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INTERSTATE COMMERCE COMMISSION

REPORT OF THE DIRECTOR OF THE BUREAU OF SAFETY IN RE INVESTIGATION OF AN ACCIDENT WHICH OCCURRED ON THE WABASH RAILWAY NEAR TOLONO, ILL., ON JULY 29, 1925

MARCH 16, 1926

To the Commission:

On July 29, 1925, there was a derailment of a passenger train on the Wabash Railway near Tolono, Ill., resulting in the death of one passenger and the injury of five passengers and four employees.

LOCATION AND METHOD OF OPERATION

This accident occurred on the ninth district of the Decatur Division, eastern district, extending between Tilton and Decatur, Ill., a distance of 71.7 miles; in the immediate vicinity of the point of accident this is a single-track line over which trains are operated by time-table, train orders, and a manual block-signal system. The accident occurred about 2 miles east of Tolono, on an embankment about 6 feet in height; the track is tangent for a considerable distance in either direction from the point of accident, while the grade is ascending for westbound trains, being 0.315 per cent at the point of derailment. The track is laid with 90-pound rails, 33 feet in length, with an average of 21 oak and pine ties to the rail-length, single-spiked, partly tie-plated, and ballasted with gravel to a depth of about 12 inches.

The weather was partly cloudy at the time of the accident, which occurred at about 5.53 p. m.

DESCRIPTION

Westbound passenger train No. 53 consisted of one combination car, one coach, one deadhead chair car, and one deadhead coach, all of wooden construction, in the order named, hauled by engine 653, and was in charge of Conductor Patrick and Engineman Judy. This train passed Philo, 5.8 miles east of Tolono, at 5.46 p. m., 12 minutes late, and on reaching a point approximately 3.8 miles beyond Philo was derailed while traveling at a speed estimated to have been between 45 and 50 miles an hour.

Engine 653, its tender, and the rear truck of the first car were not derailed, while the rest of the train was derailed to the south

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The head end of the engine was about 675 feet west of the initial point of derailment The second and fourth cars came to rest practically upright, while the third car was leaning to the south, a distance of 118 feet separated the second and third cars

SUMMARY OF EVIDENCE

The first knowledge members of the crew had of anything wrong was when the accident occurred Engineman Judy said that when the engine passed over the initial point of derailment he felt nothing to indicate a broken rail Immediately afterwards, however, he felt a lurch which retarded the engine and on looking back he saw the cars derail Fireman Davidson said the first he knew of anything wrong was when the air brakes were applied as a result of the derailment Conductor Patrick and Brakeman Frame were riding in the second car at the time of the accident and said the car seemed to drop to the ties, these employees estimated the speed to have been between 45 and 50 miles an hour at the time of the accident Conductor Patrick and Engineman Judy went back after the derailment and found a broken rail on the south side of the track, at a point about 245 feet to the rear of where the last car came to rest, this point being 334 feet east of mile post 336

This accident was caused by a broken rail An investigation into the reason for the failure of this rail was conducted by Mr James E Howard, engineer-physicist, whose report immediately follows

REPORT OF THE ENGINEER-PHYSICIST

The derailment of westbound train No 53, near Tolono, Ill, on July 29, 1925 was due to a broken rail, which fractured at a transverse fissure This rail was rolled by the Illinois Steel Co, in the month of February, 1916 and laid in the track in the month of April next following Its weight was 90 pounds per yard, A R A section, heat number 49052, and ingot letter C It had the following chemical composition Carbon, 0 70, manganese, 0 69, phosphorus, 0 032, sulphur, 0 030, silicon, 0 24

The initial point of rupture was 20 feet 6 inches from its receiving end A transverse fissure was located in the head of the rail at this place, weakening it and leading to its fracture The leaving end of the rail was broken into six short fragments

Incipient transverse fissures were displayed in some of these short fragments Two fragments were again broken under a steam hammer in quest of still other fissures but none was found

Six years five months prior to this derailment, the track was injured by a broken wheel Forty-three rails were damaged, of which number 14 were immediately removed. The remaining 29 were strengthened with angle irons at those places where the heads had been indented by the broken wheel. It was one of these rails which caused this derailment. The wheel-indented places remained intact. Transverse fissures were developed in other parts of the rail, without relation to the indented sections.

