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INTERSTATE COMMERCE COMMISSION.

REPORT OF THE CHIEF OF THE BUREAU OF SAFETY COVERING THE INVESTIGATION OF AN ACCIDENT WHICH OCCURRED ON THE ST. LOUIS-SAN FRANCISCO RAILROAD NEAR KEIGHLEY, KANS., ON DECEMBER 26, 1918.

JUNE 24, 1920.

To the Commission:

On December 26, 1918, there was a derailment of a passenger train on the St. Louis-San Francisco Railroad near Keighley, Kans., which resulted in the death of 2 employees and injury of 11 passengers After investigation I beg to submit the following report:

The Wichita subdivision of the northern division of the St. Louis-San Francisco Railroad, on which this accident occurred, extends from Neodesha, Kans, to Wichita, Kans, a distance of 104 miles, and is a single-track line, over which train movements are governed by time-table and train orders No block-signal system is in use. Approaching the point of accident from the east the track is straight for more than a mile, with a grade varying from 0 9 to 1 per cent, descending for westbound trains. The derailment occurred in a cut approximately 2 feet high about 650 feet west of its eastern end.

The track in the vicinity of the point of accident is laid with 70-pound steel rails, 30 feet in length, with about 18 oak ties to the rail. The rails are single spiked and no tie-plates, braces, or anticreepers are in use. The ballast consists of 6 to 12 inches of chatt, with a shoulder at the ends of the ties. The surface and alignment of the track were in only fair condition. The weather at the time of the accident was clear, with a temperature of about 15° above zero, and a very heavy snow was on the ground.

Westbound passenger train No. 305 consisted of locomotives 1102 and 223, 1 mail and baggage car, 1 baggage car, 1 coach, 1 chair car, and 1 Pullman sleeping and café car, in the order named, and was in charge of Conductor Lester and Enginemen Dale and Friend. This train left Neodesha at 1.55 p. m., 2 hours and 35 minutes late, and on account of the snow on the ground continued to lose time; it left Beaumont Junction at 4.20 p. m, 2 hours and 55 minutes late, and at 4 55 p. m., while running at a speed estimated at 25 miles an hour, was derailed at a point 3 7 miles west of Keighley, Kans.

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Locomotive 1102 broke away from locomotive 223 and ran a distance of about 400 feet before coming to a stop, the wheels of the leading engine remaining on the rails while the wheels of the tender were derailed Locomotive 223 turned over on its left side and lay parallel with the track, with its tender lying crosswise the track and jammed against the boiler head The first two cars of the train derailed to the left of the track and came to rest tilted at an angle of 45°. The coach, the third car in the train, was derailed, but remained on the roadbed in an almost upright position, while the chair car had only its front trucks derailed, and the rear car was not derailed.

An examination of the track after the accident disclosed that a rail on the south side of the track had broken into four pieces, the first break occurring 1 foot 5½ inches from its receiving end Opposite this rail, on the north side of the track, another rail was found broken into two pieces, the break in the north rail occurring 19 feet 4 inches from its receiving end, or 1 foot 2½ inches farther west than the first break in the south rail Both of these rails and the rails for the next half panel west showed badly roughened surfaces on the balls of the rails, apparently caused by an engine slipping on account of being stalled in the snow The rails also indicated some flange wear

The crew of freight train No 32, which passed over this point 2½ days prior to the time of the accident, stated that they became stalled in the snow at the point where train No. 305 was derailed, and that the locomotive of their train slipped more or less in an effort to get through the cut. It was their opinion that this slipping may have burned the rails, although they did not examine them and could not say positively.

The crew of train No. 306, which passed over this track about 2 hours before train No 305 was derailed, stated that they noticed snow-burnt rails at this point, and, while they were quite noticeable, they did not think the condition sufficiently dangerous to require a report

Engineman Dale, of the leading locomotive of train No. 305, stated that at the time of the accident he was using just enough steam to cushion the valves and that the speed was about 25 miles an hour. The first intimation he had of the accident was a noise and a jar, which he thought was caused by a broken rail, and he immediately made an emergency application of the brakes He thought that his locomotive passed over the broken rail and that the tender wheels were pulled off the track by the derailment of the second locomotive when it turned over Engineman Dale further stated that he had had a good deal of experience with snow-burnt rails, and, while the rails involved in this accident were burned a longer distance than most snow-burnt rails, they were no more badly burned than many others he had seen, and he would not have considered their condition dangerous.

