1427

INTERSTATE COMMERCE COMMISSION

REPORT OF THE DIRECTOR OF THE BUREAU OF SAFETY IN RE INVESTIGATION OF AN ACCIDENT WHICH OCCURRED ON THE MISSOURI PACIFIC RAILROAD AT WEST JUNCTION, KANS., ON JUNE 25, 1928

JULY 18, 1929

To the Commission

On June 25, 1928, there was a derailment of a passenger train on the Missouri Pacific Railroad at West Junction, Kans., resulting in the injury of 47 passengers and 4 employees, 2 of whom were dead-heading

LOCATION AND METHOD OF OPERATION

This accident occurred on the Coffeyville district of the Southern Kansas division, extending between Coffeyville and Osawatomie, Kans a distance of 134.66 miles, in the 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 on a fill about 6 feet in height, at a point approximately 921 feet east of the junction switch at West Junction, approaching from the west there is a tangent beginning a short distance west of the junction switch and extending nearly 4,000 feet beyond the point of derailment The grade for east bound trains is level at the point of derailment The track is laid with 85-pound rails, 33 feet in length, with about 19 ties to the rail-length, partly tie-plated, single-spiked, and ballasted with cinders to a depth of about 17 inches Measurements of the cross levels and gauge, taken at every rail joint, the joints being staggered, showed the track to be uniform in these respects

The weather was clear at the time of the accident, which occurred at about 4.03 a m

DESCRIPTION

Eastbound passenger train No. 116 consisted of 1 mail and baggage car, 2 baggage cars, 1 coach, 1 chair car, and 2 Pullman sleeping cars, all of steel construction, hauled by engine 6434, and was in charge of Conductor Gardner and Engineman White. This train left Buffalo, 7.47 miles west of West Junction, at 3.49 a. m., according to the train sheet, 46 minutes late, and shortly after passing West Junction it was derailed by a broken rail while traveling at a speed estimated to have been between 45 and 55 miles per hour.

The engine, tender, and the second car in the train were not derailed, but the first car, the rear wheels of the third car, and all of the remaining cars were derailed. The engine and the first four cars remained coupled, passed over a 128-foot trestle, and came to a stop with the forward end of the engine approximately 1,162 feet east of the initial point of derailment. The fifth car was derailed to the left, fell from the trestle, a maximum drop of 18 feet, and came to rest on its left side in the bed of the water course, 202 feet back from the head portion of the train. The sixth and seventh cars were also derailed to the left and came to rest on their left sides, a distance of 286 feet separating them from the fifth car, while the rear end of the seventh car was 192 feet east of the initial point of derailment. The injured employees on duty were the conductor and brakeman, the injured employees deadheading were an engineman and a paint foreman.

SUMMARY OF EVIDENCE

Engineman White stated that the first he knew of anything wrong was when Fireman Bachman informed him that fire was flying from under the train and that the cars were derailed. He estimated the speed of the train to have been about 50 miles per hour at this time and said that he immediately applied the air brakes in emergency. Engineman White did not feel any lurch of the engine as it passed over the point where the first car was derailed, but said that something felt as if it had struck the engine or the side of the ash pan, it was not a jar. After the accident he saw the broken rail that caused the derailment. Fireman Bachman estimated the speed to have been about 45 miles per hour at the time of the accident. Statements of other members of the crew developed nothing additional of importance.

Division Engineer Murray stated that the track in this vicinity was good for the maximum speed permitted for passenger trains, 55 miles per hour. His examination showed that the rail broke as a result of a transverse fissure and that the fissure could not have been detected during the course of visual inspection. He thought that the rail was broken by the engine of the last westbound train to pass over it, train No. 115, due at West Junction at 3.28 a. m., saying that there was a slight battered place on the east end of the ball of a short piece of the rail that could only have been made by a westbound train. No other train passed between this time and the time train No. 116 encountered the broken rail. Division Engineer Murray stated that the track is carefully inspected every day, Sunday excepted, and that such inspections have disclosed broken rails in time to avert accidents. Assistant Division Engineer Heasley shared the views of Division Engineer Murray as to the rail having been broken by the westbound train.

This accident was caused by a broken rail, and an examination as to the reason for the failure of the rail, made by Mr. James E. Howard, engineer-physicist, whose report follows, shows that the failure was due to a transverse fissure.

As noted by Doctor Howard in the present report, 18 years have elapsed since this type of rail fracture was brought to general notice. Much research work has been done during this period. Now that facilities are at hand for the detection of these insidious fractures in the laboratory and in the track, means would seem to be available for securing exact information concerning their formation and development. A general, comprehensive inquiry, on lines suggested by Doctor Howard, should be undertaken.

Respectfully submitted.

W. P. BORLAND, *Director*.

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The accident to train No 116 on June 25, 1928, near West Junction, Kans , was apparently due to the presence of transverse fissures in one of the rails of the track The rail involved was rolled by the Colorado Fuel & Iron Co in December, 1916, and put into the track early in the following year It was branded "Colorado Sec 850 XII O H 7789 X "

The rail broke 14 85 feet from its receiving end, at a large transverse fissure Two other fissures, each of large size, were displayed at places beyond the initial break These fissures had evidently reached the peripheral surface of the head of the rail prior to the time of the accident

The engine and tender passed over the rail and remained on the track All wheels of the first car were derailed The second car remained on the track and the forward wheels of the third All other wheels of the train in the rear of these were derailed The four forward cars passed over a 10-panel trestle, remaining upright, and did not leave the roadbed The fifth, a chair car, fell from the trestle and spanned the channel of the creek, while the rear two Pullmans left the roadbed and fell upon their left sides The engine came to rest 1,162 feet from the point of derailment, the last Pullman 192 feet beyond

The broken rail was fragmented at the time of the accident beyond the locations of the several transverse fissures In all, 10 fragments were detached The circumstances attending the derailment lead to the belief that the rail was not broken until train No 116 came upon it

No unusual events attended the accident The track had been weakened by the presence of transverse fissures and a derailment followed Fortunately it terminated without more serious consequences There was property damage, and a considerable list of personal injuries, but without fatalities

Figure 1 illustrates the position of the chair car, where it fell from the trestle It was a car of steel construction, having sufficient strength to fall and span the creek without material injury Figure 2 illustrates the positions of the last two Pullman cars of the train, lying on their sides parallel to the right of way The complete destruction of the track structure in that vicinity is shown

Figure 3 illustrates the transverse fissure which was located 14.85 feet from the receiving end of the broken rail. The nucleus of the fissure was on the gauge side of the head. It had reached the periphery, admitted air and became darkened. Transverse fissures which reach the peripheral surface of the head commonly appear on the gauge side, and at the fillet under the head. A thin layer of metal next below the running surface usually remains unbroken, while the metal of the outer half of the head also remains intact.