Subsequent to this derailment another transverse fissure was discovered about 400 feet away, and rail removed from the track. This rail was rolled by the same steel company and had the same weight per yard and cross-section dimensions as the one which caused the derailment.

Pieces from each of these rails were examined for structural condition at the central parts of their heads. Metal from the tops of the heads was planed off in successive decrements of one-eighth inch, pickling each of the exposed surfaces in their turn in hot hydrochloric acid. Included in this examination also was a piece of an 85-pound rail which displayed a transverse fissure and caused a derailment on the Southern Railway near Juliette, Ga., on August 2, 1925.

Alternate planing and pickling the sections constituted the examination now made, having reference to the state of the metal in different parts of the head. Previous examinations of transverse fissured rails have been directed to other features, chemical and metallurgical.

Interest attaches to conditions which prevail at the nuclei of transverse fissures, whether or not there is continuity of the metal at such places antecedent to the inception of the fissures. Shattered zones are encountered in the central core of the head, groups of cracks where no foreign inclusions of any kind are found. They represent cooling effects, where the rails in cooling from the finishing temperatures of the rail mill acquire internal strains, culminating in some cases in small irregularly oriented fissures. Cooling strains, in a measure, are relieved when cracks ensue.

Some metallurgists and engineers are of opinion that an incipient crack of this kind is the necessary antecedent condition for the formation of a transverse fissure. All rails are subject to cooling strains of some degree. The formation of cracks signalizes that a partial relief from a maximum state of strain has been experienced by reason of the rupture of the metal. It is not the elimination, complete or partial, of one component tending to cause an interior fissure which is held a necessary precursor in the formation of a transverse fissure, but the resulting discontinuity of the metal locally intensifying the strains imposed by the wheel pressures. The explanation of the genesis of transverse fissures does not introduce factors peculiar to rails which have displayed transverse fissures, but rests upon features of common occurrence in all. Fundamentally the rupture of steel, whether in a rail or elsewhere, depends upon the magnitude of the strains imposed and modified by the manner of application.

With these features in mind relevant evidence was sought in the examination of the present rails. For convenience of reference the rails were given identifying letters as follows:

A. Ninety-pound rail involved in the derailment of train No. 53 on the Wabash Railroad near Tolono, Ill., July 29, 1925.

B. Ninety-pound rail discovered in the track with a transverse fissure, Wabash Railroad, 400 feet from the location of rail A.

C. Eighty-five-pound rail involved in the derailment of train No. 4 on the Southern Railway near Juliette, Ga., August 2, 1925.

The head of rail A was planed off in successive decrements of one-eighth inch and pickled in hot hydrochloric acid at each stage. At a depth of one-fourth inch no cracks nor seaminess was shown. At a depth of three-eighths inch an incipient transverse fissure was revealed, measuring five-sixteenths inch long, taken crosswise the rail. Its maximum length was found to be one-half inch. It disappeared at a depth of 1 inch.

At the depth of one-half inch below the running surface longitudinal seams were displayed, but no transverse cracks. At five-eighths inch and three-fourths inch, respectively, short transverse cracks were displayed in the central core of the head, longitudinal seams also being shown.

The metal of the head of rail B was examined in a similar manner. A transverse fissure over 2 inches in diameter was located at one end of this fragment. Planing off the head of the rail a depth of one-fourth inch revealed another well-developed transverse fissure, located 1⅞ inches from the transverse fissure which was displayed in the track. This fissure was found to have a diameter of 1⅜ inches. It may be remarked in passing that the development of two large transverse fissures in such close proximity to each other precludes their formation being attributed to bending stresses of the rail considered as a beam. It attaches responsibility to the impinging pressures of the wheels on the running surface, they only being competent to cause the formation of two closely adjacent fissures.

