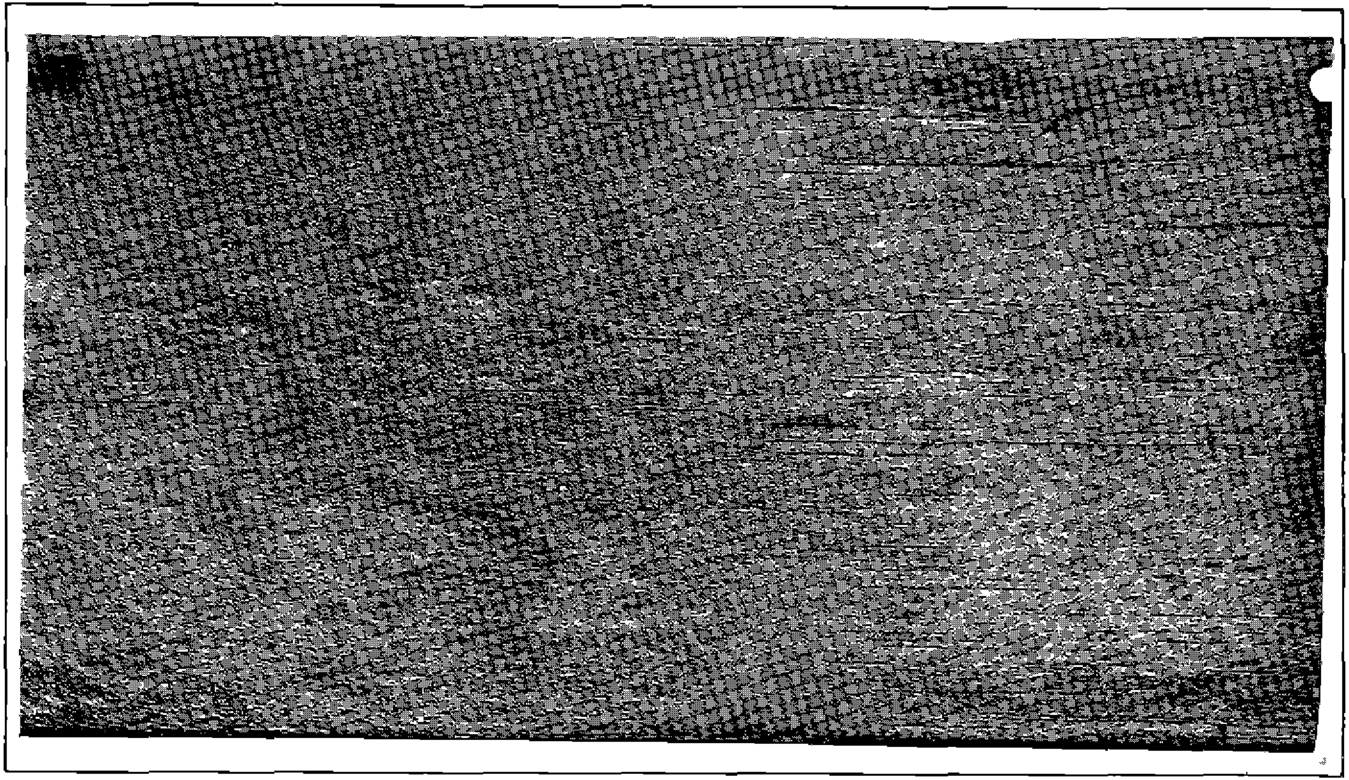

FIG. 5.—Cambria 1903 rail. View of base near leaving end. Appearance of surface after pickling in hot hydrochloric acid. Surface seams revealed by pickling nearly effaced on part of base which rested on tie plate. Drilled hole 1/16 inch diameter near edge of flange.