INTERSTATE COMMERCE COMMISSION.

REPORT OF THE CHIEF OF THE BUREAU OF SAFETY COVERING THE INVESTIGATION OF AN ACCIDENT WHICH OCCURRED ON THE CHESAPEAKE & OHIO RAILWAY NEAR HARDWARE, VA., ON JANUARY 7, 1919.

FEBRUARY 21, 1920.

To the Commission:

On January 7, 1919, there was a derailment of a freight train on the Chesapeake & Ohio Railway near Hardware, Va., which resulted in the death of two employees After investigation as to the nature and cause of this accident, I beg to submit the following report:

The part of the Rivanna District of the Chesapeake & Ohio Railway on which this accident occurred is a single-track line, over which train movements are governed by time table, train orders, and a manual block signal system The accident occurred at a point about 2,200 feet west of the west passing track switch at Hardware, approaching which point from the west there is a tangent 840 feet in length followed by a 1° curve to the left, approximately 1,518 feet in length, the accident occurring on this curve 792 feet from its western end. The grade approaching the point of accident is slightly descending for eastbound trains The track in the vicinity of the point of accident was laid with 90-pound rails, 33 feet in length, on 18 to 20 ties to the rail. The rails are single spiked to the ties, no tie plates being used. The ballast consists of about 2 feet of crushed stone. As a whole the track was in fairly good condition, although at several joints the rails did not fit closely.

The train involved in this accident was eastbound freight train first No 76, consisting of engine 480, 6 loaded coal cars, helper engine 4518, 45 loaded cars and a caboose, in the order named, and was in charge of Conductor Boltz and Enginemen Taylor and O'Neil. This train left Gladstone, Va., at 5.10 p. m., 2 hours and 50 minutes late, and at 9.55 p. m., while running at a speed estimated at about 8 miles an hour, was derailed near Hardware, 47 miles east of Gladstone.

The first car to leave the rails was the sixth car in the train, the one immediately ahead of the helper engine. This car turned over on its right side and fell down a 12-foot embankment. The helper engine turned over on its left side across the track with its head end down the embankment, while the cistern of the tender was torn from its frame and fell down the embankment. The car behind the helper engine remained upright but went partly down the embankment and the next car remained upright diagonally across the track. None of the other cars was derailed. About 100 feet of track was torn up by the derailment The two employees killed were Engineman O'Neil and Fireman Ritchie of the helper engine.

Conductor Boltz stated that he had received orders to take the siding at Hardware in order to permit train second No. 76 to pass at that point and the speed of the train had been reduced to about 8 miles an hour preparatory to taking the siding when the derailment occurred. In his examination of the track and equipment after the derailment he found a broken rail on the inside of the curve or on the north side of the track which he concluded was the cause of the accident. He stated that he found no marks on either the rails or ties west of this broken rail and while his inspection of the equipment was not thorough he found no defect that might have led to the derailment.

Engineman Taylor, in charge of the leading engine, stated that prior to the derailment the train had been drifting for a considerable distance. He was just in the act of making an application of the brakes for the purpose of further reducing the speed in order to permit the brakeman to get off and open the switch at the west end of the siding when he felt the brakes applied in emergency, causing the train to come to a sudden stop He estimated that at this time the speed of the train was about 8 miles an hour He also stated that he made no examination of the track or equipment subsequent to the derailment and was therefore unable to express an opinion as to its cause.

Fireman Bagby and Head Brakeman Hughes, both of the leading engine, stated that they noticed no unusual motion of the engine at the time it passed over the rail that was afterwards found broken They estimated the speed of the train at the time of the derailment to have been about 10 miles an hour

Track Walker Goff, who was temporarily in charge of the section on which the accident occurred, stated that he went over the portion of the track where the accident occurred at about 10.20 a. m. on the day of the accident and again at about 4 30 p m On both occasions he found the track to be in good condition

Track Supervisor Staples stated that he arrived at the scene of the accident about four hours after its occurrence and found a broken rail on the outside of the curve, which he considered to be the cause of the accident He stated that he found nine pieces of this rail, which comprised 27 feet of the rail, but was unable to locate the remaining portion. He stated that his examination of the rail showed a dark spot about the size of a half dollar at the first break and silvery spots at the other breaks He stated also that there were other rails broken by the accident, but was sure that this was the one that caused the accident. Track Supervisor Staples further stated that recently several broken rails had been found on his section which showed the same kind of defects as the one here involved.

