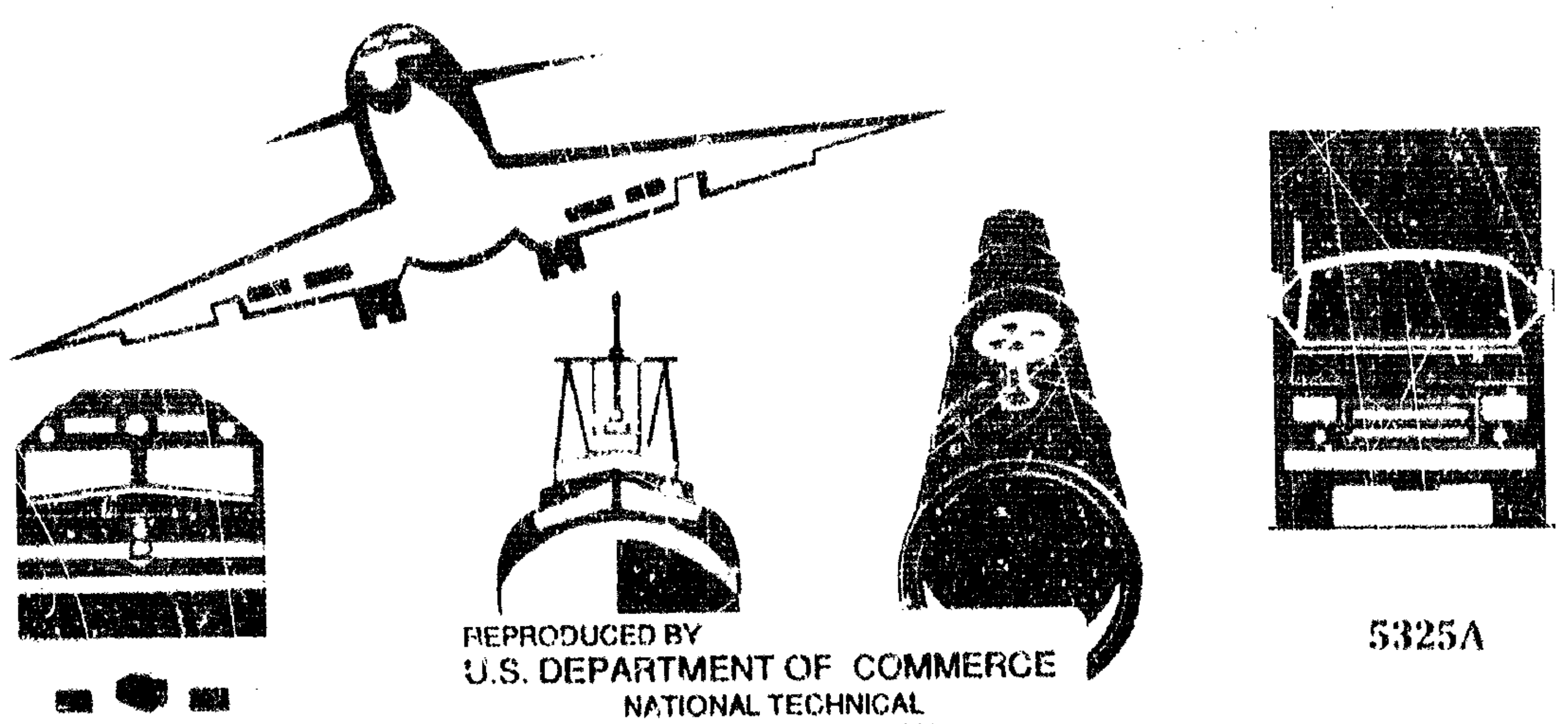
PB91-916305
NTSB/RAR-91/05

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT OF AMTRAK TRAIN NO. 6 ON THE BURLINGTON NORTHERN RAILROAD BATAVIA, IOWA APRIL 23, 1990



5325A

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RAILROAD ACCIDENT REPORT

ADOPTED: DECEMBER 10, 1991

NOTATION 5325A

Abstract: This report explains the derailment of Amtrak Train No. 6 on the Burlington Northern Railroad at Batavia, Iowa, on April 23, 1990. The safety issues discussed in this report are: the lack of consistency, continuity, and comprehensiveness in Burlington Northern's Maintenance of Way Standard Practice Circulars; the efficacy of the rail expansion and contraction tables in Burlington Northern's Maintenance of Way Rules for in-track electric flash butt-welding operations; the propriety of conducting in-track electric flash butt-welding operations and out of face maintenance operations in cold weather; the effectiveness of Burlington Northern's track buckling prevention seminar for the in-track electric flash butt-welding operation; the adequacy of Burlington Northern's supervision of in-track electric flash butt-welding operations and implementation of maintenance of way standards; the ambiguity of Burlington Northern's rail temperature record form; and the lack of temperature quality control measures such as the use of match marks for in-track electric flash butt-welding operations.

