IN RE INVESTIGATION OF AN ACCIDENT WHICH OCCURRED ON THE ATLANTA, BIRMINGHAM & ATLANTIC RAILWAY AT CASCADE CROSSING, GA., ON SEPTEMBER 7, 1921.

September 28,1921.

On September 7, 1921, there was a derailment of a freight train on the Atlanta, Birmingham & Atlantic Railway at Cascade Crossing, Ga., which resulted in the death of 1 employee and injury to 3 employees.

Location and Method of operation.

The line on which this accident occurred is part of the Birmingham Division and extends from Atlanta, Ga., to Manchester, Ga., a distance of 78.2 miles. It is single-track, trains being operated by time-table and train orders, no form of block system being used.

The point of derailment was under an overhead highway bridge known as Cascade Crossing located about 10 miles east of Atlanta. It is at the foot of a descending grade for eastbound trains varying from .5 to 1 per cent, $4\frac{3}{4}$ miles in length and at the beginning of an ascending grade varying from .88 to 1 per cent $3\frac{1}{2}$ miles in length. Beginning at a point about 2,100 feet west of the point of accident and proceeding eastward the line is tangent for 1,000 feet. This is followed by a 6-degree curve to the right 1,370 feet in length and having a superelevation varying from .5 to 6 inches. The overhead highway bridge is 1,108 feet from the beginning of this curve. At this point the track passes through a cut approximately 20 feet deep. The bridge is about 12 feet wide, of wooden construction and is supported by four bents, two

on each side of the track. The initial point of derailment appeared to have been under the eastern edge of this bridge on the left hand rail.

The track at this point is laid with 80-pound 33 foot steel rails on cypress ties, about 20 ties to the rail. The ballast is slag and about 18 inches in depth. The rails are fastened with 4-hole angle bars and the bolts are staggared. Tie plates are used through the cut and the rails are single spiked. The track is fairly well maintained.

Description.

Eastbound freight extra 102, consisting of locomotive 102, 33 loaded and 2 empty cars and a caboose, 959 tons, en route from Atlanta, Ga., to Fitzgerald, Ga., was in charge of Conductor Ross and Engineman Morris. At Bellwood Yard, its initial station it received the following train orders:

Order No. 10

Order No. 13 of Sept. 6th, is annulled. Do not exceed speed authorized by bulletin at any point and approach all bridges curves and switches carefully account of track having been tampered with. Reduce speed to 10 miles an hour at D.275-1/2 M.P. and at D.282-1/2 M.P.

Order No. 14.

Eng. 102 run extra Bellwood to Manchester.

In addition the crew was given the following message:

To C. and E. Extra 102 East.

Run with extreme caution tonight Bellwood to Manchester and look out for trouble.

A. L. M. (Supt.)

The train left Bellwood Yard at 8.00 p.m. and was derailed at Cascade Crossing 7.5 miles east of Bellwood at 8.30 p.m. while running at a speed estimated by members of the crew to have been between 15 and 20 miles per hour.

The engine and tender came to rest on its right side, parallel to and about 10 feet south of the south rail with the forward end of the engine 223 feet east of the initial point of derailment. The pilot had been torn off and the engine truck was on the roadbed about the middle of the engine. The left front engine track wheel was missing and found at the top of the embankment on the left side of the track where it had apparently been thrown and rolled some 120 feet east from the initial point of derailment. The first car, loaded with sheep, came to rest at right angles across the track with its left front corner at the rear of the tender. The next, a box car, was derailed and came to rest at the left of and parallel to the track. Following this were 2 box cars directly across the track, another box car to the left of and parallel to the track. The next 7 cars including an empty tank car were stacked side by side almost directly across the track, the last 2 remaining under and supporting the highway bridge, the bents of which had been displaced by the derailed cars. The last car to be derailed came to rest on the roadbed with its forward end turning to the south. The 3rd, 7th and 9th cars being old and entirely of wooden construction were practically destroyed. The

remainder of the train including the car of sheep, none of which were injured, was slightly damaged. The locomotive was very slightly damaged and bore no marks to indicate the cause of derailment. The glass in the headlight and the glass in the window on the left side of the cab remained intact.

The track was badly torn up; the rails displaced and ties shattered. There was evidence given to show that directly under the east side of the bridge and under the left hand rail there was found after the accident a crater in the ballast conical in shape about 4 feet in diameter with a maximum depth of 18 inches.