Assistant Superintendent Briant stated that he arrived at the scene of the accident about five hours after it occurred and found two pieces of a broken rail at the point where the wreckage began to pile up, this rail being on the south side of the track After daylight he made a further investigation and found six pieces of rail, all of which showed defects in the head of the rail In his opinion the breaking of this rail was the cause of the derailment

The testimony was conflicting as to whether the broken rail which caused the derailment was on the north or south side of the track. The investigation disclosed, however, that the initial break occurred in a rail on the south side of the track, or the outside of the curve. The first break was about 14 inches from the receiving end. In all, nine pieces of this rail were recovered, the total length of the nine pieces being about 26 feet 6 inches. The receiving ends of many of the fragments were battered by wheel flanges passing over them, and these battered fragments, coupled with the slightly curve-worn condition of the rail, indicated that this rail was the one which caused the accident and that its location was on the outside of the curve.

Acknowledgment is made of the cooperation of and cordial assistance rendered by the officials of the Illinois Steel Co., the Bethlehem Steel Co., the Chesapeake & Ohio Railway, and the Chicago & North Western Railroad in the investigation of this rail and the development of the data included in the report. The work done by the steel companies, upon which explicit statements are based, was extensive. The work of Mr R. H. Christ, metallographist of the Bethlehem Steel Co., on the identification of the shattered metal in the rail heads is specially mentioned. In immediate association with Mr. G. M. Davidson, chemist and engineer of tests, Chicago & North Western Railroad, the engineer-physicist examined a large number of rails at the laboratory of the former, establishing and confirming many features of importance.

This accident was caused by a broken rail. The investigation to determine 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 rail which failed, causing the derailment of train No. 76, had been in service nine years and seven months. It presented externally a good, serviceable appearance prior to its rupture. Internally, seven transverse fissures were displayed on its broken ends. It was a 90-pound rail, section A. R. A.–B., branded as follows: "Bethlehem Open Hearth 90 C IIIII 09."

It had the following chemical composition: Carbon, 0.860; manganese, 0.78; phosphorus, 0.038; sulphur, 0.030; silicon, 0.132; nickel, 0.07; chromium, none.

Figure 1 is a diagram showing the manner in which the rail was broken. Nine principal fragments were recovered, in length aggregating 26 feet 6 inches. Missing parts represented 6 feet 6 inches in length. The transverse fissures were located in different parts of the length of the rail, ranging in diameter from 1⅜ inches to 2⅛ inches The line of rupture believed to have been the initial break was 14 inches from the receiving end. At this place there was a transverse fissure 1¾ inches in diameter. The seventh and last fissure in the order of their alignment was located 50 inches from the leaving end of the rail. This fissure had a diameter of 1⅜ inches. The rail was broken at four other places which did not show fissures.

These transverse fissures presented the usual appearance of such fractures, each a progressive one from a well-defined nucleus. The nuclei were located about five-eighths inch below the running surface and all were on the gauge side of the head.

In the examination of this rail it was not considered necessary to make measurements on the state of the internal strain which it had acquired in the track as a precursor to or cause leading to its manner of failure. Strain gauge measurements of this kind have been made in extenso and the results presented in reports upon other rails. They have established the disposition and magnitude of the internal strains of tension and compression, strains which are present in greater or lesser degree in all rails which are in service.

The subject of shattered metal as an influence affecting the resistance of rails against the formation of transverse fissures is given prominence in this report. The Altoona laboratory of the Pennsylvania Railroad had the honor of bringing this matter to general