As a result of this investigation, the Safety Board made recommendations to the Federal Railroad Administration, the Burlington Northern Railroad Company, the National Railroad Passenger Corporation (Amtrak), and the Association of American Railroads.

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EXECUTIVE SUMMARY

About 1:26 p.m. central daylight time on April 23, 1990, eastbound National Railroad Passenger Corporation (Amtrak) train No. 6, the California Zephyr, derailed at Batavia, Iowa, while operating on the Burlington Northern Railroad (BN). One passenger received serious injuries; 10 crewmembers and 75 passengers received minor injuries. The estimated damage was $1,835,000.

The National Transportation Safety Board determines that the probable cause of the accident was improper rail installation during cold weather operations resulting from ineffective training programs, inadequate supervisory oversight and quality control measures, and an ineffective data collection system. Also causal to the accident was the failure of Burlington Northern procedures to require that crews readjust/destress continuous welded rail (CRW) after the track had been disturbed, which resulted in a track buckle under Amtrak train No. 6.

The major safety issue in this accident is: Burlington Northern's installation, maintenance, and inspection of in-track electric flash butt-welded rail. Specific areas include:

- o The lack of consistency, continuity, and comprehensiveness in Burlington Northern's Maintenance of Way Standard Practice Circulars.
- o The efficacy of the rail expansion and contraction tables in Burlington Northern's Maintenance of Way Rules for in-track electric flash butt-welding operations.
- o The propriety of conducting in-track electric flash butt-welding operations and out of face maintenance operations in cold weather.
- o The effectiveness of Burlington Northern's track buckling prevention seminar for the in-track electric flash butt-welding operation.
- o The adequacy of Burlington Northern's supervision of in-track electric flash butt-welding operations and implementation of maintenance of way standards.
- o The ambiguity of Burlington Northern's rail temperature record form.
- o The lack of temperature quality control measures such as the use of match marks for in-track electric flash butt welding operations.

As a result of this investigation, the Safety Board made recommendations to the Federal Railroad Administration, the Burlington Northern Railroad Company, the National Railroad Passenger Corporation (Amtrak), and the Association of American Railroads.

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INVESTIGATION

The Accident

On April 21, 1990, eastbound National Railroad Passenger Corporation (Amtrak) train No. 6, the California Zephyr, originated in Oakland, California, en route to Chicago, Illinois. After receiving an initial terminal airbrake test[1] and final inspections, the train departed about noon The train consisted of three diesel-electric locomotive units under the control of an engineer and fireman as the engine crew, followed by 17 cars under the direction of a conductor and two assistant conductors. The train also had 19 on-board service personnel, including car attendants and food service personnel. On the eastward journey, the train dropped off one car in Salt Lake City for connections with another Amtrak train, which mandated another initial terminal inspection at that point. The train also received two other "1,000-mile" inspections[2] as required by the Code of Federal Regulations (CFR): one at Denver, Colorado, where it entered onto the Burlington Northern (BN) system, and one at Omaha, Nebraska.

On April 23, the train reached Lincoln, Nebraska, a crew change point, where the accident train crew went on duty at 5:24 a.m. central daylight time. The train crew of Amtrak No. 6 was working their regular assignment on the date of the accident. This consisted of making two round trips per week between Galesburg, Illinois, and Lincoln, Nebraska. Galesburg was their home terminal assignment. The engineer and fireman had been off duty for 28 hours 14 minutes before reporting for duty on train No. 6. In later testimony, the locomotive crew stated that they were well rested before they departed on train No. 6. The train departed Lincoln at 7:39 a.m., one hour 15 minutes later than the scheduled departure time due to a variety of track, station, and operational delays en route.

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[1]As outlined in Title 49 Code of Federal Regulations (CFR) Part 232.12, this test consists of charging the air brake system to within 15 lbs of the regulating or feed valve, making a 20 psi brake pipe reduction, checking the brakes applied on the entire train, and then checking the brakes released on the entire train. The test also includes a leakage test.

[2]The road train and intermediate terminal train air brake test is found in Title 49 CFR Part 232.11 and 232.13. This test is commonly called the "1,000-mile inspection" because the CFR dictates inspection points not more than 1,000 miles apart. This test is essentially the same as the initial terminal test except that there is no specified charge in the brake system, and the train is not inspected for released brakes.

According to the engineer, after the train left Lincoln, the dispatcher radioed the train crew about possible "flat wheels on the second car from the rear." A section man had reported to the dispatcher that he heard the sound of a flat spot[3] after the train had passed. At Ashland, Nebraska, the engineer stopped the train for 15 minutes while the conductor and two assistant conductors inspected the last two cars of the standing train. No defects were found. The conductor then rode the suspect car to listen for any unusual noises but did not note any. The train had also passed two BN wayside hotbox detectors without any reported problems.

