INTERSTATE COMMERCE COMMISSION

REPORT OF ACCIDENT ON NEW YORK CENTRAL & HUDSON RIVER RAILROAD AT HYDE PARK, N. Y. MARCH 31, 1912

BY THE CHIEF INSPECTOR OF
SAFETY APPLIANCES

ACCOMPANIED BY

REPORT OF THE ENGINEER-PHYSICIST OF THE
BUREAU OF STANDARDS

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INTERSTATE COMMERCE COMMISSION

REPORT OF THE CHIEF INSPECTOR OF SAFETY APPLIANCES COVERING HIS INVESTIGATION OF A DERAILMENT WHICH OCCURRED ON THE NEW YORK CENTRAL & HUDSON RIVER RAILROAD NEAR HYDE PARK, N Y, MARCH 31, 1912, ACCOMPANIED BY REPORT OF THE ENGINEER-PHYSICIST OF THE BUREAU OF STANDARDS COVERING HIS INVESTIGATION OF THE TRACK CONDITIONS, AS WELL AS OF THE BROKEN RAIL SUPPOSED TO HAVE CAUSED THIS DERAILMENT

September 4, 1912

To the Commission

On March 31, 1912, a passenger train was derailed on the New York Central & Hudson River Railroad near Hyde Park, N Y, resulting in the injury of 51 passengers, 1 trainman, 3 postal employees, 5 Pullman employees, and 13 dining car employees

After an investigation as to the nature and causes of this accident and of the circumstances connected therewith, I beg to submit the following report

This train was second No 26, and was known as the Chicago section of the Twentieth Century Limited It consisted of engine No 3414, one buffet car, four sleeping cars, one dining car, and one observation car, all of steel construction except the dining car, which had a steel underframe with wood superstructure The train was in charge of Conductor Lee and Engineman Ryan It left Albany, N Y, at 7 45 a m, 1 hour and 15 minutes late, and was derailed at 8 53 a m at a point about 1¼ miles south of Hyde Park

The Hudson Division of the New York Central & Hudson River Railroad at the place where this accident occurred is a double track line running north and south The movement of trains is governed by automatic block signals The track is laid with 100-pound steel rails, with about 20 pine ties under each rail A small percentage of the ties had been treated with creosote and tie plates were used on these treated ties The ballast is crushed limestone The rails are double spiked on the outside and single spiked on the inside Six hole angle bars are used to splice the rails

About 1 mile south of Hyde Park station there is a curve of nearly 2° leading toward the east and passing through a rock cut Just beyond the middle of this curve is an overhead bridge, and just north of this bridge the first indications of the derailment were found. These consisted of wheel marks on the outside rail, marks on the ties, and two bolts broken out of an angle bar. These marks were about 2½ rail lengths north of a broken rail which early in the investigation was supposed to have caused the derailment. The distance from the first marks of derailment to the point where the engine and tender stopped was about 1,700 feet, and the outside rail was turned over throughout this whole distance. Nearly a mile north of the overhead bridge there is a track water pan 1,400 feet in length, where engines scoop water. On this division the speed of trains while passing over water pans is limited by time-card rule to 45 miles per hour, and on all other parts of this division the speed of passenger trains during the severe weather of the past winter season was limited by special bulletin order to 60 miles per hour.

After the accident the engine, tender, and buffet car were still coupled together. The engine and the wheels of the forward tender truck were not derailed; the rear tender wheels had fallen between the rails; the outside forward wheels of the buffet car were standing on the overturned rail, and the rear truck of this car was derailed. About 100 yards behind the buffet car was the first sleeping car; it was entirely derailed and only one set of trucks remained under it. The remaining five cars left the roadbed more than 200 yards farther north, went down an embankment, and came to rest on the ice at the edge of the Hudson River, three of them lying on their sides and the other two remaining upright. None of the cars was telescoped or crushed.

Engineman Ryan stated that the speed of the train at the water pan was 45 miles per hour, and it was slightly accelerated after scooping water, so that at the time of the accident the train was running at a speed of 48 or 50 miles per hour. He noticed nothing unusual until he felt a jerking of the train as if an air hose had burst. Engineman Ryan also stated that the signals at tower No. 62 were set at clear. This would indicate that at that time the rails in this block were sufficiently intact to form a continuous path for the electric track circuit.

Fireman Ferris stated that the speed of the train at the time of the accident was about 50 miles per hour. He noticed nothing unusual until the air brakes were applied as if by the bursting of an air hose. Neither the engineman nor the fireman felt any unusual jar such as might have been caused by passing over a broken rail.

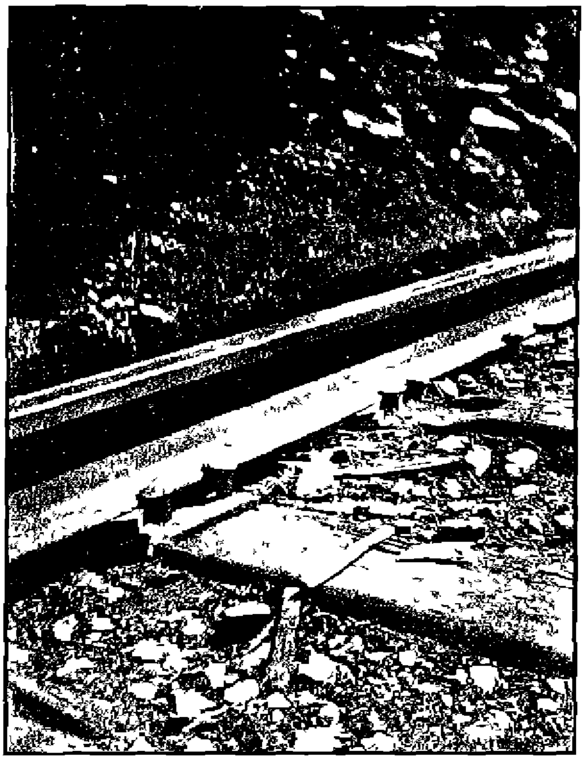
As one of the causes or results of this accident was a broken rail, arrangements were made to have the Bureau of Standards cooperate with the commission in this investigation. Mr. James E. Howard, engineer-physicist of the bureau, accompanied me to the scene of the accident and we made a careful examination of the track and roadbed. Portions of the broken rail were sent to the Lackawanna Steel Co. at Buffalo and there subjected to drop tests. The pieces of this broken rail and the two rails which were immediately north of it in the track were sent to the Bureau of Standards where they were subjected to examination, analysis, and tests. The results of this investigation are set forth in Mr. Howard's report, which, together with the illustrations accompanying it, is attached to and made a part of this report.

The derailment occurred in a cut, the drainage of which was poor. The ground had been alternately thawing and freezing, and this created considerable unevenness in the track and roadbed. On the day preceding the accident the section gang in charge of this track had been working in this cut and had placed shims under some of the rails. The section foreman stated that shims had been placed under the broken rail, but no work had been done north of that rail on that date. However, there were shims under the rail immediately north of the broken rail, and in this vicinity many shims were used to maintain proper level of both rails, the shims varying in thickness from a quarter of an inch to 1 inch. In some instances shims were used on a number of ties in succession. The accompanying photograph shows two shims under the inside rail of the northbound track directly opposite the point where the derailment occurred and illustrates the method of shimming employed in the vicinity of the accident. The next photograph shows high shimming at the water pan at Hyde Park, N. Y., which was necessary to maintain proper rail level.

The gauge of the track for 600 feet north of the place where the derailment occurred varied from 4 feet 8¾ inches to 4 feet 9½ inches and the superelevation of the outside rail varied from 3½ to 4½ inches, according to measurements made after the accident. On account of the complete destruction of the track, no measurements were made south of the point where the derailment occurred.

It is believed that the use of shims, together with irregularity or unevenness in the track, so weakened the track structure that it could not withstand the tremendous strain due to the heavy locomotive and train rounding the curve at high speed, and the outside rail was forced outward, probably by the engine, the first wheels to drop between the rails being the rear tender wheels. This theory is practically substantiated by the condition of the spikes and spike holes in the ties after the derailment. A number of the spikes on the inside of the third rail beyond the initial marks of the derailment were left practically undisturbed, and the spikes on the outside of the rail were crowded outward.