Rails which display transverse fissures not infrequently contain more than one. They display fissures in different stages of development. The present rail was no exception to this rule. Two fissures which had not reached the surface were subsequently discovered. They will be referred to in a later part of this report.

GENERAL REMARKS

Transverse fissures have been described in earlier reports of the Bureau of Safety. The first report upon this type of fracture was published by the Interstate Commerce Commission relating to an accident on the Lehigh Valley Railroad of August, 1911. Little remains to be said about them descriptively. They are fractures of interior origin, with loci in the heads of the rails, and generally on the gage side. They have definite nuclei, of dull gray appearance, surrounded by areas of silvery luster. In the early stages of development a silvery crescent forms, which later develops into an oval surface. If they are discovered in the track before actual separation at the surface, it is by reason of the display of a rust streak where the fissure is about to break through. Previous to this stage of development, macroscopically, they are an unknown danger. The rail is seriously weakened before transverse fissures admit of detection by surface inspection.

CONCERNING THE PREVALENCE OF TRANSVERSE FISSURES AND THEIR DANGER

Prior to the year 1911 few fractures of this type had been observed. They had not been recognized as a distinct type of fracture up to the time of the accident at Manchester, N. Y., of August 25, 1911. Several years elapsed before much attention was given their prevalence. They were not immediately taken as a serious menace to safety of travel, rather as a transitory matter which would be recovered from. As time passed they appeared in numbers. Now they are reported from different parts of the country in increased numbers. The annual rate of display appears to exceed 4,000, with the probability of other thousands in embryonic state, at different stages of development. At present they are recognized as the most insidious, dangerous type of fracture known. Their menace is not local; it is national.

The situation demands a thorough, comprehensive inquiry into the ability of steel rails to endure present track stresses. The entire transportation system of the country depends upon the strength and safety of the track structure, of which rails are the vital parts. Broken rails, caused by transverse fissures, are of daily occurrence.

CONDITIONS ESSENTIAL FOR SAFETY IN ENGINEERING STRUCTURES

Study has long been made of the physical properties of steel. It is known that certain unit stresses may be endured for indefinite periods of time. The essential requirement for permanency may be stated in a few words. Steels must not be strained beyond certain limits. To destroy a structure, the only requirement is to overstrain its members. In a practical manner it is not difficult to judge between safe and unsafe loads, when a reasonable margin separates them.

STEEL RAILS AS BEAMS

One of the first requirements of a rail, but the most easily met of all, is its strength as a beam. With all the uncertainties of supporting power of ties, ballast, and subgrade, computations on assumed reactions and measured fiber stresses in the track, none show irremediable cause of weakness in rails taken as beams. If evidence of weakness should ever appear, the remedy is so obvious it would be immediately applied. Simply displacing one section of rail for another of greater section modulus would end the trouble.

It has not come to notice that present rails fail under beam action. A slight permanent bend would appear, the earliest indication of overstrain. Under high bursts of speed, where the effect of the counterweight of the drivers practically doubled the static load, permanent sets have occurred. It is no cause for surprise, however, that heavy engines are run over light rails without fracture. Repeated sets would be attended with irregular surfacing and would not fail to be noticed.

DROP TESTS AND GAGGING

Rails display permanent bends and necessarily permanent elongation of the outside fibers under the drop test. A drop test does not represent the conditions of service It merely stands for one method of test in the display of physical properties Suddenness of rupture has an influence on the manner of fracture of rails The effect of shape is felt in all cases of sudden ruptures

Examples have been witnessed in which the fractures of rails in the drop test originated not in the outside fibers but under the head, at the fillet of the web Also cases where dog marks in the web located incipient points of rupture Under high explosives, when rupture is caused in the briefest interval of time, slight changes in sectional area have a pronounced influence in locating incipient points of rupture Symmetry of section and easy transition from one cross section to another are features of importance to successfully resist shock tests

Gagging necessarily overstrains the outside fibers of the rail The elastic limit of the steel is locally exceeded, and the mill scale disturbed A slight indentation results at the place where the gag is applied These manifestations constitute all the evidences of the operation of gagging The microscope does not reveal any interior change of structure The operation does not go far enough to sensibly change the appearance of the microstructure Gagging, however, profoundly modifies and frequently reverses the interior strains of cooling Roller gagging would be expected to disturb the initial state of strain over the entire length of the rail, excepting the extreme ends not reached by the rolls Detrimental effects of gagging have not been witnessed in fractures of rails in the track

COOLING STRAINS IN RAILS

Cooling strains are set up in all structural shapes, under normal conditions of cooling in the open air, whether forged or rolled members The first evidence of cooling strains in a rail is its change in shape after cambering Rails tend to straighten themselves during cooling on the hot bed One part of the cross section acts against the other, affecting the rail as a whole

Individual portions of the cross section likewise act upon each other The effects of longitudinal strains are thus observed

Still further, strains between the exterior and interior metal are introduced The effects of the latter attract the most attention, since they often result in shrinkage cracks, and such cracks by some are held to be essential precursors in the display of transverse fissures Shrinkage cracks occur in both the head and the base No attention, however, has been given those of the base

COLD ROLLING STRAINS IN RAILS

The impinging pressures of the wheels in service set up internal strains in the heads of rails They are strains of compression immediately below the running surface, with reaction of tension in the interior of the head The strains are both lengthwise and crosswise the rail Crosswise strains tend to cause split heads, those which are lengthwise tend to cause transverse fissures Each of these interior fractures, split heads, and transverse fissures are of tension

Previous reports of the Bureau of Safety have given the results of investigations of these strains and furnished numerical values In brief, the cold rolling strains of compression are far greater than either those of tension or compression sustained by the rails taken as beams Likewise, the internal strains of tension in the interior of the head are greater than the strains of tension as they have been measured in the track under train loads In other words, the greatest strains which rails are required to endure in service come from the impinging pressures between the tread of the wheel and the running surface of the head

