INTERSTATE COMMERCE COMMISSION

WASHINGTON

REPORT NO. 3594

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY

IN RE ACCIDENT

NEAR ORWOOD, CALIF., ON

SEPTEMBER 22, 1954

SUMMARY

Date:	September 22, 1954
Railroad:	Atchison, Topeka and Santa Fe
Location:	Orwood, Calif.
Kind of accident:	Derailment
Train involved:	Passenger
Train number:	2
Engine number:	Diesel-electric units 31C, 31B, 31A, and 31
Consist:	12 cars
Speed:	72 m. p. h.
Operation:	Timetable, train orders, and automatic block-signal system
Track:	Single, tangent; 0.13 percent descending grade eastward
Weather:	Clear
Time:	1:04 p. m.
Casualties:	59 injured
Cause:	Broken axle

INTERSTATE COMMERCE COMMISSION

REPORT NO. 3694

IN THE MATTER OF MAKING ACCIDENT INVESTIGATION REPORTS UNDER THE LOCOMOTIVE INSPECTION ACT OF FEBRUARY 17, 1911, AS AMENDED, AND THE ACCIDENT REPORTS ACT OF MAY 6, 1910.

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY

November 12, 1954

Accident near Orwood, Calif., on September 22, 1954, caused by a broken axle.

REPORT OF THE COMMISSION[1]

CLARKE, Commissioner:

On September 22, 1954, there was a derailment of a passenger train on the Atchison, Topeka and Santa Fe Railway near Orwood, Calif., which resulted in the injury of 40 passengers, 18 dining-car employees, and 1 train-service employee. This accident was investigated in conjunction with representatives of the Public Utilities Commission of California.

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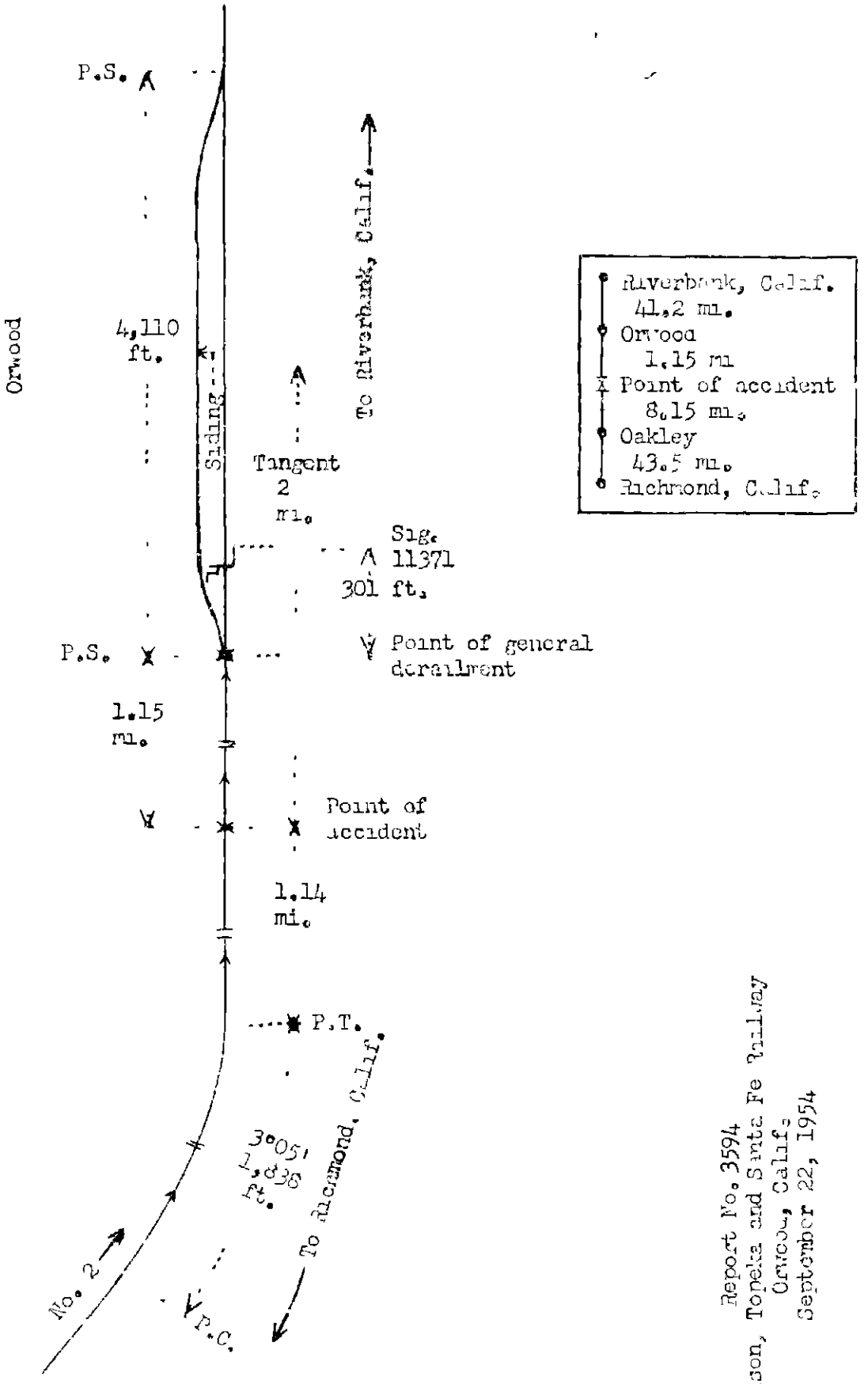
[1] Under authority of section 17 (2) of the Interstate Commerce Act the above-entitled proceeding was referred by the Commission to Commissioner Clarke for consideration and disposition.