In illustration No 2 accompanying Mr Howard's report the first rail that was disturbed is marked No 1 On the inside of this rail there were 11 spikes that were partially pulled the spikes farthest south being lifted the most On the inside of rail No 3 the first seven spikes were left intact in the ties, the outside spikes having been crowded outward more than their width, as is evidenced by the tops of the spike holes being elongated This clearly shows that the track spread at this point and it is believed that this occurred under the engine on account of the high speed however the first wheels

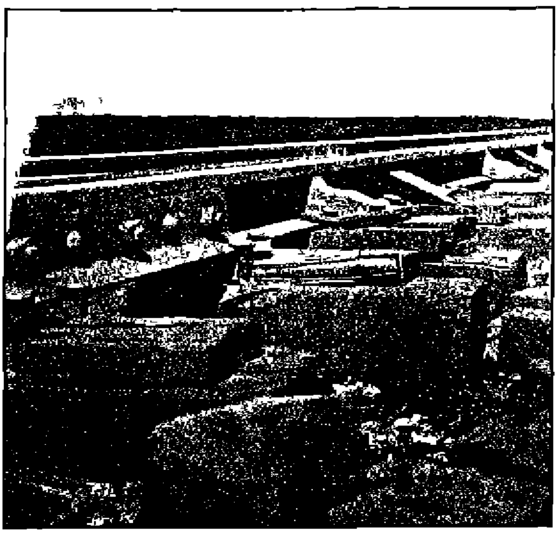


Shimming on north bound track opposite point of accident illustrating method of shimming employed in this vicinity

to drop between the rails were the rear tender wheels, which ran along in this position until the engine came to a stop crowding outward the west rails of the track The flange marks on the webs of these rails indicate that the wheels on that side of the train ran along on the webs of the overturned rails

Attention is called to Mr Howard's discussion of the progressive features of the destruction of the track in this derailment and to his statements that the spreading of rails Nos 1 2 and 3 was doubtless the cause of the derailment the fracture of rail No 4 being the result of and not the cause of the accident

Attention is also called to that portion of Mr Howard's report relating to tests of rails, showing that while the drop tests of pieces of the broken rail did not disclose any imperfections subsequent examination made by the Bureau of Standards as to the structural soundness of the broken pieces revealed streaks or seams in the metal But the examination showed that while seams were not entirely absent yet this was a better rail than any of the other rails involved in accidents which had been examined and reported upon To determine the tensile strength of the steel in the broken rail tests were made of longitudinal and cross-section specimens taken from this rail Seams were present in each specimen These tests dis-



High shimming at water pan north of point of derailment

closed much greater tensile strength of the longitudinal specimens and confirmed statements made in previous reports upon defective rails, namely that crosswise stresses are directly accountable for flange breaks in the bases of rails in service and this is due to the fact that on account of longitudinal seams in the metal rails are not able to withstand severe bending strains in a crosswise direction Mr Howard, in the accompanying report points out that " flange fractures of the base in a crosswise direction are known to be the most common fractures of rails when in service " Present steel rail specifications do not require tests in the direction in which rails most commonly fail The tests now required strain the steel in a longitudinal direction but no bending tests in a crosswise direction are required. In the tests conducted at the Bureau of Standards the specimens displayed good bending properties when longitudinally strained, but under crosswise bending the flanges were broken with limited elongation. Present rail specifications contain no requirements as to elastic limit or tensile strength of the metal, although in the case of practically all other steel materials the specifications prescribe certain values of elastic limit and tensile strength.

The facts disclosed by the investigation of this derailment call attention to the need of collecting data on track conditions, such as the actual stresses which are set up by locomotives and cars of different weights and at varying speeds, and of definitely determining the magnitude of the stresses on the outer rails on curves under service conditions.

Mr. Howard also points out the fact that—

The line of demarcation between safe and unsafe conditions has not been demonstrated in practical railway engineering. It is not known how much or how little margin of strength resides in the track. It is a rare occurrence when direct experimental research is made for the purpose of ascertaining the stresses which rails in service are called upon to sustain, and yet such knowledge should be the basis for judging of the safety of railway travel. There is urgent need of information on the elastic and ultimate strength of track as constructed and used and also a direct determination of the magnitude of the stresses which the track under service conditions is called upon to resist. In few branches of engineering work can it be said that so meager information is available pertaining to the structural value of the material and the working stresses as in the case of railway track, the most common of all engineering structures.

While the instructions to enginemen required that they should not exceed a speed of 60 miles per hour, this engine was not equipped with a speed recorder, and an investigation made by the New York Public Service Commission, second district, showed that the speed limit had not been strictly observed. In checking up the records of seven different fast trains in the months of February and March, 1912, 290 cases were noted where the speed limit of 60 miles per hour was exceeded; of these cases there were 142 where the speed was between 60 and 70 miles per hour, 122 where the speed was between 70 and 80 miles per hour, and 26 where the speed exceeded 80 miles per hour.

Notwithstanding the fact that both Engineman Ryan and Fireman Ferris stated that the speed of this train was only about 50 miles per hour at the time of the derailment, it is believed that it was considerably higher, as the engine did not come to a stop until it had run 1,700 feet beyond the first marks of the derailment and several hundred feet beyond where the train parted.

In view of the fast and heavy traffic over it, this track was subjected to severe strains, which required constant inspection and requent maintenance work to insure that it would be in safe condition. While the rails and ties were in good condition, comparatively few tie plates were used.

On account of the heaving of the roadbed, due to the action of frost, it was necessary to use shims to maintain proper track surface. In this connection the following is quoted from Mr. Howard's report:

That the means employed to maintain the track intact were for some reason inadequate the result shows. If the speed of the train was greater than supposed, an exceptional strain may have been put upon the track. If the speed was an ordinary one, no margin in strength existed. * * * Track in general in northern climates is less strong as spring approaches, due to winter conditions requiring the use of shims to maintain the surfacing. With the use of shims between the rails and the ties the spikes have diminished holding power and furnish less resistance against spreading of the track.

One obvious remedy for this condition is the use of longer spikes where shimming must be resorted to.

In many other derailments that have been investigated speed was no doubt a contributing factor, and the direct cause of the five derailments listed in the following statement was excessive speed in view of existing track conditions.

Railroad	Date	Number killed	Number injured	Cause
Lake Erie & Pittsburgh	Sept. 13, 1911	4	16	Picking up over new track at excessive speed.
New Orleans & Northeastern	May 6, 1912	9	50	Soft and uneven roadbed, and excessive speed in view of this condition.
Nashville, Chattanooga & St. Louis	June 12, 1912	4	65	Excessive speed in view of existing track conditions.
Illinois Central	July 12, 1912		18	Excessive speed over bad track.
Southern	Aug. 25, 1912	1	32	Excessive speed in view of existing track conditions.

In none of these cases was there any speed restriction in effect at the time of the derailment. Where the first two accidents occurred the track was known to be poor. In the first case there was a bad stretch of track which was unsafe for high speed, but no slow orders had been issued and no slow board had been installed. Where the second derailment occurred the track was known to be unsafe at times, particularly during rainy weather, and considerable special work had been done there. Slow orders covering this section of track had been issued from time to time, but none of them was in effect at the time of this derailment. Three of the derailments occurred on straight track and two of them on curves of about 3½°.

A study of the conditions surrounding these derailments emphasizes the fact that in many places and on many roads in this country track is not properly constructed or sufficiently well maintained to provide for the safe operation of trains at high speed. It is believed that means should be taken to ascertain the limit of speed at which trains can be safely operated and to provide an adequate margin between this limit of safety and the highest speed permitted or attained.

Respectfully submitted,

H. W. Belnap,
Chief Inspector of Safety Appliances.

REPORT OF THE ENGINEER-PHYSICIST

I have the honor to report upon the inspection and examination of the rails of the southbound track of the New York Central & Hudson River Railroad at a place about 1¼ miles south of Hyde Park N Y where the second section of train No 26 the Twentieth Century Limited en route from Chicago to New York was derailed on the morning of March 13 1912 at 8 55 a m

The train consisted of locomotive No 3414 Pacific type and seven cars the latter all with underframes of steel enumerated as follows

	Length over all		Weight
	Ft	*in*	*Pounds*
Locomotive	77	4½	417 500
Engine			269 000
Pilot truck two axles per axle			25 000
Forward drivers			56 000
Middle drivers			59 500
Rear driver			56 000
Tender four axles per axle			37 125
L S & M S buffet No 177	88	1	171 500
Pullman Honeoye	81	10	150 000
Pullman Macedonia	81	10	150 000
Pullman Phelps	81	10	150 000
Pullman Bay Pond	81	10	150 000
N Y C & H R diner	78	8	150 700
Pullman observation car Watertown	83	1	150 000
Total			1 491 700

