INTERSTATE COMMERCE COMMISSION

REPORT OF THE CHIEF OF THE DIVISION OF SAFETY COVERING THE INVESTIGATION OF AN ACCIDENT ON THE SOUTHERN RAILWAY NEAR TUXEDO, N C, ON AUGUST 12, 1914

FEBRUARY 8, 1915

To the Commission

On August 12, 1914, there was a derailment of a passenger train on the Southern Railway near Tuxedo, N C, which resulted in the death of the fireman and the injury of the engineman and nine passengers After investigation of this accident the Chief of the Division of Safety reports as follows

Westbound train second No 13 consisted of one baggage car, two coaches, and one Pullman sleeping car, hauled by locomotive No. 4610, and was in charge of Conductor McHarge and Engineman McSherry, en route from Savannah, Ga, to Asheville, N C It left Saluda, N C, at 8 19 p m and at about 8 30 p m was derailed at a point about 800 feet east of the station at Tuxedo, which is 5 3 miles from Saluda, while running at a speed estimated to have been about 25 miles per hour

The engine turned over to the left against the wall of the cut, which was about 6 feet high at this point The tender remained coupled to the engine and came to rest across the track in an upright position. The baggage car was derailed and slightly damaged none of the other cars being derailed

This part of the Asheville division of the Southern Railway is a single track line, train movements being governed by the manual block signal system The track is laid with 85 pound rails 33 feet in length, with about 18 or 20 oak ties under each rail It is tie-plated, three spikes being used with each tie plate, two on the outside and one on the inside of the rail The ballast is of stone, about 10 inches in depth Approaching the scene of the accident from the east there is a curve to the left of 12°, followed by a short tangent, and then a curve of 10° to the right The derailment occurred on the second curve at a point about 400 feet beyond its eastern end The grade at the point of accident is 1 55 per cent, ascending for westbound trains, and the superelevation on the curve is 4 inches The weather was cloudy

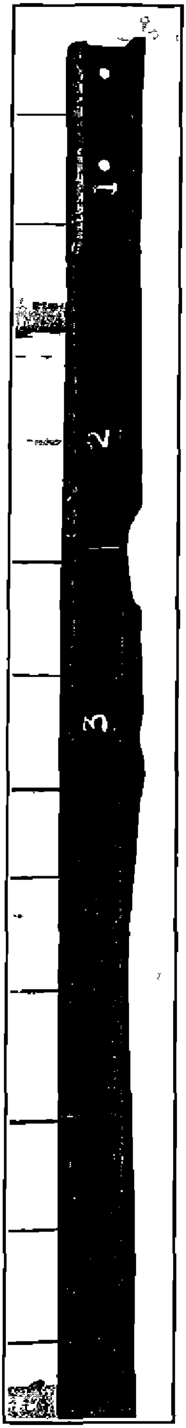
Examination of the track showed that a rail on the outside of the curve had been broken in two places near the leaving end, the receiving end of the rail being intact for a distance of 29 feet 9½ inches The second piece was 1 foot 10½ inches in length, and the third portion, which remained connected to the rail immediately west of it, was 1 foot 4 inches in length This rail was rolled in April, 1912, and laid in the track at this point in June, 1912 There was a zigzag mark across the ball of the rail, this mark being about 4 feet east of the first mark that appeared on the ties The initial marks on the ties were on the outside of the rail at a distance of about 8 inches therefrom These marks continued in a straight line away from the rail, and were 21 inches from the rail opposite the point where the rail broke These marks then continued westward for a short distance, beyond which point the track was torn up by the derailment

Engineman McSherry stated that while the locomotive was running at a speed of about 25 miles per hour he felt the engine drop down on the ties and at once applied the emergency air brakes When the forward end of the engine dropped down, he noticed the rear end rise up He thought the driving wheels were the first to be derailed