Report No. 3594
Atchison, Topeka and Santa Fe Railway
Orwood, Calif.
September 22, 1954

LOCATION OF ACCIDENT AND METHOD OF OPERATION

This accident occurred on that part of the Valley Division extending between Richmond and Riverbank, Calif., 94.0 miles. In the vicinity of the point of accident this is a single-track line, over which trains are operated by timetable, train orders, and an automatic block-signal system. At Orwood, 52.8 miles east of Richmond, a siding 4,110 feet in length parallels the main track on the north. The initial derailment occurred on the main track at a point 1.15 miles west of the west siding-switch at Orwood, and the general derailment occurred immediately east of the switch. From the west there are, in succession, a 3°05' curve to the left 1,838 feet in length, and a tangent 1.14 miles to the initial point of derailment and more than 2 miles eastward. The grade is 0.13 percent descending eastward at the initial point of derailment, and it varies between 0.13 percent descending and 0.09 percent ascending eastward between that point and the west siding-switch.

In the vicinity of the point of accident the track structure consists of 115-pound rail, 39 feet in length, laid new in 1949 on an average of 26 ties to the rail length. It is fully tieplated with double-shoulder tieplates, spiked with two rail-holding spikes and two plate-holding spikes per tieplate, and is provided with 6-hole 36-inch joint bars and an average of 14 rail anchors per rail. It is ballasted with crushed rock to a depth of 10 inches below the bottoms of the ties. In the vicinity of the west siding-switch at Orwood the track is laid on a fill approximately 90 feet in width and 15 feet in height.

This carrier's operating rules read in part as follows:

TRAIN AND YARD SERVICE

815. * * *

Trainmen must inspect their trains frequently while running and when standing, to detect hot journals, stuck brakes and other defects. They must observe meeting and passing trains to detect and call attention to anything that might endanger the operation of such trains, giving stop signals if necessary.

ENGINEMEN AND FIREMEN

891. They must look back frequently, and especially while rounding curves * * * to detect any defects in their train and for signals * * *

* * *

The maximum authorized speed for passenger trains in the vicinity of the point of accident is 79 miles per hour.

DESCRIPTION OF ACCIDENT

No. 2, an east-bound first-class passenger train, consisted of Diesel-electric units 31C, 31B, 31A, and 31, coupled in multiple-unit control, one baggage car, four chair cars, one dining car, one dome car, one dining car, and four sleeping cars, in the order named. All cars were of lightweight steel construction, and all units of the train were equipped with controlled slack couplers. This train departed from Richmond at 11:59 a. m., 3 minutes late, passed Oakley, 43.5 miles east of Richmond and the last open office, at 12:56 p. m., 1 minute late, and, while moving at a speed of approximately 72 miles per hour, the front wheels of the front truck of the third Diesel-electric unit were derailed at a point 1.15 miles west of the west siding-switch at Orwood. The other wheels of this unit, the entire fourth Diesel-electric unit, and the first to the ninth cars, inclusive, were derailed immediately east of the west siding-switch.