The rail immediately over the point where this crater was found was an open hearth Tennessee rail rolled in April, 1916, heat No. 74216, ingot letter D. After the accident this rail was found to have a sharp outward bend or kink, located about 31-inches from the delivering end of the rail. Coincident with this bend there was a crescent shaped piece about 3-feet in length broken from the inside of the base of the rail and bent downward at each end. About the middle of this break and also about the middle of the outward bend of the rail there appeared on the head of the rail a slight upward kink. About 3 inches back of this there was a slight downward kink, at which point the impression of the chiller marks appearing on the tread of the forward engine truck wheel could be plainly seen on the head of the rail. There

were also several other marks and abrasions on the rail but all of which were apparently the result of the derailment.

Summary of evidence.

Locomotive 102 is of the 4-6-0 type having a total length including the tender of 67 feet. The weight of the engine alone is 186,200 pounds of which 19,700 pounds rest on each pair of the engine truck wheels. The running gear and under side of the engine bore no marks which would indicate the cause of the derailment. Parts of broken pilot slats were found scattered over a considerable area ahead of the engine, the most distant being 429 feet east from the initial point of derailment. The axle and remaining wheel of the forward pair of wheels of the engine truck remained practically in place in the truck frame, the left journal box being destroyed. The axle was found to have a slight bend of about 5/8 inch at the left journal bearing. The engine truck wheels were 28-inches in diameter. The forward pair were of cast iron made by the Southern Car Wheel Company and each were cast June 6, 1921. The record produced by the railroad company shows that the wheels were placed on the axle by the Atlanta, Birmingham and Atlantic Ry. Co., at the Fitzgerald, Ga., shops, between June 23 and June 27, 1921, and that a maximum pressure of 50 tons was used in forcing them on. They were applied to engine 102 at Atlanta, Ga., on August 11, 1921, and up to the time of the accident had made approximately 1400 miles.

The end of the axle from which the wheel was detached

bore slight tool marks but showed no other unusual indications. According to statements of railway officials who were on the ground shortly after the accident occurred the first marks made by the wheel appeared on the left hand embankment about 11-feet above the top of the rail and about 60-feet from the initial point of derailment. The second mark appeared about 13-feet further on and nearer the top of the bank. Both marks appeared to have been made by the tread and flange of the wheel as if it had been rolling. At the top of the bank a flange mark could be traced in a semi-circle to the point where the wheel came to rest on its side about 50-feet from where it first reached the top of the bank. These marks seem to indicate that when the wheel left the journal it rolled on its edge in a diagonal line until it reached the top of the bank. The wheel bore no marks which would give any indication of the cause of the accident.

Considerable evidence from persons living within a radius of 4½ miles of the point of accident was introduced tending to show that the sound of an explosion was heard by them about 8.30 p.m. on the night of the accident.

Conductor Ross of extra 102 stated that approaching the point of accident he was riding in the cupola of his caboose. The air brakes had been applied but when the train was about one-half mile from the beginning of the ascending grade the brakes were released. At the time of the accident he estimates the speed of his train to have been between

15 and 20 miles per hour. The first indication of trouble which he received was the sound of an explosion from the forward end of the train followed by four distinct jars. He looked at his watch immediately and found the time to be 8.30 p.m. He stated there was no explosive in his train and that none of the freight cars were blown up.

Brakeman Wilson stated that at the time of the accident he was riding on the fireman's seat on the left side of the engine. The engineman had released the brakes and the train was running smoothly. When the engine was under the bridge there was an explosion which raised the engine up from the rails and it came down on the ties. He estimated the speed of the train to have been 18 or 20 miles per hour.

Fireman Powell stated that he received no warning prior to the explosion. The explosion was accompanied by a flash. He substantiates the statement of the brakeman that the engine was raised from the rail and came down on the ties.

The engineman was killed by the overturning of the engine.

An extra fireman also riding on the engine was injured by escaping steam and died a few days later without making any statement.

Assistant Superintendent Huddleston stated that the slow order given to extra 102 was a standing order given to all trains and that the bulletin referred to in the order

restricted the speed of freight trains to 20 miles per hour. The additional message given to the crew before leaving its initial station was sent by him on account of the actions of certain parties under observation which lead to the belief that an attempt at violence might be made that night. He stated that he arrived at the scene of the accident about 2.00 a.m. and made an examination of conditions. He found a bowl-shaped hole about 4-feet in diameter and 18-inches deep in the ballast under the left hand rail about the center of the bridge. The broken and bent portion of the rail appeared directly over the hole and the cross ties were blown to pieces. He examined the track west of the crater and found no marks which would indicate a derailment, parts of the pilot were found scattered a distance of 429-feet from the hole. The left front engine truck box was destroyed and the frame of the engine truck was bent slightly upward. He found no marks indicating a loose engine truck wheel.

