INTERSTATE COMMERCE COMMISSION

WASHINGTON

REPORT OF THE DIRECTOR

BUREAU OF SAFETY

ACCIDENT ON THE

CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC RAILROAD

SAUGUS, MONT.

JUNE 19, 1938.

INVESTIGATION NO. 2278

SUMMARY

Inv-2278

Railroad:	Chicago, Milwaukee, St. Paul & Pacific
Date:	June 19, 1938
Location:	Saugus, Mont.
Kind of accident:	Derailment
Train involved:	Passenger
Train number:	No. 15
Engine number:	220
Consist:	11 cars
Speed:	51 m.p.h.
Operation:	Timetable, train orders and manual block-signal system
Track:	Single; tangent; 0.43 percent grade ascending westward
Weather:	Cloudy
Time:	12:35 a.m.
Casualties:	47 killed; 75 injured
Cause:	Bridge piers undermined by high water resulting from cloudburst

Inv-2278

August 9, 1938.

To the Commission:

On June 19, 1938, there was a derailment of a passenger train on the Chicago, Milwaukee, St. Paul & Pacific Railroad, near Saugus, Mont., which resulted in the death of 41 passengers, 2 persons carried under contract, and 4 employees on duty, and the injury of 56 passengers, 1 person carried under contract, 13 employees on duty and 5 employees off duty. The investigation of this accident was made in conjunction with a representative of the Board of Railroad Commissioners of the State of Montana.

Location and method of operation

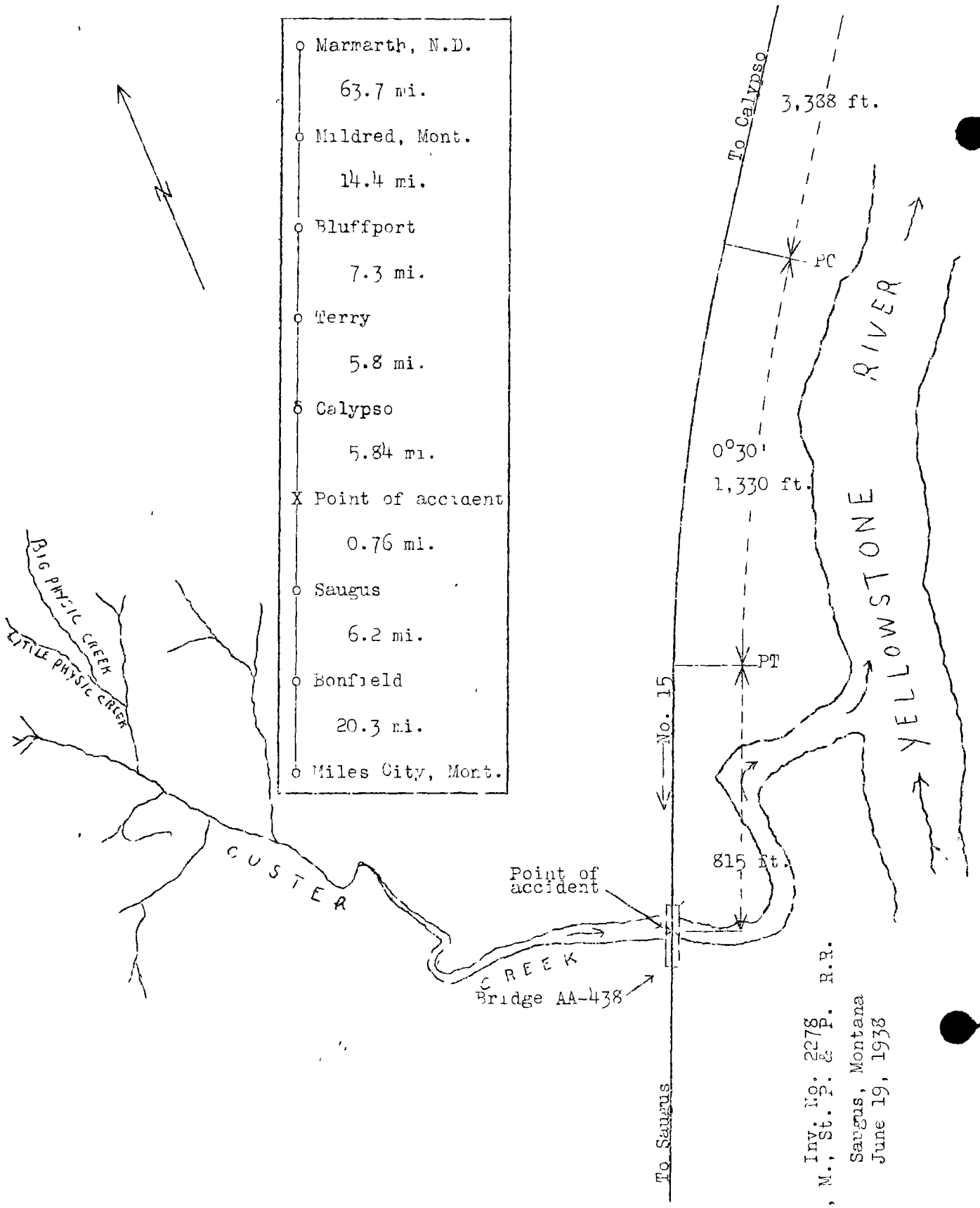
This accident occurred on that part of the Trans-Missouri Division designated as the Marmarth to Miles City Subdivision which extends between Marmarth, N. Dak., and Miles City, Mont., a distance of 124.3 miles. This is a single-track line over which trains are operated by timetable, train orders and a manual block-signal system. The derailment occurred on Bridge AA-438 which spans Custer Creek at a point 4,022 feet east of the station at Saugus; normally this is a dry stream bed for about 9 months of the year and at other times the depth of water in the stream does not exceed 3 or 4 feet. Approaching this bridge from the east the track is tangent for 3,388 feet, followed by a 0°30' curve to the left 1,330 feet long and then tangent track for a distance of 815 feet to the middle of the bridge and for some distance beyond. From a point 2,000 feet east of the bridge the grade is ascending westward, ranging from 0.25 percent to 0.64 percent, and is 0.43 percent at the point of accident.