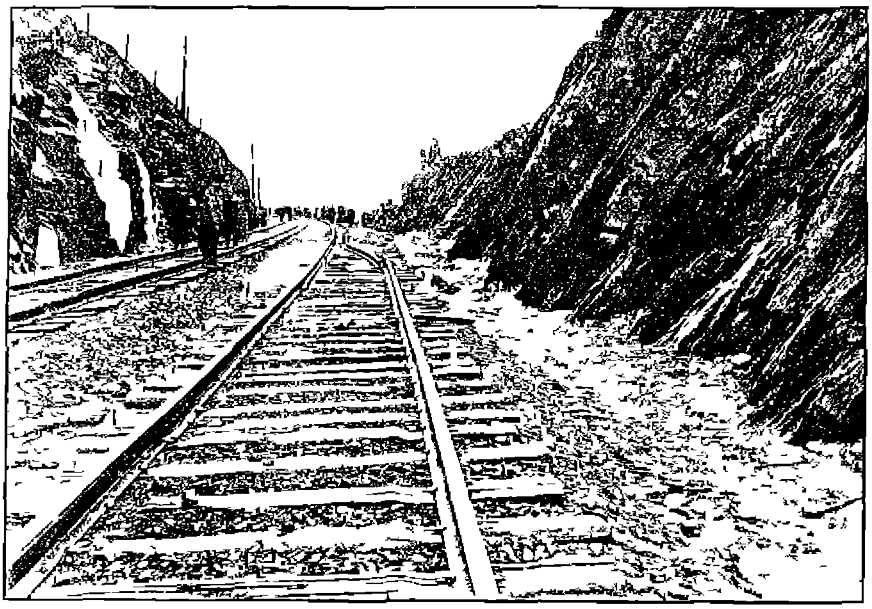
The train was running in a southerly direction when its derailment occurred which took place on a 1° 48¾″ curve about 1¼ miles south of Hyde Park Station The damage to the track began in a rock cut The outer west rail of the track was torn from the ties for a distance of 1 637 feet the greater part of this length being on a tangent south of the curve

The casualties were 73 persons injured none killed The locomotive came to a stop without derailment excepting the wheels of the rear axle of the tender The buffet car remained attached to the locomotive with the west wheels of its forward truck on the web of the overturned west rail all other wheels of the car being on the ties

The second car Honeoye broke loose and stopped 317 feet to the rear of the forward end of the locomotive The photographic print shows this car with west wheels of forward truck on the web of the overturned rail, east wheels on the ties. The rear truck had been torn from the car before it came to a stop.

The other five cars of the train left the roadbed and came to a stop on the ice of the river at its edge. The forward car of these five was 1,008 feet to the rear of the front end of the locomotive.

Concerning the events which preceded this result, it appears that the train was rounding the curve under steam; that derailment occurred commencing at some point on the curve in the rock cut; that the train was separated into three parts; and that the first knowledge of the accident on the part of the engineman and fireman came from



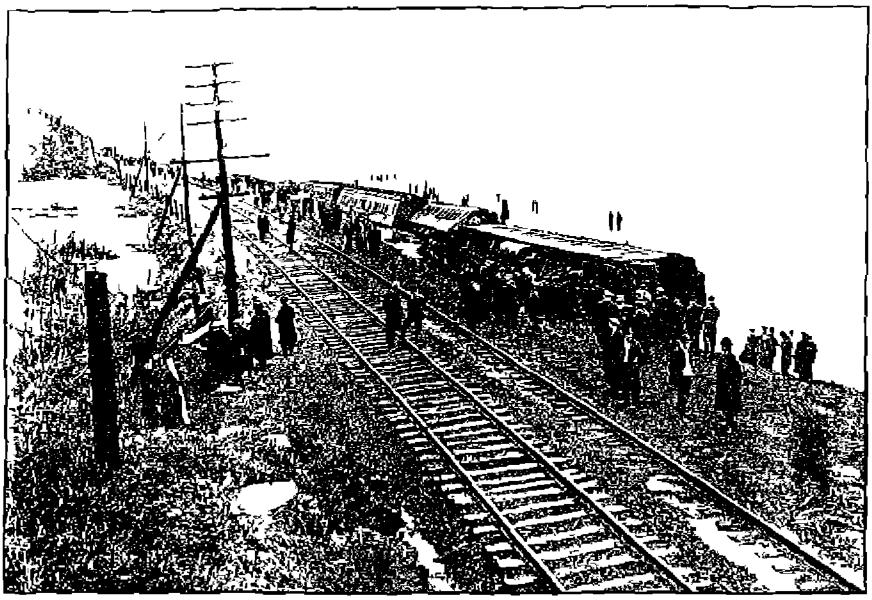
View looking south, showing point where derailment began

the air-brake system after the cars began to leave the track. The west rail was torn from the ties a distance of 1,637 feet, beginning at a place in the rock cut and ending at the place occupied by the rear axle of the tender when the locomotive came to a stop.

A series of four general views of the scene of the wreck accompany herewith, reproduced from photographs taken on the day of the derailment. The track was restored and opened to traffic for speed of 6 miles per hour at 5.45 p. m. of the same day, or 8 hours 50 minutes after the derailment.

Describing conditions as shown by these photographic prints, which were taken some time during this interval of track repairing, beginning at the northern end of the affected section, it appears that the first rail which was disturbed had spikes partly pulled from 11 ties but with stems remaining in contact with the flange on the gauge side of the rail at its south end. The spike in the tie farthest north was pulled the least, that at the south end of the rail the most, progressively increasing from north to south. This rail will be called No. 1. The rail next south, which will be called No. 2, is shown in position very near that which it occupied in the track prior to the derailment. No spikes appear on the photograph engaging the flange on the gauge side of this rail.

The north half of rail No. 2 showed no injury from the accident. It was cut apart near the middle of its length and the north end



General view of derailment looking south.

temporarily used in the repairs to the track, being subsequently removed and shipped to the Bureau of Standards. The south end of this rail was very slightly twisted with the head outward. The most northern place of prominent deformation on the rail is a downward bend of the edge of the inner flange between ties at a distance of 12 feet from its south end. At intervals between ties going south the downward bends in this flange were more pronounced, but did not indicate that many blows had been received nor that they were severe ones. There was a sharp downward bend directly under the north end of the splice bar which connected rails Nos. 2 and 3, doubtless caused by a wheel blow. At this place the rail was also bodily bent in a horizontal direction, concave on the gauge side. There were

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SEPTEMBER 4, 1912.

TO THE COMMISSION:

On March 31, 1912, a passenger train was derailed on the New York Central & Hudson River Railroad near Hyde Park, N. Y., resulting in the injury of 51 passengers, 1 trainman, 3 postal employees, 5 Pullman employees, and 13 dining car employees.

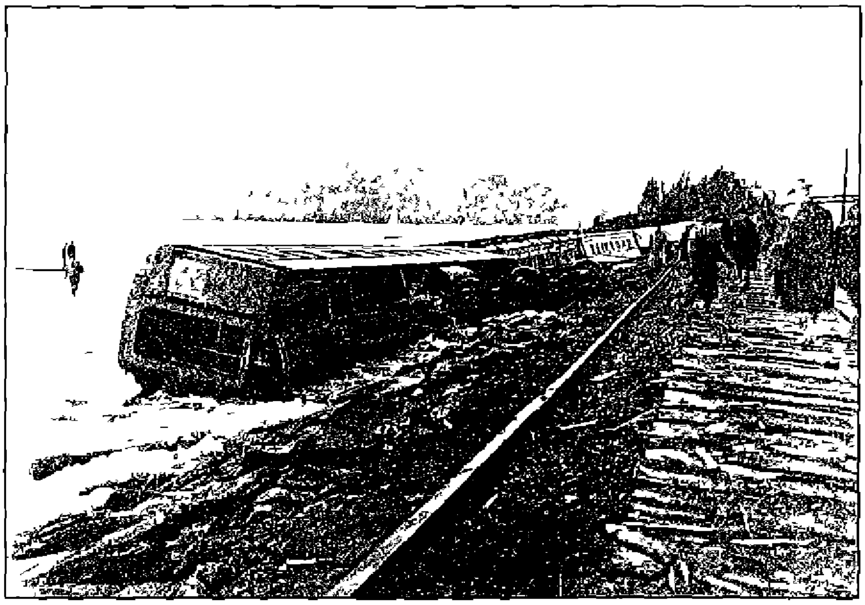
After an investigation as to the nature and causes of this accident and of the circumstances connected therewith, I beg to submit the following report:

This train was second No. 26, and was known as the Chicago section of the Twentieth Century Limited. It consisted of engine No. 3414, one buffet car, four sleeping cars, one dining car, and one observation car, all of steel construction except the dining car, which had a steel underframe with wood superstructure. The train was in charge of Conductor Lee and Engineman Ryan. It left Albany, N. Y., at 7.45 a. m., 1 hour and 15 minutes late, and was derailed at 8.53 a. m., at a point about 1¼ miles south of Hyde Park.

The Hudson Division of the New York Central & Hudson River Railroad at the place where this accident occurred is a double track line running north and south. The movement of trains is governed by automatic block signals. The track is laid with 100-pound steel rails, with about 20 pine ties under each rail. A small percentage of the ties had been treated with creosote and tie plates were used on these treated ties. The ballast is crushed limestone. The rails are double spiked on the outside and single spiked on the inside. Six-hole angle bars are used to splice the rails.

