February 6, 1913.

In re Investigation of Accident on the Pennsylvania Railroad Company near Glen Loch, Pa., On November 27, 1912.

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On November 27, 1912, there was a derailment on the Pennsylvania Railroad near Glen Loch, Pa., which resulted in the death of 2 passengers and 2 Pullman employees, and the injury of 77 passengers, 2 Pullman employees, and 5 employees of the railroad.

After investigation of this accident and of the circumstances connected therewith, the Chief Inspector of Safety Appliances reports as follows:

West-bound passenger train No. 19 departed from New York, N. Y., at 8:30 p.m., en route to St. Louis, Mo. At the time of the accident the train consisted of 1 postal car, 1 combination car, 1 coach, and 9 Pullman sleeping cars, all of steel construction, hauled by engines Nos. 2426 and 1618, and in charge of Conductor Wetsel and Enginemen Himes and Redmond. This train left Philadelphia at 10:54 p.m., and was derailed at 11:39 p.m. while passing over bridge No. 43½, about ¼ mile east of Glen Loch, or 25 miles west of Philadelphia. The speed of the train at the time of the derailment was about 50 miles per hour,

Engine No. 2426 came to a stop 1900 feet beyond the bridge, the forward drivers and the rear tender wheels being derailed on the south side. Engine No. 1618 stopped about 60 feet east of engine No. 2426, with the forward drivers and the forward wheels of both tender trucks derailed, all derailed wheels being on the south side of the rail. The drawbar on the tender of this engine was missing. About 50 feet behind this engine stood the postal car and the combination car, both upright, with all wheels derailed. The condition of the brake beams and trucks of these two cars indicated that they were derailed by the drawbar of engine No. 1618 pulling out and dropping down on the track. The first of the sleeping cars, the Glen Rock, rolled down the embankment on the north side, the roof being badly crushed by coming in contact with a steel gondola car loaded with coal, which was standing on the track at the foot of the embankment. Figure A shows the condition of this car after the derailment. The four sleeping cars immediately behind the Glen Rock also went down the north side of the embankment but were not materially damaged. Figure B shows these cars after the accident. The four rear cars in the train remained upright on the road bed, the last two not being derailed.

This division of the Pennsylvania Railroad is a four-track road, and train movements are governed by automatic block signals. The rails are 33 feet in length, weigh 100 pounds to the yard, and are single spiked to untreated oak and pine ties, laid about 19 under each rail. Many tie plates are in use. The ballast is of crushed stone, about 15 inches in depth. The track is on a fill of about 25 feet, with a descending west-bound grade of about one-third of one per cent. Approaching the scene of the accident the track is straight for about one mile. The accident occurred on a curve of 2 degrees leading toward the south. The sharpest point of the curve is nearly in the center of Bridge No. 43½. The elevation of the outer rail at the point of the derailment was 3 inches. After the accident the track was found to be properly gauged.

Engineman Himes, in charge of the leading engine on train No. 19, stated that when approaching the bridge he saw nothing wrong with the track. When passing over the bridge the engine dropped down and then raised up. The rolling motion of the engine knocked him from his seat box. After he felt the jar he applied the emergency air brakes and then tried to reverse the engine, but was unable to do so. When his engine came to a stop he did not know that the train had been wrecked. The engine had one driving wheel and two tender wheels derailed on the south side. He estimated the speed of the train at the time to have been from 48 to 50 miles per hour. When passing over the bridge there was little side motion to the engine, the drop being the principal effect. His statements were corroborated by Fireman Arandale.

Engineman Redmond, in charge of engine No. 1618, stated that he felt the engine sway toward the right and then he noticed fire flying. He at once tried the emergency brakes but they had already been applied. When the train stopped some of the wheels of his engine were derailed. Fireman Bickel, of the same engine, stated that his first intimation of trouble was when the engine dropped down and then raised up.

Bridge No. 43½ is an iron half-through plate girder type bridge, 166.3 feet in length, built in 1890. It consists of four girders, two on each side, varying from 66.3 to 84.6 feet in length.

The outer ends of the girders rest upon stone abutments; the inner ends rest upon a box girder, which in turn is supported underneath by a row of 8 latticed columns, standing upon a center wall of stone between the tracks which the structure spans. On top of each column there is a cover plate 24 inches square and ¾ inch thick. Guard rails are located in the center of the track, and extend some distance beyond each end of the bridge. Yellow pine guard timbers are also located along the ends of the ties.

Examination of the bridge after the derailment showed that the cover plate of the most northerly column had broken parallel with the south edge of the column, allowing the box girder to settle 16 or 18 inches upon the column. This in turn allowed the rails of track No. 4, on which train No. 19 was running, to settle under the train, causing the derailment. Figure No. 2 of Mr. Howard's report shows the condition existing here just after the accident. This break probably occurred under the engines of train No. 19, as about six minutes before the occurrence of this accident engines Nos. 1725 and 3413, hauling a train of 73 freight cars, passed over bridge No. 43½ and at that time the crew of this train noticed nothing wrong. In order to determine what caused this cover plate to break, arrangements were made with the Bureau of Standards, of the Department of Commerce and Labor, for the purpose of having it examined and the cause of its failure ascertained. This examination was conducted by Mr. James E. Howard, Engineer-Physicist, and the report covering the results of his examination, together with the illustrations accompanying the same, is attached to and made a part of this report.