The track is laid with 90-pound rail, 33 feet in length, on 20 oil-treated fir ties to the rail length; it is single spiked, fully tieplated, ballasted with gravel 2.2 feet deep, and is well maintained.

In the vicinity of the point of accident the maximum authorized speed for passenger trains is 65 miles per hour.

Rule 1118 of the transportation rules for the government of section foremen reads as follows:

> Whenever violent rain or wind storms, or a sudden rise in streams occur, carefully examine condition of the track, bridges and culverts, and if unsafe, protect as prescribed in rule 1115, reporting to the chief dispatcher at first station.



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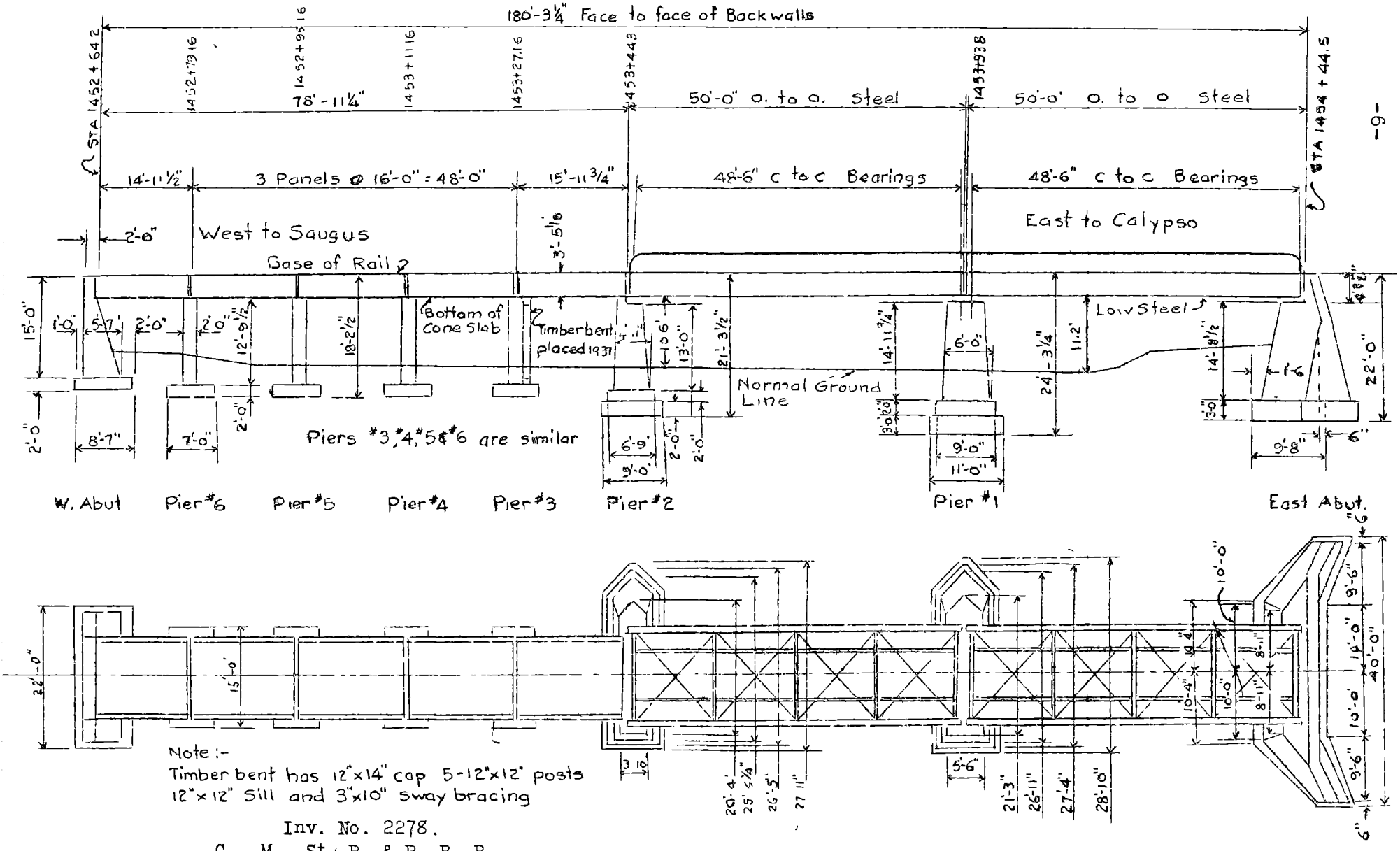
Bridge AA-438, constructed in 1913-14 to replace a pile and timber trestle which was originally built at this location in 1907, was a single-track steel and reinforced-concrete structure having an approximate length of 180 feet. The structure was supported by two abutments and six intermediate piers. East to west, it consisted of two 50-foot through-plate girder spans and five reinforced concrete trestle-slab spans, each of the latter measuring approximately 16 feet in length. The steel girders rested on the east abutment and piers 1 and 2, while the concrete-slab spans rested on piers 2 to 6 and the west abutment. The girders were constructed of 72-inch by 3/8-inch web plates with full length 14-inch by ½-inch top and bottom cover plates, each reinforced by an additional 14-inch by ½-inch cover plate, 28 feet 8 inches in length. Flange angles were 6-inch by 6-inch by ½-inch "L" sections and stiffener angles were provided at approximately 4-foot intervals. The girders rested on abutment and pier bedplates, having 48 feet 6 inch center-to-center bearing.