The train stopped with the front of the locomotive 1,056 feet east of the west siding-switch. The third and fourth Diesel-electric units stopped approximately in line with the track. The first, second, and third cars stopped approximately in line, with the front end of the first car on the track structure and the rear end of the third car 50 feet south of the track. The coupler shank on the front end of the fourth car was broken, and a separation occurred between the third and fourth cars. The fourth car stopped parallel to the track, with the front end 50 feet south of the track and 35 feet west of the rear end of the third car. The fifth car stopped with the rear end between the main track and the siding. A separation occurred between the fifth and sixth cars when the uncoupling attachments were operated as a result of the action of the cars during the derailment. The sixth and seventh cars stopped in line, with the front end of the sixth car against the rear end of the fifth car, and the rear end of

the seventh car 25 feet south of the track. The eighth car stopped with the rear end on the track structure of the siding, and the ninth car stopped with the rear end on the track structure of the main track. The derailed cars leaned to the south at angles of from 5 to 45 degrees. The trucks and brake equipment of the third and fourth Diesel-electric units, and the first, eighth and ninth cars were somewhat damaged. The second to the sixth cars, inclusive, were considerably damaged, and the seventh car was badly damaged. Much of this damage occurred as a result of contact between the derailed cars and a cantilever signal bridge and concrete foundation located south of the track and 301 feet east of the west siding-switch.

The conductor of No. 2 was injured.

The weather was clear at the time of the accident, which occurred about 1.04 p. m.

EXAMINATION OF TRACK

Examination of the track disclosed that a pair of wheels had become derailed to the north at a point 1.15 miles west of the west siding-switch. The marks on the ties inside the south rail were considerably heavier than those outside the north rail. These marks continued in line with the track to the west siding-switch. The switch points at this switch were battered, and the switch was somewhat damaged. The general derailment occurred immediately east of the frog. The track between this point and the point where the third Diesel-electric unit stopped was badly damaged.

DESCRIPTION OF LOCOMOTIVE UNIT INVOLVED

Unit 31-A, the third unit in the locomotive, coupled in backward movement, was built in September, 1948, at La Grange, Illinois, by the Electro-Motive Division of General Motors Corporation. It was equipped with one E.M.D. 1500 horsepower model 16-567-B engine with direct connected generator. Each axle of the B-B, 4-wheel trucks, was motor driven and had $6\frac{1}{2}$ x 12 inch journals which were equipped with Hyatt oil lubricated roller bearings. The specified diameter of the wheels when new was 40 inches. The unit was constructed for use as a trailing unit in a multiple unit locomotive. Total weight on driving wheels was 248,000 pounds and tractive effort 62,000 pounds. The unit was designed for a maximum speed of 100 miles per hour.

DESCRIPTION OF PARTS INVOLVED

The failed axle on unit 31-A was a part of a driving wheel set consisting of the axle, wheels, and axle gear and was equipped with roller bearings. The wheels which were in number 4 position and were in lead position in direction of movement, were Class B multiple-wear rolled steel wheels manufactured by the American Steel Foundries in June 1953. The right wheel was stamped A-79158 and the left wheel was stamped A-79312. The Hyatt bearing on the gear end of the axle was applied new at San Bernardino, California, on May 11, 1954.

The axle was stamped 1695 W4270 SSW NTS 2-26-49 SB2. It was machined at San Bernardino on February 26, 1949, from a normalized and tempered billet furnished by the Standard Steel Works Division of Baldwin-Lima-Hamilton Corporation. The billet had been purchased in August, 1947, to AT&SF Ry. specification L-210-B, covering medium steel forgings, normalized and tempered. Since first being placed in service on April 17, 1949, wheels had been mounted on the axle as follows:

Place	Date	Mileage of Axle
San Bernardino	May 30, 1950	223,932
San Bernardino	April 8, 1951	420,676
San Bernardino	Nov. 19, 1951	565,820
San Bernardino	August 23, 1953	994,373

At the time wheels were last applied on August 23, 1953, the inner races were removed and the axle magnafluxed. No cracks were found.

On May 14, 1954, this axle was applied to unit 31-A where it remained in No. 4 position until the failure occurred. The wheels had been turned in place on a wheel-truing machine at Barstow, California, on June 5, 1954. The axle had made 1,312,142 miles when it failed, or 317,769 miles since last magnafluxed.

EXAMINATION OF PARTS INVOLVED

The roller bearings on the failed axle were found to be in good condition and were well lubricated. The right No. 4 wheel was 37 9/32 inches in diameter, flange 1 1/16 inches high, tread wear 5/64 inch, flange wear 5/32 inch,

and rim thickness 1½ inches. The left No. 4 wheel was 37 19/64 inches in diameter, flange 1 1/16 inches high, tread wear 5/64 inch, flange wear 3/32 inch, and rim thickness 1¼ inches. The rim of the left No. 4 wheel showed where contact with the south rail occurred after the derailment. No evidence of heating was found on the axle or wheels, and no flat spots were found.