Wreck Master McNamara stated that when the wrecking train arrived at the scene of the accident he did not make a very close inspection of the track, but noticed that the receiving end of the broken rail was still spiked down He noticed marks on the ties about 10 or 12 feet east of where the rail was broken, and, judging from these marks, he thought that the lead truck of the engine was derailed before the rail broke He noticed the irregular mark on the ball of the rail, and he thought it was due to the pressure placed upon the wheels while rounding the curve Opposite the break the marks on the ties were about 10 or 12 inches outside of the rail and went off the ends of the ties about 8 or 10 feet beyond the break In his opinion the forward driving wheels broke the rail, the engine being entirely derailed at this point He based this opinion on the fact that no other wheel was derailed until the point of the break was reached and that the track was torn up beyond that point He stated that if the rail had been broken by the forward driving wheels it was improbable that the mark on the ties east of the broken rail could have been made by the trailer wheel, but did think that the marks could have been made that distance from the rail by the wheel of the lead truck He further stated that the dropping down of the locomotive at the break would not have had a tendency to draw the trailer wheel from the rail, in his opinion the lead truck was de railed on account of the track being out of line, and when the wheel which made the mark on the rail dropped off on the ties it skipped one tie, the second tie being the first to be marked

Civil Engineer Redinger examined the track and found no evidence that the receiving end of the broken rail had been turned outward, it being spiked down to the ties He stated that it was 18 feet from where the mark crossed the rail to the point where the rail was broken The first mark on the ties was 4 feet 4 inches beyond the end of the mark on the ball of the rail The mark on the rail was a light mark, about 13 inches long, and was irregular, running on the rail, then lengthwise, and then running off on the outside He gauged the receiving portion of the rail at the point where it was broken, and found the gauge to be 4 feet 9⅛ inches The mark on the ties was 1 foot 9 inches from the rail at the point where the rail broke There was only one mark on each tie, indicating that but one wheel had been derailed at that time In his opinion the broken rail was the cause of the accident, he stating that by the time the driving wheels would be leaving the rail at the break the trailer truck would be about at the mark on the ball of the rail, also that the mark on the tie, being 1 foot 9 inches from the rail at the point where it broke was too far from the rail to have been made by the lead truck and at the same time have the driving wheels remain on the rail, as the stress would have been great enough to overturn the rail Mr Redinger further stated that if the lead trucks had been derailed with the driving wheels still on the rail, and the rail showed no evidence of turning, the tendency of the mark made by the lead truck would have been to run parallel to the rail and not work off to the ends of the ties The marks on the web of the 22-inch fragment of the rail indicated that this fragment turned outward and that some great weight had passed over it, making marks on the web and breaking a piece out of the base He did not notice the condition of the rail joint immediately west of the broken rail, but the ties west of the break showed marks made by several wheels

Master Mechanic Sweetman stated that he made a careful examination of locomotive No 4610 and found the flanges to be in perfect condition He gauged all the wheels and measured the lateral The lead truck had a lateral play of one half inch, the forward driving wheels, three sixteenths of an inch, the intermediate and main driv



No 1 —General view of the fractured portion of the rail from the gauge side Direction traveled by the train, from left to right

ing wheels had seven thirty seconds of an inch, the back driving wheels three eighths of an inch, and the trailing truck three eighths of an inch The greatest side lateral which the lead truck could have, with the maximum pressure placed upon it, which would have been the case if it had left the rail, would have been not over 3½ inches, and in his opinion it would have been impossible for the wheel of the lead truck to have made the marks on the ties without either the driving wheels or the rail turning over

Supt Hodges stated that from his examination he thought the rail broke, allowing the engine truck to drop through first and the driving wheels to follow When the driving wheels dropped off, the rear end of the engine raised up until the trailer truck was high enough to clear the rail He further stated that the receiving end of the broken rail was intact, properly spiked, and to gauge, and he did not think it possible for the driving wheels to remain on the track without overturning the rail, with the lead truck running away from the rail until it was 21 inches distant