The floor beams consisted of two end cross-frames and three intermediate beams to each steel span, spaced 11 feet 11 inches apart. They were constructed of 36-inch by 3/8-inch web plate with two 6-inch by 4-inch by 9/16-inch angles at top and bottom. The stringers were centered 7 feet 6 inches apart and constructed of 21½-inch by ½-inch web plate with two 6-inch by 6-inch by ½-inch angles at top and bottom. The lateral angles were of 3½-inch by 3½-inch by 3/8-inch material riveted to lateral plates at intersections and on the stringers and girders. The ties were 8-inch by 12-inch by 10-feet, laid on edge 12 inches center to center. The outer guard rails on the steel spans were of wood, laid 1 foot 5¼-inches from the rail while the inner guard rails were constructed of steel angles backed by timber and were located 10 inches inside of each rail.

Each of the concrete spans consisted of two pre-cast concrete slabs laid parallel, longitudinally of the span, with 15-foot center-to-center bearing. The slabs were 15 feet 11½ inches long by 6 feet 5½ inches wide, and 2 feet 2 inches thick where they abutted at the center line of the track, the thickness diminishing toward the outer edge for drainage purposes to a minimum of 1 foot 11 inches. They were heavily reinforced for tension, compression, and shearing stresses, and the outer edge of each slab had a 1 foot 3 inch parapet. The guard rails on the concrete spans were constructed of 60-pound rail. Both the steel and the concrete spans were designed for Cooper's E-55 loading, with a safety factor in excess of three.

The east abutment was of the wing type, constructed of monolithic concrete with reinforced backwall. The footing extended 11 feet below the ground line and measured 20 feet 8 inches long, 9 feet 8 inches wide and 3 feet thick, with wings extending 10 feet 2 inches on each side. The neatwork was 20 feet long by 7



Note :-
Timber bent has 12"x14" cap 5-12"x12" posts 12"x12" Sill and 3"x10" sway bracing

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feet 6 inches wide at the bottom, 14 feet 8½ inches high, and 17 feet long by 5 feet 2 inches wide at the shelf. The abutment contained approximately 98 cubic yards of concrete with an average bearing on soil of 1.5 tons per square foot and a maximum of 3 tons per square foot.

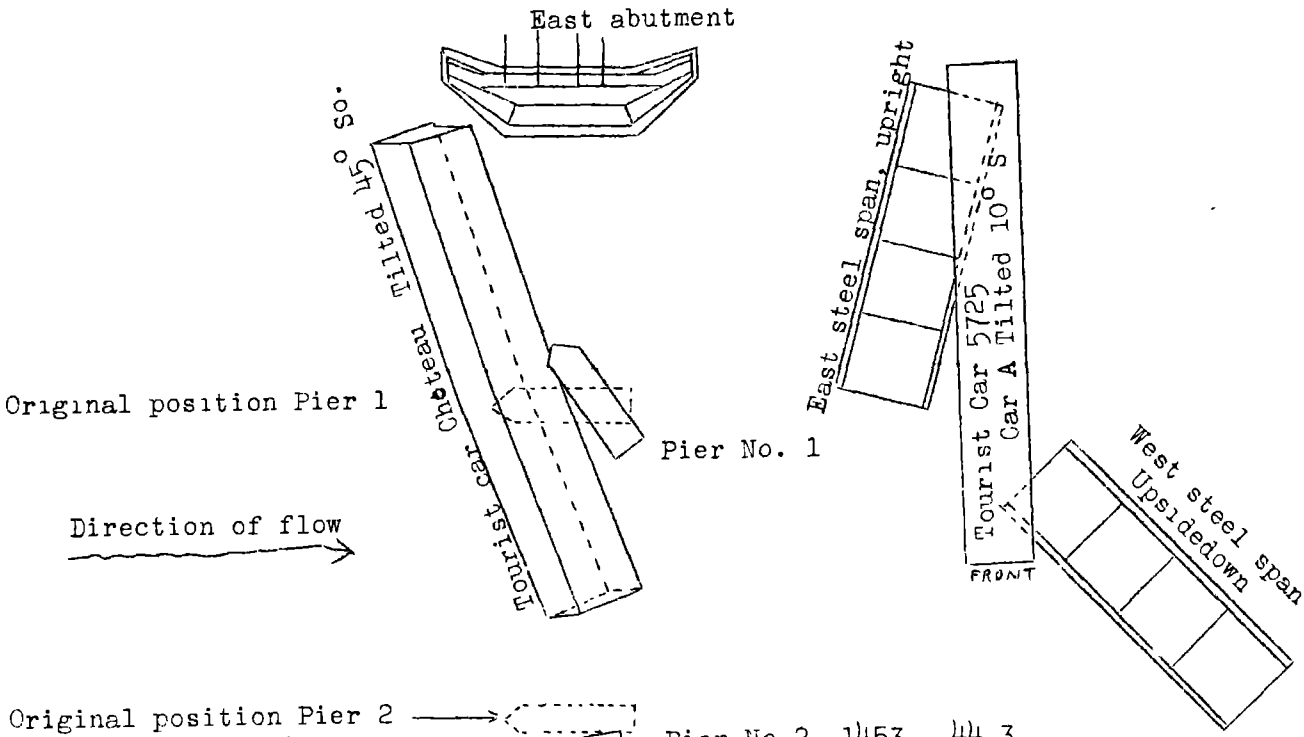
Piers 1 and 2 were of the pyramid type, constructed of monolithic concrete.