The right No. 4 journal, which was the left front journal in the direction of travel, failed near the wheel end of the inner race of the roller bearing. Appearance of the cup shaped fracture indicated that the initial failure had occurred at the outer surface of the journal and continued until approximately 80 percent of the cross-sectional area had failed at the time the final break occurred. The broken journal was on the gear end of the axle.

The failed journal had been built up by use of the metal spraying process which extended into the fillet. This metallizing had broken from the axle surface near the fractured face. The axle at point of failure was burned and scored by contact with the bearing housing. Magnaglo inspection of the axle gave indications of a discontinuous crack 5.68 inches long in the right wheel seat 6.10 inches from the outside wheel seat shoulder. The wheel hub was 6.36 inches long. The largest continuous crack was 1.78 inches in length. Micrometer measurements of the metallized journal surface and of the inside diameter of the inner race indicated an interference shrink fit of 0.0027 to 0.0036 inch.

Comparison of the chemical analysis of drillings secured from the broken journal and the axle specification follows:

	Per Cent	
	Axle	AT&SF Specification L-210-B Medium
Carbon	0.49	0.40 - 0.55
Manganese	0.79	0.60 - 0 90
Phosphorus, Max.	0.019	0.045
Sulphur, Max.	0.045	0.050
Silicon, Min.	0.26	0.15

The Brinell hardness of a transverse section varied from 171 to 179. Mechanical test of the journal material gave the following results.

Specimen	Yield Strength	Ultimate Strength	Elongation in 2 inches	Reduction of area
	Pounds per square inch	Pounds per square inch	Percent	Percent
Outside	42,400	88,900	28	46.9
Standard	41,900	88,600	24	41.7
AT&SF Spec. L-210-B Medium	43,160	83,000	24	38.0

INSPECTION AND REPAIR REPORTS

The last annual inspection of all units was made at San Bernardino, Calif., on May 18, 1954, and the last monthly inspection was made at Barstow, Calif., on September 4, 1954.

Daily inspection reports filed at Richmond, Calif., since August 1, 1954, were examined and nothing was found reported that would have any bearing on the accident.

SUMMARY OF EVIDENCE

Before the accident occurred a section force was working on the track at a point approximately a mile west of the west siding-switch at Orwood. As No. 2 approached the foreman stepped to the south side of the track, and when the front of the train reached a point about 350 feet west of him he saw ballast flying from underneath the locomotive. As the locomotive passed him he saw that a pair of wheels was derailed. He gave stop signals, but the front of the locomotive had passed before he gave the signals and the signals were not observed by members of the crew.

As No. 2 was approaching the point where the accident occurred the engineman were in their usual positions on the control compartment at the front of the locomotive, the front brakeman was in the rear vestibule of the third car, the conductor was in the fourth car and the flagman was in the vestibule of the rear car. The train brakes had been tested and had functioned properly when used en route The engineer said that he inspected the train as it rounded a curve to the right at Oakley, and the fireman said that he inspected the train on the curve to the left west of Orwood. They observed no defective condition. These employees saw the members of the section force west of Orwood, but they did not

continue to watch them after the front of the train passed. They did not see a stop signal given. As the train approached Orwood the engineer made a light service application of the brakes and applied the dynamic brake in order to comply with a speed restriction east of Orwood. The enginemen were not aware that anything was wrong until the locomotive was passing the west siding-switch at Orwood. They then felt a slight lurch, and immediately afterward the brakes became applied in emergency as a result of the derailment. The front brakeman opened the vestibule door and inspected the left side of the train as it moved on the curve to the left west of Orwood. He observed no defective condition. A short time later he observed an unusual amount of flying dust on the south side of the train. The general derailment occurred before he could take action to stop the train. The flagman opened the vestibule door of the rear car and inspected the left side of the train on the curve west of Orwood. He observed no defective condition. After the train passed the curve he closed the vestibule door He first became aware that something was wrong when the brakes became applied in emergency. Neither the front brakeman nor the flagman saw the members of the section force west of Orwood. The conductor was so seriously injured in the accident that he was not questioned during this investigation. According to the tape of the speed-recording device, the speed was approximately 72 miles per hour at the initial point of derailment and 57 miles per hour at the west siding-switch.