Section Foreman Jones stated that he was over the track a short time before the derailment and found it to be in good condition The track had received general repairs in June, bad ties being replaced, and the track surfaced, aligned, and gauged He was at the scene of the derailment about 20 or 25 minutes after it occurred, but made no detailed examination of the track with a view to determining the cause of the accident He stated, however, that the receiving end of the rail which broke was still spiked and to gauge

In order that careful examination and test of the rail might be made with a view to determining the reason it failed and whether its failure was the cause or the result of this accident, the two short pieces, together with a part of the receiving end, were taken to the shops of the Southern Railway, at Alexandria, Va The report of Mr James E Howard, engineer physicist, covering this part of the investigation, immediately follows

REPORT OF THE ENGINEER PHYSICIST

The fractured rail was an 85 pound A S C E section, open-hearth steel, rolled by the Tennessee Coal, Iron & Railroad Co , in the month of April, 1912, and laid in the track in the month of June following Its length of time in service was therefore two years and two months It was an A rail, heat number 11297, and branded "85 O H Tennessee 4 1912"

In the track it occupied a place on the outside of a 10° curve, with a prescribed superelevation of 4 inches At the time of derailment it was broken in two places near its leaving end, the position of which fractures are shown on figure No 1 The lengths of the several fragments, beginning at the receiving end, were 29 feet 9½ inches, 1 foot 10½ inches, and 1 foot 4 inches, respectively

The two short fragments, and a portion of the longer one, were shipped to the testing laboratory of the Southern Railway Co , Alexandria, Va , where chemical analyses and physical tests of the metal were made, Mr J C Ramage, superintendent of tests of the Southern Railroad, and Mr J R Harris, chemist of the Tennessee Coal, Iron & Railroad Co , participating in the investigation

The investigation of the material comprised chemical analyses of the metal of the head, web, and base, tensile test on specimens from the head and the base, also transverse tests in three positions, namely with the base, head, and outside flange of the base in tension in each test In addition there were striation tests on the metal of the head and the base These were made by crosswise bending of the metal of the head, to permit which thin strips were prepared, reducing the depth of the head by planing off the running surface and also metal from the underside of the head The flanges of the base were broken in these crosswise tests without reduction in cross section

The results of the test were as follows

Chemical analyses

Drillings from—	Carbon	Phosphorus	Sulphur	Silicon	Manganese
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Head	0 64	0 038	0 025	0 075	0 88
Web	81	059	025	056	90
Base outside flange	67	035	025	070	89
Base inside flange	73	036	025	069	85

Tensile tests, length of stems 8 inches

Specimen from—	Diameter	Sectional area	Elastic limit per square inch	Tensile strength per square inch	Elongation in 8 inches
	Inch	*Sq inch*	*Pounds*	*Pounds*	*Per cent*
Head	0 946	0 703	59 460	116 070	4 0
Base	711	397	55 670	115 370	12 5

Elongation of inch sections, on stems of test pieces

From head	0 03	0 03	0 05	0 03	[1] 0 06	0 03	0 05	0 04
From base	16	[1] 26	12	10	11	09	09	07

Appeaiance of fractuies, specimen from the head, fine granular, specimen from the base, granular with silky center

TRANSVERSE TESTS

In these tests short sections of the rail weie used, suppoited on bearings 2 feet 6 inches apart, and loaded at the middle

The first section tested was loaded with the head up Pronounced yielding began when a load of 120,000 pounds was reached The loading was continued to 180,000 pounds, during the advance of which the rail acquired a decided permanent set The second section was loaded in reverse position, the base being up Pronounced yield ing occuired under substantially the same load as in the fiist test Loads were advanced to 154,600 pounds when the test was discon tinued The third test was made with the iail on its side, the outer flange being on the tension side of the bend Rapid deflection occurred at 20,000 pounds, which became moie pionounced as the loads were increased A decided permanent bend was given the iail with 60,000 pounds load The test was discontinued at 80,000 pounds

