RAILROAD ACCIDENT REPORT

RICHMOND, FREDERICKSBURG AND POTOMAC RAILROAD COMPANY TRAIN NO. 10/76 DERAILMENT WITH THREE FATALITIES AND NUMEROUS PERSONAL INJURIES FRANCONIA, VIRGINIA JANUARY 27, 1970

NATIONAL TRANSPORTATION SAFETY BOARD

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Washington, D. C. 20591

REPORT NUMBER: NTSB-RAR-71-1

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Adopted: February 3, 1971

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FOREWORD

This report by the National Transportation Safety Board is based on facts developed in a field investigation and a public hearing. The field investigation was conducted by the Safety Board in cooperation with the Federal Railroad Administration (FRA). The public hearing was conducted by the Safety Board in Washington, D. C., on March 24, 25, 26, and 27, and on April 8, 1970.

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DERAILMENT WITH THREE FATALITIES AND NUMEROUS PERSONAL INJURIES NEAR FRANCONIA, VIRGINIA, ON JANUARY 27, 1970

I. SYNOPSIS

Train No. 10/76 derailed on Richmond, Fredericksburg and Potomac (RF&P) tracks near Franconia, Virginia, at approximately 12:10 a.m. on January 27, 1970. Of the 101 passengers in the 10 cars, three were killed, five incurred injuries requiring hospitalization and 45 persons were treated for less serious injuries. Total estimated damage, including personal injuries, approximated $637,050.

Train No. 10/76 departed Richmond, Virginia, at 10:30 p.m., January 26, 1970. The train consisted of one express car, one postal car, two baggage cars, four coaches, two sleeping cars, and three diesel-electric locomotive units. The train proceeded northbound on No. 2 track and at Possum Point, 80 miles north of Richmond, crossed over to No. 3 track to avoid conflict with a local freight. On approaching Franconia, speed was reduced from 80 miles per hour to 70 miles per hour; at Franconia, speed was further reduced to 65 miles per hour, and as the train traversed the north end of a curve, the locomotive lurched severely to the left. Immediately thereafter, the derailment occurred.

The accident resulted in the derailment of the eight rear cars of the train. The third, fourth, and fifth cars remained upright and coupled to the head end of the train. A separation occurred between the fifth and sixth cars, and between each of the following cars. The sixth through 10th cars veered to the left down a bank, and either partially or completely overturned.

The National Transportation Safety Board determines that the probable cause of the derailment was the lateral movement of the track immediately ahead of the locomotive, due to conditions resulting from inadequate track maintenance procedures.

II. FACTS

A. Location and Method of Operation

1. Site

The derailment occurred approximately 1 mile north of Franconia, Virginia, and about 99 miles north of Richmond, Virginia, on trackage of the Richmond, Fredericksburg and Potomac Railroad Company.

The railroad, from Richmond to Washington, D. C., runs generally from south to north. Through the derailment area the geographic direction of the railroad varies, but, for purposes of this report, the timetable directions of south and north will be used.

2. Operating Procedure

In the derailment area, there are three main tracks numbered from east to west as tracks 1, 2, and 3. All tracks are equipped with automatic signals for train movement in either direction on signal indication. The automatic-block signal system is part of a traffic control system centrally operated from Richmond. Usually, northbound trains operate on No. 1 track, and southbound trains on No. 3 track. Trains operate on No. 2 track in either direction on signal indication. At the time of the accident, Train No. 10/76 was operating northward on No. 3 track to avoid conflict with a local freight.

The maximum authorized speed for passenger trains on No. 3 track was 65 miles per hour, and on Nos. 1 and 2 track 80 miles per hour at the time of the derailment. Freight trains, except for "piggyback" trains, were restricted to a maximum speed of 55 miles per hour on all tracks. "Piggyback" trains were authorized a maximum speed of 65 miles per hour.

Approximately 10 days after the derailment, the maximum authorized speed for passenger train operation over the entire railroad was reduced from 80 to 70 miles per hour. Authorized speeds of 70 miles per hour, or less, were maintained at previous levels for normal operation. Railroad employees at the public hearing said the speed was reduced to improve passenger comfort without affecting scheduled operation.

B. Description of Accident

1. Weather

The temperature at the time of derailment approximated 42° F. The sky was clear. The highest temperature of the month, 60° F., was recorded the preceding day in the derailment area. This occurred following a 23-day cold spell, during which the temperature had averaged 27° F., or 10° F. below the normal mean temperature. Precipitation for the preceding 30 days occurred as rain and snow, and amounted to 2.28 inches water equivalent. Of this, 1.03 inches occurred on December 30, 1969, and 0.51 inches on January 17. Normal precipitation for this area during the month of January is 3.03 inches.

2. Alignment, Grade, and Superelevation

The general derailment occurred on a 2°00' curve to the right, looking from south to north. The beginning of this curve is 2,000 feet south of the first flange mark of derailed equipment. The end of the curve is 447 feet north of the first flange mark. From the end of the curve, the spiral transition from curved to straight track is accomplished in 475 feet. The track is straight through the remainder of the accident area.

The entire curve is on a 0.75 percent descending grade to the north. At the north end of the curve, the grade changes to 0.80 percent descending, and continues at this rate through the accident area.

The outer rail of the curve was elevated 4¼ inches above the inner rail throughout the body of the curve. The equilibrium speed for the curve was 57 miles per hour, and the comfortable speed for 3 inches of unbalanced elevation was 74 miles per hour.[1/] At one time in the past, No. 3 track was superelevated to 6 inches and had an authorized speed of 80 miles per hour, consistent with tracks 1 and 2. The present 4¼-inch superelevation and 65 mile-per-hour speed were established to minimize rail wear resulting from southbound freight operation on the 0.75 percent grade.

3. Track

a. Track Structure

No. 3 track consisted of 140-pound jointed rail laid in 39-foot lengths. The crossties were creosoted timber, 7 inches by 9 inches by 8 feet 6 inches, spaced at 20-inch centers or 23 crossties per 39-foot rail. The crossties were fully plated with 7- by 14-inch double-shoulder tieplates. The rail was secured to the crossties by two rail-holding cut spikes per tieplate. Hairpin lock anchor spikes were in place on approximately one-third of the crossties. The rails were joined by 36-inch joint bars with six 1-1/8 - by 5-3/4-inch bolts per joint. Anchorage of the rail against longitudinal movement was accomplished with grip-type anchors installed eight per rail for southbound traffic and four per rail for northbound traffic. The rail in No. 3 track was rolled by the Bethlehem Steel Company in 1953 and installed in track the same year.

b. Track Inspections

No. 3 track was last inspected by a foreman-inspector on January 26, 1970, the day preceding the derailment. A missing bolt was replaced in the general derailment area, but otherwise no exception to the track

1/ See Appendix B for definitions of equilibrium speed, comfortable speed, and unbalanced elevation.

condition was taken during the inspection. Previous inspections by this foreman-inspector were made on January 8, 14 and 19. The track supervisor had inspected No. 3 track last on December 23, 1969. The chief engineer rode over, and observed, No. 3 track from the rear of a train on January 21, 1970.

The Association of American Railroads recommends minimum track inspection standards which prescribe that tracks that carry freight trains at speeds in excess of 50 miles per hour, or regularly scheduled passenger trains, should be inspected twice a week. RF&P inspections did not conform to these standards as intervals between inspections had varied from 5 to 7 days prior to the derailment.

c. Trackwork

The track in the derailment area had been surfaced last in May, 1969. Tie renewal work was initiated on the 2°00' curve on December 9, 1969. Prior to December 1969, the last tie renewal work in this area was in 1960. The work was scheduled to include the renewal of all deteriorated crossties, surfacing with additional ballast, and aligning the track through the entire curve. Before work was initiated, new crossties were unloaded throughout the curve and placed on the west side of No. 3 track. The tie renewal work was accomplished by a gang equipped with spike puller, tie axe, tie-bed scarifier and tie inserter, plate setter, tamper, spike driver, and a ballast regulator. The tie renewal work was to be followed by surfacing and aligning work 1 to 2 months later in accordance with general industry practice.

Tie renewals averaged 16 of the 23 ties per rail length. The work was accomplished in two passes whereby approximately one-half of the crossties renewed were installed on the first pass, with the balance on the second. The initial renewal work was at the south end of the curve and was accomplished on December 9, 10, 11, and 12. On December 15, renewal work was started approximately 1,375 feet south of the first flange mark of derailed equipment and progressed northward. On December 16, the first pass was completed to a location 385 feet north of the derailed flange mark. The next tie renewal work in this area was done on December 23 and 24 on straight track south of the curve involved. Operations were then suspended until January 2, 1970, when work was again performed on the straight track south of the curve, and the second pass of renewals was made from the location 1,375 feet south of the first derailed flange mark to a point 88 feet south of the flange mark. No further tie renewal work was done in the area prior to the derailment on January 27, as repairs at another derailment site received priority consideration.

The tie-renewal operation necessitated the removal and resetting of rail anchors on affected crossties. This was accomplished in the derailment area on December 16 and January 2, when the maximum temperatures were 38° F. and 41° F., respectively, and the average temperature for both days was 33° F.

The tie-renewal operation necessitated the removal of some ballast from cribs adjacent to renewed crossties and all of the shoulder ballast on the outside ends of the renewed crossties. Following the insertion of the new crossties and the placement of tieplates, the new crossties were tamped by a vibratory tamper sufficiently to raise the crossties to a position firmly beneath the rail, using the ballast available in the cribs. Old crossties were tamped only when low spots were visually noted by the foremen in charge. Evidence at the public hearing indicated no abnormality in tamping operations.

After tamping, the crossties were spiked with two rail-holding spikes per plate. Following the spiking, the first pass was deemed complete. No speed restrictions were invoked following the completion of this work.

The procedures for the second pass were the same as for the first except that the ballast regulator normally followed the spiking operation. The ballast regulator dragged up the ballast that had been deposited outside of the normal shoulder and then shaped it to restore the ballast section on the shoulders and in the tie cribs as much as possible with the ballast available. On January 2, the ballast regulator completed work 461 feet south of the first derailment flange mark, leaving 373 feet of completed tie renewals for which the ballast had not been regulated. Upon completion of work on January 2, the track was released for normal operation and speed.

d. Track Condition

The requirements for track maintenance on the RF&P include a book entitled "Rules and Instructions for the Government of Maintenance of Way Employees," subsequent written and verbal instructions, past practice, and experienced judgment of the employees involved. Applicable excerpts from the rule book are included in Appendix C.

Measurements of the track conditions on 761 feet of undisturbed track south of the derailment area were made following the derailment. In this area the curvature varied from 1°26' to 2°15', superelevation, from 3-3/4 inches to 5½ inches; and gage, from 56-9/16 inches to 57-1/8 inches. The change in cross level in 39 feet equaled or exceeded the permissible one-half inch at six locations, with the greatest change being 1¼ inches. At six locations, the superelevation equaled or exceeded the allowable one-half inch deviation from that specified, with the largest variance being 1¼ inches. The majority of the gage measurements indicated locations where the gage equaled or exceeded the prescribed 56½ inches by the allowed one-half inch. The change in surface per 31 feet equaled or exceeded the design grade by the allowed three-fourths of an inch at two locations. The maximum change per 31 feet in excess of the design grade was 1 inch. Appendix D tabulates the track measurements taken south of the derailment area.

The RF&P does not prescribe measureable conditions for their standard ballast section, except when track has been raised. Evidence at the public hearing indicated a variance of opinions by RF&P track experts as to what constituted an acceptable finished ballast section. The engineer-of-track indicated that the finished product should conform to the American Railway Engineering Association's "Manual of Recommended Practice." This would require ballast level to the top of crossties with 6-inch wide shoulders on each crosstie end. The chief engineer indicated that the top of ballast should be 2 inches below the base of rail. The ballast section in the derailment area did not conform to either of these practices. Figure 1 on page 7 depicts undisturbed trackage south of the derailment site where tie renewals were completed but the ballast regulator had not worked. Figure 2 on page 8 depicts undisturbed trackage south of the derailment where tie renewals were completed and the ballast regulator had worked.