About 1 mile south of Hyde Park station there is a curve of nearly 2°, leading toward the east and passing through a rock cut. Just beyond the middle of this curve is an overhead bridge, and just north no marks of consequence on the web of this rail At some stage of the derailment the south end of rail No 2 moved in a westerly direction increasing the gauge of the track sufficiently to let a wheel or wheels down upon the inner flange and this occurred while the rail was in nearly an upright position

Such spreading of the track could occur with the rail in an upright or nearly upright position only by displacement of the spikes on the outside of the rail moving them outward at their upper ends Spike holes were found in the ties in the vicinity which showed they had been forced outward to an oblique position and sloping from the



View of derailed cars looking north

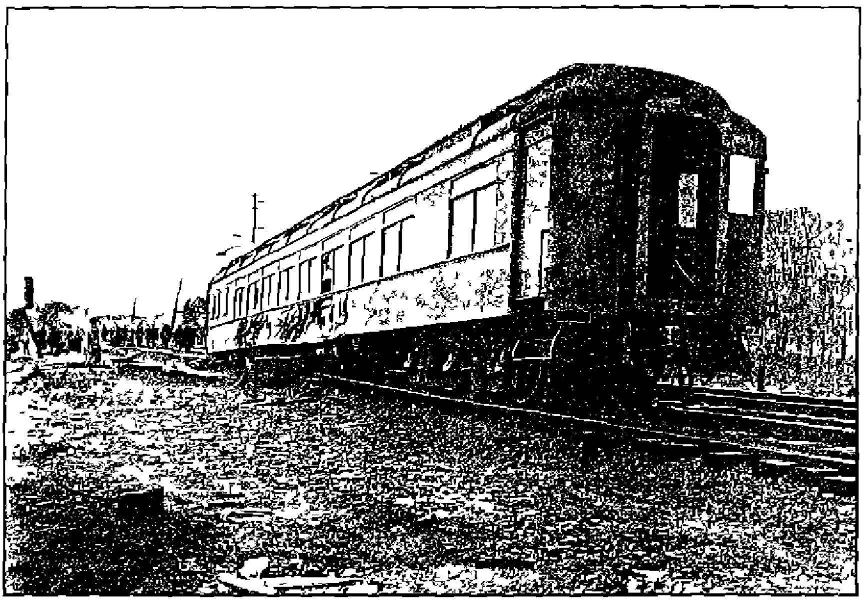
track The upper ends of the spike holes were elongated one or more diameters

The train ran on the inside corner of the head of rail No 2 for more than half its length at its south end the rail at that stage having been tilted outward and resting on the outer flange of the base The obliquity of the rail was greatest at its south end at this stage apparently judging from the disturbed metal at the junction of the running surface and the flange side of the head

Rail No 2 appears to have sprung back or was moved back and indistinctly shown by the photograph seems to rest upon and partly cover some of the inside spikes

Rail No 3 was permanently twisted about 20° in its full length From the evidence presented it would appear that this rail was in the first instance forced outward and was then followed by a torsional movement. At about 6 feet from the receiving end the inside flange was bend downward and at the same place there was a sharp bend in the rail as a whole, normal to the web and concave on the gauge side of the rail. The downward bend of the flange probably occurred immediately upon the spreading of the track and the bodily bend took place after the rail had turned over on its side.

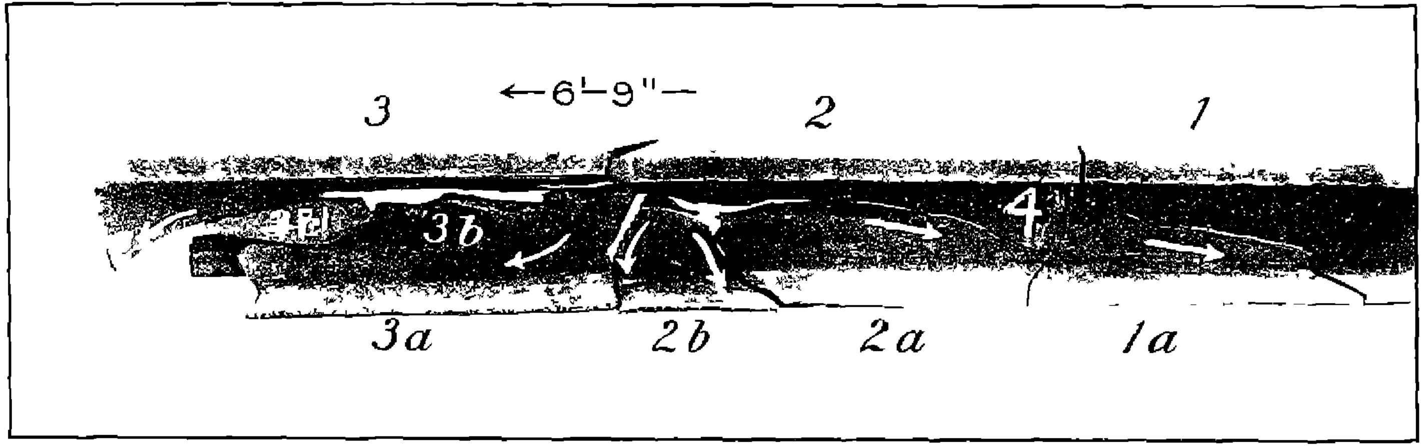
There were numerous marks scored on the inside surface of the web along two-thirds of the length of the rail at its southern end while but few marks were found on the northern one-third. Along



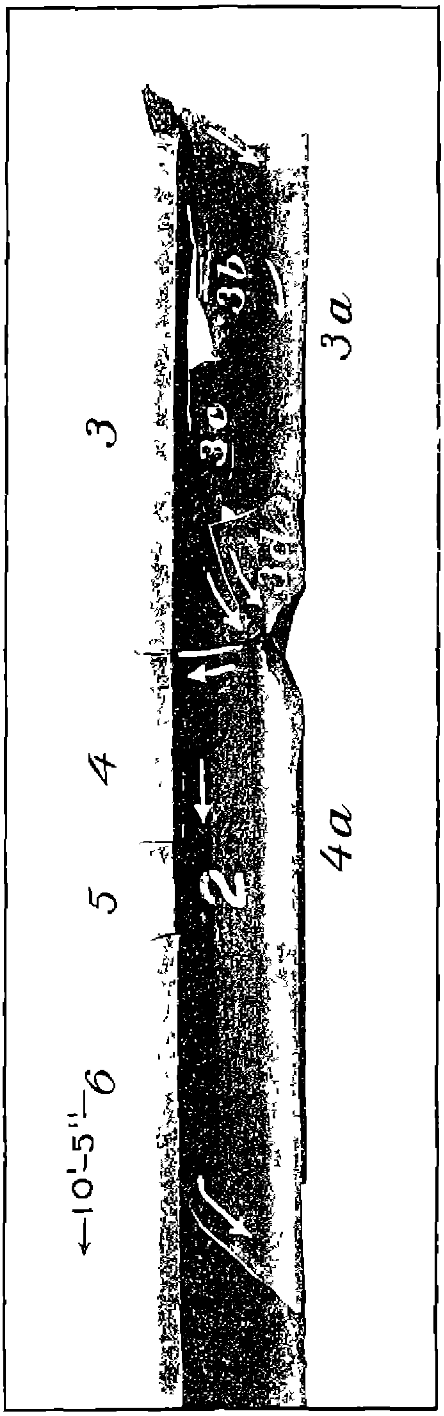
Pullman sleeping car "Honcove," showing wheels of forward truck resting on web of overturned rail.

the northern part there was evidence of wheels having run on the inside corner of the head in the same manner as it occurred on rail No. 2.