DEFINITION OF THE RAIL PROBLEM

The above facts should be sufficient to center attention upon the specific feature which constitutes the rail problem The crux of the problem is located in the upper part of the head of the rail It results from the intense impinging pressures which are received there Such pressures carried to extremity would destroy any known grade of steel The query is presented whether there now exists a safe margin in the endurance of rails against current wheel pressures The display of thousands of transverse fissures is taken as evidence that a safe margin does not exist

The problem is to make rails safe against present track conditions They can not be called safe when numerous fractures of a particular type continue to occur Transverse fissures should be investigated until it is definitely established whether there is a remedy for their display Energetic efforts are demanded No additional equipment is needed to inaugurate such an investigation, and it would be idle to say that enough material is not at hand

The construction of a special experimental track, special equipment, and special heats of steel are unnecessary and would be well calculated to indefinitely defer an answer

LINES OF INQUIRY OPEN FOR INVESTIGATION

One of the most glaring lines of inquiry for immediate inauguration refers to the influence of shrinkage cracks in the central zone of the head. Would their suppression lengthen or shorten the lives of rails? The examination of a few of the many thousands of rails, which annually display transverse fissures, would assist in the solution of this question, and possibly yield a definite answer.

It is a matter of general comment that certain heats of steel display transverse fissures while others do not under similar conditions of service. Is there any peculiar structural, physical, or chemical reason which will account for such results? Abundant material is at hand for comparison of rails which fracture and those which do not.

Compound transverse fissures, those which deflect from incipient horizontal split heads, have origins which are well known. Can seaminess, the cause of their formation, be eliminated?

Is there any foreign inclusion at the nucleus of a transverse fissure? Is there any peculiar structure at or in close proximity to the nucleus of a transverse fissure? Inquiries have already been made along these lines with negative results. Has anything been left out in those investigations which further study will reveal?

Through the efforts of Mr. E. A. Sperry material may now be obtained in which transverse fissures in different stages of development are definitely located. Such examples would afford opportunity to ascertain what microconstituents are involved in the inception of a transverse fissure.

What characteristics predominate in rails of greatest endurance against the display of transverse fissures is an open question.

In the investigation of shrinkage cracks, and their display after the steel is pickled in hot acid, it will be borne in mind that steel which has been overstrained goes into solution more rapidly than understrained metal. This leads to the query whether all of the cracks subsequenly found, preexisted before pickling. Means should be adopted for differentiating between cracks due to shrinkage conditions and those which result from the cold rolling action of the wheels. Are cooling strains on the verge of rupture converted into open cracks by wheel loads?

In view of modifications in the composition of rail steel the characteristics of medium manganese steel would be of interest to acquire information upon. If any grade of steel is found to possess superior durability against the formation of transverse fissures, that steel should be given suitable study.

TWO DISTINCT PROBLEMS

The suppression of the formation of transverse fissures is one problem. Their detection in their incipient or advanced stages is another problem quite apart from the first.

Since steel is fractured only by excess strain and since all rails in service are subjected to strains of magnitude it would seem that the fundamental cause for the display of transverse fissures could not be eliminated. Steels, however, differ in their ability to endure strains, therefore, by selection, a grade of steel may be found best adapted to meet the requirements of track conditions. There is no hope whatsoever for such a reduction in wheel loads that overstraining the metal at the top of the head of the rail will be avoided.

The real question is what can be done to make travel safer under current track conditions, as against the display of transverse fissures. To this question, which affects the entire traveling public, the most serious attention should be given. A grave responsibility rests somewhere, present tendencies and results emphasizing this fact.

A great step forward has recently been made in the physics of steel. What has heretofore been denied is now an open book. Means are available for detecting the presence of hidden fissures within the heads of rails. A demonstration was made late in the year 1923 by Mr. E. A. Sperry in which the presence of a gap in the continuity of the metal in the head of a model rail, corresponding to a transverse fissure, was indicated by an electrical resistance method. Laboratory equipment followed and numerous tests of full-sized rails have been made with complete success. Rails collected from different sources have been examined, and the locations of hidden fissures indicated subsequently found to be true. On the other hand, rails have been examined which displayed transverse fissures in service, and the announcement made that no other fissures existed in them. Subsequently the most diligent efforts failed to reveal any. Thus it has been shown that rails containing transverse fissures were identified, and those in which there were none were pointed out with equal reliability. Track equipment for the detection of transverse fissures became available early in the year 1928.

If the matter was not so colossal it would appear that the detection of transverse fissures, and therefore immunity against unexpected fractures in the track, was a possibility. The magnitude of the problem is its appalling feature. It has been allowed to run and reach a state until its contemplation is bewildering. What can be more depressing than the realization that lives are in jeopardy, known to be so, and definite action thereon not taken Eighteen years have elapsed since transverse fissures have been publicly known Their numbers have swelled to approximately 30,000

Two outstanding matters of importance are presented for urgent action, concerted, active steps, on a scale commensurate with the magnitude and gravity of the subject, ascertaining definitely whether difficulties are insurmountable or not in the elimination of transverse fissures, and concurrently take adequate steps to remove the menace of transverse fissured rails from the track

INCIPIENT TRANSVERSE FISSURES LOCATED BY THE SPERRY DETECTOR

One of the longer fragments of the rail involved in the accident near West Junction, Kans, was forwarded to the laboratory of the Sperry Development Co, at Brooklyn, N Y, where it was examined for the presence of additional transverse fissures

Two additional fissures were detected, their places located and marked on the surface of the rail It was also stated that they differed in size, and which was the larger was foretold They were subsequently found in the places indicated and in their relative sizes

These were not the first hidden fissures which had been accurately located, but it was nevertheless an impressive matter to be told what condition existed within a piece of steel by the first man who had ever done so What greater honor can attach than to such an achievement pertaining to a matter of nation-wide importance?