4. Roadbed and Ballast Condition

a. Topography

The roadbed for tracks 2 and 3 was originally constructed in 1903. No. 1 track was constructed during 1946 and 1947. The original construction centered the trackage on the west side of a moderately steep slope to the Backlick Creek Valley. East of the trackage is a stepped bank, rising to a plateau approximately 45 feet above the track. West of No. 3 track, in the area where the derailed cars came to rest, the ground descends from the track on approximately a 2:1 slope.

The valley ground level west of the track is from 10 feet to 50 feet below the track, increasing in depth proceeding northward. Defined ditches are provided on both sides of the tracks with flow lines well below the ballast line. The ditches were weed-grown, but generally were providing drainage in accordance with design. Figure 3 on page 9 depicts ground contours of the area.

b. Composition

The track was ballasted with 3-inch to one-quarter inch crushed stone, laid to a depth of approximately 17 inches under the crossties. The crushed stone ballast was underlaid with old, washed gravel varying in size from 2 inches to sand, and in some areas contained some

Figure 1

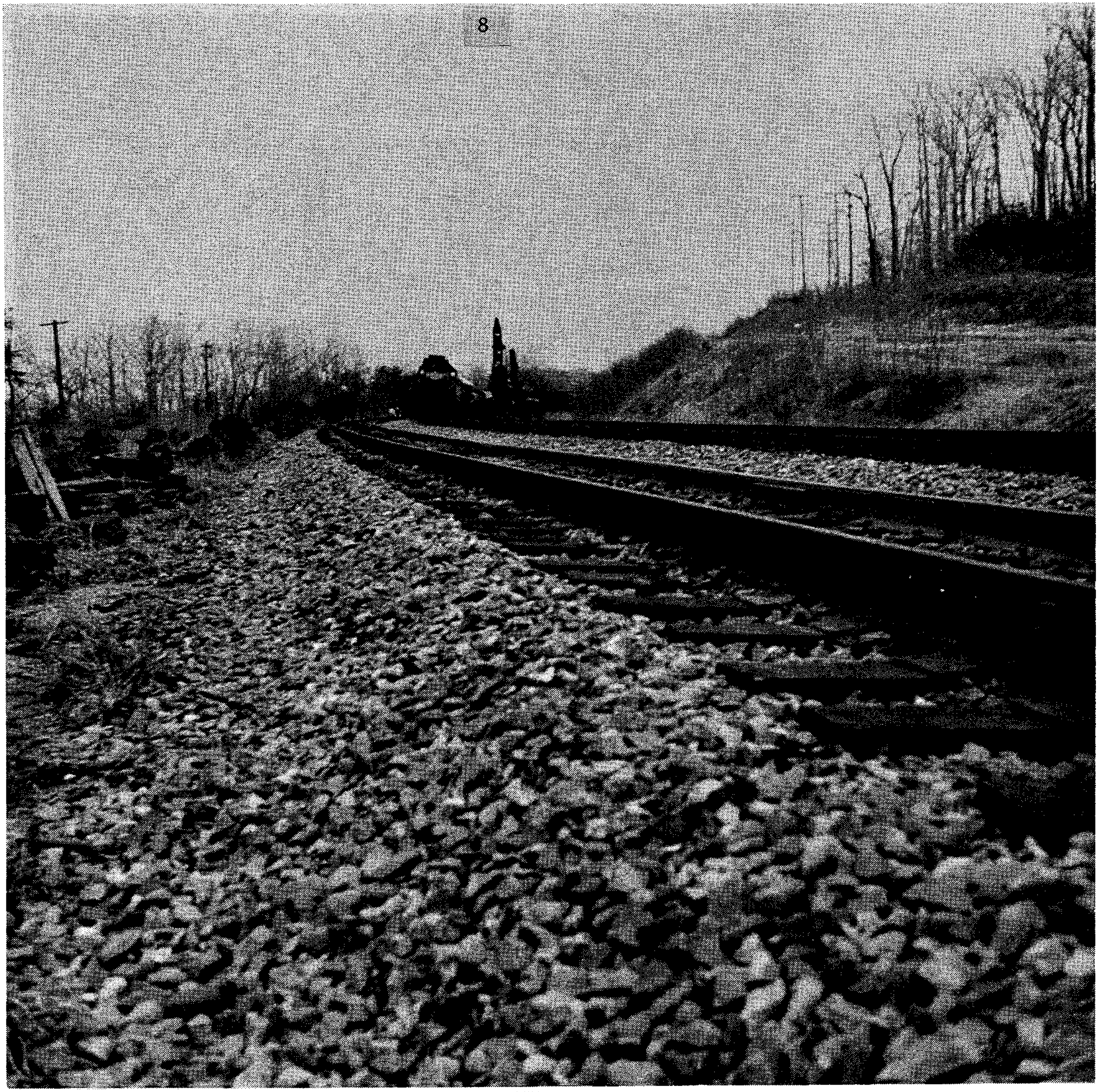

Figure 2

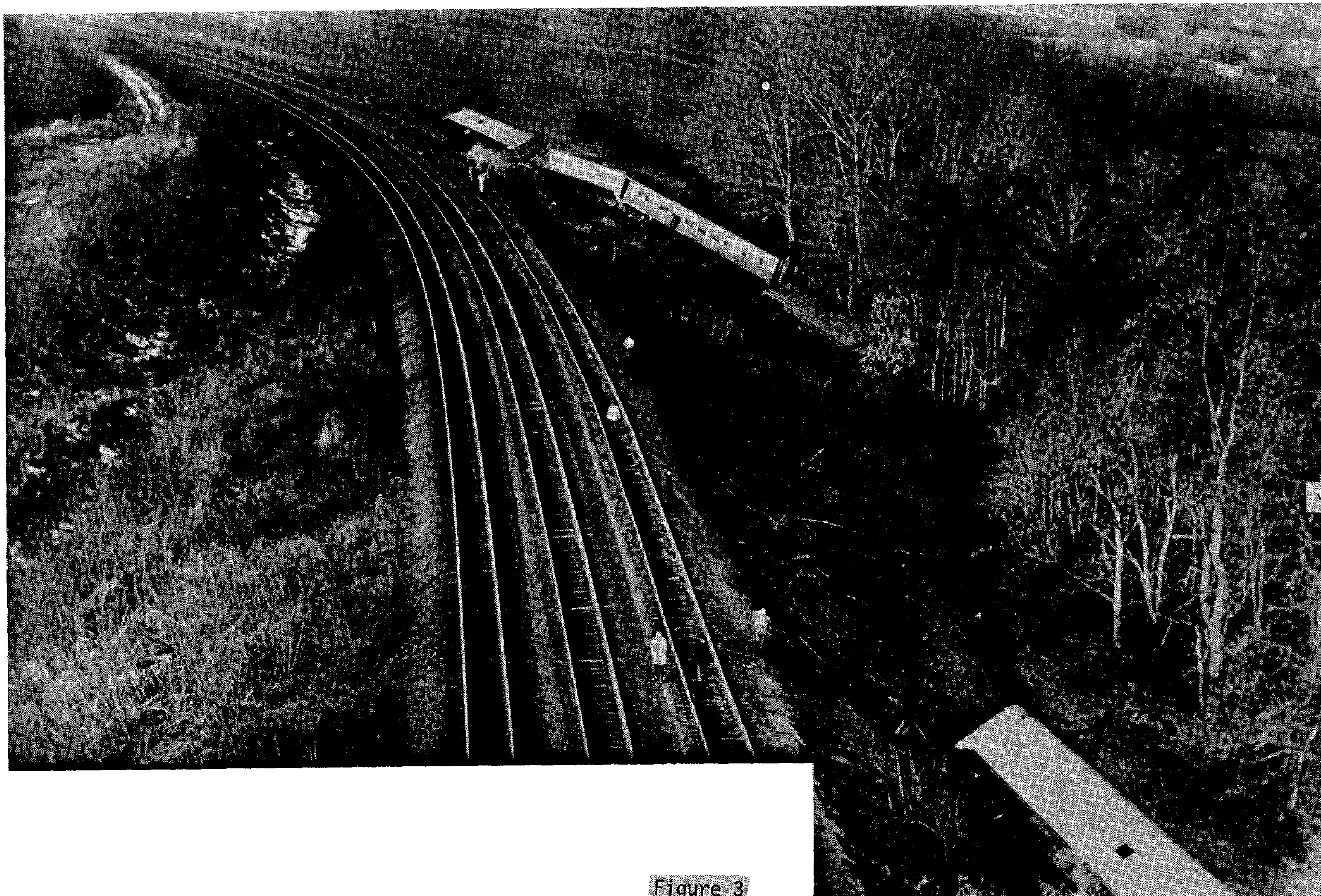

Figure 3

cinders. The depth of gravel averaged 26 inches. The gravel was relatively free-draining. Under the gravel was a layer of yellow-brown clayey sand and gravel averaging 23 inches in depth. This layer was underlaid with "a stiff and over-consolidated" Cretaceous Patapsco clay, natural to the area.

c. Stability

The maintenance history for this area indicated past difficulty with unstable soil conditions, although not with No. 3 track in the specific area where the derailment occurred. Instability had been experienced following periods of heavy rainfalls on No. 3 track commencing 416 feet north of the first derailed flange mark and on No. 1 track 217 feet south of the derailment. To correct this, in 1952, rails were driven vertically into the side of the embankments at 18-inch centers. Tracks 1 and 3 have been problem-free since this work was accomplished.

In 1970, localized settlement of No. 2 track was detected at a location 600 to 700 feet south of the derailment and, although it was initially corrected, it has been sporadically recurring.

Because of the history of roadbed instability in the area, a thorough investigation of conditions was initiated. The Board's technical staff and railroad personnel made studies, and the RF&P retained a geologist and a soils engineer to survey the circumstances and report their findings. The technical staff of the Federal Railroad Administration also presented an analytical approach to the subject.

The studies conducted by the geologist and soils engineer indicated that the ballast was in good condition, of sound quality, well graded, free-draining, and not susceptible to frost-heave or ice-lensing. The ballast was considered stable under existing conditions.

The investigation indicated that the Patapsco clay subgrade possessed a shear strength substantially higher than that required to retain the embankment at the observed slopes. Evidence of previous embankment movement was apparent in the area where trouble had been experienced in 1952. This evidence consisted of tilted trees and earth mounds (surface slumps). There were no similar signs adjacent to the derailment site. A survey was conducted to determine the location of No. 2 track as related to the original surveyed location, and no movement was detected.

The Federal Railroad Administration's study indicated that the maximum pressure on a crosstie did not exceed the average shear stress of the Patapsco clay.

5. Traffic

Some 342 trains utilized No. 3 track through the derailment area in the 30 days preceding January 27, 1970. Of this total, 313 trains were southbound and 29 were northbound. Train No. 10/76 was the first northbound train to use No. 3 track on January 26, arriving at the derailment site shortly after midnight on January 27.

The last train to use No. 3 track prior to the derailment was Train No. 91. This train was southbound and passed the derailment site approximately 2 hours before the accident occurred. The engineer estimated that the train speed was 55 miles per hour around the involved curve. No exceptions were noted.

6. Train No. 10/76

a. Passengers and Destination

RF&P Train No. 10/76 was a consolidation of Seaboard Coast Line Train 10 and 76. Train No. 10 originated in Columbia, South Carolina, and Train No. 76 in Jacksonville, Florida. The two trains were consolidated at Richmond, Virginia, and departed Richmond at 10:30 p.m. on January 26, 1970, destined for Washington, D. C. At the time of the derailment, 91 passengers were assigned to coaches and 10 to sleeping cars.

b. Equipment

The train consisted of one express car, one postal car, two baggage cars, four coaches, two sleeping cars and three diesel-electric locomotive units.