Conductor Lester, of train No. 305, stated that on the day of the accident he held an order to look out for snowdrifts over the division, and he said Engineman Dale was observing this order, as he noticed the brakes being applied approaching various cuts He estimated the speed of the train at the time of the derailment at 25 miles an hour. Conductor Lester further stated that after the derailment he did not examine the track and he could give no cause for the accident.

Roadmaster Vermillion stated that he reached the point of the accident at 1 30 p. m the following day and found two broken rails, which had been snow burnt for 30 or 40 feet by wheels slipping on the snow, and he said that both rails showed signs of being burned at the points of breakage. He stated that the two snow-burnt rails were nearly opposite each other in the track and that the one on the south side was broken into three pieces, with about 3 feet of the ball broken out, while the rail on the north side of the track was broken into two pieces. He thought the rail on the north side of the track was the first to break, as that rail was burned more seriously than the one on the south side.

Investigation definitely developed the fact that the cause of the accident was due to the failure of two rails, which had been snow burnt some time previously by an engine slipping on the rails in the snow An investigation of these rails and other relevant matters was conducted by Mr. James E Howard, engineer-physicist, whose report follows Acknowledgment is made of the assistance of Mr. R H. Christ, metallographist of the Bethlehem Steel Co, in the microscopic examination of the metal of these rails.

REPORT OF THE ENGINEER-PHYSICIST.

The rails involved in the present derailment were 70 pounds weight per yard, A. S. C E. section, and rolled by the Carnegie Steel Co. in May, 1897 They were originally laid on another division of the railroad; relaid in 1911 at the place where derailment occurred One rail on each side of the track was fractured, the north rail being broken into two pieces and the south rail into four pieces.

Each had been wheel burnt practically its entire length, adjacent portions of the track also being affected. The term "snow burnt" was used by the officials of the railroad in describing them, having the same meaning as "wheel burnt," being indicative of the season of the year in which it occurred. These terms, as well known, refer to the effects of the slipping of driving wheels, which abrade the top of the rail, cause intense local heating, and result in the formation of shallow zones of hardened metal next the running surface.

These rails had recently been exposed to injury of this kind. About two days prior to the derailment an eastbound train was stalled by snow at this place, experiencing difficulty in getting through the drift. It is believed to have caused injury to the track by the slipping of its wheels.

The circumstances attending the accident make it appear that the rails were broken by the leading engine of the derailed train, although this engine did not leave the track. Its tender, the second locomotive, and portions of the train were derailed.

It is not uncommon for the engine which breaks a rail to pass over it in safety, the following cars meeting with injury. Or if the latter escape derailment a succeeding train is affected, providing the broken rail remains undiscovered.

Little or no doubt concerning the responsibility for this derailment attaches to the wheel-burnt condition of these rails, although direct evidence thereupon was not furnished by their fragments. Influences both weakening and strengthening in their tendencies are recognized in wheel-burnt rails. It is a matter of importance to acquire data which shall illustrate the phases through which the steel passes, and specifically explain the manner in which rupture is reached in cases of this kind.

Large numbers of wheel-burnt rails are in service. Hardly a station is without such rails in its vicinity. They are found near signals, water towers, in yards, or wherever trains usually stop and start. The condition of such rails can be judged of only by their external appearance Characteristic features may guide in forming judgment concerning their relative safety, but their identification as such has not been brought to a conclusion. The present report will be considered as a progress report upon this important subject.

The data acquired upon the present rails will first be presented, followed by remarks upon phenomena displayed by steels which have been exposed to heat and mechanical action, resulting in effects similar to those witnessed in wheel-burnt rails.

Figure 1 illustrates the appearance of wheel-burnt portions of the heads of fragments of these rails The slipping of the wheels distorted and scored the metal at places along the running surface, slightly hollowing the head in spots Intense hardness of the metal was imparted covering areas of one or more square inches The edges of these areas were more or less ridgy or rippled. The metal was dragged by mechanical, abrasive action, heat generated by frictional resistance, and the surface hardened by sudden quenching through conductivity of the cold metal below

Figure 2 is a closer view of the end of one of the fragments shown by figure 1, representing the piece nearly full size. Figure 3 represents another wheel-burnt portion of the same rail as above, after pickling in hot hydrochloric acid. On this and other wheel-burnt areas patches of hardened metal were found with intact surfaces, crimping of the metal occurring at their boundaries. Hardening of the metal took place, for a limited depth, without shattering the surface.

Figure 4 shows the appearance of a strip, in cross section, taken from the top of the head; in the upper view the rail had not been wheel burnt, in the lower view it had. The cut is nearly full size. The steel was etched with picric acid. The hardened metal, shown in white, extended nearly across the width of the head, having a maximum depth of 0.07 inch

Figure 5 is a photomicrograph of the structure of the zone of hardened metal, which appeared white in the preceding cut It shows the conversion of the steel into the microconstituents, martensite, and troostite. Magnification, 500 diameters.

