INTERSTATE COMMERCE COMMISSION

WASHINGTON

REPORT OF THE DIRECTOR

BUREAU OF SAFETY

ACCIDENT ON THE

ATCHISON, TOPEKA & SANTA FE RAILWAY

COCONINO, ARIZ.

JULY 27, 1939.

INVESTIGATION NO. 2371

SUMMARY

Inv-2371

Railroad:	Atchison, Topeka & Santa Fe
Date:	July 27, 1939
Location	Coconino, Ariz.
Kind of accident:	Derailment
Train involved:	Passenger
Train number:	Extra 3704
Engine numbers:	3853 - 3704
Consist:	13 cars
Speed:	12-25 m. p. h.
Operation:	Timetable and train orders
Track:	Single; $10^{\circ}04'$ left curve; level
Weather:	Clear
Time:	8:17 p. m.
Casualties:	146 injured
Cause:	Believed to be a combination of wide gage, curve-worn rail, loose spikes, worn flanges, and driving-wheel brakes remaining applied on curve, which resulted in a wheel on low side dropping inside rail and high rail overturning.

Inv-2371

November 8, 1939.

To the Commission:

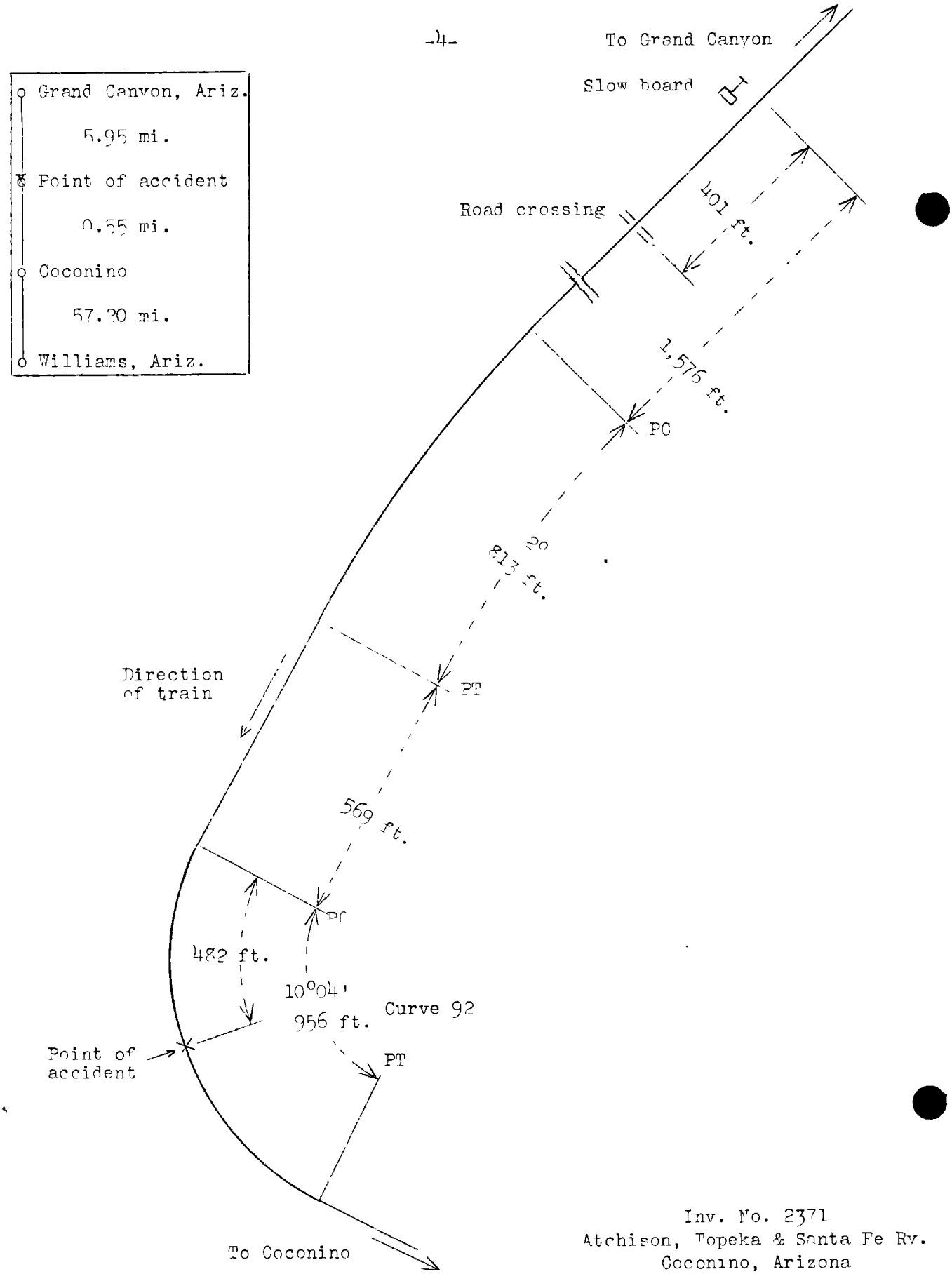
On July 27, 1939, there was a derailment of a passenger train on the Atchison, Topeka & Santa Fe Railway near Coconino, Ariz., which resulted in the injury of 120 passengers, 13 dining-car employees, 9 Pullman porters, and 4 train-service employees. This accident was investigated in conjunction with the Arizona Corporation Commission.