The three locomotive units were E-8 passenger A-units constructed by the Electro-Motive Division of General Motors. The locomotives were not equipped with speed-recording devices but did have speedometers. The locomotives were equipped with automatic train control with speed governors set for approximately 81 miles per hour.

The locomotives had two-way radios for communicating with land stations and other trains on the same frequency within range. The conductor was furnished a "walkie-talkie" radio which allowed communication with the engineer, land stations, and other trains within a limited range.

The express car, postal car, both baggage cars, and one coach were of all steel construction varying in weight from 79,200 pounds for the express car to 166,100 pounds for the coach. The other three coaches and the two sleeping cars were of stainless steel, lightweight construction. The weight of the coaches averaged 123,700 pounds each and the sleeping cars weighed 150,200 and 127,400 pounds, respectively. The express car had Type F, interlocking couplers. The locomotives and all other cars were equipped with Type H, tightlock couplers. The seats in the coaches were of similar types. Each seat had a reclining back, accommodated two persons, and could be rotated by manual movement. There was no positive latch to prevent the seat from rotating under crash loads. The windows of the passenger cars had double-glazed sashes with one-quarter inch plate glass on the outside and one-quarter inch laminated safety glass on the inside. The coach windows were retained in place by rubber molding. The coaches were equipped with overhead baggage racks on each side, with no restraining device to retain luggage in place except the slope of the rack and a lip on the edge. Each car was equipped with emergency tools sealed in a glass-enclosed cabinet, painted the same color as the wall of the car. The only exits provided were the doors at each end, opening inward.

c. <u>Trip</u>

The locomotives and cars had received the required inspection and tests before departing Richmond. During this inspection, it was noted that the sanders on the lead truck of the lead locomotive unit were not functioning because of an exhausted sand supply. Since sanders were functioning on the other two units and on the rear truck of the lead unit, the train was judged safe for operation and dispatched. Federal regulation, 49 CFR 191.235, requires that "each locomotive unit shall be equipped with proper sanding apparatus, which shall be tested before each trip." No other exceptions were taken during the inspection and testing of locomotives and cars.

Upon departure, Train No. 10/76 proceeded north on No. 2 track for approximately 80 miles until reaching Possum Point. At Possum Point, Train No. 10/76 crossed over to No. 3 track to avoid conflict with a local freight.

Two irregular occurrences were noted during the trip from Richmond to the area of derailment. The first occurred approximately 17 miles north of Richmond where a hot-box detector indicated an overheated journal on the seventh car in the train. The train was stopped and inspected by members of the crew. No hot journals were discovered, and it was assumed by the crew that the indication was triggered by steam escaping from a steam line. The second incident occurred approximately 10 minutes prior to the derailment. At that time, employees in the postal car heard a sudden, distinct noise resembling that occurring "if you hit the side of the car with a sledge hammer or some object of that nature." After a brief discussion as to cause, they dismissed the occurrence without notifying the engineer or conductor.

d. Crew

The engineer operated the locomotive from the seat on the right-hand side of the front end of the lead unit during the trip from Richmond. The engineer had an unblemished record since he entered service with the railroad in 1925. The fireman occupied the seat on the left-hand side of the operating compartment. The train crew consisted of the conductor, a flagman, a baggagemaster, and a porter. The rest and hours of service of the train and engine crew were within the requirements of the Hours of Service Law. Crewmembers had not received training in first aid or emergency evacuation procedures in qualifying for their positions, or subsequently.

In addition to RF&P employees, the sleeping cars were manned by porters employed by the Seaboard Coast Line, and the postal car carried 11 employees of the U. S. Post Office Department.

7. Derailment

Approaching Franconia, the engineer reduced the speed from 80 miles per hour to 70 miles per hour. He made a slight brake application (about 6-pound reduction) as he passed Franconia, and the train entered the south end of the curve at 65 miles per hour. By the time the brakes were released, the speed had been reduced to 62 miles per hour. As the locomotive approached the north end of the curve, the speed began to increase, and the engineer increased the throttle from No. 2 to No. 3 position. The train was running approximately 65 miles per hour at the time of derailment.

The speedometer had been checked against running time between mileposts at the start of the trip and had been determined to be accurate. This was confirmed later by calibrations in the shop.

Neither the engineer nor fireman saw or heard anything unusual as they traversed the curve. In the vicinity where the general derailment occurred, a severe lurch to the left was experienced on the locomotive and this was followed by an emergency application of the train brakes not initiated from the locomotive. Because he did not know what initiated the brake application, the engineer released the locomotive brakes but brakes on the cars remained in emergency application until the train stopped. Releasing the locomotive brakes allows the head part of a separated train to run faster than the rear part, thus preventing a collision of the two parts if they both were on the rails.

The first occupied car in the train was the postal car, the second car behind the locomotive. The supervisor of this car indicated that an increase in car vibration was first noticed as the train was going down the grade, and this was followed immediately by a definite lurch to the left. The lurch caused boxes to topple and mail to fall into the aisles. The postal supervisor stated that following the lurch, the vibration and car motion were similar to that of a derailed car. After the train stopped, an inspection indicated that the postal car was still on the rails but that the lead truck of the following baggage car was derailed to the east.

After the postal car, the next occupied car was the first coach, the fifth car in the train. The baggagemaster and porter were riding in this car, with approximately 15 passengers. The first indication of trouble was the derailment of the car and subsequent bouncing on the crossties.

The sixth car, and second coach, carried approximately 50 passengers but was not occupied by crewmembers. The first sign of anything unusual on this car was at the moment of derailment.

The third coach was not occupied by passengers because of malfunctioning lights; however, the train conductor was in this car. The derailment was his first indication of trouble.

Witnesses occupying the fourth coach and the two sleeping cars on the rear of the train stated that their first indication of anything unusual was at the moment of derailment.

The time of derailment was established as 12:10 a.m., January 27, 1970.

C. Results of Derailment

1. Trajectory of Cars and Casualties

The lead trucks of the third and fourth cars and both trucks of the fifth through the 10th cars derailed. There was a separation between the fifth and sixth cars, and between each of all following cars.

The third, fourth, and fifth cars remained upright and coupled to the head part of the train. The lead trucks of these cars derailed to the east, or inside of the high rail or the curve. The rear trucks of the third and fourth cars remained on the rails. The rear truck of the fifth car came to rest with all wheels west of the west rail. The south end of the fifth car stopped at a point 3,870 feet north of the first derailed flange mark. The head end of the locomotive was 4,435 feet from this first mark. During the derailment, and while bouncing over the crossties, luggage in the first coach, or fifth car, became disarrayed and fell from the overhead luggage racks. A few of the seats turned, but remained intact. Some of the passengers and crew were hit by falling luggage, but there were no serious injuries in this coach.

The sixth car, or second coach, experienced the most violent reaction upon derailment. This coach carried approximately 50 passengers. After derailment, this car first separated from the following, or seventh car, and continued northward on the west side of the track with the south end of the car partially down the bank. A separation between the sixth car and the preceding car then took place, and the car overturned and plunged down the embankment. The coach came to rest on its west side approximately 700 feet from where the general derailment occurred, 50 feet west of the track and 20 feet below.

During the derailment of the sixth car, the lights went off, luggage was disarrayed, seats turned, seat backs were dislodged and a water cooler overturned. At least eight people were thrown through the windows of the car, three of whom were injured fatally by being crushed between the car and the ground. Five passengers of the sixth car were hospitalized for periods ranging from several days to 7 weeks. A large number of the remaining passengers were examined, treated at local hospitals, and then released.

After derailment, and upon separation from the sixth car, the seventh through 10th cars headed down the embankment. The seventh car overturned onto its west side, the eighth car remained approximately upright, and the ninth and 10th cars overturned to the west at an angle of 70° from vertical. The seventh car came to rest approximately 80 feet from the track and 30 feet below track level, while the 10th car stopped 20 feet from the track and 5 to 10 feet below. The derailed positions of the sixth through 10th cars are shown in Figure 3 on page 9.

The seventh through 10th cars were sparsely occupied. Some seats turned during the derailment, and in the seventh car a seat broke loose, but, generally, interior damage was minimal. The lights remained on in some cars after the cars came to rest. Injuries were experienced in these cars, but no one required hospitalization.

Total casualties of the derailment included the three fatalities, five injured and requiring hospitalization, and 45 less seriously injured.

2. Rescue Action

a. Train Crew

When the emergency brake application was initially experienced in the locomotive, the engineer immediately contacted the one train in the area by radio, and advised that train crew to beware of obstructed track. Upon stopping, the engineer dispatched his fireman rearward to determine the difficulty.

Meanwhile, the baggagemaster, who was riding in the fifth car, determined that the third, fourth, and fifth cars were derailed and that the rest of the train had separated. After determining that no passengers in his car required immediate attention, he mounted the rear locomotive unit and used the radio to contact help. He was successful in contacting the operator at AF Tower, which is approximately 9 miles south of Washington. The baggagemaster advised of the circumstances, requested that train movements on all tracks be blocked, and asked for all emergency assistance available. The engineer and baggagemaster then left the fireman at the front end and went back to the general derailment to assess the situation and render assistance.

The conductor was injured during the derailment and was hampered in escaping from the overturned coach, but, upon getting out, he tried to contact help with his portable radio. He heard the transmissions between the baggagemaster and the operator at AF Tower. He later confirmed the fact that all tracks were blocked for train movement and that emergency help was on the way. The conductor then attempted to lend assistance to passengers.

The flagman was in a bedroom of a sleeping car and also was injured and had difficulty escaping. Since the car was overturned on its side, he had to make his way through the bedroom door which was overhead, and then crawl through the aisle passageway. He escaped from the car 20 minutes after the derailment occurred, and then rendered assistance to passengers.

The porters in the sleeping cars gave their general attention to the passengers in their cars, assisted them in escaping from bedrooms where doors were jammed, and helped them through the inclined aisles. In the ninth car, complete evacuation was not accomplished until rescue squads had arrived.

b. Passenger Escape

In spite of the obvious disaster experienced, calm prevailed among the passengers, and there was no panic following the accident.

Escape from overturned cars proved to be the major problem. The lights were extinguished on most of the cars by the derailment, and this hampered escape procedures. Except for the sixth car, all windows remained intact and escape from the seventh through 10th cars was accomplished through the regular exits on each end. In overturned cars, this necessitated maneuvering down the side of the car or aisle, avoiding seats, disarrayed luggage, and open bedroom, lavatory, or vestibule doors. In the last four cars, no apparent attempt was made to break windows for an avenue of escape.

On the west side of the sixth car, six windows were broken as the overturned car slid down the embankment and passengers were thrown out of the car. The broken-out window openings were used as escape routes for many passengers after the accident. In addition, a window was broken on the east side of the car during rescue operations. No attempt was made to use emergency tools to facilitate escape in any of the cars.

Upon emergence from the cars, passengers assisted the injured. One particularly helpful unidentified passenger was singled out for his actions and assistance. This passenger had indicated he had received previous rescue squad training.

c. Rescue Squads

The RF&P had established a comprehensive listing of procedures to be followed in an emergency. The procedures outlined the course of action for various occurrences and resulted in positive steps in this instance. The radio transmission between the baggagemaster and railroad personnel initiated immediate, efficient action to effect rescue and protection.

Emergency equipment, representing fire, police, and rescue squads from three jurisdictions, responded to the call for help. The first units arrived at the scene within 10 to 20 minutes after the derailment occurred. Evacuation of the injured, protection against subsequent hazards, and organizations of followup operations were quickly accomplished by rescue and railroad personnel.