Permanent bends were given each test piece, which each iail length, however, endured without rupture The diminished resistance of the rail in a sidewise direction over its upright position was con spiciously shown, a result in harmony with the diffeience in the moments of iesistance of the section in these two directions

STRIATION TESTS

The metal of the head of the iail at diffeient parts of its depth was examined for the presence of striæ, streaks, or lamination In the upper third of the head there were streaks ranging in length from 1⅛ to 2¼ inches In the middle third, the centei of the head, the streaks were from 3¼ to 3½ inches long In the lower third the

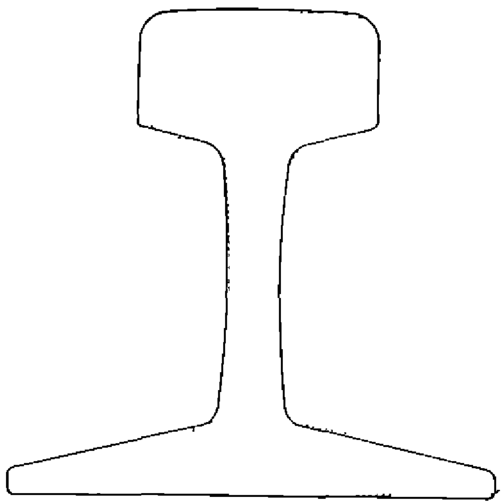
[1] Indicates fractured inch section

metal was practically free from lamination, traces only being present

In the base there were short surface seams as well as interior streaks The interior streaks were located at depths of one fourth to one half inch from the lower surface of the base In places the metal was free from all traces of lamination

With these tests the direct examination of the rail was completed

The results of the chemical analyses showed segregation of carbon and phosphorus in the metal of the web Streaks corresponding thereto were present on the polished and etched cross section of the rail So far as revealed, however, this segregation did not influence the failure of the rail in the track The initial fracture which developed at the time of derailment had its origin at the edge of the outer flange, at a place where the carbon content practically had its lowest value



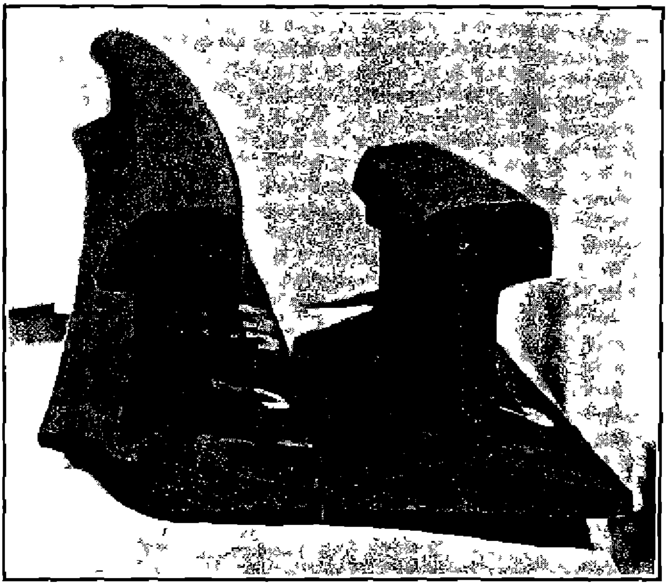
Amount of flange wear indicated by dotted lines

The rail did not display appreciable permanent bending in its fracture in the track, but broke with the brittleness which is generally characteristic of service fractures

Referring to the circumstances which attended the fracture of this rail and the derailment of train second No 13, it occurred under engine No 4610, of the Mikado type, 2–8–2 wheel arrangement, having a total weight of 272,940 pounds The average weight per driver was 26,962 pounds This engine was built for freight purposes and commonly used in that branch of the service

The estimated speed at the time of derailment was 25 miles per hour, or 5 miles less than the rules of the road prescribed for freight trains That the speed of the train was low was clearly indicated by the short distance it traveled after derailment and within which it came to rest