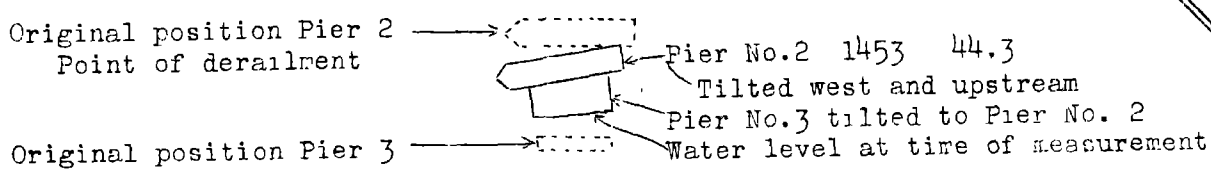
The footing of pier 1 extended 9½ feet below the ground line and consisted of a base 28 feet 10 inches long, 11 feet wide and 3 feet thick, upon which was a setback 27 feet 4 inches long, 8½ feet wide and 2 feet thick; the neatwork was 15 feet high and measured approximately 26 feet 10 inches long, 6 feet 9 inches wide at the bottom and 21 feet 3 inches overall length at the top by 5 feet 6 inches in width. This pier contained approximately 92 cubic yards of concrete and the bearing on soil was similar to that of the east abutment.

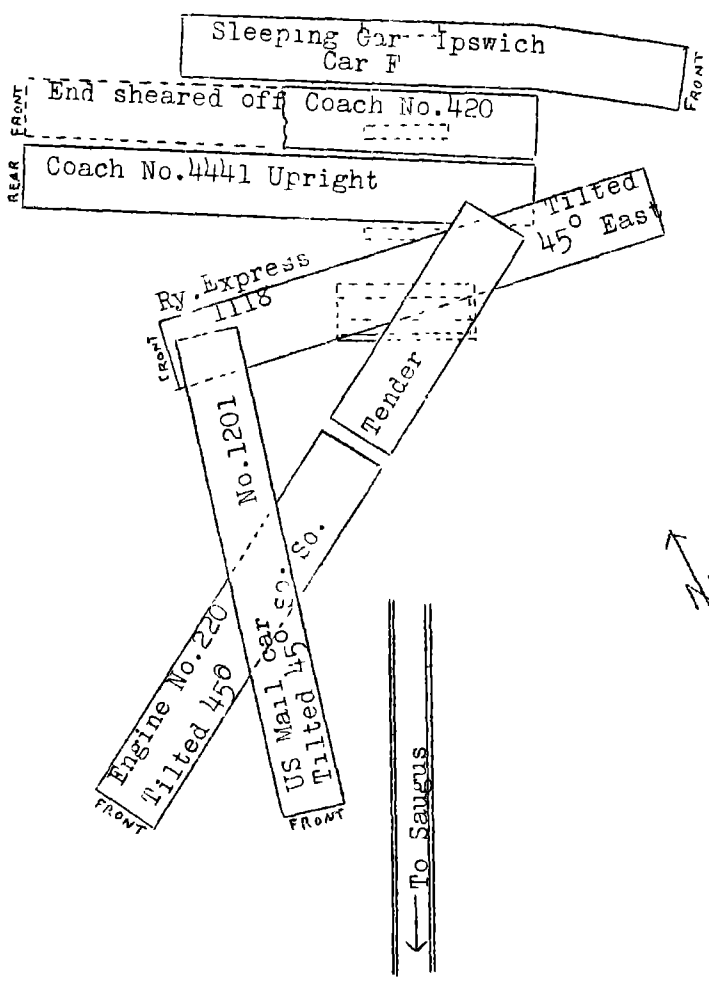
The footing of pier 2 extended 7 feet below the ground line and consisted of a base 27 feet 11 inches long, 9 feet wide and 2 feet thick upon which was a setback 26 feet 5 inches long, 6 feet 9 inches wide and 2 feet thick; the neatwork extended 13 feet above the setback to a shelf with a backwall 10 inches high and 1 foot thick. This shelf supported the girder bedplates and the backwall supported the concrete slabs. The top of the pier had an over-all dimension of 20 feet 4 inches by 3 feet 10 inches. This pier contained approximately 68 cubic yards of concrete and the bearing on soil averaged 1.5 tons per square foot with a maximum of 2.75 tons per square foot.

The upstream ends of both piers 1 and 2 were blunt-nose 90° angles with a batter of 4 inches to the foot, equipped with three nose bars. The neatwork of each had a face batter of ½ inch per foot and a downstream-end batter of 1 inch per foot.

The dimensions and construction of piers 3, 4, 5 and 6 were similar, with footings 15 feet long, 7 feet wide and 2 feet thick extending 4½ feet below the ground line, reinforced longitudinally and transversely. The neatwork was without batter and measured 12 feet by 2 feet, extending 12 feet 9 inches in height, reinforced vertically and horizontally. Each pier contained approximately 19 cubic yards of concrete and had an average bearing on soil of 1.5 tons per square foot and a maximum of 2.75 tons per square foot. In 1937 a wooden bent was erected on the east shelf of the footing of pier 3; this bent was constructed of five 12 inch by 12 inch posts, a 12 inch by 14 inch cap, a 12 inch by 12 inch sill and 3 inch by 10 inch sway braces.







Pier No.4, sheared off

Pier No.5, sheared off

Pier No.6, sheared off

West abutment,
sheared off

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The footing of the west abutment was of reinforced concrete extending 5½ feet below the ground line and measured 22 feet long, 8 feet 7 inches wide and 2 feet thick; the neatwork was of monolithic concrete, 15 feet in height, 21 feet by 5 feet 7 inches at the bottom and 21 feet by 2 feet at the top; a notch 13 feet 1 inch long and 3 feet 5½ inches deep was cut equidistant through the top surface. The batter of the front face was 3¾ inches per foot while the back face was perpendicular. Approximately 49 cubic yards of concrete were used in this abutment and the bearing on soil was similar to that of piers 3, 4, 5 and 6.