3. Equipment Damage

a. Locomotives

The three locomotive units were thoroughly inspected immediately following the derailment and subsequently upon movement to Washington and back to Richmond. The inspections included observations for impact damage that would occur upon striking an object on the track. The condition of the locomotives met the prescribed standards. There was no indication that any object was struck.

b. Cars

The first two cars did not derail and therefore incurred no damage. These cars offered no clue as to the cause of derailment. The third and fourth cars incurred minor wheel damage on the derailed lead trucks. The fifth car sustained side paneling damage on the west side, and the uncoupling lever on the west side, south end, was missing. There was evidence that this was caused by uninstalled crossties distributed adjacent to the track. The coupler yoke broke on the south end of the fifth car. The yoke was found 30 feet north of the sixth car with indications of an entirely new break.

The sixth car incurred considerable structural damage on the west side, including several large indentations in the roof. Creosote marks indicated that some of this damage resulted from striking a telephone pole or uninstalled crossties. There were also dirt and debris lodged in the roof, indicating that the car had completely overturned onto its west side. The six large windows accommodating the main seating area of the coach were broken out on the west side of the car. The west side uncoupling levers on both ends of the sixth car were bent and inoperative and the car incurred considerable underside damage. However, the structure was essentially intact, except for the lost retention capability of the large windows. Figure 4 on page 19 shows the west side of the sixth car after the car was rerailed. Figure 5 on page 20 shows the interior of this car.

The seventh through 10th cars received only minor structural damage, but all incurred considerable underside damage. The uncoupling levers on all of these cars were generally bent, inoperative, and in some instances had parts missing. The knuckles on the south ends of the seventh and ninth cars were open, and the coupler stem on the south end of the eighth car was broken, but the knuckles remained coupled.

The evidence indicated that all damaged or missing parts resulted from the derailment. No condition of the cars was detected that could have caused or contributed to the initial derailment.

c. Miscellaneous Equipment

Two items were discovered in the wreckage that were foreign to the train and track structure. The first consisted of a spike puller used by maintenance crews in the tie renewal work. The machine was part of the equipment that had been used in the renewal

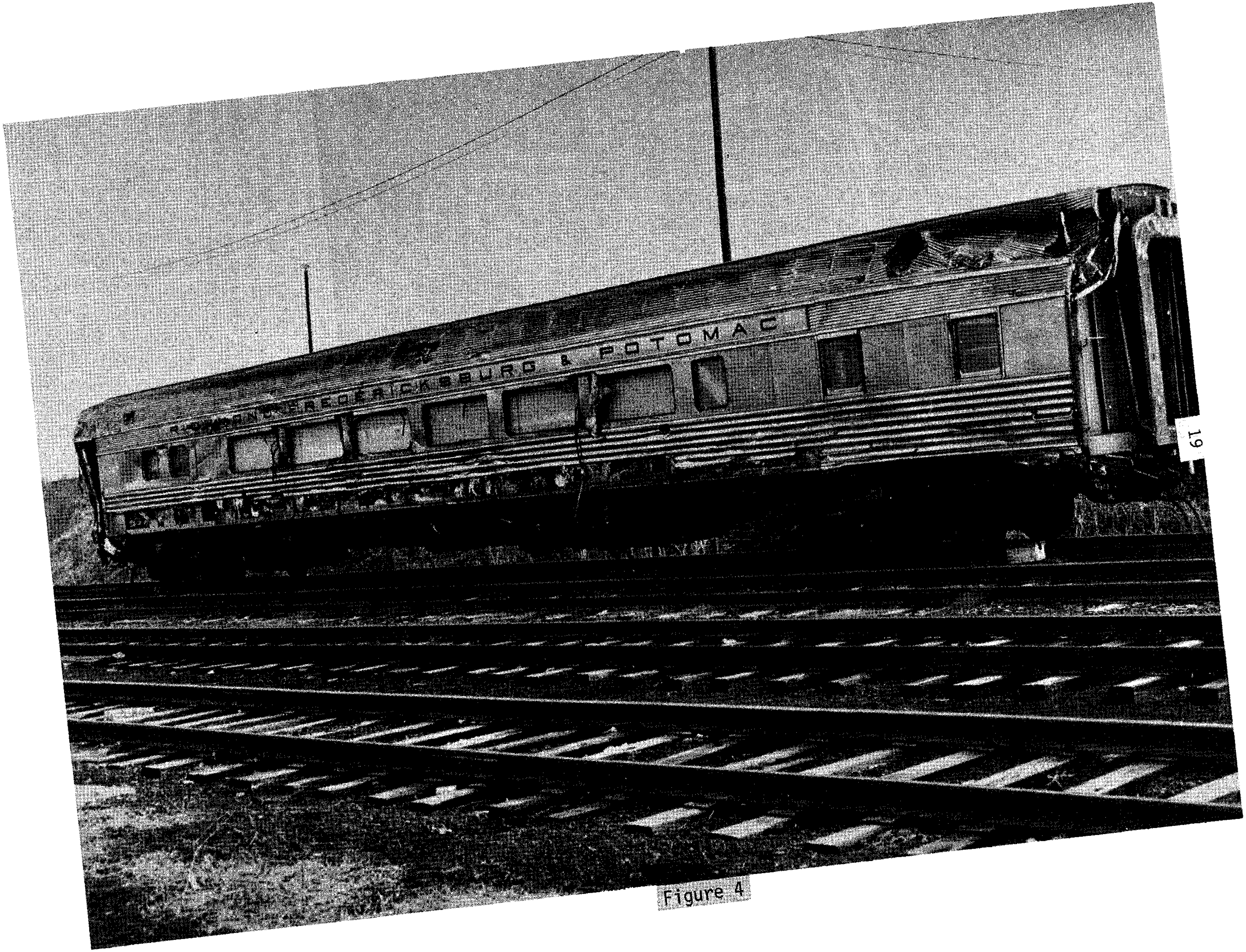

Figure 4

Figure 5

work on January 2, 1970, and had been stored west of No. 3 track since that time. The machine was found approximately 30 feet west of No. 3 track, 137 feet north of the first derailed flange mark adjacent to the 10th car. The machine was completely destroyed from impact. As originally constructed, the spike puller was approximately 4 feet high, 4 feet long, and 8 feet wide, and weighed 690 pounds.

The second item discovered was a bicycle which was found under the seventh car. The wheels of this bicycle were bent and the back portion crushed. There was no indication that the wheels of the train had passed over it.

4. Track Damage

No. 3 track was the only one damaged by the derailment. The damage extended over 4,260 feet, commencing at a location 156 feet south of the first derailed flange mark. The first 200 feet of damage consisted of the track being moved westward on the roadbed. The movement over this area varied proportionately from zero to approximately 4 feet. The track was basically intact through this initial 200 feet. Figure 6 on page 23 shows the track movement.

The track was then torn up for approximately 200 feet in the general derailment area. In the area where the cars plunged over the embankment, a joint in the west rail separated because of broken bolts. Figure 3 on page 9 depicts the track damage in the derailment area.

The track was disturbed from the original roadbed for a total distance of 1,289 feet. To the north of disturbed track, damage was light and consisted primarily of the broken bolts, spikes, and anchors associated with derailed wheels bouncing over crossties.

The first unusual marks found on the track structure in the direction of movement were located 5,457 feet north of Franconia. These flange marks were inside of the west rail as shown in Figure 7 on page 24. One wheel flange was following the west rail, riding the edge of the tie plates, while a second wheel was riding the crossties and progressing toward the center of the track. Indications of this movement continued into the general derailment area. North of the general derailment, flange marks on the crossties were noted inside and outside of the west rail, as would be expected by the derailed position of the third through fifth cars.

5. Cost of Derailment

The estimated cost of the derailment to the RF&P was:

Track and roadbed	$ 11,500
Equipment	180,550
Personal injuries	445,000
Total	$637,050

Legal costs, the delay to passengers, and the interruption of freight service were not considered in the above costs.

Figure 6

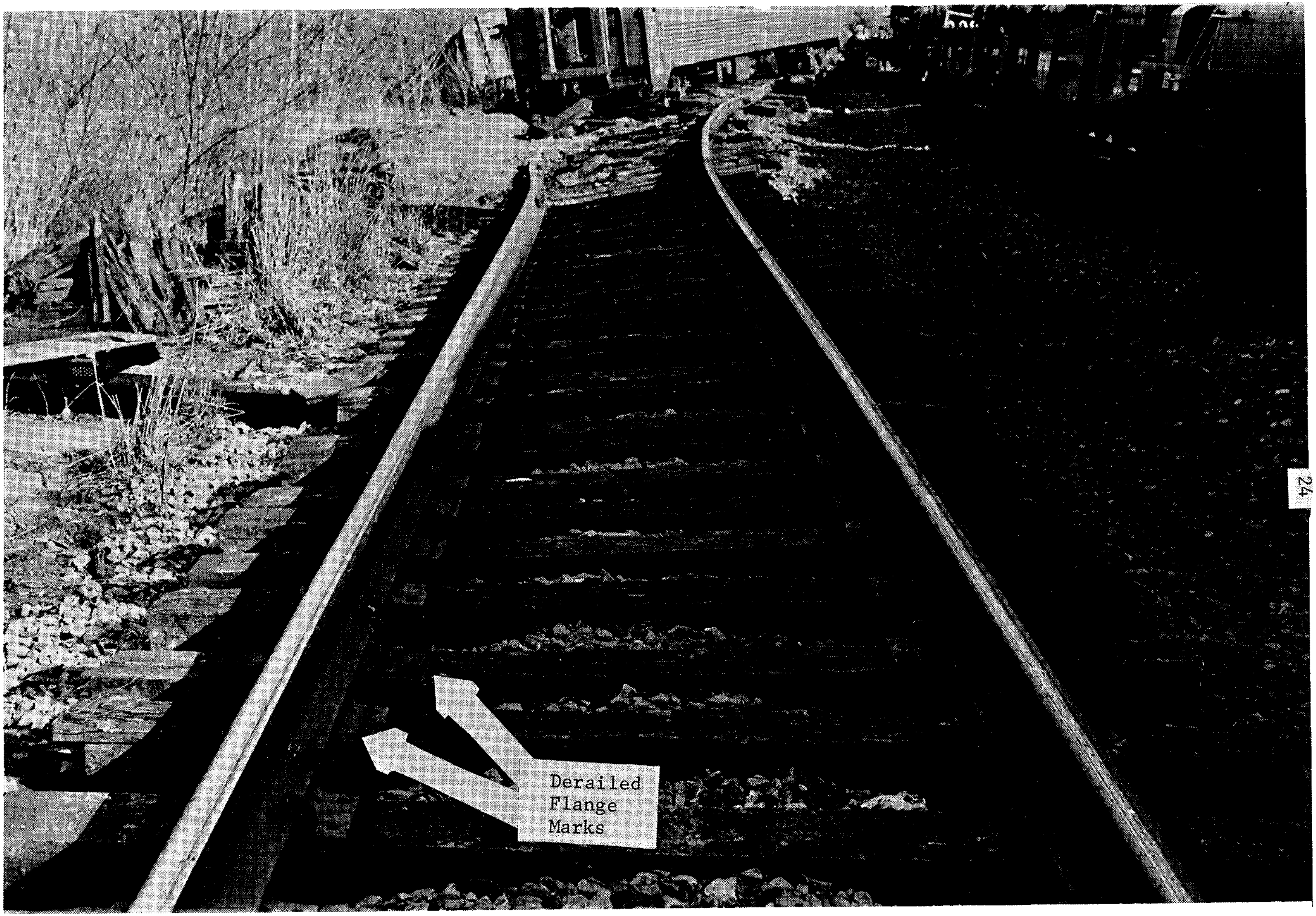

Figure 7

III. ANALYSIS

A. Consideration of Noncausal Factors

1. Equipment

A thorough inspection and investigation of all equipment of Train No. 10/76 revealed no condition that would cause, or contribute to, the derailment. Although equipment failure was detected, the evidence indicated that the failures occurred after initial derailment. Although the lead unit of the locomotive was dispatched from Richmond without a sand supply for the lead truck in violation of Federal regulations, this was not a contributing factor in the derailment and, because the locomotive brakes were released, had no effect in stopping the front portion of the train.