Figure 4 represents the places of the three fissures which were displayed at the time of the accident, while Figure 5 shows the places of the incipient fissures detected in the laboratory of Mr E A Sperry

Figure 6 is a side view of the rail after the completion of the fracture at the larger transverse fissure located by the Sperry detector, 26 inches from a transverse fissure displayed at the time of the accident This fissure was brought to the surface by peening Figure 7 shows the fractured surface, containing the transverse fissure, the side view of the rail appearing on Figure 6

TRANSVERSE FISSURE BROUGHT TO THE SURFACE BY PEENING

An experiment was made upon the rail at the location of the larger fissure, by peening with a light hand hammer It should be mentioned, as stated on different occasions, the belief is entertained that internal strains set up in service by the impinging pressures of the wheels, are instrumental and basic in the formation of transverse fissures The internal strains are the essential factors, the means employed for their introduction immaterial Since internal strains may be set up by peening the surface of the head, it might be expected that peening would assist in the development of an interior fissure Accordingly this experiment was made

The rail was peened in the vicinity of the larger hidden fissure After a number of hammer blows the transverse fissure made its appearance at the surface of the head Internal strains were thus introduced, extending the boundary of the internal fissure until the peripheral metal of the rail was reached

The limited time and small number of hammer blows which accomplished this result are significant features They suggest the probable rapid development of transverse fissures in the track

Next in turn is the query whether a preexisting tendency resides in transverse fissured rails or whether track conditions alone are responsible for the display of transverse fissures If the nucleus was small there would seem little difference in the initial effort necessary to enlarge the fissure over the effort required to originate it

The character of the surface enlarged by the peening was the same as that of the remaining portion of the cross section The silvery luster displayed by transverse fissures was not displayed on the extended area of the fissure It was not expected to be The silvery luster of a fissure is due to the burnishing effect of the opposite faces as they are brought together when the rail, above its neutral axis, is put into a state of compression When a wheel is directly over a fissure the opposite faces are doubtless forced against each other The reaction of peening was tension only

When the upper part of the rail is in tension in its action as a beam the opposite faces of a transverse fissure should not be in parallel planes, but slightly divergent The space at the sides of the gap should be proportional to the distance above the neutral axis of the rail Occasionally the burnishing effect on the faces of a fissure illustrate this feature

VARIABLE BURNISHING EFFECT ON SURFACE OF TRANSVERSE FISSURE

Figure 8 is an example in which the upper part of the area of an incipient fissure showed more complete burnishing than the lower portion It does not follow, however, that actual extension of a transverse fissure takes place only when the rail above its neutral axis as a beam is in tension Much might be said upon this point Longitudinal vibrations suggest themselves as factors

INCIPIENT TRANSVERSE FISSURE COMPLETED BY LONGITUDINAL VIBRATIONS

Figure 9 illustrates the fracture of a rail containing an incipient transverse fissure, the completion of the fracture having been accomplished by longitudinal vibrations This and two other fractures in the same piece of rail, each at a transverse fissure, were made by blows of a light sledge hammer delivered endwise on the rail Wave motions under high-speed trains, transverse and longitudinal vibrations present matters for mathematical analysis Profitable lines of inquiry suggest themselves whenever a careful consideration is given the conditions under which steel rails are exposed in service

FRACTURE UPWARD FROM BASE DOES NOT PASS THROUGH TRANSVERSE FISSURE

Figure 10 illustrates a transverse fissure in a 115-pound rail which was located by the Sperry detector A saw scarf was made in each flange of the base, directly opposite the indication of the transverse fissure in the head The rail was then broken as a beam with the base in tension

The plane of rupture, notwithstanding the transverse fissure was a large one, took an oblique course and separated the metal of the head at a short distance from the fissure Other saw scarfs were made and the metal wedged off, revealing the fissure at the place where its presence had been announced

Figure 11 is a side view of the 115-pound rail, the dotted line on which represents the plane of rupture where it reached the head of the rail There was no evidence on the fractured surface of the presence of the transverse fissure which existed in the immediate vicinity The explanation of this feature was apparent, an open joint, as it were on the compression side of the neutral axis, did not weaken the rail as a beam Compression joints in columns of architectural examples are virtually transverse fissures, but do not impair the strength of members exposed to compression stresses only There can not be a doubt that transverse fissures are tension fractures, these examples furnishing confirmatory data

IS THERE A RAIL SAFE AGAINST BRITTLENESS IN FRACTURE AT PRESENT KNOWN?

All grades of carbon steel will, under certain circumstances, display brittleness in fracture Dead soft steels and tool steels are alike in this respect The hard steels are susceptible to injury from slight mechanical causes, the dead soft steels yield readily to repeated stresses of low magnitude

Manganese steel, 12 per cent manganese, properly treated, has this remarkable property, it retains toughness under conditions where other steels are brittle But cold rolling of the running surface of this steel destroys its toughness at the immediate surface and originates a brittle fracture which may be extended by repeated stresses However, even after half the cross section is ruptured, the balance of the rail has been shown to retain the normal toughness of the metal

LIMITATIONS OF STRESSES IN RAILS—WHAT STRESSES ARE PERMISSIBLE—HAVE ANY BEEN DEFINED?

In important engineering structures limiting unit stresses are carefully prescribed In tension the usual range is from 12,000 to 16,000 pounds per square inch In compression substantially the same limits prevail, but modified in the case of columns according to their ratio of slenderness In long columns the permissible unit stress is lowered Any engineering example outside of a track structure designed without regard to limiting fiber stresses is inconceivable

Rails stand alone without any definition of what the stresses in service shall be The difficulties of the problem are recognized, nevertheless, there is no obstacle to giving the matter some consideration

ANNUAL FAILURES OF ENGINEERING STRUCTURES

Rails are the only steel members upon which annual reports of failures have been published Specific causes of failure have not been adequately presented pertaining to the rails themselves nor the conditions of service The sources from whence the broken rails came, however, have been enumerated, and the relative standing of the several sources duly announced Other engineering examples do not furnish material for reports of annual failures

SUMMATION

Important engineering structures should possess a suitable margin in safety This is obtained by limitation of the working stresses

In rails a serious condition is presented Wheel loads of motive power and equipment each overstrain the metal in the upper part of the heads of all rails Strictly, no rail is immune from fracture after a period in the track Theoretically and practically all rails are exposed to conditions which culminate in the destruction of the metal Internal strains set up by the wheel loads is proof of this assertion The results of measured strains in rails, which have been in service, carry with them the deduction that a definite known margin in safety does not exist in rails. There is no known steel which has properties which enable it to resist current wheel pressures without the introduction of internal strains. Strains have not been measured in 12 per cent manganese steel, due to the inability of machining this metal, but its inherent toughness has been destroyed at the immediate running surface of the rail by wheel loads, rupture ensuing.