The photographic print shows some seven undisturbed spikes at the receiving end of rail No. 3, on the inside of the base. This condition would again indicate that a direct outward spreading of the track took place. There was a sharp bend in the inner flange of rail No. 3 17 to 18 inches from the leaving end and a bodily bend at the same place concave on the guage side. Near the middle of the length of the rail there was a short crescent-shaped flange break on the gauge side. The general condition of the ties remained unchanged for that part of the track which was under rails Nos. 1 to 3. Beyond the leaving end of rail No. 3 the ties were more or



No. 1 — Fragments of rail No. 1 viewed from gauge side. Initial point of fracture at junction of head and web between pieces Nos. 3 and 3a at distance of 6 feet 9 inches from receiving end of rail



No. 2. Fragments of rail No. 1 (continued). Fragment ended 10 feet 5 inches from receiving end of rail. Arrows indicate directions in which the line of fracture were developed.

less shattered by the wheels, and so continued from that point southward

Rail No 4, the next rail in order following the direction of the train, was broken into a number of small fragments, which comprised about one-third its length, at the receiving end Figures Nos 1 and 2 show the appearance of the fractured parts These fragments were made when the rail was lying on its side Prior to its overturning it appears that this rail had been spread, at least at its north end The inner flange at pieces marked 1a and 2a was bent downward on the gauge side at a place 5 feet from the receiving end of the rail This was done before the line of fracture between pieces 1a and 2a was formed, and constitutes evidence which is believed to show that spreading occurred prior to its overturning

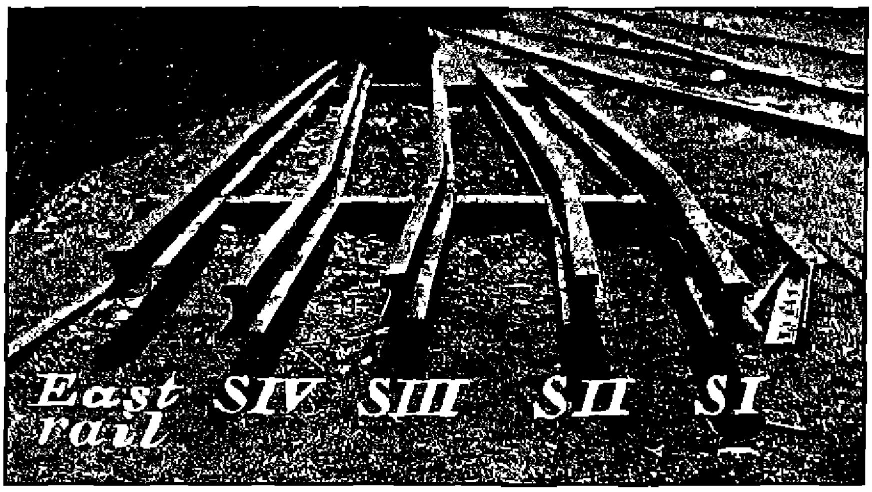
When lying upon its side the wheels of the train struck the web of the rail heavily at a place about 6 feet 9 inches from its receiving end At this place the initial point of fracture was found to be located The long, flattened, crescent-shaped break in the web under pieces marked 2 and 3, was apparently the first to be developed extending in each direction, north and south, from the initial point, which was close under the head on piece 3 near the line of rupture which separated it from piece 2 The lines of rupture separating the web and base were secondary, as were the fractures which detached pieces 1a, 4, 4a, and 5 Undoubtedly some of the smaller fragments were violently thrown about and received blows from different directions during the remaining stages of the derailment There were wheel-flange marks on the web of rail No 4 and on the webs of some 25 other rails located in the track in a southerly direction beyond this point

Abreast rail No 4 and for a number of rail lengths beyond the rails of the east side of the track were bent The photographic negative of the general view of the track, in the rock cut, shows that some of these east rails were bent concave on their gauge sides the reproduced cut not showing this feature so clearly as the negative Which truck was accountable for this effect on the east rail of the track is conjectural, with the probability of its being one of the trucks of the forward cars of the train or the rear axle of the tender

The rails next south of No 4 were marked SI to SIV, inclusive The webs of these rails were the most deeply grooved and scored of any pertaining to the derailment The markings were on the gauge side of each The inside flange of rail marked SI was fractured in a number of places, and one piece detached from the base of SII

These four rails were bent concave on the gauge side sharp bends occurring at distances ranging from 7 to 8 feet from their receiving ends The bends were without doubt made by the wheels of the train in dropping from the splice plates to the webs of the overturned rails There were also sharp bends about 18 inches from the leaving ends of the rails, caused by blows received when the wheels, running on the web, encountered the ends of the splice plates

Figure No 3 shows these four rails, and a fifth one, the latter a rail from the east side of the track Bends, in SI to SIV some 7 to 8 feet from the receiving ends, appear in the cut This east rail of the photograph was concave on the gauge side The wheel-flange marks on the webs of rails SI to SIV were very pronounced, and were without a doubt made when the rail lay on its side with the head toward the west



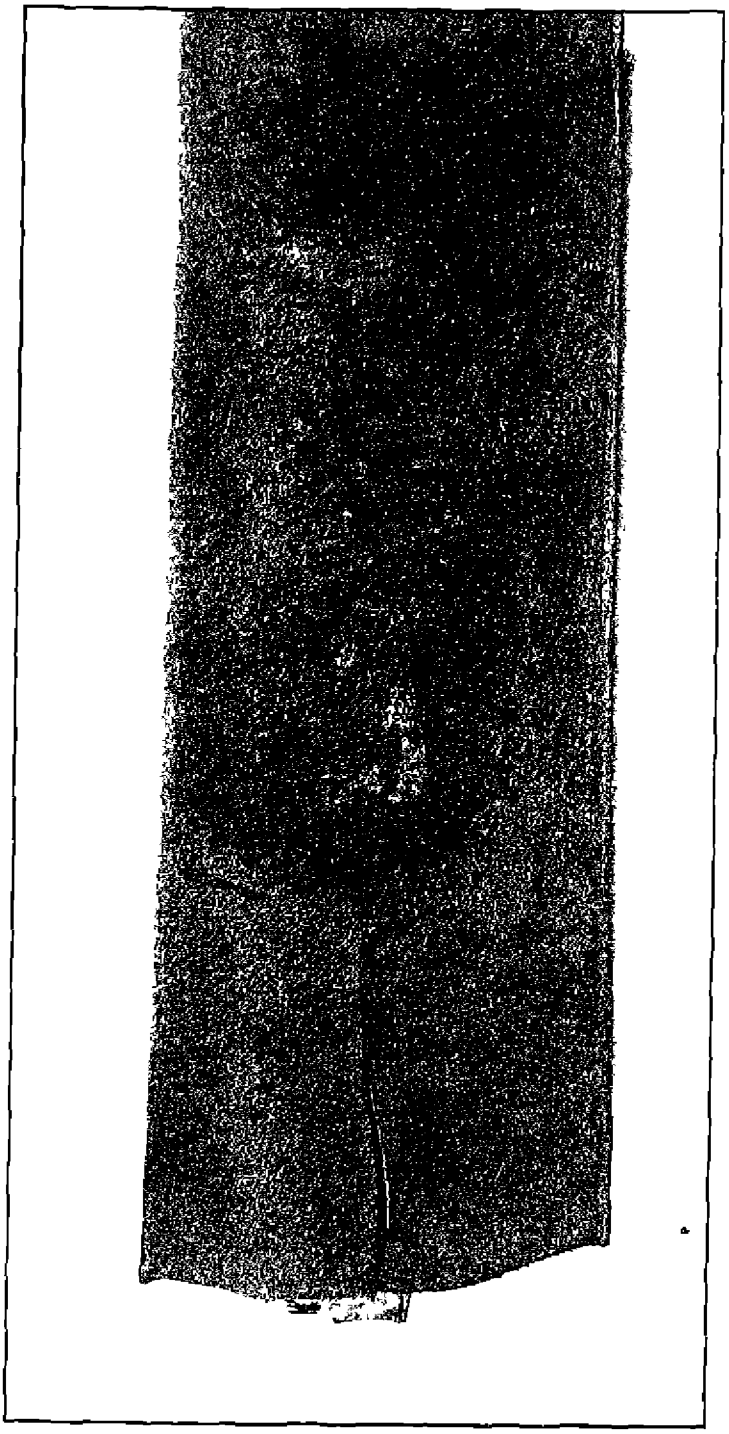
No 3 —Four bent rails from track next south of broken rail No 4 Rail on left side of cut came from east side of track This rail was bent concave on the gauge side

The rails which were located next south of the group, marked "SI to SIV," also showed pronounced wheel-flange marks on the inner surfaces of the webs The markings were less numerous on the rails farther down the track, finally disappearing at about the fourth rail from the southern end of the disturbed section Five cars having left the roadbed at an intermediate place the rails farther south were not exposed to the full number of wheels of the train