The pickled surfaces revealed a few short crosswise cracks, none being in the vicinity of the transverse fissures. Figure No. 3 shows the appearance of the incipient transverse fissure found in this fragment, photographed at a depth of 1 inch below the running surface of the head. The pickling bath enlarged the crack representing the transverse fissure.

Absolute proof is wanting in many cases whether a minute shrinkage crack was at the nucleus of a fissure, whether internal strains on the verge of rupture existed at that place, or whether the inception of the transverse fissure was due solely to the internal strains set up by the wheel pressures Transverse fissures located entirely outside the limits of shattered zones presumptively owe their inception to wheel pressures alone Interesting questions abound descriptive of the phases of rupture as well as those explanatory of the cause of transverse fissures

Rail C had the following composition Carbon, 0 68 manganese, 0 80, phosphorus, 0 029 sulphur 0 025 It had been in the track a period of 14 years 4 months when it displayed a transverse fissure It was examined in the same manner as rails A and B No additional transverse fissures were discovered The pickled surfaces showed longitudinal serrations, hardly described as seams, parallel to the direction of the rolling of the rail A crosswise crack three-hundredths of an inch long appeared at a depth of one-half inch, and two others at a depth of three-quarters inch The hot acid developed a few pinholes in the pickled surface when planed to different depths No manifestations of consequence were displayed, negative evidence only being acquired Such tests, however, have their values, eventually leading to sound explanations by eliminating untenable ones

Photographic prints are introduced to illustrate the appearance of transverse fissures Figure No 1 shows a transverse figure which was displayed by a 90-pound rail on the Chicago & Alton Railroad This fracture, originating in the head over the gauge side of the web separated the larger part of the cross section of the head It had reached the peripheral surface when it fractured under a train This rail had been in the track 7 years and 10 months

Figure No 2, *a* and *b*, illustrates two other transverse fissures, from another rail, at earlier stages of development These fissures presented a silvery luster, common to incipient fissures before exposure to the air The surfaces are commonly darkened when viewed on transverse fissured rails which have caused a separation of the rail in the track

Incipient transverse fissures at their earliest stages usually display silvery crescents, concentric with the nuclei The nuclei of transverse fissures retain their gray color whence it is inferred that in their formation the metal is torn apart by a longitudinal tensile force and the opposite faces do not again come into contact with each other In regard to the corona of fissures, their silvery luster is attributed to a burnishing effect, the opposite faces making contact when the section of the rail, above its neutral axis, is strained by compression loads There is no display of ductility in the steel in the extension of a transverse fissure The burnished faces are separated hardly a measurable distance

The opinion prevails among those who are not prepared to place full responsibility for the formation of transverse fissures to service strains and stresses received in the track, that some antecedent state exists which creates a nucleus, all admitting that the extension or enlargement of the transverse fissures are due to track strains and to those strains only

The nucleus of a transverse fissure representing its point of inception, displays an area of 1 per cent or less of the sectional area of the head The explanation offered is not an encouraging one, which places responsibility for the occurrence of a transverse fissure upon a preexisting crack in the head of the rail not exceeding one one-hundredth of its area, taking into consideration also that the preexisting crack occupies a position not among the fibers which are most remote from the neutral axis of the rail The first stage of enlargement of such a preexisting crack would obviously demand a force nearly identical in magnitude to one necessary to start a crack in an intact rail This argument does not give much encouragement to the elimination of transverse fissures, which have their origins as shrinkage cracks nor does it remove the responsibility far from the influence of the wheel pressures taken alone

Omission of the consideration of the effects of the intense impinging pressures between the tread of the wheel and the head of the rail has been quite general This feature which constitutes the real crux of the rail problem has been practically ignored, a better understanding of the case will be reached when it is taken into account Weights and shapes of rails are changed and specifications revised without touching upon this vital element