2. Objects on Track

The engineer and fireman were observing the track as the train approached the derailment area and did not see anything on the track or hear or feel the locomotive strike anything. A thorough inspection of the locomotive immediately following the derailment revealed no impact damage. The size of the spike puller would indicate that it would be observed or that a collision would be heard if it were hit. In addition, the weight of the machine would make it very difficult to be placed on the track by vandals.

Consideration of all evidence indicated that a foreign object on the track did not cause the derailment.

3. Operation

Because speed recorders were not used, it was necessary to establish whether the speed of train operation at the time of the accident was in accordance with rules and testimony. To accomplish this, two sets of tests were arranged to simulate the conditions of January 27, 1970. Although those tests did not indicate the speed of the train at the time of derailment, they did corroborate the engineer's testimony as to the behavior of the train preceding the moment of derailment. (See description of engineer's actions on page 13) There was no evidence to disclose that the train was going faster than the 65 miles per hour stated by the engineer.

4. Roadbed

If the derailment resulted from settlement of the track, the settlement would necessarily be induced by either (1) a mass movement of the embankment; (2) softening or settlement of the ballast; or (3) localized failure of the subgrade.

Mass embankment movement in this area had not been experienced since 1952, and then the movement had been preceded by periods of heavy rainfall.

Precipitation had not been excessive prior to the derailment, and the ditches appeared to handle the runoff that occurred. This, coupled with the natural shear strength of the Patapsco clay and the lack of visible or measurable evidence of embankment sliding, discounted the theory of mass movement.

Settlement of ballast is not an abnormal experience in railroad track maintenance, but settlement generally occurs in a gradual manner with insufficient magnitude to derail a train or cause a severe lurch to the left as described. Because the tie renewal work had been performed when temperatures were recorded below freezing, ballast softening, or settlement, had to be considered as a causal factor.

The geologist, retained by the railroad, summarized his investigation as follows:

> "Though ballast conditions may not have been perfect, there was normal machine compaction under fair conditions on January 2, 1970, at the time of ballast reworking. The writer concludes there was little to no chance for freezing of the ballast in a manner to cause subsequent settlement, unless the ballast was not up to normal compaction."

The evidence did not disclose any abnormality in ballast compaction, and therefore softening or settlement of the ballast was dismissed as the cause of the derailment.

Localized subgrade failure would provide a reaction similar to that of ballast settlement, which again is not consistent with the description of the accident. The depth of ballast and sub-ballast also suggested that the shear strength of the relatively compact Patapsco clay was not exceeded. To confirm this, the Board's techncial staff made an analysis of soil pressure consistent with current practice. Although it is conceded that the present state-of-the art of track dynamics is largely empirical with many indeterminants, the resulting soil pressure did not approach the shear strength of the Patapsco clay.

The Federal Railroad Administration also made an analytical investigation of subgrade failure and their conclusions were consistent with those of the Board.

B. Causal Factors

The Board's reconstruction of the sequence of events that led to the derailment of Train No. 10/76 is as follows:

The trackwork accomplished in this area prior to the derailment markedly decreased the resistance of the track to lateral movement. It also resulted in the destressing 2/ of the rail at a temperature well below the mean temperature for the region. The relatively sudden temperature increase on January 26, coupled with the location on a substantial grade, resulted in compression and a tendency for the rail to relieve the compression by moving northward. The track had inadequate anchorage to resist longitudinal rail movement and the passage of southbound trains throughout the day intensified rail movement and stress buildup. The northbound movement of Train No. 10/76 moved both rail and track ahead of the train concentrating lateral stresses at locations with track irregularities. The wavelike motion of the track ahead of the train further reduced its resistance to lateral movement, and lateral buckling occurred immediately ahead of the locomotive as the locomotive approached. The misalignment felt by the engineer was progressively increased by the lateral accelerating forces induced by the equipment moving around an irregularly curved track, and the derailment followed when the wheels could no longer follow the increasing misalignment.

The inital derailment evidently occurred at the first flange mark shown in Figure 7. The locomotive and following two cars were able to negotiate the initial misalignment but their movement over the buckled track increased the outward curve in the track until the lead truck of the third car derailed. Because of the abrupt change in alignment to the west and the rocking of equipment traversing the irregularly curved track, the derailment occurred to the east, not outwardly on the curve. With the passage of the train, the track continued to slide outward. This continual movement was indicated by the diverging paths of the initial two sets of flange marks.

One set of wheels followed the inside base of the west rail flattening rail-holding spikes and pushing outwardly against the rail. At one rail joint, track bolts were sheared off at the inside of the joint and the centrifugal force of the train, acting to place tension on the rail, caused the remaining three bolts to fail. With all lateral restraint removed, the rear of the fifth car moved to the outside of the track structure and the trailing cars followed. Crossties stored along the track were then struck. They spun up and hit the uncoupling levers between the sixth, seventh, and following cars, allowing the cars to separate and go down the bank where they subsequently overturned. The sixth car at first remained coupled to the preceding car but the rear portion of this car slid down the bank as the head end of the train continued on. The strain and twisting motion exceeded the design stress of the coupler yoke, and it failed. The sixth car subsequently went down the bank and overturned.

The above analysis indicates that the causal factors of the initial derailment, acting in combination, were: (1) the substandard ballast section reduced the resistance of the track to lateral movement; (2) the disturbed ballast reduced the resistance of the track to lateral movement; (3) the

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2/ Rail is destressed when restraints (rail anchors) are removed and the rail adjusts itself to a stress-free condition at the prevailing temperature. After the rail is re-anchored, it is in compression at temperatures above the destressed temperature and in tension at temperatures below the destressed temperature.

renewal of most of the crossties, not yet solidly embedded in the ballast, reduced the resistance of the track to lateral movement; (4) the destressing of the rail at a temperature significantly below the mean temperature for the area resulted in a compressive outward force in the rail when the temperature increased on the day of the accident; (5) the irregularities in track geometry resulted in shaking of the track while a lateral force was applied; (6) the rail was inadequately anchored for the grade and operating conditions; and (7) the normal wavelike motion of the track ahead of the train reduced the resistance of the track to lateral movement while a lateral force was applied. With the exception of the increase in temperature, the location, and the wavelike motion of the track, all factors were controllable and these items would not have been problems in the absence of other factors.

Perhaps the most predominant causal factor was the uncompleted tie renewal work which had been suspended. Initially, the prudence of deferring tie renewals until 70 percent replacement was necessary is questionable, particularly on a 2^{o} curve. The chief engineer indicated that deferred maintenance was not involved in this decision, but that it resulted from a very high replacement factor during World War II. In any event, the practice of replacing of an average of 16 of 23 ties per rail length without restriction of speed or operations, and without prompt completion of the work, warrants reexamination. The practice of renewing a high proportion of ties has received some reappraisal by this railroad as the RF&P now restricts speed to 45 miles per hour when such work is being accomplished.

The instability of track immediately after it has been disturbed in its entirety has long been recognized by railroad personnel. This recognition is aptly illustrated in the following RF&P Rules: 3/

"2.-B Tie Renewal:

* * * * *

2. When renewing ties, the track must be considered obstructed where two adjoining ties on tangents, or three adjoining ties on curves, on each side of the tie removed, are not fully spiked, tamped and in sound condition.

* * * * *

2.-E Raising Track and Maintaining Cross Level:

1. The track must be considered obstructed where the line and surface has not been completed and the track has not been ballasted so that 1/2 the thickness of the ties extends above the level of the ballast.

* * * * *

2.-G Cleaning Ballast:

1. The track must be considered obstructed where the track has been skeletonized during process of cleaning ballast.

* * * * *

3/ Appendix C.

CROSSTIES

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6. Whenever possible tie renewals should be made at the time that the track is being surfaced to secure more uniform bearing for the new ties. Where it is necessary to make spot tie renewals without surfacing the track, extreme care must be taken to see that the new ties are properly tamped and maintained in good bearing against the rail."

Evidence at the hearing indicated that these rules were not intended to apply to the type of trackwork accomplished prior to the derailment; however, as a result of this trackwork all of the conditions described by these rules existed.

Following the trackwork on January 2, and prior to the accident, the track was inspected four times by the foreman-inspector and once by the chief engineer. Neither these people nor the other railroad witnesses connected the underlying principles of the above rules with the circumstances that were present with respect to the trackwork accomplished at the derailment site and similar work done over the entire railroad. It appears that with the advent of trackwork mechanization, established rules have been discarded without replacement and without a thorough examination of their original purpose.

There were no written objective standards being enforced which specified the minimum condition for safe track. The RF&P chief engineer, track engineer, and track supervisor were not able to recite a consistent opinion as to what constituted a minimum safe track. The chief engineer described the track immediately south of the point of initial derailment which did not have the ballast regulated (Figure 1 on page 7.) as "perfectly safe." The track engineer thought the ballast section should conform to the requirements of the American Railway Engineering Association (AREA), but considered that track shown in Figure 1 as acceptable because it was not finished. He said this in spite of the fact that he acknowledged that the variations exceeded the measurements which require that the track be considered obstructed. The track supervisor said that even though the ballast was not up to the standard which he described as 2 inches below the tops of the ties, he saw nothing that, in his opinion, made the track unsafe for 65 miles per hour. Further, he said that if those ballast conditions were encountered in finished track by a track inspector, it should be reported for correction. The opinion expressed by the chief engineer and his staff, that certain criteria were not applicable to that track because the tie-renewal work was incomplete, is a dangerous one when viewed in the light of a suspension of work which exceeded 3 weeks.

As indicated, instability immediately following disturbance of track in its entirety has long been recognized. Testimony at the hearing indicated that concern for instability was prevalent when the track had been skeletonized, surfaced in its entirety, or when the weather was hot. Although concern under these circumstances is justifiable, the same conditions were introduced in the trackwork performed in December and January prior to the derailment.

The track was not skeletonized in its entirety but 70 percent of the crossties were removed. This necessitated the removal of all ballast from the outside ends of old crossties. In order to insert the new crossties, a tiebed scarifier loosened and removed ballast from the bottom of the tie beds and from the cribs. The tamping of the new crossties used additional crib ballast. The net result was skeletonized track. The track in the area of initial derailment was left in this condition.

The track was not surfaced, but again the 70 percent tie renewal resulted in a condition quite similar. In addition to tamping and disturbing ballast on all new crossties, a few of the old crossties were tamped where joints were observed to be low. Most of the old crossties were not tamped, but disturbance of these crossties occurred with the high percentage of tie renewals. Ballast particles ranged in size from one-quarter to 3 inches. The use of 3-inch ballast for tamping track resulted in voids, the number and size dependent upon the gradation of the ballast. The net result was track with a preponderance of new crossties that were not embedded in the ballast, and the crossties had an unknown number of voids beneath them. The old crossties remaining had also been disturbed and thus, in practicality, the track possessed the qualities of newly surfaced track with insufficient ballast.

The weather was not hot on the day of the derailment, reaching a maximum of 60° F. Hot weather generally would be assumed if the temperature reached 90° F. The temperature was hot, however, in relationship to the destressed temperature of the rail. In this instance, when the crossties were renewed, it had been necessary to remove and reapply a majority of rail anchors. This resulted in the rail being destressed to the temperature of the date work was performed, or a maximum of 41° F, average of 33° F. The minimum 19° F. temperature variation, between 60° F. and 41° F, would bear the same relationship as 71° F. would to 90° F. and, therefore, the amount of expansion of the rail would be the same.