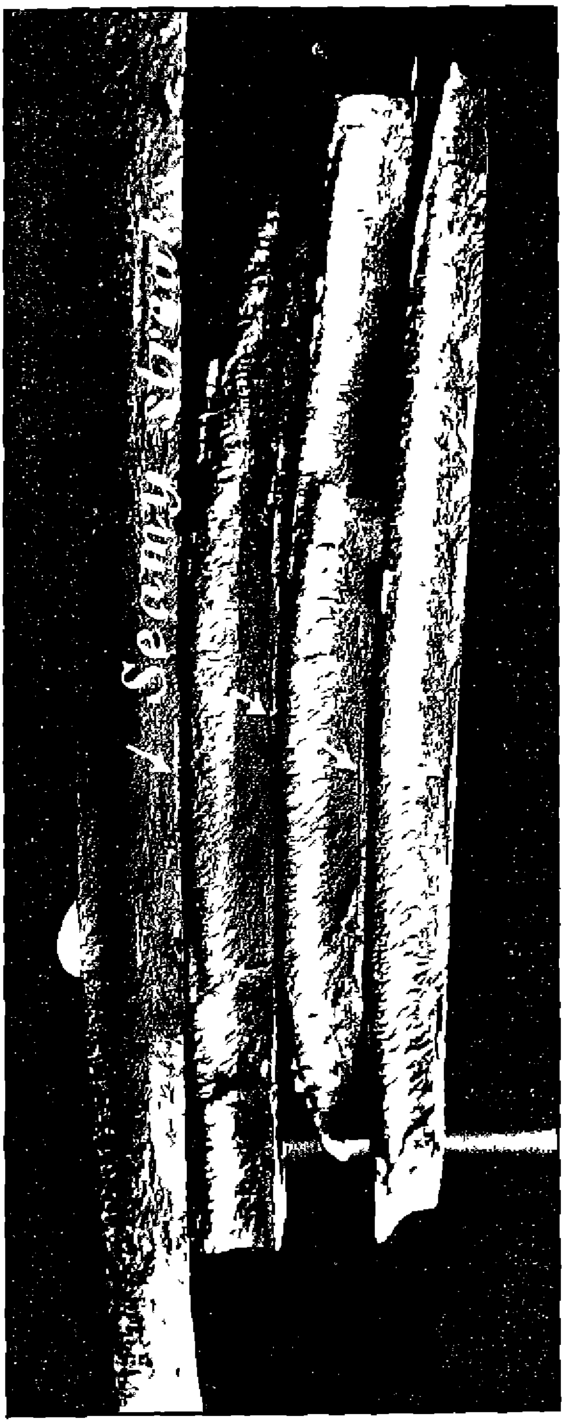
There were other broken rails resulting from the derailment, the identity of some of which, in respect to position in the track, was not well established

Three rails were bent, two of which were broken which had the gauge side of each on the outside of the bend One fragment, 16 feet 5 inches long, was bent toward the gauge side, with a deflection of 3½ inches One full-length rail had a deflection of 35 inches while

No. 1. Bent rails from west side of track and short fragment lying between ties with broken flanges. These rails were bent convex on gauge sides. From left to right they were marked W 28 B river W 36, W 29 B and Ice W 37



No. [illegible]. Crack in base of rail No. 1 developed when struck by tup in drop test. Rail tested with head down.



No 6—Pieces of flanges from rail No 4 Crosswise fractures of flanges developed after drop tests had been made, showing longitudinal seamy streaks

another was bent into the shape of a huge interrogation point, with a maximum deflection of 7 feet The upper end of this huge figure was the receiving end of the rail

Figure No 4 shows the appearance of these bent and broken rails The one marked "Ice W 37" was broken into three pieces These broken rails were found abreast of or in the vicinity of the five cars which left the roadbed and went into the river Some of the fragments went into the river at its edge, while one piece was thrown a distance upon the ice, which at that time covered the river

The bends shown in the cut, which would be inward in direction if the rail was upright, would take an upward turn when the rail was on its side If these rails were not the direct cause of the train separating probably some of them were bent by the last five cars of the train

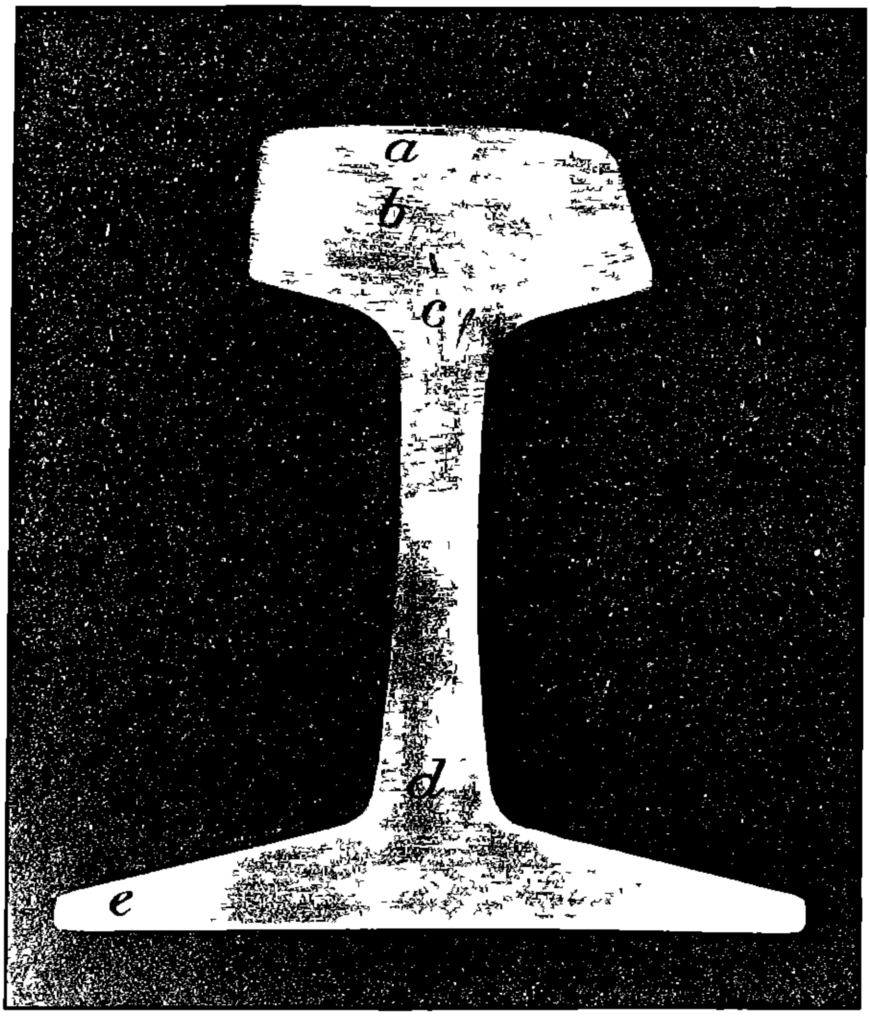
Events pertaining to rails No 2 and No 3 were doubtless of prime importance in causing the wrecking of the train, while the succeeding events were of secondary importance and the outcome of what happened to one or both of these rails The fracture of rail No 4 was a secondary affair, it is believed

Drop tests were made by the New York Public Service Commission on short lengths taken from the south end of rail No 4 Figure No. 5 shows a longitudinal crack made by the drop test in the base of one of its pieces It was reported that the first blow of the drop test developed this crack in the base, 5 inches in length and one-half inch deep The base was on the compression side, the rail having the head down in this test The crack was reported as having been due to the condition of the striking face of the tup The second blow of the drop test fractured the rail Two drop tests were made, the fractures of which were reported as not revealing any imperfections in the steel

It has been found in the examination of other rails that the drop test did not reveal imperfections which existed in the steel when the imperfections consisted of streaky and seamy metal, imperfections which were revealed however, by bending the flanges of the base in a crosswise direction

An examination for structural soundness of these pieces was subsequently made when the broken ends from the drop tests were returned to the Bureau of Standards Streaks were noticeably less prevalent in this rail than have been found in many earlier examinations although streaks and seams had not in this rail been entirely eliminated A number of short seamy streaks were revealed upon bending the flanges in a crosswise direction Figure No 6 shows four pieces of the flanges of this rail on the fractured surfaces of which appear short seamy streaks, along the lines of which fractures took place The surfaces of the seams were bright and lustrous and free from oxidation These streaks were generally located near but at a short distance above the lower surface of the base

A cross section of the rail was polished and etched with tincture of iodine as shown by figure No 7 There were markings on the



No 7—Cross section of rail No 4 polished and etched with tincture of iodine showing markings in lower part of head and web Chips for chemical analyses taken from places marked with the letters a, b c d and e

base which the photographic print does not bring into view—that is markings which were comparatively few and small in size The steel was more nearly structurally sound than has been witnessed in some rail steels examined on other occasions The etching solution brought out markings in the lower part of the head and the upper part of the web which appear in the cut

This cross section also shows the flange wear that had taken place on the gauge side of the head. The flange wear is evidence of the outward thrust of the wheels of the train against this rail. The wear exhibited by the outer rail of the southbound track was much greater than that of the corresponding rail of the northbound track at this curve.

Chemical analyses of samples taken from the piece of rail shown by cut No. 7 gave the following results:

Location from whence sample was taken	Carbon	Phosphorus	Manganese
Just below running surface of head	0.50		
Middle of head	.55		
Lower part of head and upper part of web	.65	0.145	0.92
Lower part of web	.53		
Near edge of flange	.50		

Tensile tests were made on specimens taken longitudinally from the outside portion of the head and from the base. The latter specimens were taken in both longitudinal and crosswise directions.

In the base specimens there were present longitudinal seams, streaks.