Figure 6 is the same as figure 5 at the lower magnification of 300 diameters.

Figure 7 shows the microstructure at the junction of the hardened zone and the normal metal of the interior, illustrating the incipient stage of conversion of pearlite to troostite and martensite, with ferrite boundaries not materially effaced Magnification, 300 diameters.

The normal structure of the rail is shown by figure 8 at a magnification of 300 diameters.

Figure 9 shows the appearance of the metal in the hardened zone after exposure to a temperature of 1,000° F, effecting a partial restoration from the state shown by figures 5 and 6.

Figure 10, a photomicrograph at 100 diameters magnification, was taken at the edge of a wheel-burnt zone. A longitudinal crack is here shown, separating the hardened metal and extending into that of normal structure below the hardened zone All photomicrographs were taken on transverse sections.

Strips removed by machining from the tops of the heads of these rails sprung convex in a pronounced degree, indicating the relief of internal strains of compression. The several fragments of the rails showed lines of rupture having their origins at the running surface, thence extending downward through the head, web, and base

Herein reside features which require further detailed tests in order to explain definitely why the rails broke. Cooling strains of fabrication introduce compression at the periphery of the head, the cold rolling action of the wheels sensibly increases the internal strains of compression at the running surface, and hardened steel, by reason of its diminished density, is expected to attain a state of internal compression. These several features appear as strengthening factors against the failure of the rails by tension at the top of the head. Notwithstanding their influence the rails broke by tension from the top of the head

An explanation for the occurrence should probably be looked for in the intermediate stages of the hardening of the steel at a time when the exterior metal is first quenched and passes through a state of tension The metal at the bores of guns, momentarily exposed to a wash heat of high temperature, ultimately reaches a state of tension. A network of fine cracks covers the surface of the bore Similar cracks are witnessed in some rails. It appears that the rate of quenching may be a controlling factor, having such influence that hardened metal results in some instances without thermal cracks, while in other cases they are formed Shop practice in the hardening and tempering of tools furnishes examples suggestive of such an explanation.

Indications in the present rails direct attention to the boundaries of wheel-burnt zones as places susceptible to injurious strains Much might be said in a speculative manner on the differences in action of the wheels in respect to abrasion, heating, and quenching effects. as confined within narrow dimensions on the rail head. The subject of wheel burning is not a simple one in respect to the manner in which ultimate rupture of the rail is reached. The present report will be submitted as a preliminary inquiry into a common source of injury and cause of rail failures, the importance of further investigation upon which is recognized In but few instances does steel externally afford opportunity for judging of its structural integrity Wheel-burnt rails afford visible evidence of injury, and such evidence is probably in some degree indexical of the extent and gravity of the injury.

The suggestion that wheel-burnt rails indiscriminately be removed from the track as a menace to safety would not appear justifiable in view of the inadequacy of the data upon their condition and the large number of such rails which are carrying present equipment without rupture. They are due to a condition so common that avoidance of their formation would likewise appear an impracticable demand. Other data are being acquired which will be embodied in a succeeding report dealing with a derailment due to causes involving similar fundamental features as the present derailment on the ability of steel to endure track conditions

SUMMARY.

The rails which failed in the present derailment had been exposed to a very common occurrence, namely, they had been severely wheel burnt Their failure is attributed to this cause. Rails are rendered very brittle along the tops of their heads by such injury and fail without display of toughness

At first sight it seems a very simple matter to account for the rupture of rails under these circumstances, but such is not the case The Engineer-Physicist points out features which have a strengthening influence, in this respect, that they cause internal strains of compression next the running surface of the rail and thereby increase the range of stress which the top of the head must undergo before fracture by tension is feasible. On the other hand, the quenching of steels from high temperatures frequently results in hardening cracks, which in a rail would be a serious condition.

Measured stresses on rails in the track as a rule do not show the prevalence of high fiber stresses in the tops of the heads, due to bending stresses alone Tensile fractures in the head, therefore, appear to leave some factors still to be accounted for.

Wheel-burnt rails are numbered by the thousands. The majority perform satisfactory service without rupture The means of distinguishing between safe and unsafe rails of this type unfortunately has not been made known, nor does the present report purport to solve the question It invites attention to relevant features, while further investigative work on the same subject is in progress having to do with another derailment.

Respectfully submitted

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Chief, Bureau of Safety.

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