Location and Method of Operation

This accident occurred on that part of the Albuquerque Division designated as the Grand Canyon District which extends between Grand Canyon and Williams, Ariz., a distance of 63.7 miles. In the vicinity of the point of accident this is a single-track line over which trains are operated by timetable and train orders, no block system being in use. According to time-table directions the train involved was west-bound, but according to compass directions it was moving southward when the accident occurred; compass directions are used in this report. The accident occurred on Curve 92, at a point approximately 2,765 feet north of Coconino. Approaching this point from the north there is a tangent 569 feet in length, followed by a 10°04' curve to the left 956 feet in length; the accident occurred on the curve at a point 482 feet from its northern end. The grade for south-bound trains is 1.94 percent descending a distance of 3,600 feet; it is then level about 1,300 feet to the point of derailment.

The north portion of Curve 92 is laid on a fill about 8 feet in height, and the south portion extends through a rock cut about 420 feet in length, 11 feet in depth, 20 feet in width at the bottom, and 30 feet in width at the top. The derailment occurred about 75 feet south of the north end of the cut, and practically at the middle of the curve.

In the vicinity of the point of accident the track structure consists of 90-pound re-laid rail, 33 feet long, laid on 22 treated hardwood ties to the rail length; it is double-spiked on the gage side and single-spiked on the outside, fully tie-plated, provided with 6 rail anchors and 5 gage rods to the rail length, and ballasted with 6 inches of volcanic cinders. The maximum superelevation of the outside rail of the curve is 4 inches. The gage varies between 4 feet 8-1/2 inches and 4 feet 9-1/8 inches.



Inv. No. 2371
Atchison, Topeka & Santa Fe Ry.
Coconino, Arizona
July 27, 1939

The maximum authorized speed for passenger trains on this district is 45 miles per hour; however, bulletin instructions restrict the speed of all trains to 20 miles per hour on the curve involved. A permanent slow board for south-bound trains is located 2,958 feet north of Curve 92.

The weather was clear at the time of the accident, which occurred at 8:17 p. m.

Description

Extra 3704, a west-bound passenger train, consisted of one combination smoker-baggage car, three tourist cars, one dining car, one lounge car, and seven Pullman sleeping cars, in the order named, all of steel construction, hauled by engine 3853, of the 2-10-2 type, and engine 3704, of the 4-8-2 type, and was in charge of Conductor Parks and Enginemen Sparks and Robillard. This train left Grand Canyon at 8:05 p. m., according to the train sheet, and, approximately 5.95 miles beyond, it became derailed on Curve 92 while moving at a speed variously estimated to have been from 12 to 25 miles per hour.