The results of the tensile tests were as follows:

Location of specimen	Dimensions	Sectional area	Elastic limit per square inch	Tensile strength per square inch	Elongation in 2 or 1 inches	Contraction of area	Elongation of inch sections	Appearance of fracture
	Inches		*Lbs.*	*Lbs.*	*Per ct.*	*Per ct.*		
Head longitudinal	0.505 diam.	0.20	52,500	104,300	22.0	37.1	0.17 0.23 0.26	Silky, interspersed with fine granulation
Base longitudinal	.400 × 1.35	.54		99,630	14.5	28.7	*.17 .12	Silky 60 per cent, granular 40 per cent
Do.	.401 × 1.34	.54		95,180	14.5	30.7	.15 .11	Silky
Base crosswise	.375 × 1.36	.51		86,470	4.0	7.1	.04 *.01	Granular. Fractured at a streak
Do.	.375 × 1.25	.46		93,700	5.5	4.8	.05 .06	Do.

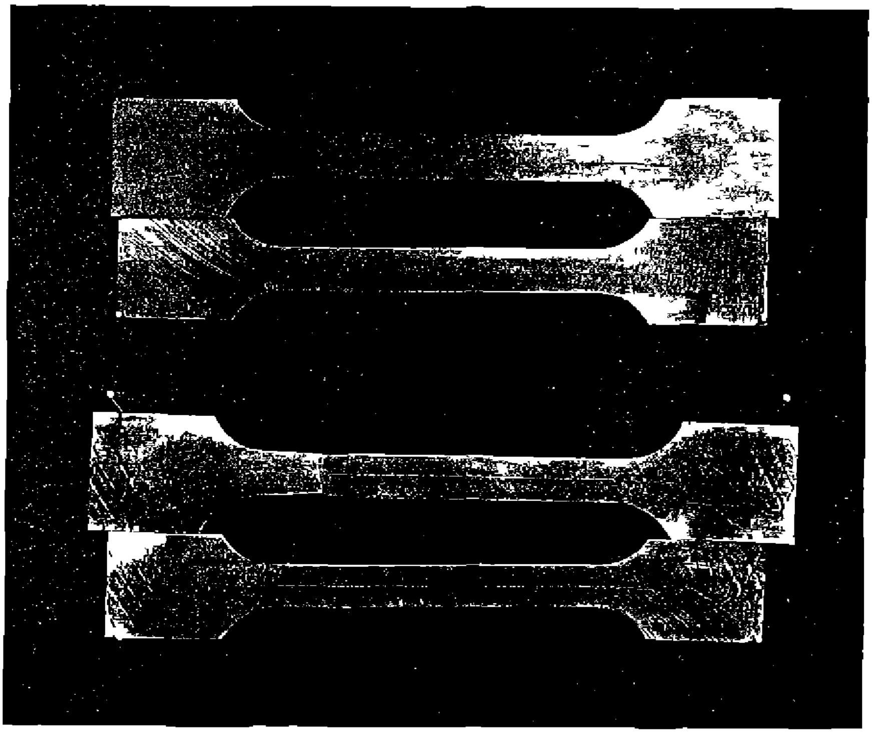
* Indicates fractured section.

Figure No. 8 shows two of the specimens which were taken from the base of the rail as they appeared before and after fracture by tensile stresses.

There were streaks present in each specimen. In the longitudinal specimen the streaks were parallel to the length of the stem and therefore parallel to the direction of pull, whereas in the crosswise specimen the streaks were at right angles to the length of the stem. The influence of the streaks in limiting the elongation of the steel is shown in the results. The metal of the longitudinal specimens elongated 14.5 per cent against 4 and 5.5 per cent, respectively, on the crosswise specimens.

Flange fractures of the base in a crosswise direction are known to be the most common fractures of rails when in service. These results show why such rail failures are overwhelmingly in the majority, if the repetition of such results are needed to establish the cause.

These results also show why several of the rails concerned in the present derailment displayed good bending properties when longitudinally strained, in one instance forming a loop 7 feet versed sine, while the *flanges* under crosswise bending were broken with limited elongation. In earlier reports mention has been made of the fact that



No. 8.—Tensile test pieces taken from base of rail No. 4 showing effect of streaks on extension of the metal. Appearance of specimens before and after testing. Upper piece of each pair longitudinal specimen, elongation 14.5 per cent. Lower piece of each pair crosswise specimen, elongation 4 per cent.

specifications governing the acceptance of steel rails do not call for tests in the direction in which rails most commonly fail, but strain the steel in the direction parallel to that in which the streaky seams extend when they are present.

It may further be remarked that steel-rail specifications do not prescribe a value for the elastic limit nor tensile strength of the metal. Since practically all other specifications prescribe limits for one or both of these values it is not clear why they should be omitted in steel-rail requirements.

Specifications for splice bars prescribe a value for the elastic limit of the metal Steel axles steel tires, and locomotive forgings all have a prescribed elastic limit or tensile strength, or both values The rail alone in this associated group of material is accepted without test for elastic limit or tensile strength It will be a step in advance when more complete data are acquired concerning the physical condition of the metal in steel rails and coupled with that information a definite knowledge of the stresses to which steel rails are exposed under usual service conditions

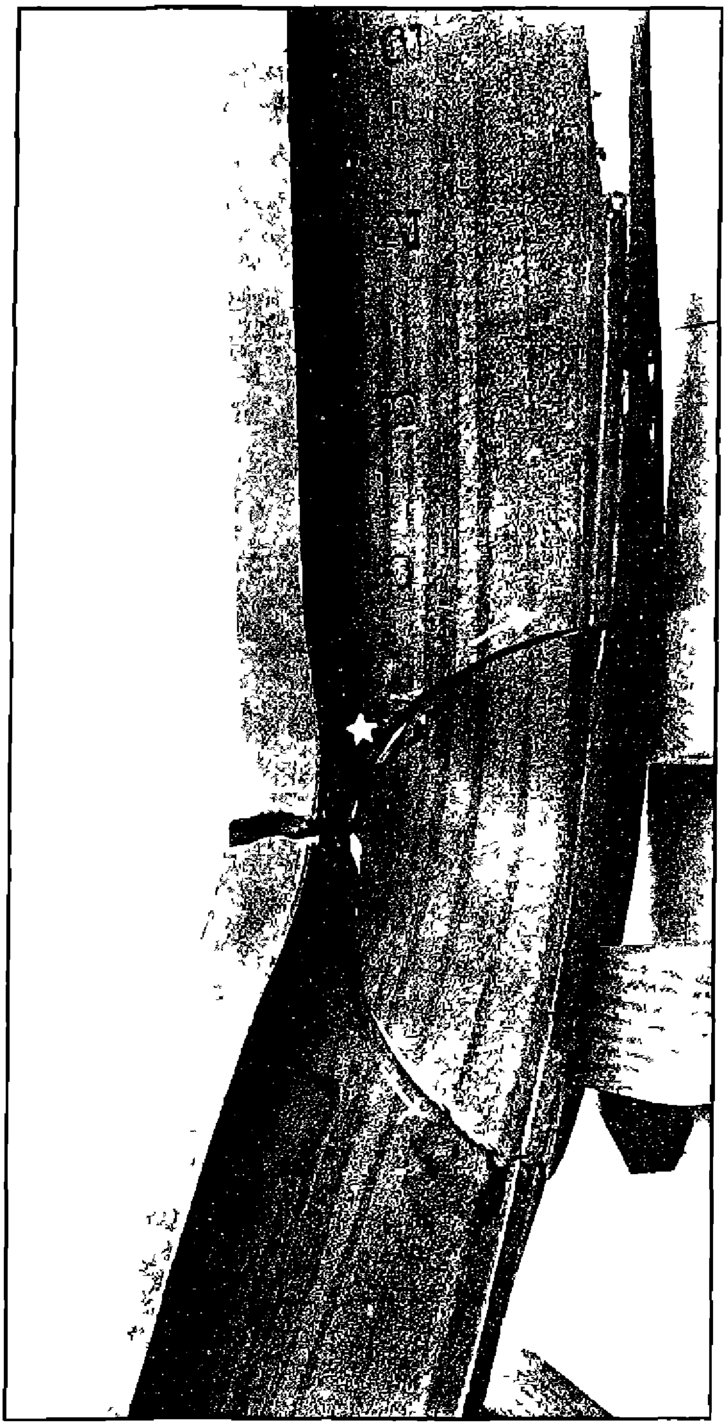
Lack of structural soundness or continuity tends to locate the place of rupture in steel when stressed and external indentations or defects particularly in hard steels have an effect similar to internal streaks and seams in locating the place of rupture when the steel is tested to destruction

An example of the presence of an external indentation locating the initial point of rupture of one of the rails of this series is found in a section which was broken in the drop test conducted by the New York Public Service Commission and shown by figure No 9