The fractured rail had experienced considerable flange wear, as shown by the accompanying sketch, where the full lines of the drawing represent the original cross section, according to the dimensions prescribed for the A S C E, 85-pound section, while the present worn shape is shown by dotted lines



No 4—Fractures at leaving ends of fragments 3 and 2 respectively taken from left to right Initial line of rupture on fragment 3 secondary line of rupture on fragment 2

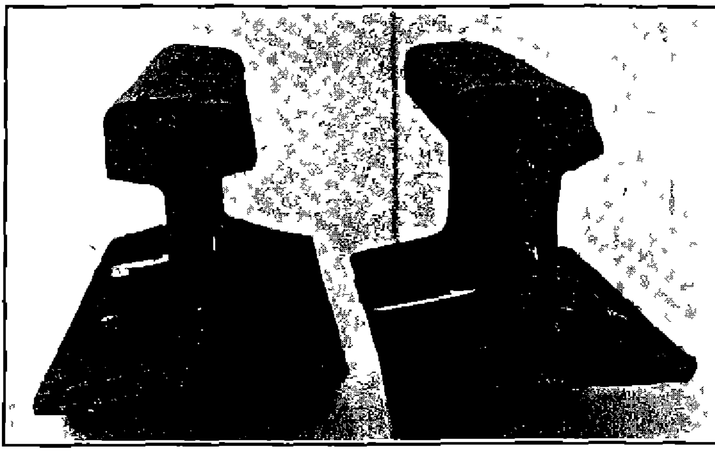
The metal which had been lost by abrasion and wear amounted to about 0 38 square inch, chiefly flange wear, and from the gauge side of the running surface of the head This abrasive loss was due to the outward thrusts of the wheel flanges, incident to its position on the outside of a sharp curve

Figure No 2 shows the appearance of the fracture, on the leaving end of fragment 3 This appears to have been the initial plane of rupture, the incipient point of which was at the edge of the flange, on the outside of the rail

Figure No 3 represents a cross section with the metal polished and etched, one half inch from the fracture shown in figure No 2

Figure No 4 shows the fractures on the leaving ends of fragments 3 and 2, respectively, from left to right on the cut The initial plane of rupture, the same as shown in figure No 2, appears in this cut on the end of fragment 3, while the secondary line of rupture of the rail appears on the end of fragment 2, the right hand figure of the cut

These two lines of rupture traversed the rail in opposite directions The primary rupture had its origin at the outside edge of the flange of the base, extending thence through the base, detaching a crescent-shaped piece from the compression side, passing up through the web and head, and completing the fracture of the rail



No 5 —Fractures at receiving ends of fragments 2 and 1 respectively taken from left to right

Initial line of rupture on fragment 2 secondary line on fragment 1 Battered edge of head on gauge side and wheel flange indentation on inside edge of web of fragment 1

The secondary line of rupture had its origin on the inside—the gauge side—of the head, taking a course in reverse direction across the rail to that of the primary fracture

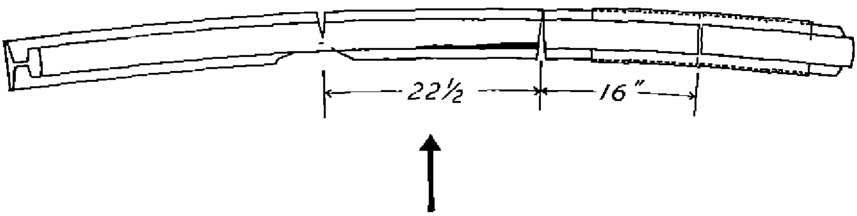
Figure No 5 shows the receiving ends of fragments 2 and 1, respectively The initial plane of rupture again appears in this cut on the end of fragment 2, the secondary plane on the end of fragment 1 The battered edge of the head of fragment 1 on the gauge side and a semicircular indentation on the inside of the web of this fragment will be noticed

A side view of fragment No 2 is shown by figure No 6 Metal was sheared from the inside edge of the head, the cut growing deeper as the leaving end of the fragment was approached