The train continued to Omaha, Nebraska, for a scheduled station stop, an inspection, and an air brake test. This was the last inspection before the derailment. At Omaha, the crew informed the private contract mechanical inspectors of the Ashland inspection results and requested that special attention be given to the wheels on the last two cars. The mechanical inspectors found a "small flat spot" that was not condemnable[4] under Rule 41 of the Field Manual of the Association of American Railroads (AAR) Interchange Rules. The unscheduled stop at Ashland, track and operating restrictions from Lincoln to Omaha, and additional station time at Omaha delayed Amtrak train No. 6's departure another hour. The train departed Omaha at 9:21 a.m., 2 hours 15 minutes behind schedule.

After crossing the Missouri River, the fireman took control of the train and ran it to a scheduled stop at Creston, Iowa. The fireman was fully qualified by Amtrak and BN to operate the train. Amtrak stated that it is common Amtrak practice for the engineer and the fireman to alternate operating the train several times during a trip to minimize fatigue and maximize alertness. From Creston, the assigned engineer ran the train to the next scheduled stop at Ottumwa, Iowa, where the fireman again took control. (See figure 1.)

Approaching Batavia, 13.5 miles east of Ottumwa, the train descended a .68 percent grade at the 79 mph maximum authorized speed, according to the event recorder, and rounded a 1° 02' left hand curve near milepost (MP) 266.4 as measured from Chicago, Illinois. A section foreman, standing on the inside of the curve, inspected the train as it passed, but noted no exceptions. According to the engineer, the fireman followed normal train handling procedures, making a minimum brake application at the time and making a brake release to control speed, shortly thereafter.

As the train moved through Batavia, the conductor was walking forward through sleeping car No. 32063, the sixth car from the head-end. The conductor stated that immediately before the derailment he felt a "tremendous bump...felt like I went up in the air." Both assistant conductors in the lower level of sleeping car No. 32064 (fourth car from the end) stated that they felt a severe bump immediately before they heard the noise of ballast striking the under frame of the car. When the train derailed, the midday meal was being served in the dining car, and many on-board service personnel were engaged in food service activities or preparing the cars for the anticipated arrival in Chicago within the next several hours.

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[3]A flat spot is an elliptical plane on the surface of a railroad wheel's tread usually created by the sliding of the wheel on rail while braking.

[4]Railroad equipment is condemnable or not fit for service if it exceeds certain prescribed limits or measurements.