The piers and abutments were set on gravel and the unobstructed water opening at the time of construction was estimated at 1,585 square feet. The east abutment and piers 1, 2 and 3 were rip-rapped when the bridge was built and in 1935 about 100 yards of rip-rapping were placed at each of piers 1 and 2 and about 50 yards were placed at each of piers 3 to 5 inclusive.

The watershed drained by Custer Creek contains about 160 square miles, extending an approximate distance of 22 miles north of the track and being about 10 miles wide at some points. The creek empties into the Yellowstone River 2,500 feet south of Bridge AA-438.

Locomotive 220, involved in this accident, was of the 4-8-4 type with the weight distributed as follows:

Engine truck	87,800	pounds
Drivers	282,320	"
Trailer truck	120,330	"
Total	490,450	" in service order.

Total weight of tender equipped for service .. 397,000 pounds.

The drivers are spaced 6 feet 5 inches apart; the center of the engine truck is 12 feet 2 inches from the center of the first driving wheel, and the center of the trailing truck is 11 feet 4 inches from the center of the rear driving wheel. The tender trucks are centered 22 feet apart, and the center of the front tender-truck is 23 feet 10½ inches from the center of the engine trailer-truck.

The weather was calm and cloudy at the time of the accident, which occurred at 12:35 a.m.

Description

No. 15, a west-bound passenger train, consisted of one mail and express car, one baggage car, two coaches, three tourist sleeping cars, one dining car, two sleeping cars and one observation car, in the order named, of all-steel construction, hauled

by engine 220, and was in charge of Conductor McGee and Engineman Merrifield. At Marmarth, 97.8 miles east of Saugus, the crew received Form 19 order No. 51, reading:

> Heavy rains reported from Bluffport to Bonfield Section men patrolling track.

Bluffport is approximately 20 miles east and Bonfield about 6 miles west of Saugus.

At Mildred, Mont., 34.1 miles east of Saugus, the crew received Form 19 order No. 395 reading:

> Do not exceed 20 miles per hour between switches at Calypso account of soft track.

Calypso is 6.6 miles east of Saugus.

Train No. 15 left Marmarth at 10:14 p.m., according to the train sheet, 19 minutes late; left Mildred at 11:47 p.m., 20 minutes late, and was derailed on Bridge AA-438 while traveling at a speed of 51 miles per hour, according to the speed-recorder tape on the locomotive.

The engine stopped on the north side of the track with its head end 76 feet west of the west abutment, headed northwest and tilted at an angle of about 45°; a rail had been driven into the front end of the engine. The tender was upright and in line with the engine. The first car stopped almost upright, diagonally across the top of the engine, and at an angle of about 15° to the track. The second car stopped in an upright position across the engine tender and at an angle of about 70° to the track. The next three cars stopped in the stream bed, close against the west abutment and directly across the right-of-way. The sixth car stopped in the stream bed almost parallel with the track, with its south side against the north end of pier 1 which had been displaced and turned out of normal position. The seventh car was upright in the stream bed, about 70 feet south of the bridge.

The east abutment of the bridge was practically undamaged. Pier 1 stood at a 45° angle to its normal position; piers 2 and 3 were tipped together, midway between their normal positions; piers 4, 5 and 6, and the west abutment were sheared off. The two girder-spans were in the stream bed about 50 feet south of the bridge.

The employees killed were the engineman, the fireman, the baggageman, and a train porter; the employees on duty who were injured were the assistant superintendent of dining cars, the conductor, the brakeman, a chef, two cooks, two porters, and five waiters.

Summary of evidence

Conductor McGee stated that a running brake-test was made at Marmarth and the brakes functioned properly at that time, as well as at other points en route. Leaving Marmarth they had an order advising of heavy rain between Bluffport and Bonfield and stating that sectionmen were patrolling the track. At Mildred they received an order not to exceed 20 miles per hour between switches at Calypso, and while at Mildred he noticed that the headlight was burning. The first intimation he had of the accident was at 12:35 a.m., when he was in the fifth car; there was a heavy crash followed by a rush of water which roared so that it was almost impossible to hear the human voice. There was no application of the brakes just prior to the occurrence of the accident. He could not recall ever having received a slow order covering movement over Bridge AA-438.

Brakeman Reece stated that he made a test of the air brakes on the cars at Marmarth. He estimated the speed at the time of the accident at about 45 miles per hour and did not observe anything unusual in the riding of the train previous to the accident. He estimated that at the time of the accident there was about 20 feet of water in the main channel of Custer Creek; he could not recall having previously seen more than 2 or 3 feet of water in the creek.

Flagman Preston stated that immediately after the occurrence of the accident he went back to flag; on the way back he observed that there were no marks to indicate that derailment had taken place prior to arrival at the bridge. He returned to the train in about 45 minutes, and at that time there was a great deal of water in the creek and it was roaring so that a person had to shout in order to be heard. He had never seen more than 2 or 3 feet of water in the stream, and then only in the spring season. At the time of the accident it was dark and cloudy but no rain was falling. He estimated the speed to have been between 40 and 50 miles per hour at the time of the accident.

Fuel Supervisor Griffith, who was a passenger on No. 15 at the time of the accident, stated that immediately after the occurrence of the accident the sixth and seventh cars in the train were standing on the girders of the bridge, but after a short time the rear end of the sixth car and the head end of the seventh car fell into the water. A little later the sixth car dropped down into the water and after another short interval the seventh car also broke away. The water was coming down stream in waves, and was up to the bottom of the girders. There was no application of the brakes immediately prior to the derailment. He estimated that an engineman on an S-2 engine could see 700 to 800 feet ahead by the light of the headlight.