Both engines and their tenders stopped against the west embankment of the cut, badly damaged, with the forward end of the first engine about 250 feet south of the initial point of derailment. The first three cars became derailed and were considerably damaged. The first car stopped on its right side on top of the west embankment and was headed southeast. The second car stopped on top of the west embankment at right angles to the track but remained upright. The third car became derailed to the left, stopped upright against the east embankment, and opposite the first two cars. The front truck of the fourth car became derailed. The train-service employees injured were the engineman of the first engine, the conductor and two brakemen.

Summary of Evidence

Engineman Sparks, of engine 3853, stated that he was familiar with conditions on this district and had frequently operated the first engine when doubleheading with engines of the type involved. At Grand Canyon a terminal test of the air brakes was made. After departure two running tests were made and the brakes functioned properly en route. The engine was in good condition. It was equipped with No. 6-ET brake equipment, and brake-pipe pressure of 110 pounds was maintained. The train handled properly en route. The engine was not equipped with a speedometer; however, it was his opinion that the speed was not in excess of 35 miles per hour at any point. No unusual slack

action occurred en route. When approaching Coconino the headlight was burning brightly, the speed was about 30 or 35 miles per hour, and the engine was riding smoothly. The independent brake was applied and as his engine passed a road crossing located 401 feet south of the slow board or 3,039 feet north of the initial point of derailment, he made a brake-pipe reduction of about 8 or 10 pounds, placed the brake valve in lap position, and worked a drifting throttle. When entering the curve involved the brakes were not released, and the speed had been reduced to about 18 or 20 miles per hour. The engine rolled, swayed from side to side, seemed to rise in front, and became derailed. He immediately placed the brake valve in emergency position. There was no evidence of anything dropping from his engine and there was no indication that the wheels ran over any foreign object. He did not know what caused the accident, but it was his opinion that an effect similar to that which occurred would have been produced by the outside rail of the curve turning over under the driving wheels.

Fireman MacLean, of engine 3853, stated that the run was being made in the regular manner and that he had maintained a lookout to the front, and to the rear on all curves, but saw nothing unusual. Approaching Coconino, at which time the speed was about 30 or 35 miles per hour, the engineman made a brake-pipe reduction and the train entered the curve at a speed of about 20 miles per hour. The first intimation he had of any irregularity was when he heard a loud crash under either the last pair of drivers or the trailer truck and simultaneously there was a severe lurch. He thought that something had broken under the engine, which settled down on the right side, made several lunges, and then fell toward the west and struck the bank, righted itself, made another lurch against the west bank and stopped. Prior to the accident he did not notice any unusual rolling of the engine, and the speed was not excessive.

Engineman Robillard, of engine 3704, stated that the brake valve on his engine was cut out, the handle was in running position, and the air brakes were under the control of the first engineman. When approaching Coconino the speed was about 40 miles per hour. As the first engine passed the slow board north of the curve a brake-pipe reduction was made and the speed was reduced to about 20 miles per hour; because the first engineman graduated part of the brake-cylinder pressure off, the speed increased slightly down the hill, with the brakes applied, and the engines entered Curve 92 at a speed of about 20 or 25 miles per hour. The first knowledge he had of anything wrong was when his own engine had passed a considerable distance around the curve and it seemed to surge to the right about 6 or 8 inches, then it

jolted along on the ties and stopped. He thought that engine 3353 was the first to be derailed. He had used only a drifting throttle en route. There was no excessive speed. While rounding curves en route he looked back to inspect the train but saw nothing wrong, and he felt no unusual slack action. He had formed no opinion as to the cause of the accident.