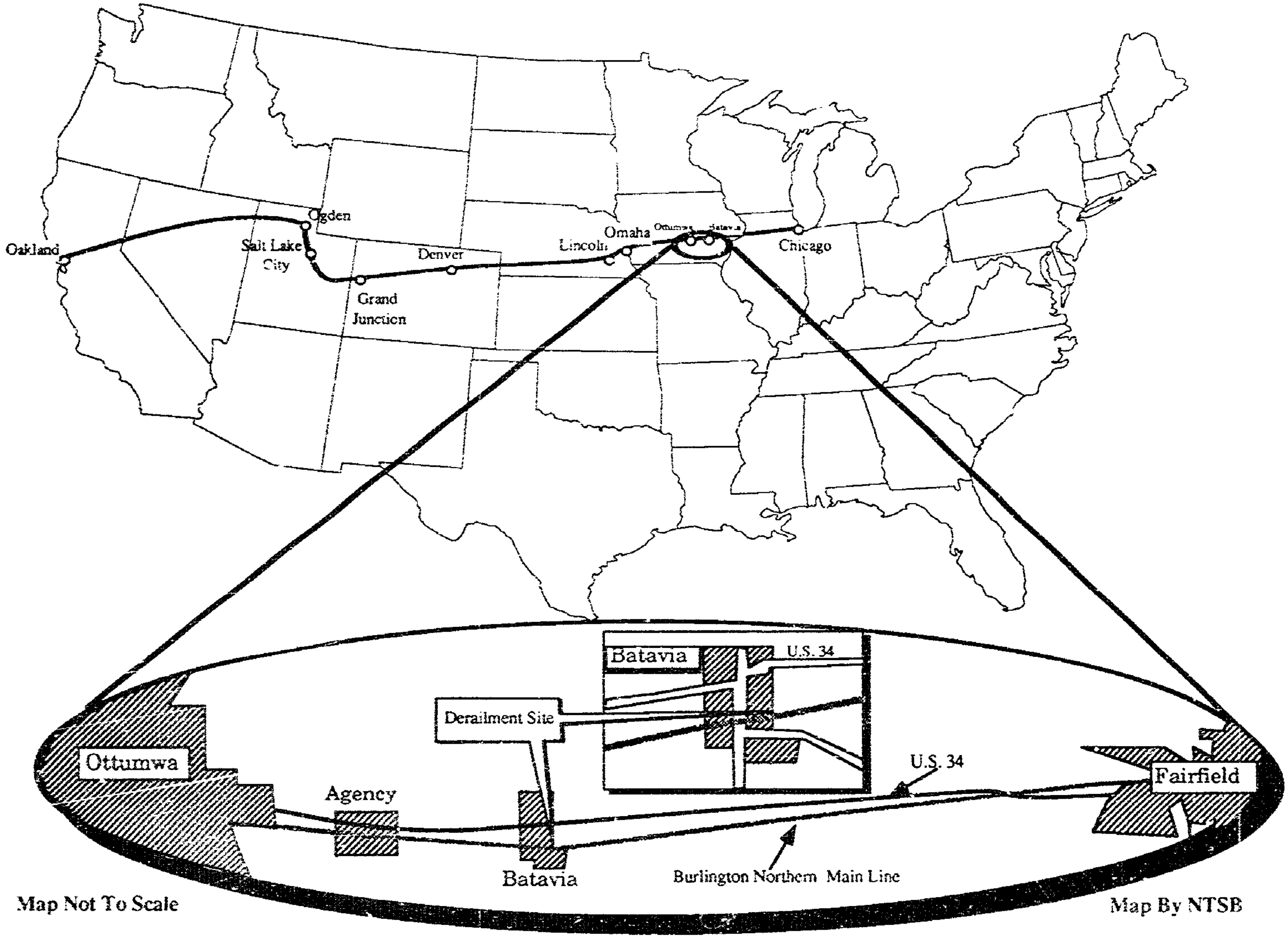

Figure 1.--Route of Amtrak train No. 6.

According to the engineer, he felt nothing unusual riding through Batavia. The fireman stated he had released his brakes approximately 1/8th mile before the train derailed while moving at 77 mph with the throttle in 4th notch.[5] The engineer said he then felt "a pretty hard jerk on the engine back and forth." Both the fireman and engineer immediately looked back at the train in their rear view mirrors and saw a cloud of dust and the erratic movement of the derailing cars. The fireman made an emergency application of the air brakes and put the throttle in the OFF position.

About 1:26 p.m., the last eight cars of train No. 6 derailed on the BN mainline track near MP 266 at Batavia, Iowa. The first derailed car, lounge car No. 33021, remained upright. The other cars, except the last one, came to rest leaning to the north at various angles; the last car leaned toward the south. The eight cars came to rest in a very shallow arc. The lead derailed car was almost centered on the eastbound track and the last car was just south of the eastbound track. The last four derailed cars had struck and sideswiped a gondola[6] car parked on an adjacent siding. None of the derailed cars rolled over on their side, although several leaned severely. The train remained coupled throughout the derailment. (See figures 2 and 3.)

According to Amtrak, 341 passengers were on the train at the time of the derailment. A total of 86 passengers and on-board service personnel were injured and taken to six area hospitals. There were no fatalities. Amtrak provided accommodations and transportation for the uninjured passengers.

The three locomotive units and first eight cars that remained on the track after the derailment were uncoupled from the rest of the train and taken to Chicago for Amtrak and Federal Railroad Administration (FRA) inspection. After inspection, Amtrak placed the nonderailed locomotive units and cars in service on other trains.

Injuries

Injury Table

	Operating	On-Board	Passenger	Total
Fatal	0	0	0	0
Serious	0	0	1	1
Minor	1	9	75	85
None	4	10	265	279
Total	5	19	341*	365

*Estimated by Amtrak.

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[5]Diesel-electric locomotive units have throttles with progressive notches or segments beginning at 1 and ending at 8 that allow the engineer to adjust the demand for power.

[6]A railroad gondola freight car is a low, fixed-side, open top car that is primarily used to transport loads that require little or no protection from the weather.