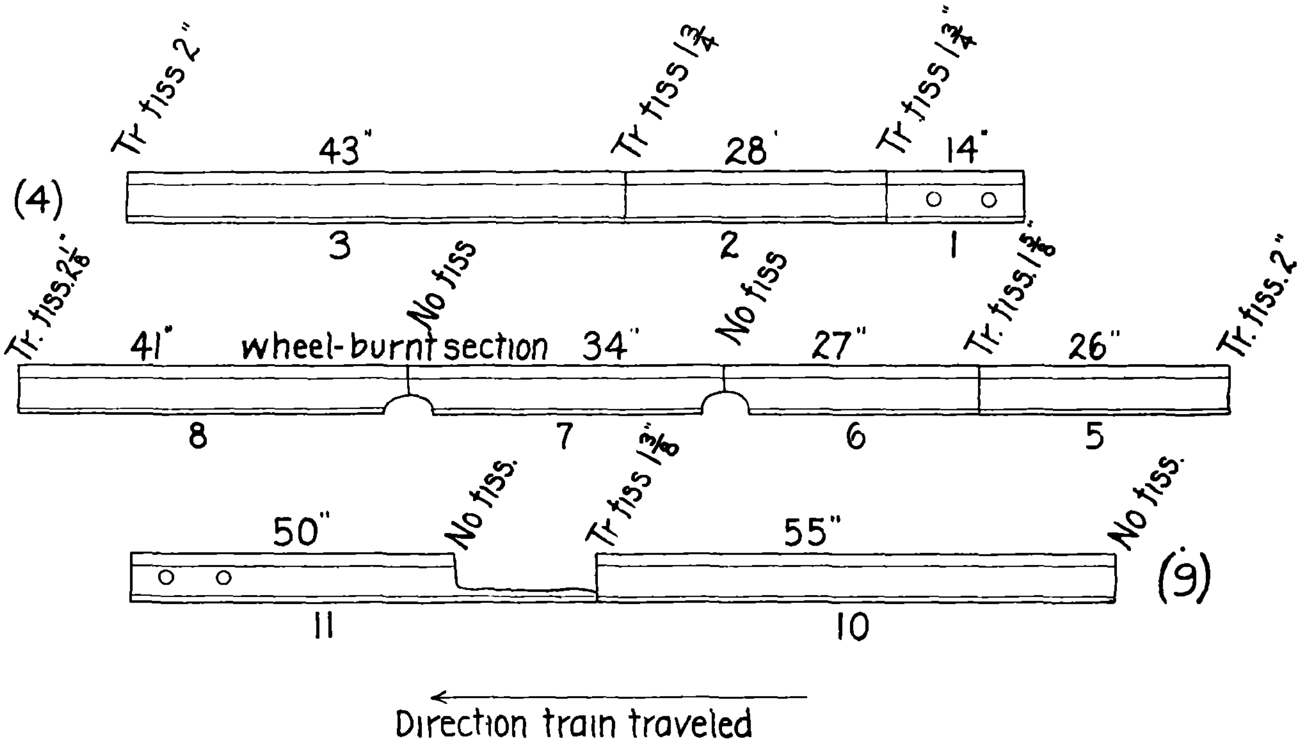

FIG 1—Diagram showing the manner in which the rail causing the derailment was broken, with the location and diameters of the transverse fissures displayed

notice on a recent occasion. It was found that the present rail displayed a shattered zone in the center of the head, the same as those discovered in rails by the above-mentioned laboratory.

Two distinct questions present themselves in considering the subject of transverse fissures, to avoid confusion each of which should be taken separately. The first question is, why does the fracture have an interior origin? The second question pertains to the endurance of different grades of steel. One has to do with a physical law affecting all steels; the other defines limiting stresses which vary in different grades of steel and are modified by structural state in the same grade. Necessarily the second question is the broader of the two, since it embraces a wide range in grades of steel and deals with conditions of service which affect the stresses in the steel.

In answer to the first question it may be stated that the interior origin of a transverse fissure is primarily due to the intensity of the tensile stresses along those interior elements of the head of the rail on which the nuclei of the fissures are located The upper zone of the head of the rail is put into a high state of compression by the cold rolling action of the wheels, setting up a wedge action which extends along the entire top of the head The metal in the interior of the head affords the necessary reaction and is put into a state of tension. Longitudinal forces are referred to In a lateral direction less resistance is encountered and permanent increase in the width of the head may result. Under the combined action of the bending stresses in the track and the internal strains induced by the wheel pressures an interior fracture is developed. This is the explanation why there is such a type of fracture as a transverse fissure. Since it has an interior origin that fact accounts for its characteristic brittleness, regardless of inherent ability to display ductility under other methods of rupture The diagrams shown by figures 2, 3, and 4 illustrate features on which the above explanation is based.

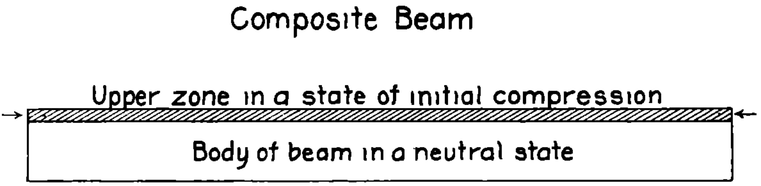

FIG 2 —Hypothetical beam, to illustrate influence of zone of metal under initial compression, inducing fractures with an interior origin

Figure 2 represents a hypothetical, composite beam. The upper zone is assumed to be in a state of longitudinal compression, while the main portion is in a neutral state. Rupture under repeated bending stresses, if it occurred on that side of the beam, would take place below the zone of metal which by an external force is kept in a state of compression, and an interior fracture would be formed. If the zone of compression metal was kept in compression by the reaction of the metal next below, as in the case of a rail, that reaction would become an auxiliary force assisting in the fracture of the beam.