Overstraining the running surface by means of wheel pressures necessarily introduces internal strains in two directions, lateral and longitudinal. The lateral component leads to mashed and split heads, the longitudinal component leads to the display of transverse fissures. It is clearly evident that there is no escape from the effects of these intense impinging pressures. As the crux of the rail problem they must be recognized and reckoned with. Since it is impossible to avoid these intense pressures, the practical question is what grade of steel will best endure them. That information must come from track records, from rails which have been exposed to the vicissitudes of service, intense impinging pressures, rapidly applied loads, vertical wave motions, and longitudinal vibrations. Loads are received along different elements of the rail heads according to the varying contours of the wheel treads.

There are two features which attach to manufacturing conditions, namely, shrinkage cracks in the central core of the head and acicular longitudinal slag streaks or extended blow holes. Longitudinal streaks undoubtedly lead to the formation of compound transverse fissures, but further data are needed to demonstrate the influence of shrinkage cracks. These data, of course, must come from the examination of rails which have been in service.

Although repeated examinations have been made of the metal in the vicinity of transverse fissures, and no foreign inclusion of any kind discovered nor any peculiarity in composition or structure, nevertheless a more intense study is desirable of these features. Fractures must have definite origins. What microconstituent is responsible for the inception of rupture? Internal strains are set up by heat or mechanical treatment, in treated and untreated steels what relations do the microconstituents bear to the points of inception of fractures. A comprehensive study of the phenomena of rupture is required in the matter of transverse fissures.

Suggestive lines of inquiry are numerous which direct efforts for prolonging the lives of rails against the formation of transverse fissures. The prevention of transverse fissures, if such is possible, or retardation of their display is a matter of vital importance in respect to safety in travel Efforts to meet such ends should not be held in abeyance Eighteen years have elapsed since this insidious type of fracture was brought to general notice and yet no adequate, comprehensive research has been inaugurated toward the amelioration of conditions

Through the efforts of Mr E A Sperry facilities are at hand for the detection of transverse fissures in the laboratory and in the track While the detection of transverse fissures, in their different stages of development, and their elimination or retardation of development are entirely different problems, nevertheless the investigation of fissures is greatly aided by means of facilities whereby they are accurately located in the rails This divining rod method indicates the exact spots at which research efforts should be directed, and where the information sought is located before it has been destroyed Never before have such favorable opportunities been presented for acquiring exact information upon the formation and development of this dangerous type of fracture On account of the magnitude of the problem and the desirability of acquiring data from general sources, to embrace conditions as they exist in different parts of the country, a joint comprehensive inquiry is urgently demanded

Respectfully submitted

JAMES E HOWARD,
Engineer-Physicist

ILLUSTRATIONS

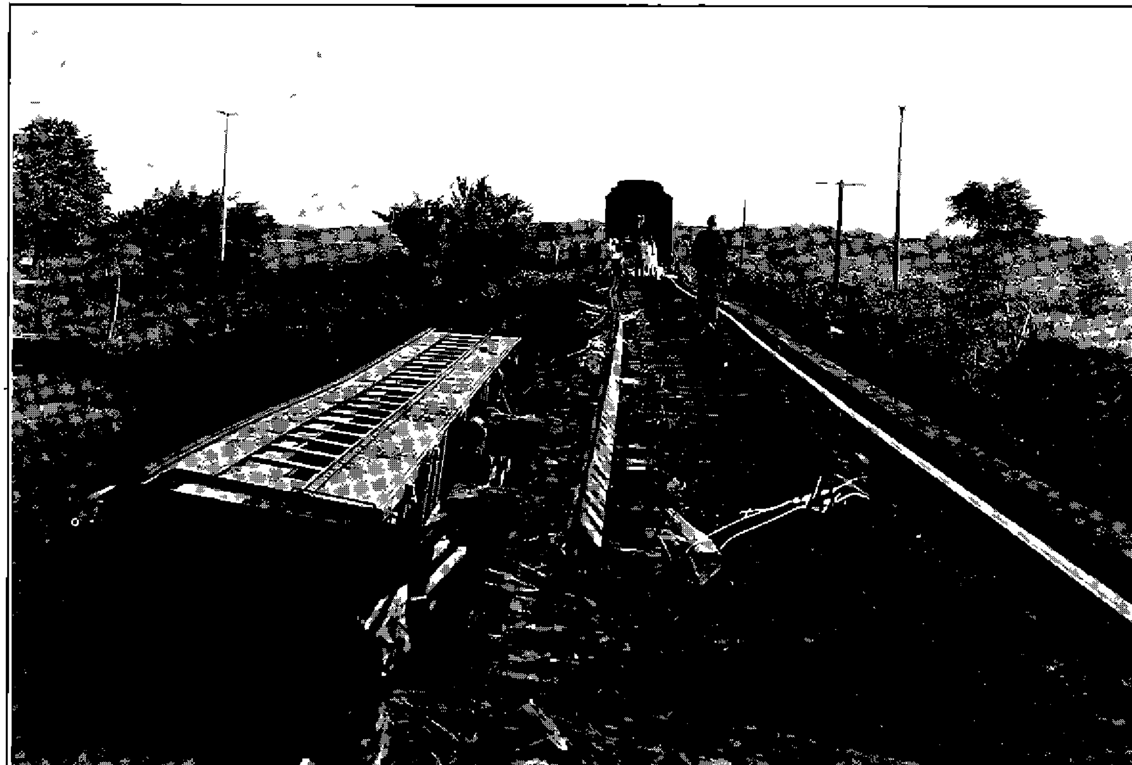
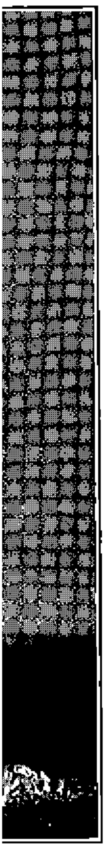


FIGURE 1.—Derailed chair car, on its side parallel to trestle, spanning the bed of the creek

FIGURE 2.—Derailed Pullmans. Cut showing destruction of track structure.