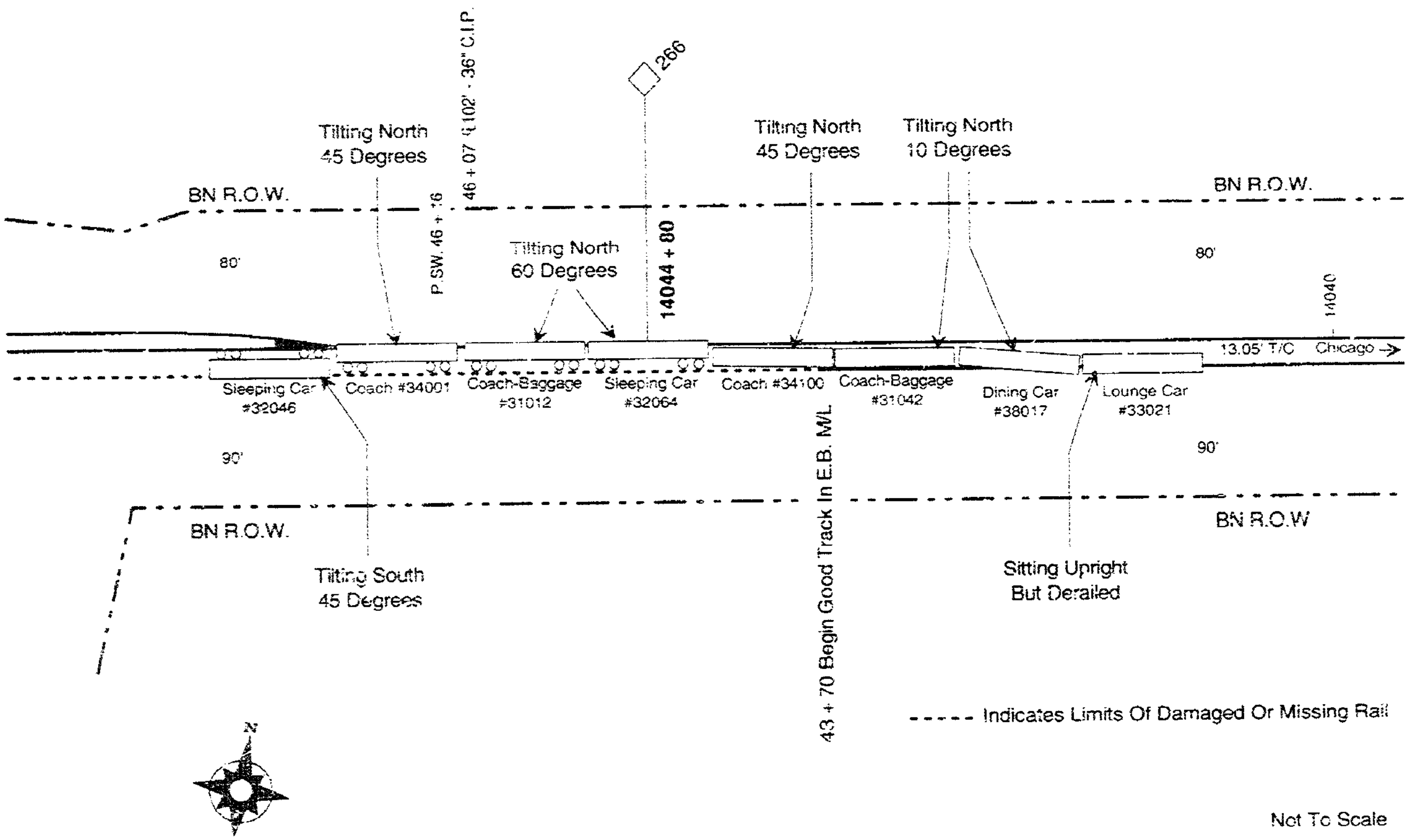

Figure 2.--Accident site diagram.