In regard to the conditions present at the time of derailment, an examination of the fragments of the rail, their fractured ends, surface indications, and the directions in which the fractures traveled, these features lead to a conclusion at variance with the testimony of those who described the conditions of the track immediately succeeding the derailment

The testimony referred to was to the effect that the longer fragment—the receiving end of the rail—"was still in the track spiked down and practically in gauge" This testimony leaves it to be inferred that that portion of the rail located to the rear of the broken end did not turn over but remained upright on the ties, and inferentially that the rail as a whole was not materially disturbed from this position Against this testimony is placed the evidence furnished by the fragments, which indicate that the rail as a whole was partially overturned at the time the initial rupture occurred, and that the short fragment at the leaving end was completely turned—that is, rotated through 90°—at the time certain wheels reached this part of its length, battering the receiving end of fragment on the gauge side of the head and also indenting the inside edge of the web of this piece

The progressive manner in which the rail broke, as indicated by the fragments, is illustrated on the accompanying sketch



A force was evidently exerted in the direction of the arrow, putting the outside flange of the rail into a state of tension, and causing the initial line of rupture to have its point of inception at the edge of the outer flange A crescent shaped piece was detached from the inner flange of the base on the compression side of the bend The general direction of travel of this line of rupture was from outside toward the inside of the rail

After the rail was broken in one place, it would then present a short overhanging end attached by the splice bars to the rail next beyond The force continuing to act on this short end would next develop a fracture starting from the inside face of the rail, extending to the outside This was the direction taken by the secondary line of rupture, as shown by the evidence on the fragments

A partial shearing of the head of fragment 2 occurred on the gauge side, indicated by the heavy line on the sketch One wheel evidently passed over this portion of the rail before fragments 2 and 1 were separated from each other A following wheel doubtless sheared additional metal from the inside face of the head, whereupon the secondary line of rupture was developed, starting on this side of the head, thence traveling down through the web and the base and completing the fracture of the rail, in its course taking the opposite direction from that of the primitive line of rupture

The receiving end of fragment 1 was battered on the gauge side of the head and also indented by a wheel flange on the inner edge of the web, further indicating that fragment 1 was on its side at this stage in the derailment, that is, turned outward with an angular movement of approximately 90° The interval of time required for a wheel to travel the length of fragment 2, about one twentieth of a second at 25 miles per hour, would seem too brief in which to accomplish the turning of the rail from an upright position at its receiving end to a quarter of a turn at its leaving end Hence the evidence presented by the fragments leads to the inference that the rail was at least partially overturned at the time of development of the initial line of rupture and subsequently completely overturned at its leaving end

There was additional evidence to this effect near the end of fragment 3 Covering a length of some 3 feet as the initial line of rupture was approached, the lower corner of the head on the gauge side was rolled down and a thin fin partially detached This is taken to signify that the rail was gradually being overturned as certain of the wheels of the engine passed over this portion of it

The arrow is placed on the sketch for the purpose of indicating the direction of the lateral force with respect to the rail, but will not be taken to signify that it was a horizontal force The failure of the rail is not attributed to a direct horizontal thrust, but to its overturning by reason of that horizontal thrust, followed by the weight of the engine breaking the rail The case would be an unusual one if the rail was fractured in an upright position, due to augmented tension of the outside flange from centrifugal forces The evidence gathered does not lead to the latter explanation, but to the former one, that the rail first turned and was then fractured when partly or completely on its side The transverse tests, which showed greatly diminished resistance when the rail was loaded on its side against the normal direction of loading, favor the probability of its rupture when on its side

In conclusion, it appears that the derailment of train (second) No 13 was due to the fracture of the outer rail on a 10° curve, which rail, according to the evidence furnished by the fractured surfaces, was in an overturned or partially overturned position The failure of the rail and derailment of the train is therefore attributed primarily to track conditions affecting the security of the rail to the ties

SUMMARY

The derailment of this train occurred on a 10° curve, on which rails of 85 pounds section were used. The outer rail of the track was broken in two places near its leaving end. Considerable flange wear was shown, 0.38 of a square inch of metal having been worn from the rail section on the gauge side and the top of the head.