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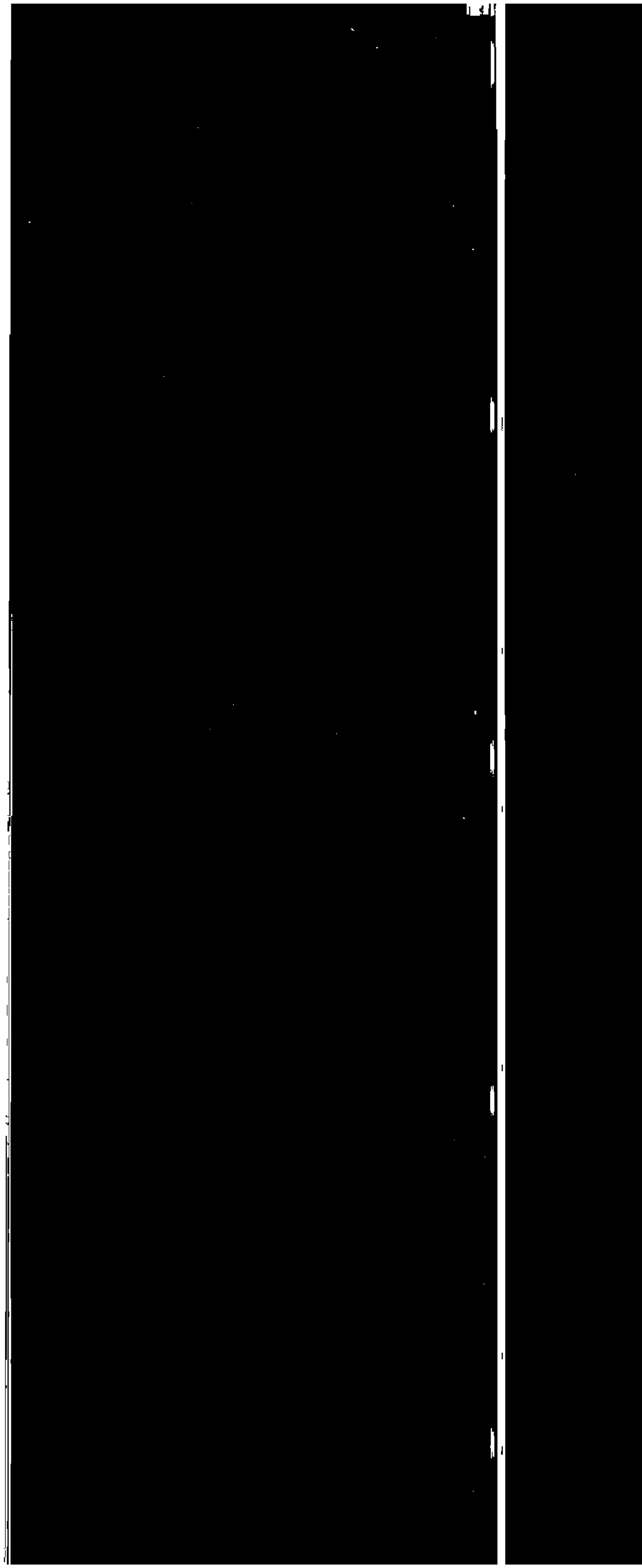

FIGURE 2.—Derailed Pullmans. Cut showing destruction of track structure.

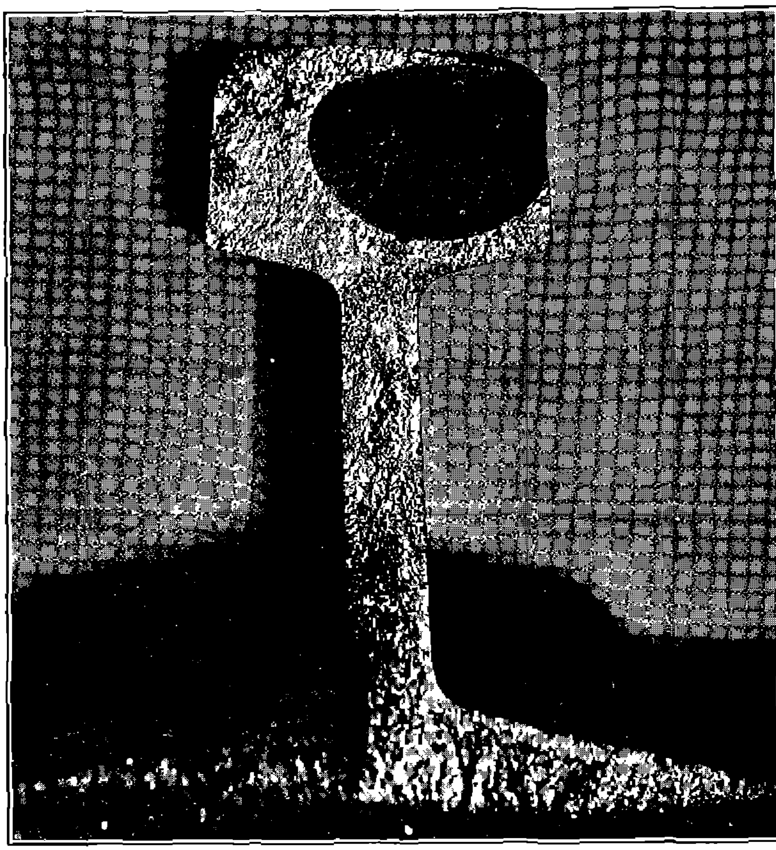

FIGURE 3.—Appearance of transverse fissure located 14.85 feet from receiving end of rail.

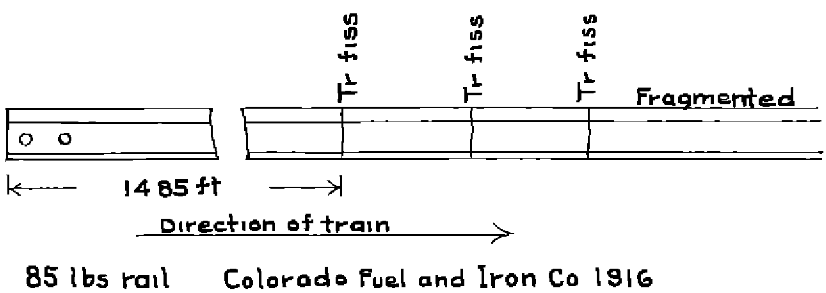

FIGURE 4.—Relative places of three transverse fissures displayed at time of accident