Engineman Davis of No. 263, the last train to move over Bridge AA-438 prior to the accident, stated that his train passed over the bridge at about 10:15 p.m. at a speed of between 30 and 35 miles per hour; at that time there was nothing noticeably wrong with it. Water in the channel was about 3 or 4 feet deep. He had encountered a heavy rain at Terry, 12 miles east of Saugus, but none west of that place, and the track was not out of line at any point.

The statements of Conductor James, Brakemen Morris and Lynam, and Fireman Cox, of No. 263, corroborated that of Engineman Davis regarding bridge, track, and water conditions in the vicinity of Saugus.

Dispatcher Hagerty, on duty at Miles City from 4 p.m. to midnight on June 18, stated that at about 7:50 p.m. he received advice from the section foreman at Calypso of a heavy rain at that point. The foreman asked for a line-up in order to patrol his section and it was given him. At about 8:30 p.m. Dispatcher Hagerty instructed this foreman to patrol the track west of Calypso, and at 10:55 the section foreman reported that heavy rain at Calypso had washed some ties into a culvert and that there was considerable water on the track and advised that a slow order be issued covering the track between switches at Calypso, which was done. About 9:45 p.m. the dispatcher received information regarding rains at Terry, Calypso, and Mildred, and as a matter of precaution he issued an order covering the territory between Bluffport and Bonfield. He received no other information regarding the condition of track or structures. He stated that when a condition which requires patrolling becomes known to the dispatcher, it is his duty to call the section foreman in charge of the section on which the trouble exists, but in this instance the foreman had gone out on his own initiative. Dispatcher Hagerty stated that he had never issued an order regarding Bridge AA-438 since he became a dispatcher on the Miles City-Marmarth district in 1928.

Dispatcher Grogan, on duty at Miles City at the time of the accident, stated that when he went on duty Dispatcher Hagerty advised him of conditions at Calypso. This was the only information he received regarding water conditions until the accident was reported. He could not recall any prior difficulty involving Bridge AA-438.

Master Mechanic Riccius stated that he removed the speed-recorder tape from engine 220 after the accident. The tape showed a speed of about 51 miles per hour at the time of the accident.

Section Foreman Goplen stated that he lives at Calypso, and his section extends from Milepost 1085, just east of Calypso, to Milepost 1095, just west of Saugus, and includes Bridge AA-438. He has a force of two men. At about 6:30 p.m. it started to rain at Calypso and the rain continued until about 8:15 p.m. Immediately after it stopped he took one of his men on a motor car and patrolled the track to a point about 1 mile beyond the west limit of his section. On the return trip he met No. 263 at Saugus at about 10:05 p.m., and he passed over Bridge AA-438 at about 10:20 p.m. He made an inspection of this bridge from the east abutment and noted that the water in the stream was about 6 or 7 feet below the girders at that time; this condition did not suggest any possibility of trouble. He continued eastward to Calypso where he found water over the track and notified the dispatcher of that condition. After he learned of the accident he went to Bridge AA-438, arriving there about 4:15 a.m. At that time water was about 2 feet below the girders. He examined the track and also part of the bridge deck, but found no marks to indicate that any part of the train had been derailed, or that any of the equipment was dragging prior to movement upon the bridge.

Section Laborer Eastwood, who accompanied Section Foreman Goplen while patrolling the section, corroborated the statement of the section foreman and added that they did not go down under the bridge at the time but the water around the piers could be seen from where they made their inspection and there was no evidence of washing around them.

Section Foreman Shear stated that from 1928 to 1937 he was in charge of the section in which Bridge AA-438 is located, and during that time the greatest depth of water in the creek occurred in 1935 when it was about 5 feet deep. At that time no damage was done to the bridge structure, nor was there any evidence of scouring.

Roadmaster Fuller stated that he passed over Bridge AA-438 in the caboose of a freight train on June 16. At that time there was no water in the stream bed and the rip-rap around the piers was visible and apparently in good shape. After the accident he inspected the tracks east of the bridge, and also part of the bridge deck, and found no marks to indicate that derailment had occurred prior to movement upon the bridge, or that any part of the equipment had been dragging.

Division Engineer Ring stated that prior to 1935 there was no need for rip-rap at Bridge AA-438, but in that year more protection to some of the piers appeared desirable. Consequently, 100 yards of rip-rap were placed around each of piers 1 and 2, and 50 yards around each of piers 3, 4, and 5. This rip-rap was rough stone in sizes ranging from derrick rock to one-man rock.

It was placed by hand and set as smoothly as possible, and, in his opinion, should have fully protected the piers from scouring or washing. He thought that the undermining of piers 2 and 3 resulted when some obstruction brought down by the flood created currents causing a scouring action of the water. After the flood subsided the rip-rap was badly scattered and covered with silt.

Bridge Foreman Shore stated that in 1937 he erected a frame bent in Bridge AA-438 just east of pier 3. At that time there was very little spalling apparent in the concrete of this pier and in his opinion the wooden bent was unnecessary. In erecting this member the bottom sill was placed on the footing of pier 3; this footing was flat and rough. The top of the bent was jacked in tightly and the rip-rap replaced at the bottom of the pier.

Instrumentman Glosup stated that he made an inspection trip early in 1938, during which he inspected Bridge AA-438. The stream bed was dry at the time and the rip-rapping seemed sufficient and properly placed. There was no evidence of scouring around any pier. The wooden bent at pier 3, which in his opinion was not necessary, was secure and in good condition.