Flange wear of this extent necessarily indicates that the rail had been exposed to severe outward thrusts during its period of service in the track of two years and two months.

The initial line of rupture showed the immediate cause of failure was due to the rail receiving a load from some source which acted in the same direction as the forces which had occasioned the flange wear. But whether this rupturing force was applied in a horizontal or a vertical direction is a feature of the case upon which there is conflict between conditions as stated to exist immediately following the time of derailment and the evidence which the fractured ends of the rail themselves presented. The immediate rupturing force was applied to the side of the rail, causing the line of rupture to have its origin on the outside flange of the base at its edge. A secondary line of rupture traversed the rail in the opposite direction. If the rail was in its normal position, resting upon the ties and spiked down, then it would follow that the rupturing load was horizontal in its direction; on the other hand, if the rail was overturned or partially overturned, then the rupturing load was a vertical one.

The conclusions of the engineer physicist, based upon the appearance of the fractured ends, are to the effect that the rail at the time of its fracture was in an overturned or partially overturned position. The diminished strength of the rail in sidewise direction as compared with its ability to support a direct load upon the head is shown in the tests which were made during the examination of the rail for the purpose of ascertaining the cause of its failure. The rail yielded more readily in a sidewise direction, as would be expected from the cross section shape. The fracture of the rail is, therefore, more readily accounted for upon the assumption that it had turned on its side when it broke, rather than that it was resting upon its base on the ties in normal position.

Under ordinary conditions of loading the weight downward is the predominant force acting upon the rail; in fact, it is the only one at times. On curves a horizontal force is exerted, greater or less, according to the rate of speed of the train. This horizontal force tends to put an additional strain of tension on the outside flange of the rail. The application of such a force is obviously a very common occurrence, and is the force which the outside rails on curves in general have to sustain.

If this rail at the time of the initial break was in an upright position it necessarily follows that the margin in strength against sidewise thrust was particularly low under ordinary conditions of service, as it was overcome on this occasion by a train moving at comparatively low speed Assuming the rail to have been upright, as would be inferred from the statements of those at the scene of the accident immediately after its occurrence, such a result as that witnessed in this derailment is one of far reaching seriousness It calls into question the safety of track in other similar situations on railroad curves throughout the country

Very meager data have been acquired on the actual strains in rails, strains which they are daily called upon to endure Such a state of affairs is probably without a parallel in the use of constructive materials With railroad mileage in this country approximating 250,000 miles, or 500,000 miles of single rails, it is far from being creditable to engineering progress that strains in rails in the track have not been accurately investigated and defined—that a state of uncertainty in this question has been allowed to continue

Touching upon this important feature the comprehensive report of the committee on rails and equipment of the National Association of Railway Commissioners, at its twenty sixth annual convention, held in Washington in November, 1914, contains this closing recommendation

> Finally service stresses should be accurately ascertained and defined and the overworking of materials on which the safety of life depends should not be permitted

The failure of this rail is more readily accounted for by accepting the evidence presented by the fragments themselves, in which case conditions of track maintenance only are involved—that is, insecurity in spiking or other irregularity of track conditions However, the statements of the employees of the road are directly at variance with the evidence presented by these fragments Their statement of conditions existing immediately after the accident puts a more grave and serious aspect upon the cause of the failure It virtually assigns as the cause of this accident a condition which is present in a much greater degree on curves where higher rates of speed are maintained

The investigation of this accident again calls attention to the urgent necessity, noted in previous reports, for a thorough study of stresses set up in railroad tracks under varying conditions of traffic, speed, and curvature, to furnish accurate and reliable data regarding these stresses and the loads to which the track can safely be subjected, in order that dangerous conditions in tracks likely to lead to accidents may be detected and corrected

Respectfully submitted

H W BELNAP,
Chief, Division of Safety

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