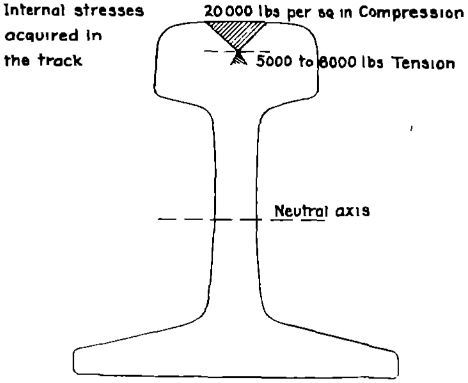

FIG 3 —Cross section of rail showing relations of internal stresses in heads of rails which lead to fractures with interior origins, i e, transverse fissures

Figure 3 represents, in outline, the cross section of a rail, on the head of which are two shaded areas representing the state of internal strains which have been found in rails taken from the track. Along the upper part of the head stresses corresponding to the measured strains not infrequently exceed 20,000 pounds per square inch In the interior of the head tensile stresses range from 5,000 to 8.000 pounds per square inch. This state of the steel is due chiefly to the cold rolling action of the wheels, a limited portion representing cooling strains of fabrication. The assumed conditions of the hypothetical beam are produced in the rail head, tending to cause the result there mentioned.

Figure 4 illustrates lines of rupture which were displayed by a 100-pound rail in service. A fragment 1 inch long was detached from the head, on each end of which was located a transverse fissure, one having a diameter of 2¼ inches and the other 1⅝ inches. The wedge action of the surface metal was essential to cause this result, without which it would not appear feasible to accomplish. There was also a horizontal shearing fracture between these two transverse fissures, located by a seam in the metal Figures 4a and 4b show the appearance of the transverse fissures.

The diagrams above described illustrate, in succession, the case of a hypothetical beam tending to display an interior fracture, the internal stresses which are acquired by rails in service having the same tendency, and the actual rupture of a rail, believed to have been the result of such internal stresses. Incipient transverse fissures are frequently found in close proximity and have approached within an inch and an eighth of the end of the rail. The presence of compression metal in the upper part of the head accounts for such concentration of fissures, which have not been accounted for otherwise.

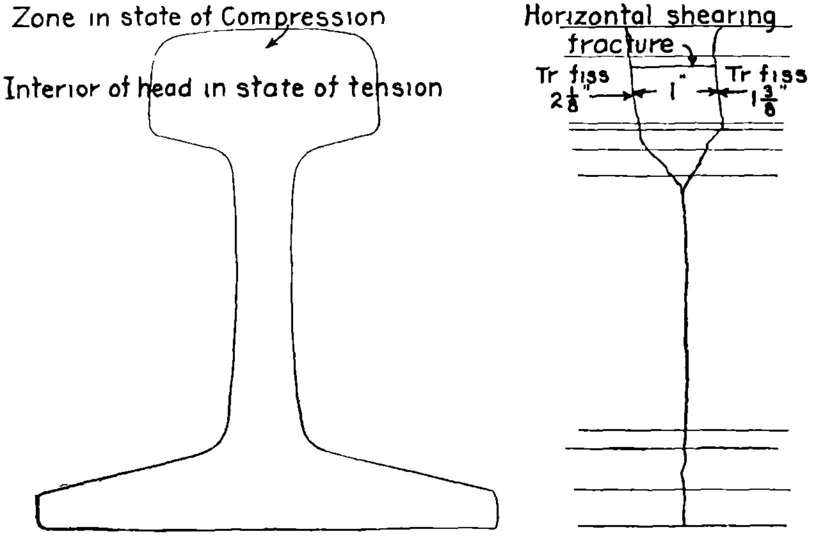

FIG 4 —Lines of rupture in 100-pound rail, made by transverse fissures, result of conditions illustrated by figures 2 and 3

It is important to consider whether there are any means of escape from the tendencies which lead to the formation of transverse fissures. In respect to the cold-rolling action of the wheels there are none. The utmost which may be accomplished is to preserve such a relation between the ability of the steel to endure these unavoidable strains and the service conditions which are responsible for them, to the end that the ultimate limit of endurance shall not be reached while the rail is in the track. As vague as the last sentence may seem, efforts to acquire the necessary information for the purpose have not been exhausted. That source of information lies in the accurate and complete record of rail failures and their proper compilation.