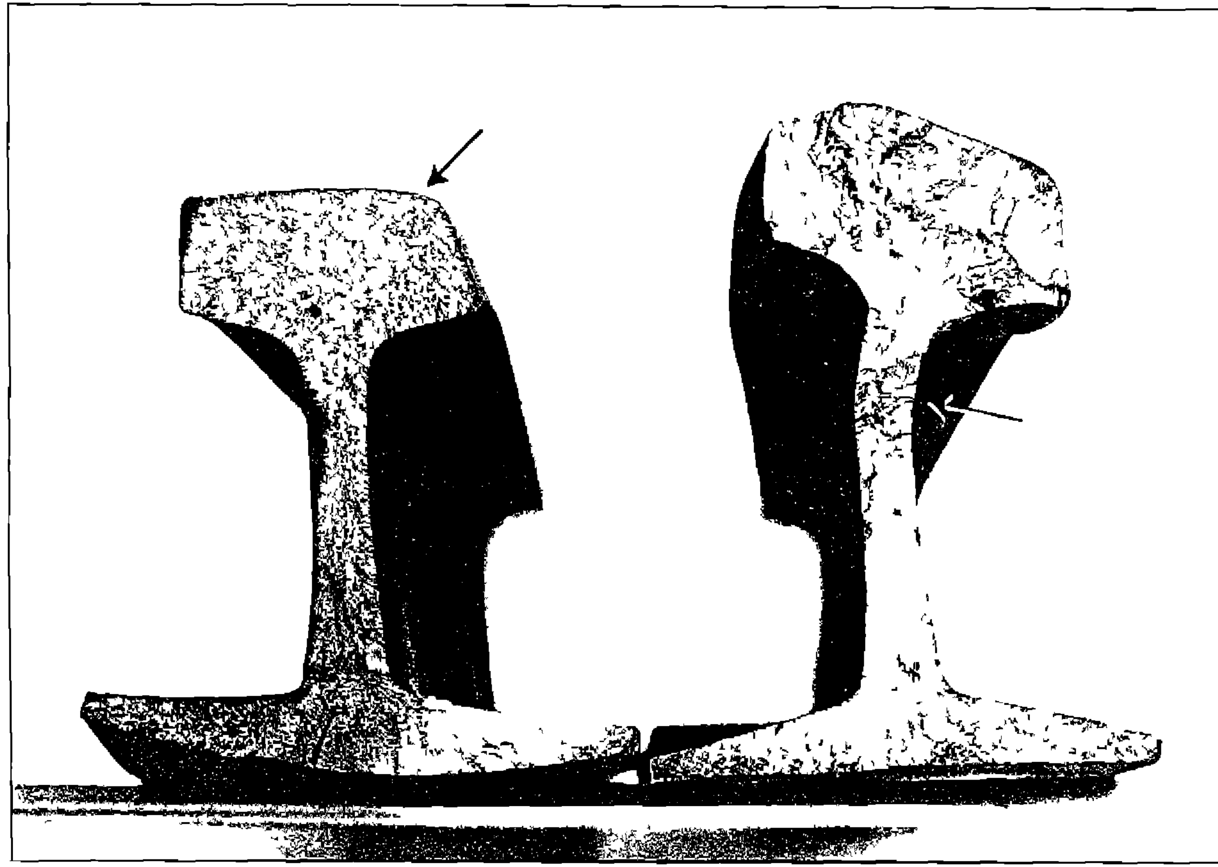
That section taken from rail No 4 was tested base down and broke at the third blow of the tup The fracture was an unusual one in respect to the direction which the lines of rupture traveled It was influenced by the indentation made by the brand marks on the web F T 38228 The fracture started at the letter F of the brand mark which was located on the web near its junction with the head and above the neutral axis of the rail A star marked upon the cut indicates the incipient place of rupture where a fine crack starting at the letter F extended through the letter T and a short distance beyond under the head of the rail

The main line of rupture started from this hair crack at the letter 'F' and extended in each direction around to the base and also from the same point up through the running surface of the head thus completing the fracture and separation of the rail The indentation at the letter 'F' was virtually a surface defect causing the line of rupture to have its origin at this unusual place As steels increase in hardness their susceptibility to injury from surface indentations or defects increase and while the metal of this rail was not particularly hard from chemical composition yet the brand marked constituted a surface defect which detracted sufficiently from the ductility of the steel to locate the incipient place of rupture

Figure No 10 shows the fractured surfaces of the two drop-test specimens The cross section on the right of the cut represents the test with the base down and on the web of which pointed out by the arrow may be seen the fine crack caused by the indentation of the letter F The crack did not reach through to the opposite surface of the web



No. 9.—Appearance after fracture by drop test of piece of rail No. 4. Tested with base down. Web branded "J 1 38228." Fine crack started at the indentation made by the letter "J." At this crack, indicated by a star in the cut, the transverse fracture of the rail had its origin.



No 10 Fractured surfaces of piece of rail No 4 after rupture in drop test Cross section on the right side of the cut shows rail tested with base down Fine crack in web caused by indentation of letter "I" of brand mark indicated by arrow Transverse fracture began at the crack Cross section on left side of the cut shows rail tested with head down Fracture began at corner of running surface and gauge side of head indicated by arrow

The cross section on the left of the cut shows the appearance of the fractured surface of the rail which was tested under the drop with the head down Fracture started at the corner of the running surface of the head and the gauge side, indicated by the arrow marked on the cut The crack in the base of this test piece shown from the under side of the base on figure No 5, is here shown viewed on end

Interest attaches to the condition of the track at rails Nos 2 and 3, as it existed just prior to the derailment Inasmuch as section men had been at work in that vicinity only a short time before the derailment it would be inferred that the alignment and surfacing of the track was believed to have been left in good condition That the means employed to maintain the track intact were for some reason inadequate the result shows If the speed of the train was greater than supposed, an exceptional strain may have been put upon the track If the speed was an ordinary one no margin in strength existed There has been no evidence presented to show that the train equipment was defective and led to the derailment Track in general in northern climates is less strong as spring approaches, due to winter conditions requiring the use of shims to maintain the surfacing With the use of shims between the rails and the ties the spikes have diminished holding power, and furnish less resistance against spreading of the track Shims had been used on the track in this vicinity as customary on all track

Two features present themselves for consideration in an endeavor to ascribe a direct cause for the derailment Was the speed of the train greater than supposed, thus bringing a more severe thrust against the outer rail of the curve, or had the shimming been carried too far, and by the use of thick shims had the margin in strength been exhausted? Evidence points to the spreading of the track by a direct outward movement, as the first occurrence in the derailment followed by an overturning of the rails Since it is not possible to apportion the responsibility between or attach it individually to one or the other of the probable causes, it would seem that the derailment should be attributed jointly to the effect of the high rate of speed of the train and to insufficient strength in the spiking or bracing of the outer rail of the curve

The line of demarcation between safe and unsafe conditions has not been demonstrated in practical railway engineering It is not known how much or how little margin of strength resides in the track It is a rare occurrence when direct experimental research is made for the purpose of ascertaining the stresses which rails in service are called upon to sustain and yet such knowledge should be the basis for judging of the safety of railway travel There is urgent need of information on the elastic and ultimate strength of track as constructed and used and also a direct determination of the magnitude of the stresses which the track, under service conditions, is called upon to resist In few branches of engineering work can it be said that so meager information is available pertaining to the structural value of the material and the working stresses as in the case of railway track the most common of all engineering structures

In conclusion, it appears that the probable primary cause of the derailment was the spreading of the track

That rails No 2 and No 3 of the outer rail of the curve were in the first instance forced horizontally outward, followed by partial overturning in an outward direction when disengaged from the inner spike heads or about that time That rail No 1 was temporarily twisted and partially drew some of its spikes, but without material displacement in position in the track

That rail No 4 was turned over on its side and fractured in that position by some of the wheels of the forward part of the train, the wheels running upon the web That rails beyond No 4 were all turned over on their sides, down to where the locomotive came to a stop

That the spreading of the track was probably started by the engine and completed by other wheels of the train

That there was insufficient strength in the spiking to maintain rails Nos 2 and 3 in place against the outward thrust of the engine, these and other rails displaced being outside ones of the curve

A conjectural explanation of the cause of inability to withstand the thrust of the engine is the probability that the track had been shimmed at this point and the holding power of the spikes impaired both against adhesive resistance in drawing from the ties, and for spikes on the outside of the rail, a loss in resistance against being bent outward The flange wear on the head of the outer rail of the curve showed the effect of the outward thrusts of the trains

Derailments of this kind emphasize the need of definite information on the magnitude of the stresses under different circumstances in the outer rails of curves caused by train loads

Respectfully submitted

JAMES E HOWARD
Engineer-Physicist

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