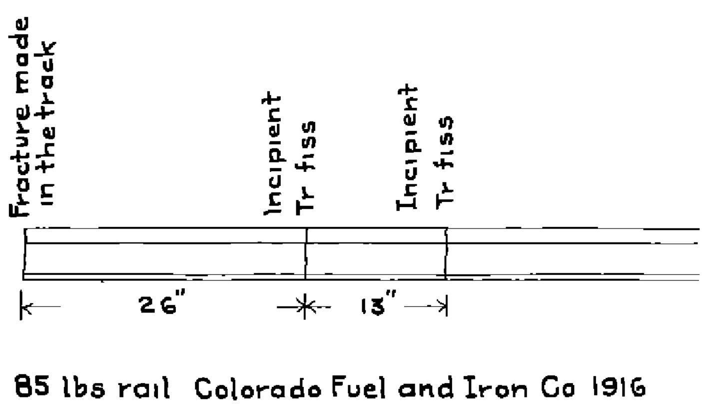

FIGURE 5.—Positions of two incipient transverse fissures located by the Sperry detector

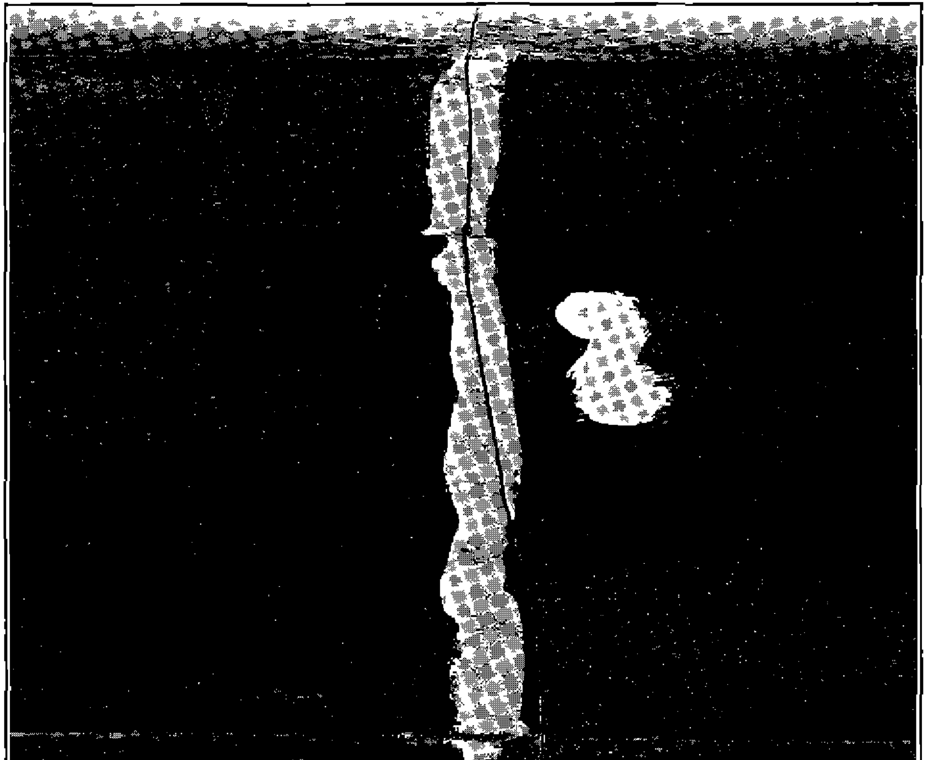

FIGURE 6.—Side view of rail after completion of fracture. Position of transverse fissure located by Sperry detector at middle of paint mark. Fracture brought to the surface by peening.

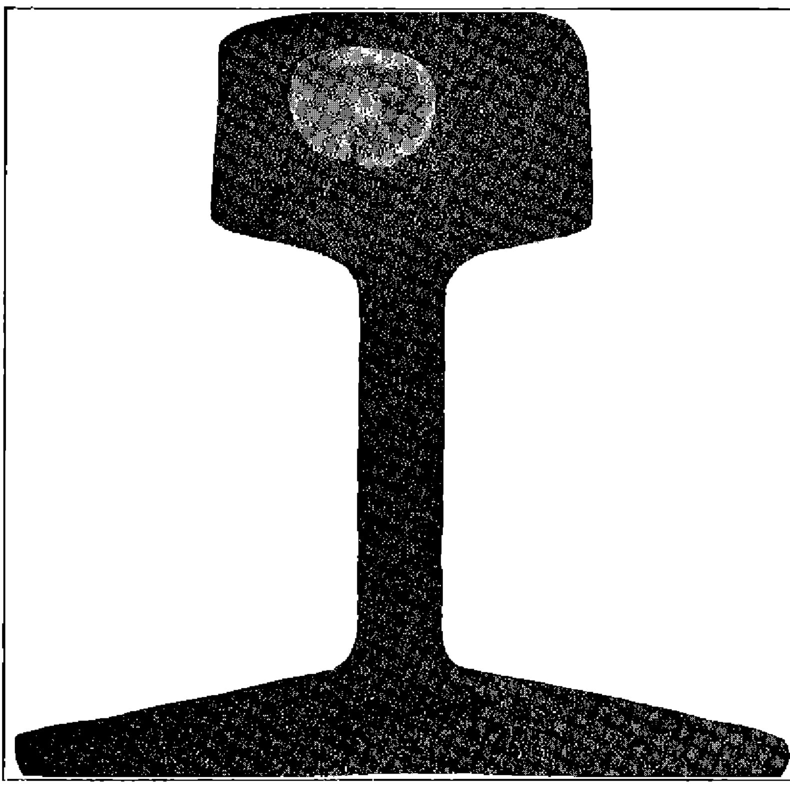

FIGURE 7.—End view of rail showing the larger of the incipient transverse fissures located by the Sperry detector

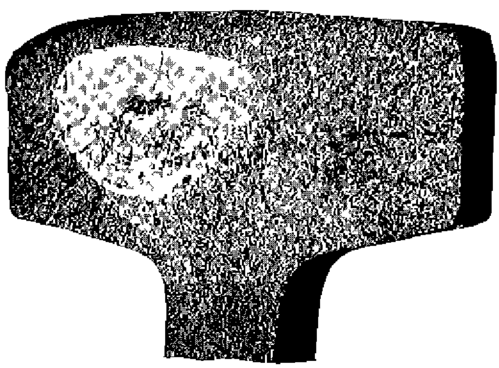

FIGURE 8.—Incipient transverse fissure showing variable burnishing effect, greatest in upper part, incomplete in lower part of its area.