Division Engineer Johnson stated that he was a member of an inspection party which made a complete inspection of Bridge AA-438 in June, 1937. The rip-rapping was found to be adequate and in good condition. The frame bent at pier 3 had not been erected at that time but as it was listed on the work sheet he gave particular attention to the condition of that pier. Although there was a slight spalling at the top of the pier on the east side and at the end of the slab, he concluded that the reinforcing bent was not necessary for the safety of the bridge and it was not treated as emergency construction but was taken care of in the course of regular work. After the accident the frame bent was gone, and some of the rip-rapping was one-fourth mile south of the bridge. He stated that he is authorized to spend any money that is necessary to correct unsafe conditions as they become apparent. It was his opinion that the accident was caused by the undermining of the north side of pier 2 and the east side of pier 3.

Assistant Chief Engineer Middleton stated that at the time Bridge AA-438 was built the drainage area of Custer Creek was estimated to be about 208 square miles. This area is approximately 22 miles long and 10 miles wide, but a map recently secured from the County surveyor shows the drainage area actually to be about 160 square miles. Such information as was available at the time of construction indicated that the high water mark was about 8½ feet below the elevation where the low steel of the structure was placed. At that time the lowest point in the bed of the stream was about 11½ feet beneath the low steel. The report covering a survey made in 1913, to assist the chief engineer in deciding upon

the type of structure to be erected, did not indicate that test pits had been dug, but it did state that there was a gravel foundation supporting some gumbo. The engineer who made the survey had been working in that territory for several years and was quite familiar with it. He was also in charge of the construction of the bridge and his construction report shows that the piers and abutments rested upon gravel, and that rip-rapping was placed around the face of the east abutment and around piers 1, 2 and 3. At the time of erection the bridge conformed to specifications of the American Railway Engineering Association for Cooper's E-55 loading; however, since that time the design of steel structures has been changed in minor details and the rating of the component parts of the girder spans now varies from the low of Cooper's E-79 to a high of Cooper's E-122 based upon the A. R. E. A. rules of 1936 for rating existing structures. The reinforced-concrete slabs rate as Cooper's E-67 under A. R. E. A. design specifications of 1935, whereas the S-2 engines are equivalent to Cooper's E-61 locomotives. The factor of safety is in excess of 3 for the structure and in excess of 2 for the piers. When the purchase of these new locomotives was under consideration it was necessary to determine whether the structures on each division were safe to handle them. Extensive alterations were necessary on some divisions but the check-up did not indicate necessity for strengthening the bridge involved in this accident. Engineer Middleton stated that the spalling of the concrete of pier 3 was not sufficient to require the erection of the wooden bent. This bent was adequately secured to the structure by being wedged under the slab so as to support some of the weight. In his opinion the bridge was adequate as to design and was structurally safe; there was no overloading or overstressing. The trouble was caused by rainfall of cloudburst proportions, much in excess of any that had been experienced before or might be anticipated at this place, the water reaching the bridge in such volume and with such velocity as to scour the rip-rapping to the bottom of the footing, causing piers 2 and 3 to settle. He thought that when the locomotive reached the structure the bridge was still intact although the upstream noses of piers 2 and 3 were undermined. When the weight of the locomotive reached pier 2 the locomotive was tipped to the right. The slabs in spans 3 and 4 collapsed as pier 3 tipped, and the locomotive struck the north slab of span 5 between the locomotive boiler and the cylinder. Lower portions of the locomotive struck and destroyed piers 4, 5 and 6 and the west abutment. The rail which had penetrated the front end of the engine was of the guard-rail type. After the accident he made an inspection of the upper reaches of the watershed of Custer Creek. He found that water in the creek had been flowing greatly in excess of normal depth and had been overflowing its banks. He estimated that in some places the water had been 12 feet deep and 3 feet above its banks. There were indications that the velocity of the water was sufficient to carry a considerable amount of silt.

There are curves in the stream in the vicinity of the railroad and at some of these curves the high water mark on the outside of the curve is between 1 and 2 feet higher than on the inside of the curve. The information which he gathered during this inspection confirmed his opinion that an unprecedented amount of water had produced a condition at the bridge such as had never occurred there before. As a result of the scouring of the stream bed, pier 1 settled 1½ feet at one end, pier 2 settled almost 5 feet, and pier 3 about 4.85 feet. To his knowledge, there had never been any case where money was not provided to take care of any work that was considered necessary for safety.

Claims Adjuster Sleavin stated that on June 20 he followed Custer Creek upstream for 8 miles, exploring the higher ground in that area, and he was convinced that there had been no run-off from the slopes into the creek for at least 8 miles north of the railroad. On June 21 he explored the headwaters of Custer Creek and its various tributaries, passing through several watersheds lying south of Custer Creek watershed and crossing the heads of various creeks; he found that on June 18 a Government dam had been washed out near the head of Mustard Creek, which lies about 8 miles west of Custer Creek and also that at the same time a dam about 16 feet high had been washed out on Physic Creek which flows into Custer Creek and was located about 9 miles east and 3 miles north of the Government dam. The limits of the cloudburst appeared to include practically all of the north portion of Custer Creek watershed; water marks visible on trees and the surface of the ground indicated that the water of the streams had been flowing with great rapidity and very high, ignoring natural channels. Large areas of the top sod had fallen after the water subsided, indicating heavy cutting of channel banks. One gulch bore evidence of being badly washed and a new head started within approximately 200 feet of the top of a hill, indicating that there had been a terrific wash of water off the top of the hill and within that 200 foot area.

Several residents who had lived within the watershed of Custer Creek the past 25 or 30 years stated that the storm of June 18 was the most severe of any in that vicinity during those years. Frank Hamlick, residing about 19 miles northwest of the point of accident stated that at about 4:30 or 4:45 p.m. a heavy rain began to fall which lasted until 6:15 p.m. About 8:45 p.m. another heavy rain commenced. He said that there was the most unusual movement of clouds in the distance that he had ever observed, appearing to be a cyclone. At about 9 p.m. a cloudburst struck in the vicinity of his ranch. The downpour lasted about 15 or 20 minutes after which it rained moderately for about 10 minutes. The following morning he found that about 6 inches of water had accumulated in a sprinkling can; this can was 10 inches in diameter and 11 inches deep with one-half of the top permanently covered with tin. This sprinkling can was empty when he

finished using it just previous to the first storm. He stated that he considered this to be the worst cloudburst occurring in that vicinity during his 33 years of residence there.