Detail sheets of rail failures such as those which are now in use contain much of the necessary information and if supplemented with a statement of the nature of the traffic, speed, and number of trains per day, weight of motive power and rolling stock, wheel pressures, tonnage, single or double track, and grades, there would be promise of reaching practical results.

Independent of the explanation why transverse fissures are formed, interest attaches to the consideration of track conditions which prevail where this type of fracture occurs, why transverse fissures make their appearance on some railroads or on certain divisions of some railroads while so far as known they are not prevalent in other places. In addition, interest attaches to a specific demonstration of what chemical composition furnishes rails which best endure service stresses against the formation of transverse fissures, also the influence of structural state of the steel, covering the query why certain rails display transverse fissures earlier than others, or display this type of fracture under conditions of service where other rails do not fail. Data upon these features are being acquired, the rate of which admits of being much accelerated by general cooperative effort on the part of the different railroad systems.

There is no essential difference in the service conditions to which all rails are exposed, except in degree. But herein lies the critical difference upon which there is need of more information. The failure of a rail per se conveys no useful information against its repetition or prevention. Knowledge of the conditions under which it failed with an exact description of its manner of failure constitutes the useful data. There is a definite cause for the failure of every rail. When charged against a given year's rolling, against a certain mill, or against a great railway system there is little cause for surprise at the lack of progress in arresting rail failures.

Cooperative work with certain of the railroads and steel mills has developed interesting data upon the subject of shattered zones in the metal of rails. The method used in revealing the presence of these short and minute cracks, which characterize the shattered zones, consisted of pickling the rails in hot acid. Hydrochloric acid alone or with sulphuric acid added, diluted with a small quantity of water, has been used.

The use of a hot acid solvent enlarges the cracks, promptly rendering visible the presence and location of those which were of minute size. It is an expeditious method of ascertaining whether or not a shattered state of the metal exists, but from its energetic action soon destroys evidence connected with the genesis of the cracks. For investigative purposes very light pickling should be employed, while other methods may be used to advantage.

In the pickling of pieces taken from the rails the rate of solubility was greater endwise the pieces than in crosswise direction, referring to the direction the rail was rolled. The ends present a pitted appearance; the sides a striated, seamy or laminated appearance, resembling woody fiber. The rate of solubility was increased by cold peening the metal. Superficially, the area of the peened surface was increased, but proportionately less than the increase in the rate of solubility. The metal adjacent to the running surface of the head of a rail, one which showed local distortion under the wheel pressures, went into solution faster than other parts of the cross section. These are illustrations of variations in the rate of solubility as influenced by the direction in which the steel was hot rolled and by the cold working which it had received

Respecting the relative rate of solubility of steel under tensile or compressive stresses, or pertaining to its microconstituents, the observations were not carried far enough to warrant a statement of the results The pickling of steel, although a very common affair in the arts, commends itself as one possibly possessing advantages for research purposes which have not yet been availed of.

It was announced and early confirmed that these shattered zones existed in new rails which had not been in service. While variations in the rate of solubility were found in the present tests no evidence was presented which would attach responsiblity for the display of shattering cracks to the action of the acid solvents Their preexistence was established beyond a doubt.

While the method of picking affords the most expeditious and convenient means for preliminary examination, the detection of shattering cracks by other means may be referred to Cracks of certain magnitude show themselves while machining the steel. A rather light depth of cut and feed of tool in the lathe or shaper reveals some cracks which either heavier or lighter cuts and feeds obscure, cracks which polishing often obliterates. Cracks of a minute order will appear in draw filing. Fine particles of the steel are magnetized and arrange themselves along the cracks and give visibility to them. Visibility is lost, however, when the fine particles are brushed away. This is a delicate manifestation of a common occurrence in cold, dry, sawing of a rail in which the fine saw dust gathers as a fringe, at times reaching an inch in length, the fringe on one side of the rail having the opposite polarity of that of the other side.

Shattering cracks were found in one of the cooperative laboratories by several methods. They were located by polishing conducted with that object in view, without either etching or pickling. A high polish was not used, thus avoiding dragging of the surface metal.

The cracks may also be revealed by tincture of iodine, ammonium copper chloride, and by ferric chloride. The obscurity of high polishing is attributed to the dragging of the surface metal across the width of opening of the crack, a width generally so narrow that it appears immeasurable. Again there is the possibility of the opposite surfaces of the crack being separated so slightly that under a mild etching solution no differentiation in appearance occurs. No foreign inclusion has been found in these cracks, hence microscopically there was no change in structure to show.