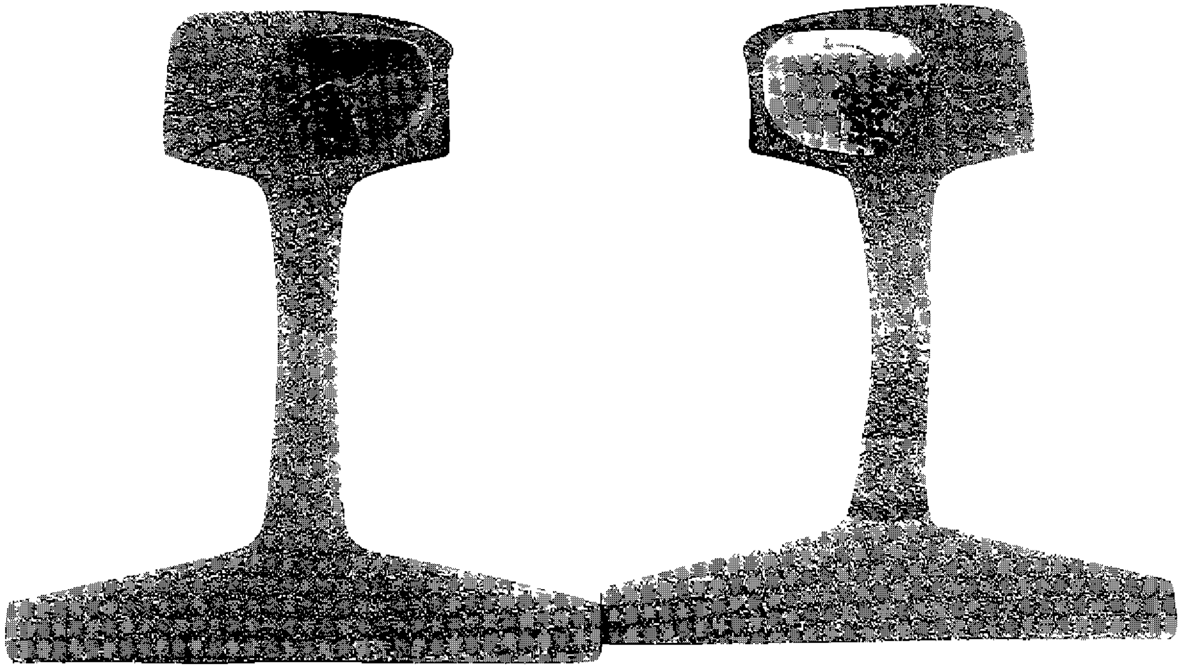

FIGURE 9.—Incipient transverse fissure in a 100-pound rail. Fracture of rail completed by endwise blows of a sledge hammer. Opposite faces of the fissure here shown.

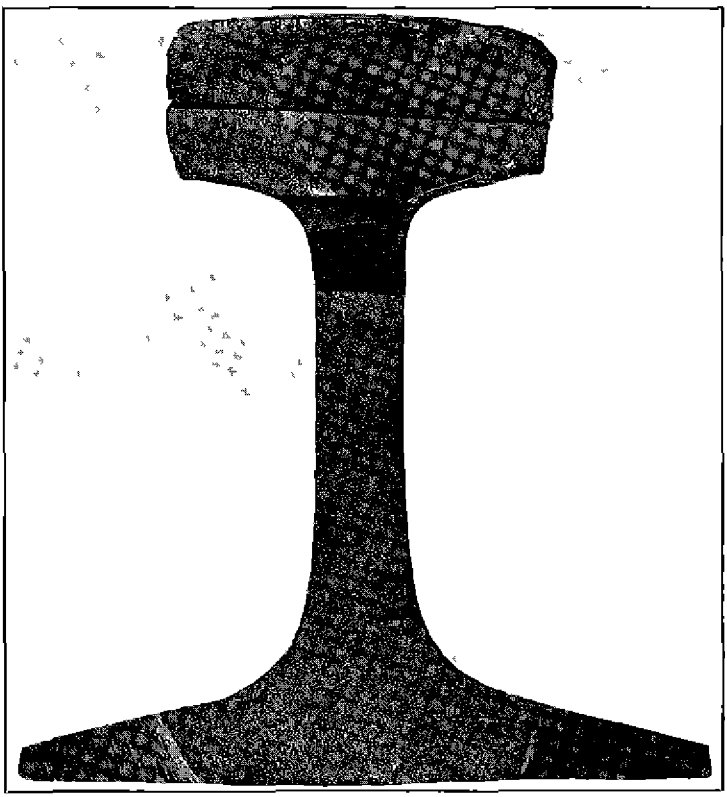

FIGURE 10.—End view of a 115 pound rail showing a transverse fissure which was located by the Sperry detector

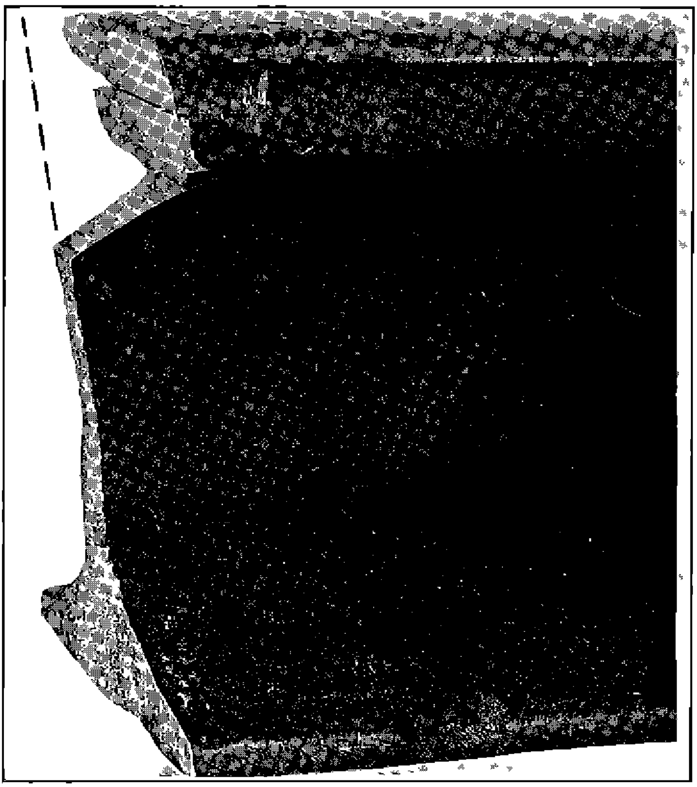

FIGURE 11.—Side view of the 115-pound rail shown by Figure 10. Oblique fracture from saw scarfs in the base. Note dotted line through the head

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