Figure No. 3 of Mr. Howard's report is an outline of the bridge. The first marks of the derailment on the ties were on the bridge at a point 66 feet west of the east end of the girder B, and abreast column No. 8. These marks were located on the north side of the north rail. They were not deep or numerous, and as the derailed wheels of the two engines were on the opposite side of the track, these marks are believed to represent a secondary occurrence and not a primary one. In the middle of the bridge there were flange marks on the south side of both rails. Between these marks and the marks previously mentioned was a rail very much bent. The middle of this bent rail was nearly opposite column No. 8, where the depression in the track was the greatest at the time of the derailment. The depression of the box girder measured about 18 inches over this column, while over column No. 7 it was much less, being only a few inches. The greatest lateral displacement of the bridge also occurred in the vicinity of column No. 8 and the bent rail. It is believed that when the engines were suddenly raised out of the depression into which they had dropped, the flanges of the derailed wheels apparently cleared the top of the south rail. From the west end of the bridge the track was torn up for a distance of 369 feet. Beyond this point the only marks were on the south side of each rail, occasioned by the derailed wheels of the two engines.

After giving a detailed statement of the condition of the bridge as found after the derailment, Mr. Howard in his report states that the initial line of rupture appears to have been the completion of a fracture which existed prior to the accident. The cover plate had previously been ruptured through the greater part of its thickness, which was ¾ inch. The initial crack extended from the outer surface downward to a depth of about 5/8 inch, leaving about 1/8 inch sound metal. The completion of this line of rupture was the immediate cause of the accident.

Attention is called to that part of Mr. Howard's report reading as follows:

> "It would seem that the cover plate of column No. 8 had been repeatedly subjected to bending stresses both from the downward weight of the trains and from their outward centrifugal trust, and that some looseness had permitted of a hammering action of the south web of the box girder upon the cover plate, all of which had resulted in the development of a progressive or detailed fracture. With such a fracture started it was only a question of time when rupture of the plate would be completed and the failure of the bridge consummated.
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> "The formation of a progressive fracture is the result of occasional overloads repeated a greater or less number of times according to their magnitude. If the overload reached a maximum at each application, rupture would soon take place, but such is not usually the case under service conditions. Doubtless it was an exceptional incident in the history of this bridge when all the conditions of loading conspired toward developing a maximum stress. In the interval of time since the bridge was built there has been a decided increase in the weights of rolling stock and concentrated loads on wheels, and higher stresses no doubt have been received by the bridge in recent years over those of former ones.
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> "The length of time during which this fracture has been in existence cannot be told. As a matter of judgment it may have been in process of development for a number of years. It could hardly have been developed, however, to any great extent four years ago, the last time the bridge was painted, since paint had not run into the crack. It is not believed to have had its origin within a period of a few months."

Mr. Howard states that during the formation and development of the rupture it would have been visible so far as being covered by any other part of the structure was concerned, but that its accessibility for inspection or detection would have been impaired by the double latticing of the vertical webs of the box girders.

The annual deflection test of this bridge by the Company's bridge inspector was made on November 26, the day before the accident, while the monthly inspection was made on November 18. Neither of these inspections developed anything which had any connection with the failure here under discussion. The deflection test consisted of observing the deflection of the main girders while trains were passing over the bridge. In this case there were two freight trains running at speeds of 20 and 30 miles per hour, and two passenger trains running at speeds of 50 and 60 miles per hour. The test developed nothing indicating weakness in the structure. In his report of the condition of the bridge after the monthly inspection, the bridge inspector stated that the inspection included all rivets, connections, and everything connected with the bridge. The fracture that caused the accident was well advanced at the time the tests were made, however, and had probably been in an advanced stage for many weeks. In fact Mr. Howard states that the cover plate had probably been in a state of partial rupture for more than a year. On this division of the Pennsylvania Railroad there are from 500 to 600 bridges to be inspected monthly, and the force doing this work consists of 6 inspectors. In the testimony taken at the investigation conducted by the railroad it was shown that the master carpenter who has charge of the inspectors knew prior to the accident that some of the anchor bolts of the main girders were disturbed, and both he and the track foreman were of the opinion that the bolts at the east end of plate girder B were broken off down in the stonework of the abutment.

Mr. Howard states that the bent anchor bolts at three of the corners of the bridge would suggest the kind of forces which were acting to strain the structure, and that the freedom of the floor beams to be moved laterally on the east abutment by centrifugal force, leading to the bending of the cover plate, might reasonably have attracted attention. Again, the signs of hammering of the south web of the box girder on the cover plate would suggest that looseness existed prior to the accident. It is believed that these forces led up to the rupture of the cover plate.

Among other conclusions, Mr. Howard states that the cover plate was a weak detail in the design and construction of the bridge; that the inspections as carried out were apparently ineffectual and inadequate to reveal the true condition of the bridge; that bridge inspectors should have a description of parts of bridges under their care which are likely to receive the greatest loads in service, and that means be provided to enable the inspectors to make proper and adequate inspection of such parts.

This accident was caused by the track being depressed under engines Nos. 2426 and 1618, due to the breaking of a cover plate. This cover plate was in a defective condition previous to the accident, and although the bridge was inspected twice within less than 10 days prior to the accident, neither inspections developed its defective condition.

In our report covering the accident which occurred on the Lehigh Valley Railroad near Manchester, N. Y., on August 25, 1911, due to a broken rail, attention was directed to the necessity of making a complete investigation of track conditions for the purpose of determining the effect thereon of recent types of locomotives with their greatly increased wheel loads. It would seem that the accident here under investigation is but another phase of this situation and to guard against a recurrence of such accidents, examination should be made of bridges for the purpose of determining whether or not any of their structural members are exposed to overstraining loads under present increased weights of equipment.