The continuity of the metal, however, is destroyed at these cracks, consequently annealing has no healing effect Their presence was rendered visible, in the laboratory referred to, by heating and decarburizing the surface, which at the same time decarburized the walls of the cracks their entire depth After the scale and a thin layer of surface metal were removed the cracks were plainly visible

Figures 5 and 6 show photo-micrographs of cracks revealed by polishing without etching and with etching; cracks natural size and under low magnification after decarburization; also the normal microstructure of the steel and the microstructure of a decarburized crack.

Shattered zones occur both in the central part of the head of the rail, and at the junction of the web and the base These zones are indicated on figure 7, which shows also the manner in which some of the rails were prepared for pickling. The top of the head was planed off in different stages, ultimately to a depth of three-fourths of an inch, and one flange of the base planed away At other times, one-half of the rail was planed away, in vertical, longitudinal section. The rail represented in this cut did not display a general shattered state. It failed, however, in service with a transverse fissure, while 21 additional incipient fissures were found in its subsequent examination on a length of 4 feet The particular section here shown was pickled on the end as well as on the sides. The uniform pitting of the end surface will be noted, showing structurally uniform metal

Sections of 40 rails were pickled in the present examination in quest of shattered interior metal. Of this number about one third displayed shattered heads, representing rails which developed transverse fissures or rails from heats which had done so About the same number of rails, each of which developed transverse fissures, did not show shattered metal. The other third in number, unshattered, represented new rails which had not been in service, some early English and domestic rails, and some which had been removed from the track on account of other types of failure

Figures 8, 9, and 10 represent longitudinal sections of three 100-pound rails rolled in 1912, two of which displayed transverse fissures in the track. One did not fail, but was removed for the present examination. The rail represented by figure 8 displayed five transverse fissures in the track. Additional incipient fissures were found when pickled, one being well advanced, having a diameter of 1⅜ inches. This was located within 1 inch of a transverse fissure which was displayed in the track. The metal in the interior of the head was in a shattered condition. The pickling was prolonged, enlarging the cracks and making them more conspicuous for photographic purposes. The upper view of this cut shows a vertical, longitudinal section, the lower view a horizontal, longitudinal section, along the middle of the width of the head, and about three-fourths inch below the running surface, respectively. Figure 9 represents the rail which did not fail in the track, although other rails of the same heat had done so. The top of the head was planed off three-quarters inch deep and pickled. On this surface, 6 inches long, there were displayed 135 short shattering cracks and seams. Figure 10 represents a rail which displayed but one transverse fissure in the track. Twenty-one incipient fissures were found in the rail within a length of 36 inches when the head was planed off and pickled. One incipient fissure was located within 1⅛ inches of the original end of the rail. The examination failed to reveal any shattering cracks in the head of this rail. These sections therefore show one rail having transverse fissures in the presence of shattered metal, another very badly shattered rail, but not yet having displayed a transverse fissure, while the other rail broke in the track with one transverse fissure, displaying a considerable number of incipient fissures in its examination, but free from a shattered state of the metal.

Efforts are being directed to ascertain the significance of these shattered zones, how and when they are formed, the grades of steel in which they are prevalent, and their influence on the durability of the rails in which they are present. The explanation which best accounts for their presence is that they are shrinkage cracks. There is general agreement that no foreign inclusion exists between their walls, and that their courses do not seem to be influenced by the microconstituents, passing through the grains or following grain boundaries in different places.

It is known, in the physics of steel, that variations in the value of its specific gravity occur in the same grade of metal, resulting from either heat or mechanical treatment and also as the result of stress, as expressed by Poisson's ratio. Variations in density in the same mass seem to be a cause for the introduction of internal strains.

In the absence of opportunity to display the phenomenon of permanent extension, rupture should take place when the ability of the steel to endure further elastic extension is reached. The opportunity to display ductility is furnished when steel is strained in one or two directions only; simultaneous stresses of tension in three directions permitting only elastic extension.

These are the premises which seem to explain how an interior shattered state may be formed, and which differentiates the shrinkage action of the interior metal over that of the exterior. The exterior of a hot bar is the first to cool, and while under tension is free to contract in diameter. The interior, last to cool, eventually acquires a state of tension. the extent of which is limited by its elastic ability The temperature when the most critical period is reached is probably a high one. Notwithstanding the fact that steel is plastic at higher temperatures it is not held to be inconsistent that it may then display brittleness under cubical extension.