Fireman Olsen, of engine 3704, stated that en route the speed was about 40 or 45 miles per hour. At the slow board north of this curve the speed was reduced to 18 or 20 miles per hour, then it increased down the hill and the engines entered Curve 92 with the brakes applied and moving at a speed between 20 and 25 miles per hour. He was looking ahead through the cut and saw fire flying in a horizontal plane from under engine 3853, apparently caused by the flanges of the left driving wheels scraping the inside of the left rails. He heard a loud noise and then his own engine became derailed. There was no excessive speed and the train was handled in the usual manner. He did not know what caused the accident.

Conductor Parks was in the fifth car and was not aware of anything wrong until the accident occurred, at which time he estimated that the speed was between 12 and 15 miles per hour. The speed on this occasion was not unusual. After the accident, having observed that the track was badly torn up, he reported the cause of the accident as being an overturned rail.

Statements of Head Brakeman Weidinger and Flagman McGlothin did not develop anything additional of importance.

The telephone line circuit was broken as a result of the derailment and Superintendent Gray furnished information that the wires failed at 8:17 p. m.

Division Engineer Pierson arrived at the scene of the accident early in the morning of July 28. He examined the track a distance of 1-1/2 miles north of the point of accident and found no indications of either obstructions or dragging equipment.

Starting at the northern point of Curve 92 to the point from which the track was completely destroyed, he checked the gage, grade, and superelevation and found them to be as follows:

Engineer's station	Grade	Gage	Superelevation
53 + 01.65	Level	4' 9"	3-1/2 inches
52 + 75	"	4' 8-7/8"	3-3/4 "
52 + 50	"	4' 8-7/8"	3-3/4 "
52 + 25	"	4' 9"	3-5/8 "
52 + 00	"	4' 9"	3-3/4 "
51 + 90	"	4' 8-3/4"	3-7/8 "
51 + 80	"	4' 8-3/4"	3-7/8 "
51 + 70	"	4' 9-1/8"	3-1/4 "
51 + 60	"	4' 9"	3-1/2 "
51 + 50	"	4' 9"	3-1/2 "
51 + 40	"	4' 8-7/8"	3-5/8 "
51 + 30	"	4' 9"	3-3/4 "
51 + 20	"	4' 9"	4- "
51 + 10	"	4' 8-7/8"	3-7/8 "
51 + 00	"	4' 8-7/8"	4- "

The condition of the rails, ties, and tie-plates was good. The low rails of the curve, at the point of accident, were flattened by wear and the high rails were curve worn. At a point 250 feet north of the point where engine 3853 stopped a rail on the outside of the curve was found turned over, broken through the web, and a 5-foot section of the ball broken out. The next rail north was twisted outward, lying on its side, but connected to the broken rail. The second rail northward from the broken one was still connected but twisted; about 6 feet of its northern end remained spiked to the ties. The third rail northward from the broken one remained upright but damaged to such extent that renewal was necessary. It was his opinion that a side thrust bent the head of the rail until the web broke under the strain. He thought that the maximum thrust was provided by either the rear drivers or the trailer of engine 3853, or the front drivers of engine 3704. The track received the full side thrust at the location of the broken rail and this caused the other rails to turn over. The position of the engines indicated that after derailment they were bearing toward the west side of the cut, scraping the cut for some distance, and the right wheels were off the ends of the ties on the ground, and the left wheels were raised sufficiently so that they did not mark the ties to any extent. There was no evidence of soft track. Rail braces are not used on this curve and the tieplates are not canted. He said that on a $10^{\circ}04'$ curve with a superelevation of 3-1/2 inches, the equilibrium speed is 25 miles per hour, the safe speed limit is 37 miles per hour, and the theoretical overturning speed 58 miles per hour. Superelevation was calculated with reference to the equilibrium and the maximum safe

speeds only, which did not necessarily mean it was entirely safe from a practical standpoint to round such a curve at a speed of 37 miles per hour but he thought that the speed limit should be somewhat under 35 miles per hour. He considered a speed of 35 miles per hour to be safe but when a curve is posted for a certain speed, that speed should be maintained. Ordinarily, at a speed of 20 miles per hour on Curve 92, he did not think that the side thrust would be sufficient to cause the rail to give way. He thought that the rail broke as a result of a speed of between 30 and 35 miles per hour. A rail detector-car was last operated over Curve 92 on September 2, 1938, and no defective-rail condition was found. He did not think that track conditions or excessive speed caused the accident.