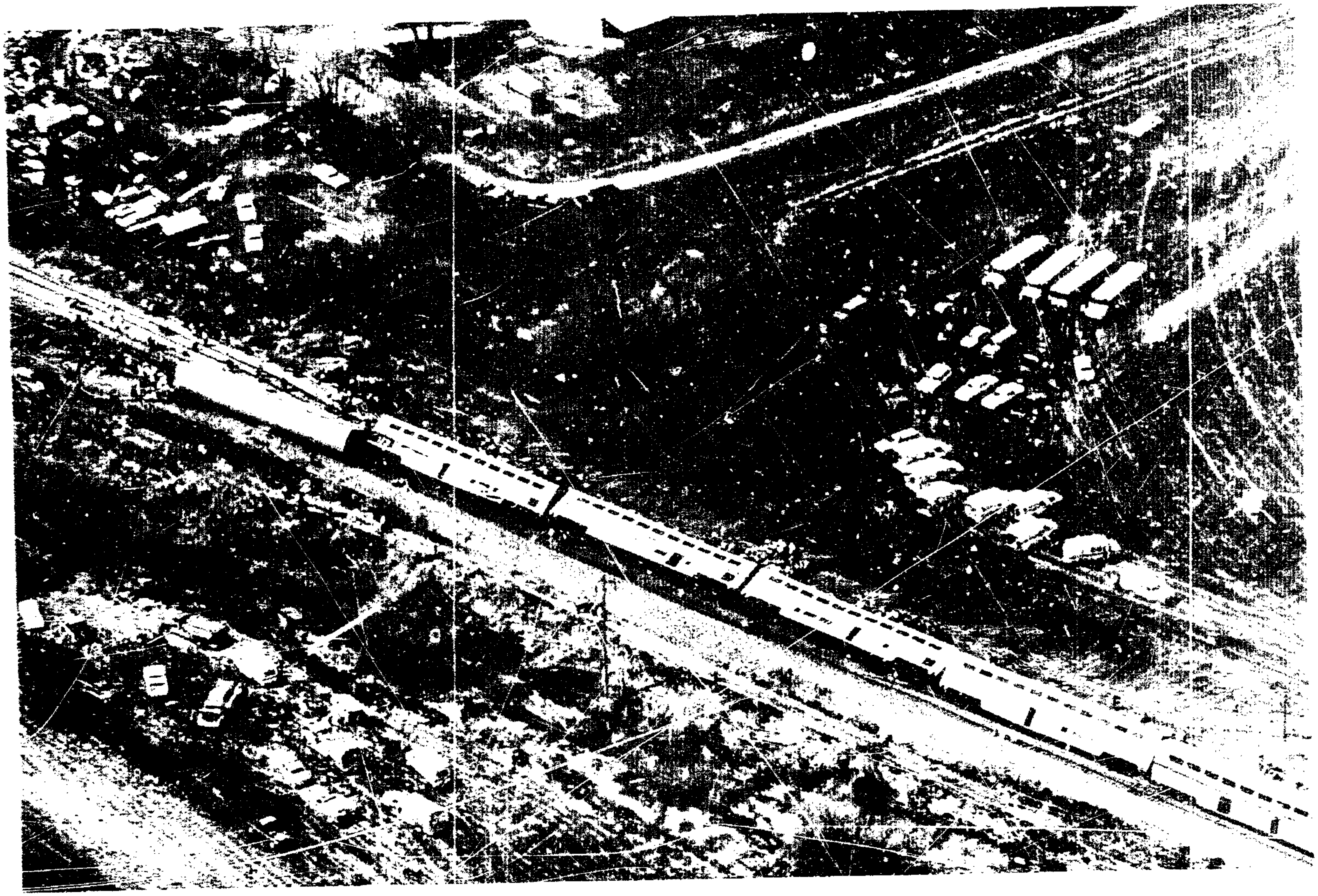

Figure 3.--Accident site photograph.

Train and Track Damage

Amtrak and BN estimated the damage as:

Amtrak Equipment	$1,705,000
BN Equipment	5,000
Track	75,000
Wreckage Removal	50,000
Total	$1,835,000

Personnel Information

Operating Personnel.--Amtrak employees on the train consisted of the operating crew (engineer, fireman, conductor, and two assistant conductors) and 19 on-board service personnel (car attendants, dining car waiters, and food service personnel).

The engineer was hired by Amtrak on March 18, 1987, from the Illinois Central Gulf Railroad (ICG). He had started his operating career on the Gulf, Mobile & Ohio Railroad (GM&O) in 1961 as a fireman and was promoted to engineer in June 1965. He continued to serve as an engineer after the GM&O merged with the Illinois Central Railroad to become the ICG.

The engineer stated that he had successfully completed his last annual rules examination on the General Code of Operating Rules (GCOR) and Amtrak rules in October 1989. The Galesburg-Lincoln run was his regular assignment. He received his most recent Amtrak locomotive engineer evaluation and examination in July 1989; it stated that he "is an above average engineer. He demonstrates very good train handling abilities as well as thorough knowledge of the territory, rules, and special instructions." According to the engineer's Amtrak record, supervisors had conducted numerous ride checks and found his operating procedures fully acceptable. On two occasions, supervisors checked five operating rules as the engineer operated trains through the Batavia area. In 1987, Amtrak's transportation manager had nominated him for the Amtrak President's Achievement Award, the company's highest honor. The engineer had been held out of service for 4-1/2 months before the accident (December 1989 to April 1990) for running a train 40 mph in a 20-mph temporary speed restriction area. In testimony after the accident, he stated that was the first time in his railroad career that he had ever been held out of service for disciplinary action. When he returned to service on April 10, 1990, he took vacation. Before the accident, he had made one trip from Galesburg to Lincoln and back.

The fireman, who was at the controls at the time of the accident, began his railroad career on the ICG railroad in April 1978. He was hired by Amtrak in April of 1988 as a fireman and had served in that capacity since then. Although called a "fireman," he was in fact a fully qualified engineer, having qualified on the territory between Galesburg, Illinois, and Creston, Iowa, in July 1988 and between Creston, Iowa, and Lincoln, Nebraska, in April 1989. He had successfully passed the most recent annual BN Book of Rules examination in November 1989. Since October 1988, the fireman had received 31 "ride checks," or evaluations by supervisors riding in the cab to check rules compliance. These evaluations covered 133 rules; some evaluations were for the same rule. Records show that supervisors noted three rule exceptions: one for "3.2 mph over the speed limit, one for "sounded whistle improperly," and one for "failed to blow into grade crossing." On July 17, 1989, during a ride check for four rules as the fireman operated through Batavia, supervisors noted no exceptions. Supervisors and evaluators rated the fireman's performance "standard"; the other two categories were "above standard" and "below standard."

The 19 on-board service personnel had completed 8 hours of recurrent emergency training in the past 2 years, as required by Amtrak.

A review of the operating crews' medical records showed that the engineer and fireman had received their required annual company physical examinations on April 10, 1990, 13 days before the accident. Both had corrected 20/20 vision. The engineer was required to wear glasses "all the time." He had been taking daily blood pressure medicine for 20 years, and his latest medical examination revealed no blood pressure problems. BN's medical examination found both the fireman and engineer physically fit for duty.