When wheel loads are mentioned those of the equipment as well as those of the motive power are included Due to the greater number of repetitions of wheel loads of the equipment, their influence appears to exceed the lesser number but heavier loads of the motive power This result is entirely consistent with carefully conducted laboratory tests on repeated stresses

In retrospect, no remedy has been found for the prevention of transverse fissures attaching to current grades of steel and present practice in wheel loads Nor has it been possible to predict when transverse fissures would display themselves with respect to longevity of the rails in service It is well established that hard steels develop transverse fissures without distortion of shape under wheel loads and with slight loss of metal by abrasion, also that all weights of rails display this type of rupture Furthermore, it has been shown that the display of transverse fissures predominates on heavy-traffic tracks in comparison with rails carrying the same engines but with light-weight equipment of return-train movements, and that low rails of curves display more fissures than high rails Efforts to detect the presence of incipient transverse fissures in rails in the track have been unsuccessful

The present situation is disquieting, with inability to prevent their recurrence, and without knowledge of their existence in the track until some untoward circumstance reveals their presence They constitute an ever-present menace to life and property, demanding more than passive endurance The most definite statement permissible is that by the process of elimination the responsibility for the display of transverse fissures attaches to high wheel loads, which merely reiterates statements which have been made from time to time since this insidious type of fracture was first brought to general notice

SUMMARY

A transverse fissure was responsible for the derailment of train No 53, a type of fracture which has defied detection in the track until actual separation of the rail has taken place Rails commonly acquire transverse fissures in several places along their lengths One rail came to notice in which 50 transverse fissures in different stages of development were present On account of their numbers and frequency, reports upon them tend to assume a perfunctory character, and would do so except for the gravity of such fractures, attended as they frequently are with serious consequences

It is the opportunity and the duty of the users of rails to look diligently into the cause of the formation of this type of fracture They have the necessary material at hand with full knowledge of its behavior The results of efforts which have come to notice have contributed toward the elimination of probable causes Positive data should now be looked for