Assistant Engineer Baldridge stated that the rail involved was first used in main-track service and was then relaid on the Grand Canyon District. Indications were that it was good rail as the breaks disclosed neither defects nor flaws; it showed some curve wear on the head but not enough to weaken it. It was his opinion that the head of the rail was forced outward by some force acting from the inside, which resulted in the breaking of the rail, but, to his knowledge, this was the first time a rail had broken in this manner. He considered gage rods a greater protection than rail braces against a rail turning over or spreading of track. In his opinion a sufficient number of rail braces shaped in the proper manner would have given additional resistance to the over stress force and might have prevented the accident.

Machinist Reed inspected both engines involved before the train departed from Grand Canyon and he observed that the wheel flanges were worn, but not to the condemning limit. This was vertical wear, as the rounded contour was gone; there were no other defects found.

Chief Engineer Nelson at Grand Canyon inspected all the cars and found nothing wrong. Roll-by inspection was made when the train departed at 8:05 p. m. and nothing was dragging or sticking.

Road Foreman of Engines Steneman stated that he inspected the engines involved at the scene of the accident about 6:15 a. m., July 28. On engine 3853, the reverse lever was in nearly full forward gear, the throttle apparently closed, the double-heading cock open as required, the automatic brake-valve in release position, and the independent-brake valve in running position. On engine 3704, the reverse lever was about 5 or 6 notches back of center, the throttle apparently closed, the

double-heading cock closed, the automatic brake-valve in service position, and the independent brake-valve in slow application position.

Mechanical Superintendent Wall inspected both the engines and the tenders and the four derailed cars; nothing was found that might have caused the accident.

Section Foreman Wall stated that his section extends from Grand Canyon to milepost 54, a distance of 10 miles. On July 25 he went slowly over the track involved on his motor-car and at that time no spikes had worked up by vibration. About 9 hours prior to the accident, he checked the gage, alinement, surface, and elevation of Curve 92 and they were satisfactory. The ties were in good condition. Some spikes on the gage side of the high rail had worked loose and were from 1/2 to 2 inches above the base of the rail; however, on the entire curve not more than 50 spikes had worked up, and not more than one spike in any tie was raised above the base of the rail; in each instance the other spike held securely. He drove all spikes in place and tapped the spikes on the outside to make sure that they were tight. After the accident the track north of the point of derailment was inspected but no indication of dragging equipment or obstruction was found. He had observed that trains obeyed the 20-mile-per-hour speed restriction on this curve. He considered the rail on the curve to be in safe and suitable condition and he could not advance any opinion as to the cause of the derailment.

Engineer of Tests Chapman stated that the broken rail was considerably curve-worn by wheel flanges and bore marks indicating that it had turned over toward the outside. After the rail became overturned, wheel flanges rode in the web and caused a longitudinal break through the web 7 feet 8 inches long, two breaks through the base, 9 and 15 feet, respectively, from the receiving end, and a break through the head about 13 feet from the receiving end. There were three half-moon breaks in the base, and there were short outward kinks about 2 feet from each end of the rail. Two transverse sections were cut for Brinell hardness and deep etching, and one longitudinal section was cut through the head to the middle of the web for deep etching only. Tension tests were made in a 100,000-pound Raihle testing machine, which resulted as follows:

Specimen	Pounds Per Square Inch Yield Point	Pounds Per Square Inch Ultimate Strength	Percent Elongation in 2 inches	Percent Reduction of area
O-1	69,000	118,000	15.5	24.4
M-1	58,800	115,500	15.5	19.5
O-2	70,100	118,700	15.0	24.3
M-2	62,700	117,500	15.0	21.8
B-2	56,400	115,900	17.0	25.6

Three drop test specimens, each 4 feet in length, were tested; a 36-inch span and a 2,000-pound tup were used and the results were as follows:

2,000-pound tup Drop in feet	Total	Deflection-middle of 36-inch span A-Head down	B-Base down	C-Base down
3	3	3/16	1/4	1/8
3	6	3/8	1/2	5/16
3	9	*Broke	9/16	9/16
6	15	--	1-1/8	1-1/8
6	21	--	1-3/8	1-7/16
6	27	--	1-1/2	1-13/16
9	36	--	1-11/16	2-1/4
9	45	--	2	3
9	54	--	2-7/8	3-7/16
9	63	--	**3	3-1/2
9	72	--	--	3-1/2
9	81	--	--	**3-1/2

*A - Head down broke at 9-foot total drop, showing cold rolled metal from normal service conditions.

**B - Base down test discontinued after 63-foot drop and C after 81-foot drop, because of badly twisted specimen. These base-down tests would have met specifications for new rail to stand one drop at 17 feet without breaking base down.

Chemical Analysis

Element	Percent Outside	Percent Middle	Percent Base	Specification 1910 - percent
Carbon	0.63	0.63	0.63	0.59 - 0.72
Manganese	0.69	0.69	0.69	0.60 - 0.90
Phosphorous	0.032	0.032	0.032	Max. - 0.04
Sulphur	0.042	0.043	0.043	----------
Silicon	0.03	0.03	0.03	Max. - 0.20

He said that the foregoing data disclosed good physical and chemical properties; the low strength, when tested head down, is normal for rail steel that has had considerable cold rolling and reduction of head section caused by abrasion as is the case of a high rail on a curve. He said that the results of his examination and tests are conclusive that this rail was first overturned and then became broken because of transverse loading, which it is not designed to carry.

The total weight of engine 3853 is 397,600 pounds, distributed as follows: pony truck, 33,300 pounds; first pair of drivers, 59,800 pounds; second pair of drivers, 61,800 pounds; third pair of drivers, 64,800 pounds; fourth pair of drivers, 63,600 pounds; fifth pair of drivers, 61,500 pounds; trailing truck, 52,800 pounds. The tender is rectangular and has two six-wheel trucks, its capacity is 5,000 gallons of oil and 15,000 gallons of water. The weight of the tender is 293,600 pounds. The drivers are 63 inches in diameter and the driving-wheel base is 22 feet long; the total wheel base of engine and tender is 85 feet 2-1/2 inches.

The total weight of engine 3704 is 551,700 pounds, distributed as follows: engine truck 58,100 pounds, drivers, 243,100 pounds, trailing truck, 50,500 pounds. The tender is rectangular and has two six-wheel trucks; its capacity is 4,000 gallons of oil and 12,000 gallons of water. The weight of the tender loaded is 242,000 pounds. The drivers are 69 inches in diameter and the driving-wheel base is 18 feet; the total wheel base of engine and tender is 76 feet 8-5/8 inches.

According to the data furnished by the carrier, the condition of the wheels and flanges on engine 3853 was as follows:

Spacing	Truck wheels	Driving-wheel tires					Trailer
		No.1 -	No.2 -	No. 3 -	No. 4	No.5	
Back-to-back (inches)	53-1/4	53	53-1/4	53	53-1/4	53	53-1/4
Flange (R)	1/16	3/16	-	-	-	-	-
Wear (L)	1/16	1/4	-	-	-	-	-

At 7 p. m., July 26, the company's engine inspector at Williams, Ariz., made a notation on a work report to the effect that the left No. 1 driving-wheel flange of engine 3853 took the 1-inch gage.