Maintenance-of-Way Personnel.--Accident investigators later identified BN maintenance-of-way (MOW) personnel (welding gang No. 41 supervisors) who had been involved with the track work in the Batavia area before the derailment. The Safety Board subsequently interviewed the system director of maintenance, the Galesburg division superintendent of maintenance and engineering, the Galesburg division manager of gangs, the Batavia area roadmaster, the welding gang No. 41 general foreman, welding gang foremen, and the welding gang heater operator.

BN is divided into nine subdivisions by geographical area, each of which is headed by a division superintendent who also serves as an operating department officer. All division-level MOW officers support the operation of trains by maintaining the track, bridges, and buildings within their divisions. Division-level MOW officers report to the division superintendent. In addition, division MOW supervisors and managers have an indirect reporting responsibility to the system chief engineer and his staff who coordinate MOW activities throughout the BN.

One of the chief engineer's staff members, the director of maintenance, oversees BN's rail grinding program and acts as "system track inspector" during his frequent travels throughout the system. He also conducts seasonal training to division supervisors and managers such as the seminar on track buckling.

The superintendent of maintenance and engineering is responsible for all MOW activities within a division. His staff members include the manager of gangs and roadmasters. The manager of gangs is responsible for documenting and coordinating the activities of the seasonal specialized production gangs throughout the division. Within each division or subdivision, roadmasters are permanently assigned maintenance and inspection responsibilities and have group of inspectors under their supervision full-time. A roadmaster may provide support to a gang that is temporarily working in his territory.

The general foreman of a gang works for the division manager of gangs and the superintendent of maintenance and engineering. Depending on work requirements, inspectors or roadmasters from one division of the railroad system may be assigned as a general foreman and/or subordinate foremen in another division during the winter or "off season" or when an area temporarily needs a gang.

The director of maintenance was hired by the St. Louis and San Francisco Railroad in 1963 as a laborer. He was successively promoted to foreman, roadmaster, division engineer, regional maintenance engineer, and director of maintenance. As maintenance director, he had been presenting the 1-day track buckling seminars annually throughout the BN system for the past 5 years.

The general foreman of welding gang No. 41 was hired by BN in 1974 as a MOW worker. He became a foreman in 1976 and also worked as a track inspector from 1976 to 1988. In 1985 he was the first foreman to be assigned to the newly created "Holland"[7] welding gang and supervised the gang in 1985 and 1986. The general foreman became part of BN management in 1988 and attended management training and "track buckling school" in 1988 and 1989. In 1989, he was again assigned to the Holland welding gang No. 41 as general foreman, having overall on-site responsibility and control.

The superintendent of maintenance and engineering received an undergraduate degree in civil engineering from the University of Minnesota in 1977. Upon graduation he was hired by BN as a management trainee in the MOW engineering department. After completion of program training, he served in various MOW positions, advancing into positions of greater responsibility until he became superintendent in October 1988.

The manager of gangs was hired by BN in June 1973 as a track laborer. He later worked as a welder, foreman, and track inspector. In July 1976, he entered management as a roadmaster. The manager of gangs was promoted to district and then general roadmaster before becoming manager of gangs in October 1988. In addition to approximately 10 weeks of track technical training classes and 15 weeks of management training classes, he had also attended the annual track buckling seminars given by the director of maintenance since 1987.

The foreman of welding gang No. 41 was hired as a BN MOW worker in June 1972 and became a foreman in December 1973. Since that time, he had worked as a foreman and track inspector. He worked as a Holland welding gang foreman in 1988 and 1989 and had attended the annual track buckling seminar with the general foreman during those years.

Train Information

Train Maintenance and Inspections.--Amtrak records show that train No. 6 was inspected under requirements set forth in 49 CFR Parts 230 and 232 for equipment. At its origin in West Oakland, California, train No. 6 received the required initial terminal airbrake tests and locomotive inspections, which also included Amtrak's routine inspections for comfort and convenience. The train received initial terminal or "1,000-mile" equipment inspections in Salt Lake City, Utah, Denver, Colorado, and Omaha, Nebraska. The inspections were mandated by the Federal Railroad Administration (FRA). No problems were found at any of these intermediate inspection points. The train passed wayside detectors (hotbox and dragging equipment) throughout the journey that reported no problems. Neither the crew nor the passengers reported any unusual noises before or after leaving Lincoln. At

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[7]BN uses Holland in-track welding equipment for field welding of CWR. BN workers therefore refer to the welding gang as "the Holland welding gang."

Omaha, private contract inspectors examined the flat spot and found it to be very minor and not beyond FRA condemning limits. Engineer reports (MAP 100) from engineers who operated Train No. 6 showed no problems or failures between West Oakland and the accident site. (See appendix C.)

Locomotive.--The train was powered by three diesel-electric locomotive units, all of which were 3000-hp F40PH models built by General Motors Electro-Motive Division. Amtrak has bought three variations or design phases of the F40PH. Except for a slightly larger fuel tank in the second and third phases, the phase differences are generally not discernible. Unit 262 was a second phase unit, and units 331 and 343 were both third phase units. An F40PH rides on two two-axle trucks with 40-inch diameter wheels. Amtrak's F40PH locomotive units are lighter (130 tons) than a typical freight unit (200 tons). According to Amtrak, lighter weight minimizes the mechanical forces on track structure at the higher operating speeds of passenger trains, allowing Amtrak to operate over the wide variety of track quality found throughout its system.