Respectfully submitted

W P Borland, *Director*

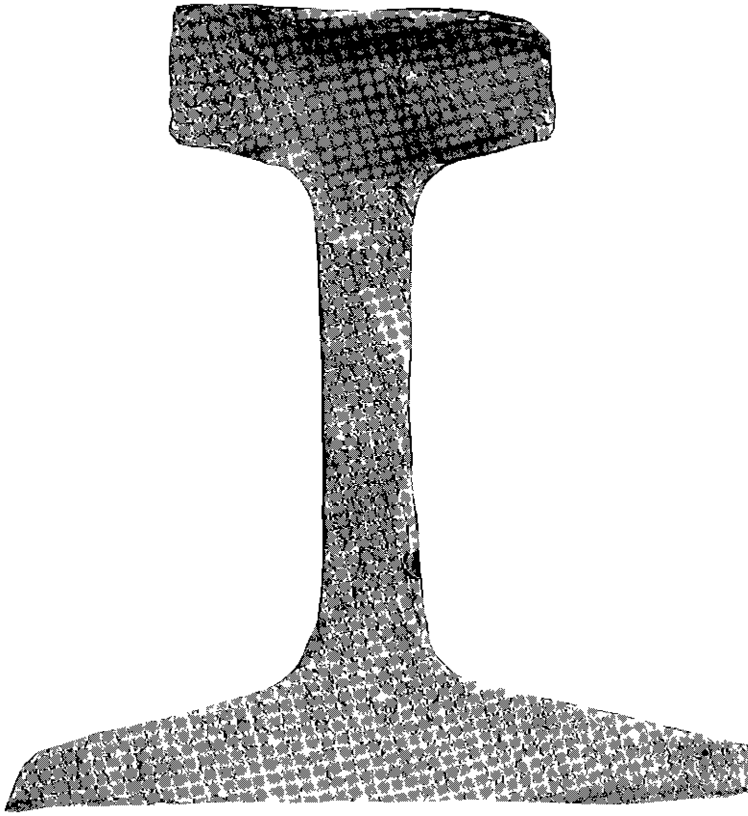


FIG. 1.—Appearance of a transverse fissure in the head of a 90-pound rail

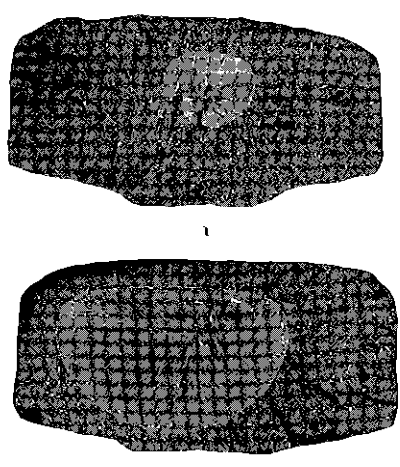
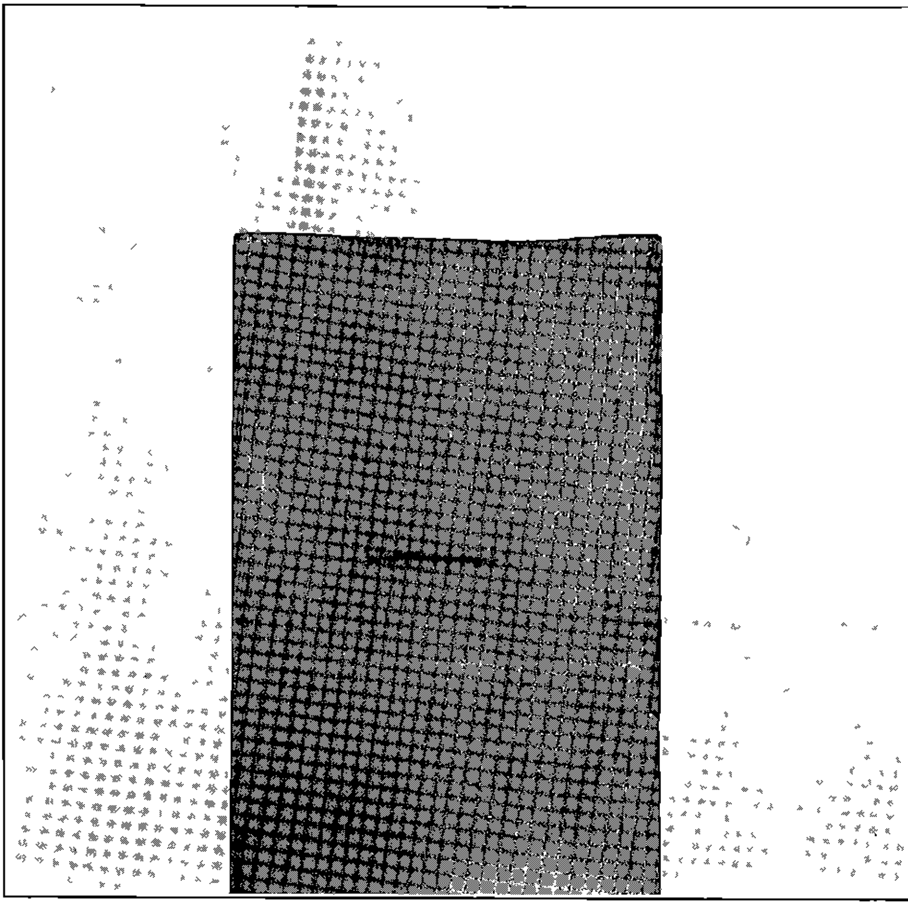


FIG. 2 (a and b).—Appearance of two transverse fissures at different stages of development in the same rail

BROKEN END OF RAIL—TRANSVERSE FISSURE



INCIPIENT TRANSVERSE FISSURE

FIG. 3.—Edge of an incipient transverse fissure in a 90-pound rail. Head planed off 1 inch and surface then pickled. Pickling increased the width of the fissure. This fissure was located 1⅞ inches from another fissure at broken end of rail.

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