Dr. Dumas, a chemist employed by the A.B.& A.Ry. to make an investigation stated that he arrived at the scene of the accident about 5.45 p.m. on the day following. He made an examination and took samples of earth from the bottom and sides of the crater. In the crater he found a fragent of iron wire about 2 inches long, a piece of rubber insulation about an inch long and several small particles of wrapping consisting of oil paper and tinfoil, in alternate layers, and in this wrapping was found particles of kieselguhr. An examination of the earth taken from the hole disclosed in-

disputable evidence of chlorate of potash and sugar which when taken together form a high explosive. In his opinion the crater was made by an explosion of chlorate of potash and sugar set off by a dynamite detonator.

Master Mechanic McPhail stated that ordinarily a 5½ inch axle that is 1/64 inch larger in diameter than the hole in the wheel will give a good fit at 50-tons pressure and he believes that to be the standard practice. According to his records the wheel which came off was placed on this axle sometime between June 23 and 27, 1921, 50 tons pressure being used and that this pair of wheels was placed under engine 102 on August 11, 1921.

Subsequent to the accident the forward pair of engine trunk wheels was taken to the plant of the Southern Wheel Company at Atlanta, where tests were conducted in the presence of representatives of the railroad company, the Southern Wheel Company, and the Governor's Special Investigating Commission, as well as representatives of this Bureau to determine what pressure would be required to replace the wheel The wheels were placed in the press and for the first inch or two little pressure was required, the pressure than gradually increased until the wheel was fully seated, at which time a maximum pressure of 15-tons was reached. The pressure was then reversed and the same wheel forced from the axle. At the beginning 20-tons pressure was applied, at which point the wheel was started from the axle. The pressure then fell gradually to zero. In order that a compari-

son might be made the opposite wheel was then placed in the press and forced from the axle. The wheel started at 65-tons pressure and gradually fell to zero. The pressure was then reversed and the wheel, forced back on the axle at a gradually increasing pressure reaching 40-tons when fully seated. Following this the wheel was again forced from the axle a pressure of 48-tons being required to start the wheel from its seat, the pressure then gradually dropping to zero.

Conclusions.

The evidence as well as an examination of the material involved in this accident indicates that this derailment was caused by an explosion.

The marks and condition of the rail point strongly to the theory that an explosive was placed between the head and base of the left hand rail, which when exploded by the passage of the left forward engine truck wheel forced the rail outward and upward creating the outward bend and leaving the impression of the chiller marks of the wheel on the head of the rail. The explosive also worked downward shattering the ties taking off a portion of the base of the rail bending its ends downward, the center being directly over a tie. It is believed that at the same instant that the engine was raised by the explosive the left forward engine truck wheel was driven from the axle, bending it slightly, and the force of the explosion together with the movement of the train threw the wheel forward with a rolling

motion until it came to rest at the top of the bank. The fact that comparatively little damage was done to the locomotive, particularly on its under side, is explained on the theory that the left front wheel being nearest the explosive received the violence of the shock while the other parts of the locomotive being more distant received a less severe blow but still sufficient force to raise the engine from the rail.

At the time of the accident both engine and train crew had been on duty 1 hour after having been off duty 26 hours.

An examination was made of the engine, its truck, axle and wheel, and site of the derailment inspected by Mr. James E. Howard, Engineer- Physicist, whose report upon the derailment next follows:

Report of the Engineer-Physicist.

The derailment of train extra No. 102, on the A. B. & A. Ry., at Cascade Crossing, Ga., was clearly the result of an explosion which occurred under the forward end of the engine on the left hand side. The time of the explosion with reference to the position of the engine was apparently when the forward left hand wheel of the pilot truck was over the explosive. The place occupied by the explosive seemed to have been near or upon the inner flange of the outer or high rail of the track, the track curving to the right at this place, and at a point nearly or quite underneath the overhead bridge of the highway crossing.

Certain parts of the engine, the high rail, the ties and the roadbed furnished conclusive evidence of there having been an explosion, while the testimony of the personnel of the train, together with that of residents of the vicinity was confirmatory of this fact, and still further the recovery of certain unburnt explosive material from the debris, in the immediate vicinity of the derailment, furnished tangible evidence of the presence of an explosive.

Sufficient evidence was presented of a positive character to enable judgment to be formed upon the probable order of events all of which took place within a very brief interval of time, measured by seconds or fractions of a second.

The violence of the explosion occurred when the forward left wheel of the engine truck was immediately over the explosive, the gasses disengaged by the explosive were at their greatest intensity of pressure at that instant. The high rail was, with the exception of its inner flange, suddenly forced upward, increasing the intensity of the pressure between the head of the rail and the tread of the forward wheel of the engine truck. The increase of pressure was so great that chiller marks on the tread of the chilled iron truck wheel were transferred to the running surface of the rail head. The chilled iron wheels on the forward axle had been in service but a short time and the chiller marks still remained upon their treads.