Jointed rail on the RF&P is anchored in accordance with the following rules: 4/

"a. Tracks with essentially One Direction Traffic
. . . Eight (8) rail anchors will be applied per 39 foot rail to prevent movement of rail in direction of traffic and four (4) rail anchors will be applied to prevent movement of rail in the opposite direction . . . .

4/ Appendix C.

b. Tracks with Traffic in Both Directions
. . . Eight (8) rail anchors will be applied to prevent movement in each direction (16 per 39' rail) . . . ."

The rail on No. 3 track was anchored for "Tracks with essentially One Direction Traffic." The anchorage was accomplished in 1953 before two-way signals were installed. No additional anchors were applied when two-way signals were installed which allowed train movement in each direction without restriction. AREA's "Manual of Recommended Practice" has recommendations for anchorage essentially consistent with that of the RF&P except that only two backup anchors per 39-foot rail are required for a "Main Track Carrying Traffic Essentially in One Direction." AREA's recommendations are supplemented by the statement "Additional anchors should be used where needed." The requirements for anchorage are therefore vague. What constitutes "Tracks with essentially One Direction Traffic" and "Tracks with Traffic in Both Directions" is merely a matter of interpretation. The two situations are not objectively defined.

Rail has a tendency to creep with traffic direction, but it also has a tendency to creep downgrade even against traffic. The derailment site was located on a 0.75 percent grade approximately 7,000 feet north of the summit. No apparent consideration for grade or the amount and speed of northbound traffic was given in establishing the anchorage requirements for this location, and no restrictions were in effect on routing trains. The fact that eight anchors are required to restrain rail movement in one direction implies that four anchors, or two as the case may be, are insufficient to restrain rail movement in the opposite direction. This is further confirmed by present procedures for anchoring welded rail which call for the same anchorage in both directions regardless of traffic. Under some circumstances, the same forces could be induced in either direction, and therefore it appears that the standards for anchoring jointed rail are based on experience rather than on an analytical approach.

As indicated, the RF&P rules involving tie renewal, raising track, cleaning ballast, and rail anchor application all required interpretation and judgment of individuals to be applied. Objective rules existed, however, in measureable allowable variations for cross level, surface, and gage, and are shown in Appendix C. The inspection of 761 feet of undisturbed track south of the derailment site indicated that the track did not conform with these standards in the specific areas of (1) change in cross level, (2) difference in cross level, (3) variations in superelevation, (4) permanent runoff, and (5) gage. In addition, irregular alignment was noted as shown in Appendix D.

The standards set forth in the "Rules and Instructions for the Government of Maintenance of Way Employees" were issued in 1949 or 1950. The RF&P's engineer-of-track indicated they were intended as minimum standards and are now considered as "idealistic" rather than minimum standards. The man in the field is allowed latitude in the rule interpretation. Despite experience, interpretation is necessarily tempered by comparison to conditions observed elsewhere, and standards possibly intended to be objective again became a judgment matter.

The measured track irregularities south of the derailment site, without the other conditions, were not of sufficient magnitude to cause a derailment. For the most part, they would affect ride comfort only to an experienced observer. They would, however, induce additional stresses on the track structure and equipment when traversed by a train. These stresses would be supplemented by gravitational, dynamic and centrifugal forces and also forces caused by designed slack in equipment components. The net effect would be a lateral force that could start or amplify lateral movement of the track.

The track irregularities could also produce a lateral force without train movement or weight. An alignment irregularity could induce a lateral component resulting from internal compressive rail stresses. On curved track, the curvature also produces a lateral component for internal rail stresses and together, these stresses may induce buckling.

Track is flexible by design and tends to lift in a wavelike motion ahead of a train. At the moment this occurs the friction between the bottoms of the crossties and the ballast is drastically reduced and the restraining effect of ballast in the cribs and at the tie-ends becomes more important. This wavelike action of the track is normal, but when coupled with a substandard ballast section, newly surfaced track, compressive stresses in the rail, and track irregularities, the momentary reduction of lateral restraint by the wave motion appears to have been the initiating factor for lateral movement in this instance.

The track possessed characteristics which increased the probability of lateral movement upon completion of work on January 2, 1970. Prudence and the objective measurable standards, dictated that the track be operated restrictively. This was not done, however, and 24 days went by before the derailment occurred. On January 26, additional forces were introduced by the substantial increase in temperature and the train movements on that date.

A relationship between the lateral movement of track and the disturbance of track by trackwork has been noted in previous cases. The track movement has not followed immediately the trackwork in all instances. The Penn-Central derailment at Glenn Dale, Maryland in 1969 5/ was attributed to buckled track. Surfacing and tie renewals at this location had occurred 2 or 3 months prior to the accident. In England, the British Railways experienced two derailments

5/ NTSB Report No. RAR-70-1.

in 1968 and three in 1969 attributed to the lateral movement of track. The incidents occurred at varying time intervals following trackwork, and a discussion of these accidents is included as Appendix E of this report.

Although the Board's analysis indicates that the lateral movement of the track was probably initiated in an area immediately in front of the locomotive of Train No. 10/76, it is conceded that another possibility exists. This involves the same basic principles and causal factors and differs only in the time at which lateral movement of the track took place.

It is possible that the initial buckling occurred under the rear portion, or in the wake, of the southbound train that used No. 3 track approximately 2 hours prior to Train No. 10/76. If this did occur, the evidence indicates that initial misalignment was slight, as it was not felt by anyone on the preceding train or seen by the engineer and fireman on Train No. 10/76. Corrective measures to prevent this possibility would be consistent with those for the determined cause.

C. Factors Contributing to the Seriousness of the Accident

1. Track Structure

If the rail joint had not failed following the initial derailment, it is probable that the west rail would have provided sufficient restraint to retain the derailed train on the roadbed. The capability of rail to perform this function has been long recognized and was apparent with the third, fourth, and fifth cars, all of which were derailed. The retention of the train on the roadbed would have in all likelihood resulted in only minor injuries.

The susceptibility of the present joint bar design to shear damage from derailed or dragging equipment has been evident in the past. The obvious solution involves the elimination of the joint through use of welded rail which has many other inherent advantages.

The crossties distributed along the roadbed, while not part of the track, were a track component. These crossties contributed to the seriousness of the accident inasmuch as they evidently were kicked up with sufficient force to operate the uncoupling levers and cause cars to separate. The practice of crosstie distribution can hardly be questioned in the present state-of-art of railroad construction and maintenance, but the time interval of exposure is controllable. In addition to the rather infrequent circumstances experienced in this incident, distributed crossties, whether new or old, present hazards to employees, potential for placement on track by vandals, and interference with drainage.

2. Equipment

Although equipment defects or failures were not a factor in initiating the derailment, equipment design was definitely a causal factor in the seriousness of the accident. After the cars were derailed, separation took place which led to overturning and the subsequent fatalities and serious injuries.

All cars affected were equipped with Type H, tightlock couplers. These couplers have been used extensively in passenger equipment, and it is general opinion that they retain the connection between cars upon derailment. In this instance, the initial separation between the sixth and seventh cars started the chain of events that resulted in loss of life.

Inspection of the coupler mechanism did not reveal any defects in construction. There was evidence, however, indicating that the uncoupling levers had been struck by crossties distributed along the track. To operate the uncoupling levers it is first necessary to lift the lever and then, holding it in a raised position, rotate it circularly upward approximately 45°. Evidently, the vibrations during the derailment, the flying crossties, and subsequent dragging in the mud provided sufficient force on the lever to duplicate the uncoupling operation, and separation occurred. This was not a chance occurrence, as indicated by the fact that separations occurred in this manner between the sixth and seventh, seventh and eighth, and ninth and tenth cars. It appears that relatively simple modifications of design would eliminate this occurrence and that the matter should be pursued further. If the cars had remained coupled, the tension in the train would have been maintained, the probability of the cars remaining upright and in line with the track would have increased considerably, and the incidence of fatal injury might have been obviated.

The largest number of injuries incurred by the train's occupants were minor and resulted from passengers and luggage tossed about. The lack of securement for passengers and luggage was also a factor in injuries sustained in the Penn-Central derailment at Glenn Dale, Maryland, previously referred to, and has been an element of other train accidents. The problem could be at least partially alleviated through the permanent anchorage of seats, installation of luggage compartments or retention devices, and by the use of seatbelts.

The structural integrity of the cars was not a factor in the injuries suffered, as the cars survived the accident relatively structurally intact. The retention of integrity of the major structure of the cars is again demonstrated to be a remarkable feature of cars of this type and an important factor in minimizing injuries.

All fatalities and most of the serious injuries were incurred by passengers thrown from the overturned sixth car. The injuries were not serious where windows did not fail. The installation, and use, of seatbelts would markedly reduce this possibility in similar incidents, but further protective measures not involving seatbelts appear available. All of the large windows on the west side of the sixth car were broken or dislodged during the derailment, despite the fact that the surrounding structure was not grossly damaged. The size and method of fastening the windows appeared to be a factor as smaller windows in the same and other cars withstood the derailment forces. It is possible that the structure surrounding the windows was elastically distorted, and the mode of fastening the windows did not adequately resist this distortion, even though no permanent deformation occurred.

3. Accident Preparedness

Although the RF&P has established a comprehensive list of emergency procedures, the procedures did not include the actions to be taken by the train crew at the scene. The performance of the train crew in this accident was satisfactory in relation to train handling and protection; however, in many cases, passengers were left to take care of themselves.

The operating rules of the railroad were explicit in instructions on protecting the train involved, protecting other traffic, and reporting of all details within 24 hours in the event of accident. Other than in general terms, however, there were no instructions, rules or training programs indicating the steps that should be taken to evacuate, inform, assist, and protect passengers in the event of an emergency. Passengers were expected to know of emergency exits and tools by observance rather than by signs and instruction by the crew. Train crews located themselves before the accident in that portion of the train that was least occupied rather than where the majority of passengers were located, and where they could have been of some assistance.

By contrast, airline accident preparedness is extensive. Passengers are furnished written instructions and briefing as to the location of exits and actions to be taken in the event of emergency. Stewardesses are trained, and react in the evacuation of passengers. They are also trained in first aid and have first aid kits readily available. Perhaps most important is the fact that they are available to provide guidance and reassurance when required. The merit of having a person available, trained in first aid and emergency procedures, was aptly illustrated in the Penn Central derailment at Glenn Dale, where a railroad nurse was available, and, in this accident, by the efforts of the unidentified passenger who had received rescue squad training.

Railroads have extensive safety programs involving the education of employees for the safe performance of their duties as it affects the individual and fellow employee. Railroads also furnish and promote the use of various safety appliances by employees. It appears that similar consideration should be given to the railroad passenger.

IV. CONCLUSIONS

1. The initial derailment occurred at the first flange marks on the crossties.

2. Equipment defects or malfunctions were not causal factors in the initial derailment.

3. The lead locomotive unit was dispatched from Richmond with a depleted sand supply for the lead truck in violation of Federal regulations. This violation did not cause or affect the derailment. Train No. 10/76 was being operated in accordance with all other applicable rules and regulations at the time of the derailment.

4. The train did not strike a foreign object on the track before the derailment.

5. The train did not exceed the maximum authorized speed.

6. Failure of the ballast or subgrade was not a causal factor in the derailment.

7. Track inspections on the RF&P were not accomplished in accordance with the "Recommended Minimum Track Inspection Standards" adopted by the Association of American Railroads on December 18, 1969.

8. The trackwork in the area resulted in a product that did not conform to RF&P rules and instructions for the work. The work produced a track with decreased resistance to lateral movement, having rail inadequately anchored and having rail destressed to a temperature below the mean for the area.

9. Track maintenance was accomplished through the application of experienced judgment rather than measurable objective standards. Rules and instructions were subject to interpretation dependent upon circumstances. Existing rules had not been updated to conform with the practices of trackwork mechanization.