Henry Haughian, a rancher who had spent his entire life within the Custer Creek watershed, stated that on June 18 he was about 13 miles northwest of Bridge AA-438. At about 5 p.m. there was a fall of rain with considerable hail. This storm resulted in some wash of sagebrush and trees into the creek. After this storm he inspected a 16-foot dam constructed across a tributary of Custer Creek and found the creek above it filled with water. Another heavy shower broke between 8:30 and 9 p.m. after which he again inspected the dam and found one end washed away, emptying the impounded water into the creek. Within about 15 minutes a third storm, which was a cloudburst, occurred and rain continued for a considerable length of time. All water holes and the various tributaries of Custer Creek in the vicinity were filled by the first storm and in the second and third storms the run-off was very rapid. The following morning he covered several miles of the watershed and saw evidence that creeks and coulees had contained the highest water in his memory.

Another rancher told of becoming marooned and having to spend the night on the bank of a creek, emptying into Custer Creek, due to a highway bridge being washed away; this was about 15 miles northwest of the point of accident.

Discussion

Custer Creek, the stream spanned by Bridge AA-438, is a small stream about 25 miles in length which flows into the Yellowstone River about 2,500 feet south of the railroad; it drains an area of about 160 square miles and is practically dry about nine months of the year. Bridge AA-438 had been in service for more than 24 years, and no trouble due to high water had been experienced at this point prior to the time of the accident. None of the employees interrogated had previously seen more than 3 to 5 feet of water at this bridge and it had never been necessary to issue train orders warning trains of high water at this point.

The investigation disclosed that between the hours of 4 p.m. and 10 p.m. on June 18, three heavy rains, one of cloudburst proportions, occurred in the Custer Creek watershed in an area several miles distant from the railroad. As a result of these storms the water in Custer Creek and its tributaries was the highest it had been in the past 25 or 30 years. The run-off was rapid and was enhanced by impounded water in reservoirs being released when dams were washed out. The current in Custer Creek was very swift, as indicated at bends in the channel where the high-water mark on the outside was as much as 2 feet higher than

on the inside, and further by the fact that pieces of rip-rap weighing hundreds of pounds were dislodged from their locations around piers 1, 2 and 3 and taken a considerable distance down the stream.

Prior to the accident a train order had been issued containing the information that heavy rains were reported and section men were patrolling the track for a considerable distance on either side of Bridge AA-438.

When No. 263 crossed the bridge at 10:15 p.m. the water was about 3 or 4 feet deep and the crew of that train found the bridge to be in normal alinement and surface. When trackmen inspected the bridge about 20 minutes later the water was about 6 or 7 feet below the girders. When No. 15 reached the bridge at 12:35 a.m. water in the channel was about 20 feet deep.

Since the engineman and fireman of No. 15 were killed in the accident there is no direct evidence as to the alinement and surface of the bridge when No. 15 entered upon it; however, the train was running at normal speed, so far as known the headlight was in proper condition, no brake application was made while the engine traveled the distance of 700 to 800 feet in which the engine crew could see the bridge, and there is no doubt, therefore, that the bridge appeared normal in alinement and surface as the train approached it. The derailment was toward the upstream side of the bridge and apparently occurred at pier 2. From the evidence it appears that the upstream ends of the footings under piers 2 and 3 were undermined due to the scouring action of the rapid current and the track under the weight of the train inclined toward the upstream side sufficiently to derail the train; displacement of the piers and the momentum of the train resulted in the destruction of the bridge. After the accident pier 1 was turned about 45° from normal position; in addition, pier 1 settled 1½ feet at one end of its footing, and piers 2 and 3 settled almost 5 feet. Piers 1, 2 and 3 were either in or near the normal channel. The rip-rap was scoured away from these piers. From the position of piers 2 and 3 it is evident that there was considerable scouring along the adjacent sides of the footings; however, the positions of the derailed cars in the stream bed may have contributed materially to this scouring action after the accident occurred. Since none of the water passed back of either abutment and did not go above the lowest part of the through-girder spans, it is apparent that the opening under the bridge was sufficient for even the abnormal volume of water at this time.

The testimony was to the effect that the bridge conformed to specifications of the American Railway Engineering Association. Under the present method of rating structures the component parts of the girder-spans vary from a low of Cooper's E-79 to a high of

Cooper's E-122, and the reinforced-concrete slabs of the structure meet Cooper's E-67 design. The heaviest locomotive to operate over the bridge was equivalent to a Cooper's E-61 rating. From these facts it is evident that Bridge AA-438 structurally was adequate as to design for the traffic it was required to support. The factor of safety was in excess of 2 for the piers and 3 for the remainder of the structure.

The investigation disclosed that several months prior to the accident a wooden bent was installed at pier 3; it does not appear that the use of this bent had any bearing on this accident. The footing of pier 1 extended 9½ feet below the normal stream bed, while the footings of piers 2 and 3 extended 7 feet and 4½ feet, respectively, below the normal stream bed, and all rested on gravel which provided a bearing surface adequate to support the weight of the bridge and any superimposed load. Since the rip-rap was displaced and the footings of the piers scoured to such an extent that they were displaced from their normal locations, it is evident that the footings did not extend far enough below the stream bed for such a volume of rapidly moving water as was involved in this instance.

Conclusion

This accident was caused by the undermining of the piers of a bridge, due to a cloudburst.

Respectfully submitted,

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Director.