The results of observation reported from time to time by experimenters, have been to the effect that a transitory change in the physical properties of steel occurs immediately after fabrication; that a measurable interval of time intervenes before this physical change is completed. Evidence of this kind comes from several sources. In the effort to reproduce some of the phenomena which shattered rails display additional evidence was presented, a certain sensitiveness being shown which the steel did not possess at later stages.

A rail was quenched direct from the hot saw, whereupon the interior of the head was found to contain cracks similar to those in rails with shattered heads. A section of the same rail cooled normally on the hot bed did not display shattered metal. Other methods of treatment, rolling green; rolling cold; gagging, light medium, and excessive; reheating and quenching in different ways—none of these resulted in the production of an interior shattered zone. Throughout these tests a high carbon steel was used.

Quenching high carbon steels severely strains the metal, frequently culminating in fractures having an exterior origin. Rail heads reheated and quenched have shown an exfoliation, concentric layers in succession being detached from the central core. Figure 11 shows the appearance of a rail head treated in this manner. The cooling was done from the sides of the head, not from the ends.

Figure 12 illustrates lines of rupture in the head of a rail which had interior origins. The crosswise fractures, occurring at fairly regular intervals, started very near the center line of the head, from which they extended in each direction to the sides of the head, or nearly reaching the periphery. Secondary lines of rupture detached a central core divided into short sections by the crosswise fractures.

The shorter crosswise cracks no doubt formed third in order, the order of occurrence of these several groups of fractures being quite definitely indicated.

A certain degree of control may be exercised over the manner in which a rail is fractured, an opportunity which will be made use of in further quest of the causes which lead to shattered rails The rails in which shattered zones have been found have been high carbon or fairly hard steels. In the softer rails shattered metal has not been found. However, but few such rails have yet been examined; the results are therefore suggestive rather than conclusive The aversion of steel manufacturers to roll the very hard grades of steel into rails is well known If a relation is found connecting shattered metal with the chemical hardness of the steel, a substantial reason will have been shown upon which preference for a given grade of metal may rest A recent examination has been made of new rails, taken from over 60 heats, in quest of shattered zones In none of these rails were they found. The examination of sections from one heat, of much harder steel, revealed the presence of numerous shattering cracks. In the light of present information, the inference is too obvious to mention; still it is too early to indulge in any vaticination for or against hard steels in respect to their influence upon shattered zones.

The reexamination of a rail in which 15 transverse fissures were found, causing an earlier derailment, revealed no shattered metal. The chemical analysis showed this rail to have a carbon content of 0.73 to 0 77, with about the same manganese Transverse fissured rails thus far examined, containing shattered metal, have generally been in service periods of 6 to 12 years Those which have displayed fissures within shorter periods of time remain to be examined

Considering in the abstract a matter which touches upon the capacity of steel to respond to elastic strains, in situations where it can not display ductility, the double radius of molecular action, as it is called, represents the limits of elastic range of the steel beyond which destruction to its integrity takes place. This distance is a minute one. The silvery luster of the surfaces and rippled zones on the faces of transverse fissures which have not been exposed to the air testify to the minute separation of those faces, which under alternate stresses appear to have burnished each other The width of openings of these shattered cracks is very minute. When at a minimum it is not believed they attain a width approaching to as much as a fifty-thousandth of an inch. It is this minute separation which makes it plausible that shrinkage conditions are responsible for the shattered zones, and leads to the further thought that some microconstituent may favor the interior extension to such a degree that actual separation may be avoided, although still leaving the interior metal in a state of local strain.

Provided the integrity of the steel has not been destroyed locally by the formation of a shattered zone, it is reasonable to suppose that the internal strains set up by the cold rolling of the wheels may constitute the additional strain necessary to inaugurate the development of a transverse fissure, and that the progress of the fissure might be facilitated by the presence of shrinkage stresses In this there would be joint action, the primitive shrinkage strains, and the augmenting cold rolling strains, their united efforts culminating in the formation of incipient fissures. Such an explanation accounts for the short intervals of length in which they occur. Shrinkage strains find relief with a limited extent of shattering, while cold rolling strains are progressive and follow up any yielding of the interior with fresh advances. The period of united action of these two forces would be limited to the incipient stages of a fissure, after which cold rolling strains only would continue.

From these premises, initial relief of internal strains should attend the formation of shattered zones. Speculating upon some of the consequences, it would seem that the diffusive action of a certain number of shattering cracks might at times ameliorate conditions, retard or possibly arrest the formation of a transverse fissure The ages of many of the shattered rails in which transverse fissures have appeared give weight to this assumption It will always be borne in mind that severity of track conditions must not be overlooked, and since transverse fissures develop so commonly on the gauge side of the head that fact also should be kept in mind. No trouble has come from the shattered zone at the junction of the web and the base, a region not directly affected bv the cold rolling of the wheels.