10. The anchorage of jointed rail was based on experience and was inadequate to restrain rail movement induced by temperature, grade, and train movement.

11. Track is not designed to restrain derailed equipment on the roadbed and the use of jointed rail decreases the resistance to equipment excursion upon derailment.

12. The Type H, tightlock couplers did not prevent separation between cars because uncoupling levers were capable of being operated by objects along the track.

13. Most of the passengers were injured by being thrown from their seats or by luggage dislodged from overhead baggage racks. The major structure of the derailed cars performed in a highly satisfactory manner in protecting the passengers. The fatalities and the most seriously injured were passengers thrown out of the sixth car through the large coach windows, broken from a relatively undamaged frame structure.

14. The efficient handling of the emergency by the police and rescue units, after derailment and notification, can be attributed to the prior establishment of emergency procedures by the railroad.

15. Train crews were not instructed in emergency procedures for evacuating, informing, assisting, and treating passengers; consequently, in many instances immediately following the derailment, passengers were left to take care of themselves.

V. PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the derailment was the lateral movement of the track immediately ahead of the locomotive, due to conditions resulting from inadequate track maintenance procedures

VI. RECOMMENDATIONS

(The number after each recommendation relates to the conclusion that led to it.)

The Safety Board recommends that:

1. The RF&P Railroad Company take the necessary steps to ensure that employees comply with existing regulations pertaining to the maintenance and operation of equipment. (Conclusion 3.)

2. The RF&P Railroad Company require that track inspections be accomplished at least in accordance with the "Recommended Minimum Track Inspection Standards" of the Association of American Railroads until uniform regulations are established by the Federal Railroad Administration. (Conclusion 7.)

3. The Federal Railroad Administration with the cooperation of the American Railway Engineering Association and the Association of American Railroads, conduct studies, research, and testing to determine the interactions involved in the lateral movement of track. (Conclusions 8-10 incl.)

4. The RF&P Railroad Company review and update their existing "Rules and Instructions for the Government of Maintenance of Way Employees" consistent with current practices and theories in track maintenance and construction to cover the interim period until uniform regulations are established by the Federal Railroad Administration. Rules should be established and enforced, providing objective measures of track condition and definite criteria for correction. (Conclusions 8-10 incl.)

5. The Federal Railroad Administration institute immediate regulations requiring the equipment of all future, new and rebuilt, passenger cars with secured seats, and luggage retention devices. (Conclusion 13.)

6. The Association of American Railroads and the National Railroad Passenger Corporation initiate programs to insure that railroad passengers are properly informed of emergency procedures and that passenger train crew personnel are versed on procedures for informing, evacuating, assisting, and treating the traveling public. (Conclusion 15.)

In addition, the Safety Board reiterates recommendations from previous accident reports as follows:

<u>Southern Railway Company; Laurel, Mississippi; January 25, 1969</u>

> "1. . . . The Federal Railroad Administration take the necessary steps to impose regulations requiring all mainline trains to be equipped with devices to record the speed of trains." (Conclusion 5.)

Penn Central Company; Glenn Dale, Maryland; June 28, 1969;

"4. . . . The Federal Railroad Administration, in cooperation with the Association of American Railroads and the American Railway Engineering Association, conduct studies, including tests, to determine desirable combinations of track and equipment components required to act as a system to keep derailed cars upon and in line with the track structure." (Conclusions 11, 12.)

"5. . . . The Federal Railroad Administration initiate studies to determine the relationship between rail passenger car design and passenger injury and, where practical, take action for correction in the design of future high-speed and rapid transit passenger cars." Particular emphasis should be given to the size, and method of retention, of passenger car windows as related to this probability of window breakage and its sequel, ejection and severe injury. These studies should include a review of the experience of window size and ejection in large buses and school buses. (Conclusion 13.)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

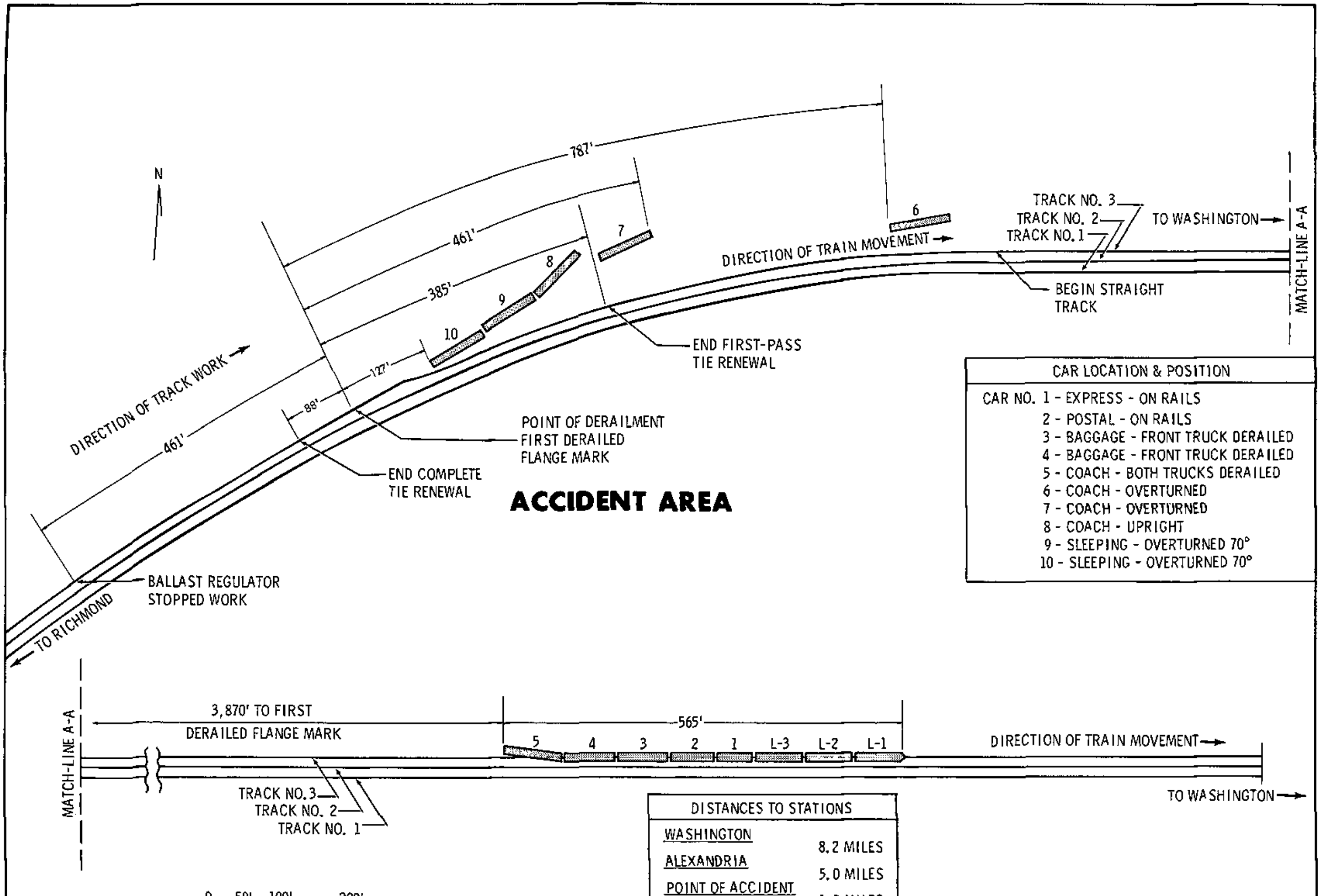
/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

February 3, 1971.



APPENDIX A

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20591

APPENDIX B

DEFINITION OF EQUILIBRIUM SPEED, COMFORTABLE SPEED, AND UNBALANCED ELEVATION

EQUILIBRIUM SPEED

High-speed curved tracks are banked or superelevated, to counteract the centrifugal force induced through circular motion. Equilibrium speed on curved track is the speed at which the resultant of the weight of a vehicle and the centripetal force (reaction to the centrifugal force) is perpendicular to the plane of the track. Therefore, the force components in the plane of the track are balanced, and the vehicle theoretically behaves as if on straight track without wheel flange pressure against the side of the rail head.

COMFORTABLE SPEED AND UNBALANCED ELEVATION

Because curved track must handle several classes of traffic operating at various speeds, it is not practical to superelevate curves to equate equilibrium speed to maximum permissible speed. If this were accomplished, excessive rail wear would be experienced on the low rail as a result of traffic operating at less than maximum speed. In order to compromise this situation, passenger cars are designed with springs and swing hangers to limit car body tilt. Experience has indicated that passenger cars will ride comfortably around a curve at a speed which would require a higher elevation for equilibrium. This speed is referred to as the "comfortable speed" and the difference between the actual superelevation and the theoretical equilibrium superelevation is referred to as "unbalanced elevation."

The RF&P superelevates curved track on the basis of 3 inches of "unbalanced elevation" consistent with the practice of many other railroads in the United States.

APPENDIX C

Excerpts from RF&P "Rules and Instructions for the Government of Maintenance of Way Employees"

TRACK OBSTRUCTION

Rule 1. Whenever it is necessary to leave main tracks in other than safe condition for the passage of trains at authorized speed, full flag protection must be provided and the Dispatcher promptly notified, giving the cause for speed restriction and the safe speed at which trains may be operated.

* * * * *

Rule 2. Any track condition that prohibits the use of any track by trains at authorized speed shall constitute a track obstruction and the track must be protected per Rule 1.... Listed below are some of the conditions that may occur from time to time in performing track work that must be protected as prescribed by Rules 1, 1A, or 2 above:

* * * * *

B. Tie Renewal:

* * * * *

2. When renewing ties, the track must be considered obstructed where two adjoining ties on tangents, or three adjoining ties on curves, on each side of the tie removed are not fully spiked, tamped and in sound condition.

* * * * *

E. Raising Track and Maintaining Cross Level:

1. The track must be considered obstructed where the line and surface has not been completed and the track has not been ballasted so that 1/2 the thickness of the ties extends above the level of the ballast.

* * * * *

3. The track must be considered obstructed where any of the following limits are exceeded for the speed shown:

	51 to 70 MPH
Change in cross level on curves, spirals or opposite rails of tangents in 31 feet	1/2 "
Difference in cross level at any two points less than 62 feet apart on curves between spirals and on tangents	1/2 "

Variation in superelevation on spirals or curves from that designated — 1/2 "

Permanent Run-off per 31 feet at end of Raise — 3/4 "

* * * * *

G. Cleaning Ballast

1. The track must be considered obstructed where the track has been skeletonized during process of cleaning ballast

* * * * *

GAGE - STANDARD

Rule 1. Track shall be maintained to proper gage which is as follows:

* * * * *

b. Curves

* * * * *

Up to and including 10 degrees — 4'8½"

* * * * *

GAGE - MAINTENANCE

Rule 1. If the gage is uniform, correction need not be made until the gage exceeds standard gage by 3/16" on tangents and 1/2" on curves where the rails are securely fastened as prescribed and the track is in good alignment.

* * * * *

CROSSTIES

* * * * *

Rule 6. Whenever possible tie renewals should be made at the time the track is being surfaced to secure more uniform bearing for the new ties. Where it is necessary to make spot tie renewals without surfacing the track, extreme care must be taken to see that the new ties are properly tamped and maintained in good bearing against the rail.

* * * * *

RAIL ANCHORS

Rule 1. a. Tracks with essentially One Direction Traffic.

Rail anchors must be spaced approximately uniformly along the rail length. To avoid tie skewing the anchors must be applied against the same tie on opposite rails. Eight (8) rail anchors will be applied per 39 foot rail to prevent movement of rail in direction of traffic and four (4) rail anchors will be applied to prevent movement of rail in the opposite direction. The reverse rail anchors will be placed near as possible to the quarter points of the rail and will be placed against the opposite face of the same ties against which forward anchors are placed.

b. Tracks with Traffic in Both Directions.