According to templates of the broken rail submitted, the ball on the gage side was curve-worn between 5/32 and 17/64 inch; the ball from the bottom to the top on the gage side was worn to an inclined plane of 12 degrees, sloping outward.

Observations of the Commission's Inspectors

The Commission's inspectors found that the track was torn up and disturbed a distance which extended between points 100 feet north and 250 feet south of the broken section of rail. There was an absence of wheel marks across the ties, which indicated that as the engines were toppling to the right the left wheels were suspended above the track.

Discussion

There was no indication of either defective or dragging equipment, or any obstruction on the rails which might have contributed to the accident. The gage of the track on the 10°04' curve varied between 4 feet 9-1/2 inches and 4 feet 9-1/8 inches. Between stations 70 and 80 feet north of the point where the track was destroyed, there was a variation of 3/8 inch in the gage; between two other adjacent stations, the variation was 1/4 inch. The greatest variation in superelevation between any two 10-foot adjacent stations was 5/8 inch; this variation was between 70 and 80 feet north of the point where the track was destroyed. The gage side of the high rail was curve worn to an extent which varied between 5/32 and 17/64 inch. Nine hours prior to the accident the section foreman had found, on the inside of the high rails of the curve, about 30 spikes loose and drawn to a height which varied between 1/2 and 2 inches, as a result of vibration. Although the speed restriction on the curve involved was 20 miles per hour, the equilibrium speed was 25 miles per hour, and the maximum safe speed was 37 miles per hour, according to the standards prescribed by this railroad for the curvature and elevation.

The brakes had been tested and they functioned properly en route. All members of the crew were agreed that the speed was neither unusual nor excessive. No member of the crew estimated the speed of the train at the time of the accident to be in excess of 25 miles per hour. The brakes had been applied for some distance, and were still applied at the time the accident occurred. The engineman of the first engine said that just prior to the derailment his engine swayed badly from side to side, and then dropped down at the rear. The fireman of the first engine also was of the opinion that the rear end was the

first to be derailed. The fireman of the second engine saw fire flying in a horizontal plane from the left driving wheels of the first engine as though they were scraping the inside of the left rails.

Tests of the broken rail demonstrated conclusively that it possessed good physical and chemical properties, and that it was first overturned and then became broken as a result of a transverse load which it was not designed to carry.

Inspection of engine 3853 disclosed that the driving wheel flanges were worn vertically to the extent of 1/4 inch on the left wheels and 3/16 inch on the right wheels.

Since the equilibrium speed for the curve was 25 miles per hour, it follows that if a train entered the curve at a higher or lower speed than 25 miles per hour there would be a tendency for the flanges to bear against the gage side of either the high or the low rail, respectively, which, no doubt, would cause a nosing, or oscillating, action of the engine in a lateral direction; the middle pair of drivers would be used as a fulcrum and the action would reverse itself from front to rear and be confined laterally by the gage of the track. The brakes, being applied, would cause the wheel base to assume a greater rigidity, which would add to the nosing or swaying action described by the engineman. The combination of open gage and flange wear would permit of more lateral sway than usual. A vertical flange contacting the inclined plane of the curve-worn rail, because of reduced frictional resistance, would have a tendency to climb the gage side of the rail. In the case in question, while there is no indication that any one factor was outside the bounds of safety, it appears that a combination of curve-worn rail, flange wear, wide gage, loose spikes, and the brakes remaining applied on the engine caused the engine to sway, following which at least one left driving wheel dropped inside the left rail and the right wheel flanges climbed the right rail to a point where the weight and the lateral force, applied at an angle, overturned the right rail outward. The flange then ran in the web of the rail, which resulted in its fracture.

Conclusion

It is believed this accident was caused by a combination of wide gage, curve-worn rail, loose spikes, worn flanges, and driving-wheel brakes remaining applied on a curve, which resulted in a wheel on the low side dropping inside the low rail and the high rail becoming overturned.

Respectfully submitted,

S. N. MILLS,

Director.