DISCUSSION

The marks on the track structure indicate that after the axle failed and the weight was removed from the left front wheel of unit 31-A the front wheels of this truck became derailed to the north. These wheels moved in line with the track from the initial point of derailment to the west siding-switch at Orwood. The general derailment occurred at the latter point.

Laboratory test of the axle material indicated that the chemical composition met the specification requirements, but the yield strength was below the minimum specification requirement. In addition to the fracture which caused the derailment it was found that the axle was also cracked in the adjacent wheel seat.

The inner races had been removed and the axle had been magnetic particle tested at time of last wheel mounting. All parts of the wheel set apparently had been mounted to the required standards and the condition of wheels and bearings was good.

In the metal spraying process, or metallizing, wire or metal powder is fed through a self-contained gun where the metal is melted, atomized with a jet of compressed air, and blown from the nozzle of the gun in the form of a fine, dense molten spray. Upon contact with the surface to be metallized, the tiny particles of sprayed metal chill almost instantly and key themselves into the base metal.

The bond between the sprayed metal and the base is purely mechanical. Preparation of the base material should produce a multiplicity of minute keys or locks for holding the sprayed molten metal firmly to the surface which thus must be roughened by mechanical means. The sprayed metal will seldom, if ever, have its original tensile strength, ductility, or elongation although these physical properties might still be present in the individual metal particles. Other physical characteristics such as hardness, compressive strength, wear resistance, corrosion resistance, and heat and electrical conductivity will remain. The spray metal coating is not fused to the base metal and stresses set up would not be transmitted uniformly through the surface of the section as would be the case in an uncoated journal. Since the metallized coating is not integral with the parent metal of the axle, it is possible for a fatigue failure to start below an unbroken surface of the coating and not be discovered in routine magnetic particle test.

Metallizing is a metal depositing process somewhat comparable to fusion welding. Metallizing differs from fusion welding in the respect that in the metallizing process fusing of the parent metal, with consequent metallurgical changes, does not occur. However, in either process concealment of any existing surface defects is equally effective.

Under standards of the Association of American Railroads, roller bearing journals are required to be free from tool marks and scratches in the fillets and on the adjoining cylindrical portions. Experience has demonstrated that surface defects, such as scratches, tool marks, ridges or corrugations, in highly stressed members subject to fluctuating loads cause highly localized stresses which initiate progressive fatigue failures.

In the instant case it would appear that metallizing had been employed because of the effect on the journal fit under the inner roller bearing race of the number of removals of the race which had occurred during the service life of the axle. The metallizing process had been used to prepare the surface of the journal to receive and support the subsequently applied race and thus extend the service life of the axle. In the investigation of this accident it could not be determined whether there were any incipient defects at the time the metallizing was applied.

In another case which was investigated by the Commission in 1947, a tender truck axle of a steam locomotive on another railroad broke while the locomotive was hauling a freight train at an estimated speed of 12 miles per hour. Two members of the engine crew were killed and one injured in the subsequent derailment.

Investigation developed that the journal, including the fillet, had been built up by fusion welding and the deposited metal had been machined to a smooth surface. Failure of the journal occurred through the fillet. Approximately 75 percent of the cross-sectional area showed a progressive fracture which extended over its entire circumference and inwardly from the surface.

The method of reclamation used was not in accordance with recognized practice of the Association of American Railroads which provides:

> "Restoring worn-out axles to the original size by welding with the exception of building up the end collars, is not permissible under Association of American Railroads rulings. Reforging of the axles is the better practice of reclamation due to the fact that the axles are re-worked and re-annealed, thus improving the structure."

In report of the accident the Commission said:

> "The prohibitions of application of fusion welding on axles and the necessity, in the interest of safety, of removing from service any axles that are found to have had such welding applied, are so well known and understood that discussion of this pernicious practice, which has been universally long recognized as destructive to life and property, would here be redundant."

In the accident here under investigation it was found that the axle which failed at Orwood had during its service life had 5 pairs of wheels mounted upon it and had accumulated nearly one and one third million service miles prior to failure. Development of the progressive fracture that culminated in failure of the journal and of the progressive fracture in the adjacent wheel seat strongly indicates that the axle had been continued in service beyond the endurance limit of the metal. The severe service conditions of wheels and axles under Diesel-electric locomotive units with axle-hung motors suggests a need for more frequent testing of axles and determination of a safe life expectancy for such axles.

CAUSE

This accident was caused by a broken axle.

Dated at Washington, D. C., this twelfth day of November, 1954.

By the Commission, Commissioner Clarke.

(SEAL)

GEORGE W. LAIRD,

Secretary.