Rail anchors must be spaced approximately uniformly along the rail length. To avoid tie skewing the anchors must be applied against the same tie as opposite rails.

Eight (8) rail anchors will be applied to prevent movement in each direction (16 per 39' rail) and shall be so placed that they are in contact with the opposite faces of the same tie.

* * * * *

BALLAST

* * * * *

Rule 2. Ballast must be maintained to the prescribed cross section.

Rule 3. Ballast must be kept from touching the rails, a space of at least 2 inches between the ballast and the base of rail being maintained.

* * * * *

MEASURED TRACK CONDITIONS AT FRANCONIA, VIRGINIA
FOLLOWING DERAILMENT ON JANUARY 27, 1970
NO. 3 TRACK

APPENDIX D-1

STATION	GAGE	LOADED CROSS-LEVEL			UNLOADED CROSS-LEVEL			STATION	SURFACE		ALIGNMENT
Approx. Joints and Centers	(Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Every 31 feet	Elevation (Feet)	Change per 31 ft. (Inches)	Curvature
Designated Standard	56 1/2	4 1/4			4 1/4					2 1/2	2° 00'
Priority Limit "Track must be considered obstructed"	+ 1/2**		1/2	1/2		1/2	1/2			2½ $\pm$ 3/4	***
62 + 94	57	3 7/8		- 3/8	4 1/8		-1/8				
								63 + 00	56.32		2° 11'
63 + 14	56 9/16	4 1/2		+ 1/4	4 5/8		+ 3/8				
								63 + 31	56.13	2 1/4	2° 08'
63 + 33	57*	4	+ 1/8	- 1/4	4 1/8	0	- 1/8				
63 + 53	57*	4 1/2	0	+ 1/4	4 1/2	- 1/8	+ 1/4				
								63 + 62	55.93	2 3/8	2° 15'

MEASURED TRACK CONDITIONS AT FRANCONIA, VIRGINIA
FOLLOWING DERAILMENT ON JANUARY 27, 1970
NO. 3 TRACK

APPENDIX D-2

STATION	GAGE	LOADED CROSS-LEVEL			UNLOADED CROSS-LEVEL			STATION	SURFACE		ALIGNMENT
Approx. Joints and Centers	(Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Every 31 feet	Elevation (Feet)	Change per 31 ft. (Inches)	Curvature
63 + 72	57 1/6*	4 1/2	+ 1/2*	+ 1/4	4 3/8	+ 1/4	+ 1/8				
63 + 92	57*	5	+ 1/2*	+ 3/4*	5	+ 1/2*	+ 3/4*				
								63 + 93	55.64	3 1/2*	2° 11'
64 + 11	56 3/4	4 5/8	+ 1/8	+ 3/8	4 1/2	+ 1/8	+ 1/4				
								64 + 24	55.47	2	1° 52'
64 + 31	57*	4 5/8	- 3/8	+ 3/8	4 1/2	- 1/2*	+ 1/4				
64 + 50	56 3/4	4	- 5/8*	- 1/4	4	- 1/2*	- 1/4				
								64 + 55	55.30	2	1° 38'
64 + 70	56 7/8	4 3/4	+ 1/8	+ 1/2*	4 3/4	+ 1/4	+ 1/2*				
								64 + 86	55.09	2 1/2	1° 56'
64 + 89	56 3/4	4 3/8	+ 3/8	+ 1/8	4 3/8	+ 3/8	+ 1/8				
65 + 09	57*	4 5/8	- 1/8	+ 3/8	4 3/4	0	+ 1/2*				

MEASURED TRACK CONDITIONS AT FRANCONIA, VIRGINIA
FOLLOWING DERAILMENT ON JANUARY 27, 1970
NO. 3 TRACK

APPENDIX D-3

STATION	GAGE	LOADED CROSS-LEVEL			UNLOADED CROSS-LEVEL			STATION	SURFACE		ALIGNMENT
Approx. Joints and Centers	(Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Every 31 feet	Elevation (Feet)	Change per 31 ft. (Inches)	Curvature
								65 + 17	54.90	2 1/4	1° 52'
65 + 28	57*	4 1/2	+ 1/8	+ 1/4	4 3/8	0	+ 1/8				
65 + 48	56 7/8	4 7/8	+ 1/4	+ 5/8*	4 7/8	+ 1/8	+ 5/8*	65 + 48	54.66	3	1° 45'
65 + 66	57*	4 3/8	- 1/8	+ 1/8	4 3/8	0	+ 1/8				
								65 + 79	54.47	2 1/4	2° 00'
65 + 87	56 7/8	5 1/2	+ 5/8 *	+ 1 ¼*	5 1/2	+ 5/8*	+ 1 ¼*				
66 + 06	57*	4 3/8	0	+ 1/8	4 3/8	0	+ 1/8				
								66 + 10	54.30	2	1° 52'
66 + 24	-	-	-	-	5 1/8	- 3/8	+ 7/8*				
								66 + 41	54.07	2 3/4	1° 38'
66 + 44	57*	4 1/4	- 1/8	0	4 3/8	0	+ 1/8				
66 + 63	57*	5	-	+ 3/4*	4 5/8	- 1/2*	+ 3/8				
								66 + 72	53.86	2 1/2	1° 52'

MEASURED TRACK CONDITIONS AT FRANCONIA, VIRGINIA
FOLLOWING DERAILMENT ON JANUARY 27, 1970
NO. 3 TRACK

APPENDIX D-4

STATION	GAGE	LOADED CROSS-LEVEL			UNLOADED CROSS-LEVEL			STATION	SURFACE		ALIGNMENT
Approx. Joints and Centers	(Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Every 31 feet	Elevation (Feet)	Change per 31 ft. (Inches)	Curvature
66 + 83	57*	4 1/4	0	0	4 1/4	- 1/8	0				
								67 + 03	53.63	2 3/4	1° 49'
67 + 04	57*	4 3/4	- 1/4	+ 1/2*	4 5/8	0	+ 3/8				
67 + 22	57*	4 1/8	- 1/8	- 1/8	4 1/8	- 1/8	- 1/8				
								67 + 34	53.42	2 1/2	1° 56'
67 + 43	57*	4 5/8	- 1/8	+ 3/8	4 1/2	- 1/8	+ 1/4				
67 + 61	57*	4 3/8	+ 1/4	+ 1/8	4 3/8	+ 1/4	+ 1/8				
								67 + 65	53.23	2 1/4	1° 52'
67 + 82	57*	4 1/2	- 1/8	+ 1/4	4 1/2	0	+ 1/4				
								67 + 96	53.02	2 1/2	2° 04'
68 + 00	57*	4	- 3/8	- 1/4	4	- 3/8	- 1/4				
68 + 21	57*	4 5/8	+ 1/8	+ 3/8	4 5/8	+ 1/8	+ 3/8				
								68 + 27	52.75	3 1/4*	1° 41'
68 + 39	57 1/8*	4 1/8	+ 1/8	- 1/8	4	0	- 1/4				

MEASURED TRACK CONDITIONS AT FRANCONIA, VIRGINIA
FOLLOWING DERAILMENT ON JANUARY 27, 1970
NO. 3 TRACK

APPENDIX D-5

STATION	GAGE	LOADED CROSS-LEVEL			UNLOADED CROSS-LEVEL			STATION	SURFACE		ALIGNMENT
Approx. Joints and Centers	(Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Every 31 feet	Elevation (Feet)	Change per 31 ft. (Inches)	Curvature
								68 + 58	52.54	2 1/2	1° 26'
68 + 60	56 7/8	4 1/2	- 1/8	+ 1/4	4 3/8	- 1/4	+ 1/8				
68 + 78	57*	4	- 1/8	- 1/4	4 1/8	+ 1/8	- 1/8				
								68 + 89	52.32	2 5/8	2° 00'
68 + 99	57*	4 3/8	- 1/8	+ 1/8	4 1/4	- 1/8	0				
69 + 17	57*	3 7/8	- 1/8	- 3/8	3 7/8	- 1/4	- 3/8				
								69 + 20	52.10	2 5/8	1° 56'
69 + 38	57*	4 5/8	+ 1/4	+ 3/8	4 3/8	+ 1/8	+ 1/8				
								69 + 51	51.89	2 1/2	2° 00'
69 + 56	57*	3 7/8	0	- 3/8	3 3/4	- 1/8	- 1/2*				
69 + 76	56 3/4	4 5/8	0	+ 3/8	4 1/4	- 1/8	0				
								69 + 82	51.68	2 1/2	1° 49'
69 + 95	56 7/8	4 1/8	+ 1/4	- 1/8	3 7/8	+ 1/8	- 3/8				
								70 + 13	51.45	2 3/4	1° 52'

MEASURED TRACK CONDITIONS AT FRANCONIA, VIRGINIA
FOLLOWING DERAILMENT ON JANUARY 27, 1970
NO. 3 TRACK

APPENDIX D-6

STATION	GAGE	LOADED CROSS-LEVEL			UNLOADED CROSS-LEVEL			STATION	SURFACE		ALIGNMENT
Approx. Joints and Centers	(Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Measured (Inches)	Change Per 39 ft. (Inches)	Variance from std. (Inches)	Every 31 feet	Elevation (Feet)	Change per 31 ft. (Inches)	Curvature
70 + 15	57*	4 1/4	- 3/8	0	4 1/8	- 1/8	- 1/8				
70 + 32	56 3/4	4	- 1/8	- 1/4	3 3/4	- 1/8	- 1/2*				
								70 + 44	51.28	2	1° 49'
70 + 53	56 3/4	4 1/8	- 1/8	- 1/8	4	- 1/8	- 1/4				
70 + 61	TRACK DISTURBED TO NORTH							70 + 61			
72 + 17	FIRST DERAILED FLANGE MARK										

* Equals or exceeds RF&P priority limit as listed in Appendix C.
** Correction to be initiated when gage exceeds prescribed by 1/2 inch but track not considered obstructed.
*** RF&P does not have priority limits for alignment variations.

APPENDIX E

DISCUSSION OF THE LATERAL MOVEMENT OF TRACK EXPERIENCED ON THE BRITISH RAILWAYS IN 1968 and 1969 6/

In 1968, the British Railways experienced 22 track distortions on jointed track and seven on continuous welded rail track for ratios of distortions per 1,000 miles of track of 1.07 and 1.78, respectively. In 1969, a significant increase in track distortions was noted, with 55 experienced on jointed track and 48 on continuous welded rail for ratios per 1,000 miles of track of 2.98 and 10.42, respectively. In 1968, two serious derailments resulted from the lateral movement of track and in 1969, three accidents resulted from the buckling of track ahead of the train.

In all of these accidents, the ballast had been disturbed by trackwork prior to the derailments. The time intervals between the accidents and the date of trackwork were 5 days, 3 months, 4 months on two occasions, and 7 months.

The British also made a detailed analysis of the 48 distortions of continuous welded rail experienced in 1969. Significant findings as related to the RF&P derailment at Franconia include:

(1) In 35 percent of the cases, the consolidation of the ballast was unsatisfactory. In the majority of these instances this was attributed to recent trackwork.

(2) In 27 percent of the cases, the track distortion could be attributed to improper trackwork, including the failure to destress track, shortage of ballast, and performing trackwork when temperatures were above the maximum permitted.

(3) The remaining cases were generally attributed to weak spots in the welded track, such as insulated joints, turnouts and crossings, or to subsidence of the roadbed.

6/ "Ministry of Transport - Railway Accidents - Interim Report on the Derailments that occurred on Continuous Welded Rail Track at Lichfield, Somerton and Sandy, British Railways and on the General Safety of this form of Track."