The second axle of the engine truck was equipped with steel wheels, thus fixing responsibility for the chiller marks, on the high rail, upon the chilled iron wheel of the forward axle.

Additional evidence of the violence of the explosion, at its initial stage, was presented by the high rail which displayed at the immediate vicinity of the chiller marks a short outward kink. It is here in evidence that the explosive was placed on or against the inner side of the high rail.

Necessarily this sudden local spreading of the gauge of the track tended, by reason of frictional resistance between the head of the rail and the tread of the left truck wheel, to disengage the wheel from its axle. The normal wheel pressure of the truck taken at 9,850 pounds per wheel was greatly exceeded at the instant the chiller marks were made on the head of the rail. The formation of the outward kink of the rail at this place would tend to carry with it the truck wheel, in this manner furnishing a longitudinal component, with reference to the axis of the axle, which would tend to remove the wheel from its axle An additional component is found in the gasses generated by the explosive, acting against the inner face of the wheel.

High explosives in a confined space develop pressures of many thousand pounds per square inch, 40,000 pounds per square inch not being an unusually high pressure. The

left wheel was reported to have been pressed on its axle with a force of 50 tons. Allowing 20 per cent increase in resistance against forcing it off, 120,000 pounds would be required for its removal. Omitting consideration of the influence of the kinking of the rail, but taking into account the area of the flat surface of the wheel, then it would appear that a pressure of 200 pounds per square inch, on the inner face of the wheel, would be adequate to remove it from its axle. In pressing this wheel on and then off the axle subsequent to the derailment much lower pressures were required. This would indicate that a force less than 200 pounds per square inch would be ample to blow off the wheel. In a mathematical sense the acceleration of the mass of the metal of the wheel and that of the axle must be considered. A force suddenly applied to the face of the wheel, if sufficiently sudden, would remove the wheel from the axle without imparting much movement to the axle.

The wheel was detached without injury to its flange, indicating that the wheel must have been raised from the head of the rail a sufficient height to permit the flange to clear the rail when the wheel left its axle. There was testimony to the effect that the engine was raised or felt to be. Other circumstances connected with the derailment confirm the belief that the engine was materially raised at its forward end, and the wheel given the opportunity to pass over the top of the rail at a stage in the explosion.

The wheel was clearly acted upon by a force against its inner face. Gasses under diminished pressure doubtless filled the space between the surface of the roadbed and the engine truck, which expended their energy in part in blowing off the left hand wheel. When detached from its axle it deflected from a tangent course, deviating outwardly, ricochetted up the left bank of the cut, rolled around a convolute circle of small diameter at the top of the bank and came to rest upon one of its side faces.

The axle was bent It had a deflection of about 5/8", the sharpest part of the bend being located in the journal bearing near the inner face of the chilled iron wheel.

A fragment of the inner flange of the rail was bent into an inverted U shape. The middle of the length of this fragment was located over a tie. The ties in this vicinity were reported as having been shattered. A number of shattered, shredded, ties were lying about in the vicinity of the derailment when a later inspection of the track was made. The crater made by the explosive was in evidence following the derailment.

Fragments of the pilot were dispersed, some having been found at a distance of several hundred feet from the point of derailment, some coming to rest on each side of the track.

The engine did not take a tangent course as would be expected in an ordinary derailment on a curve, it was deflected to the right and inwardly with reference to the

curvature of the track. This change in the direction of the course of the engine is accounted for by the action of the explosive being directed chiefly against the left forward part of the truck.

Information was not furnished upon the condition of the low rail of the curve at the point in the track abreast the outer rail which displayed the short kink. Not unlikely the explosive which made a crater in the roadbed at the high side of the track caused more or less destruction to the inside or low rail of the curve, and facilitated the derailment of the engine on the inside of the curve. The center of effort of the explosive opposed the progress of the engine in a tangent direction, and tended to change its course toward the right, the direction which the engine actually took.

Slight evidence was presented of the explosion beyond a limited zone which included the crater in the roadbed, the kinked portion of the rail, the fragment of the rail flange, the detached wheel, its axle and boxes and pilot. There was of course a diffusion of the explosive gasses, and reduction of intensity of pressure following their immediate disengagement at the time of the explosion. The gasses not being confined, the reduction in pressure took place very soon after the instant of explosion. The forward end of the engine was raised by the total pressure of moderate intensity per square inch, the detachment of the truck wheel from its axle furnishing evidence of such immediate reduction of pressure. The effects of an explosion rather

than that of a detonation were presented by the track, roadbed and derailed train. The evidence presented in detail and in its entirety harmonizes with the explanation that the derailment of this train was caused by an explosive which was located on or against the high rail of the curve and doubtless so prepared and disposed that the ill-fated train ignited the charge.