Recognition of these several influences does not encourage the belief that all of the causes which tend toward the rupture of rails admit of being eliminated. Rails can not be included in the group of engineering structures which are classified as permanent ones. It is the method of carrying loads upon wheels, the very essence of land transportation, which excludes rails from the group of permanent structures

The rail problem is one in which an understanding of the abstract matters touched upon in the preceding remarks has much to do. Specifications governing the acceptance of rails have little reference to their use in the track. Elaboration of specifications along lines not having to do with those vital questions affecting durability and safety is not a hopeful sign of progress Attention is thereby diverted from important matters upon which revision should be based The necessity for considering the ultimate effects of service stresses is greater in the case of rails than for any other prominent engineering purpose. The idea is not tenable that unbreakable rails can be made, ignoring service stresses; that rails must be made, as a mill problem, which will not fail in the track under the increasing weight of rolling stock.

Nearly nine years have elapsed since the subject of transverse fissures was brought to the attention of the railway engineering profession. During this interval thousands of rails have failed from this type of rupture They continue of frequent occurrence. A decided increase in the weight of rails has not effected their elimination, nor has the use of a hard steel been a preventive. The properties of the failed rails have been examined at length. Insufficiency of data now lies in the direction of complete and reliable track information in which all of the railroads of this country should be contributors; the immediate object of which should be to show the relations between the development of transverse fissures and service conditions.

SUMMARY.

The derailment caused by the failure of the present rail adds another fatal accident to the list of those which have been due to transverse fissures. This fracture, as a type, is displayed under conditions which make its further study an urgent matter. Transverse fissured rails fail, for the most part, without warning. The examination of those which have failed generally reveals additional incipient fissures, in different stages of development, each a plane of weakness. The condition of companion rails, yet unbroken, is a matter of grave anxiety. A menace is thus presented which should not go unheeded.

The investigations of the engineer-physicist of this bureau, on the occasion of different accident reports, have defined the strains and stresses which are peculiar to and inherent in rails, conditions which are inseparable from the method of carrying heavy loads on wheels. All rails are subject to internal strains which wheel pressures induce. Independent of such other indications as there may be, which are indexical of the properties of the steel, failure whenever it occurs is the result of overstraining forces. There are two comprehensive questions in the rail problem, namely, what are the loads or stresses which rails can endure successfully, and what are they required to do in service.

All rails are exposed to substantially the same kind of stresses, differing, however, in degree. Information, based on reliable track data, is needed to point out definitely what conditions of service are present which lead to this type of fracture in rails which have passed prescribed specifications and have been accepted as satisfactory rails. If the tests for acceptance are inadequate for their purpose, provided relief lies in that direction, they should be modified along the necessary lines to accomplish their purpose.

Or, if the limit of endurance of rails has been reached, that fact should be made clear. Since it is a question of degree in all cases when steel fails under stresses, the relation between the ability of the rail to sustain long-continued stresses and the permissible weight of equipment should be established.

The discovery of shattered zones in the heads and bases of rails gave encouragement, for a time, that a cause for their early failure, or premature failure it might be called, had been found, the elimination of which would restore a margin of safety in rails, in locations where they are now breaking. Whether these hopes will in a measure be realized it is yet too early to state. The display of transverse fissures in rails in which diligent search has so far failed to reveal shattered metal indicates their development is not basically dependent upon the presence of this particular defect.

In the investigation of rails which have failed by transverse fissures attention has been directed intensely to their physical properties and structural state. The results have brought about a clearer conception of the phases through which rails pass, which may be held as precursors to rupture No common physical defect has been discovered to the presence of which transverse fissures may be ascribed. Some grades of steel are more prone than others to develop such fractures. The interior origins of transverse fissures are explained by the engineer-physicist on physical laws.

Whether rails are likely to fail by transverse fissures or not appears to depend upon track conditions being unfavorable or favorable. With such abundant opportunities as are afforded by the combined efforts of the railroads of the country to acquire the necessary information, this phase of the subject should be actively entered upon and brought to a conclusion. In respect to the presentation of data upon transverse fissured rails it is felt that information upon the relation of equipment and service conditions to their formation has not kept apace with the investigation of the physical properties of the steel, a deficiency which calls for early correction

Respectfully submitted.

W. P. Borland,
Chief, Bureau of Safety.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D C
AT
15 CENTS PER COPY
▽