The F40PHs provide head-end power (HEP), or electrical generation, for Amtrak's all-electric passenger cars. The HEP provides electricity for the train's heat, lighting, and air conditioning systems. Generally, only one locomotive unit is required to provide HEP for a train, allowing any others to be dedicated for tractive effort.

Each locomotive unit was equipped with an Aerotron four-channel radio; schedule 26L air brake equipment; Pulse Electronics, Inc., Train Sentry II alerter; speed indicators; twin sealed-beam headlights; and over-speed limit control with a warning whistle. The first and last locomotive units also had a Pulse Electronics, Inc., multievent recorder system that measured and recorded the following onto a magnetic tape cartridge: elapsed time, distance, speed, traction motor and dynamic brake amperage, throttle position, automatic brake application, alerter cut-in/cut-out, cab signal acknowledgement, and horn. The middle locomotive unit had a paper and stylus speed recorder that indicated speed and distance.

The locomotive units also had a blended braking system that automatically mixed an automatic air brake application with dynamic braking, depending on speed and the braking demand. The engineer could nullify the dynamic portion of the blended braking by depressing the independent brake handle during a brake application.

Passenger Equipment.--At the time of the accident, the train had 16 cars. The first three were material handling cars (MHCs) used in mail and express service.

The next two cars, No. 1165 and No. 39900, were "heritage" or pre-Amtrak railroad-owned cars. Car No. 1165 was a baggage car. On-board service personnel used car No. 39900, a bilevel dormitory-coach car originally owned by the Santa Fe (ATSF) Railroad, for living quarters and as a transition car from the single-level baggage car to the more modern bilevel Superliner cars.

The remaining 11 cars in the consist were all Superliner cars, designed and built by the Pullman Standard Company of Chicago under Amtrak contract in the 1970s. The five configurations or types of superliner cars are coach, coach-baggage, dining car, sleeping car, and lounge-cafe.

Passengers entered and exited the Superliner cars through side doors on the lower level near the cars' center. On the lounge-cafe and dining cars these doors were for employee use and ordinarily used by passengers only in the event of an emergency. A stairway near the center entry doors of each car provided access to the Superliners' upper level. Passengers moved from car to car through the upper level only.

Superliner coach seating capacity was 62 on the upper level and 15 on the lower level. AMI Industries Incorporated (AMI) of Colorado Springs, Colorado, and Coach & Car Equipment Corporation of Elk Grove Valley, Illinois, manufactured the coach seats. Each double seat unit on either side of the aisle was approximately 42 inches wide. The aisle width was 22 inches. The seats were designed to rotate 180° and recline, depending on the location within the car, allowing passengers to face in the direction of movement without Amtrak having to turn the car around. A "seat lock" or antirotation device, operated by an aisle side foot pedal, locked the seat into position once it had been rotated to the desired direction. Coach & Car seats were equipped with Coach & Car seat locks; AMI seats were retrofitted with Trison seat locks. Seats were also equipped with foot rests, leg rests, and fold-down airline type tray tables. Handicapped passenger seats were on the lower level. Seats were numbered consecutively from left to right starting at the A-end of the coach. Overhead storage racks above the seats extended the length of each coach on both sides to accommodate unchecked baggage and personal belongings.

The lower level of each coach also had four unisex toilets, one ladies lounge with toilet, and one handicapped restroom. Across from the stairwell to the upper level was a storage area for unchecked baggage and a wheelchair ramp.

In the Superliner coach-baggage cars, Amtrak had replaced lower level seating with a segregated checked and unchecked baggage storage area and had increased upper level seating to a high-density seating capacity of 78. The seats in the coach-baggage cars were equipped with the same rotational seats and seat locks as those in the coaches.

The Superliner lounge-cafe car had seats for 73 passengers, 50 on the upper level and 23 on the lower level. Each end quarter of the car's upper level consisted of an "observation area" with 14 rotating seats that did not lock but were mounted on a resistance bearing. Passengers in these 28 seats were free to swivel so that they could have a maximum view of the scenery or a closed circuit TV mounted on each end wall. The middle half of the car had fixed seats in a lounge arrangement and was equipped with a bar or counter near the stairwell for serving beverages and light snacks.

The lower level of the lounge-cafe car was equipped with a full-service food and beverage bar, including two convection ovens, one microwave oven, storage freezer and refrigerator, sink, and coffeemaker. Lower level seating included 3 booths for four passengers each and 11 fixed seats in a small lounge area with an electric piano.

The Superliner dining car had a seating capacity of 72 at 18 booths with four seats each. All seating was on the upper level. The kitchen, food preparation and storage areas, dishwashing facilities, and crew toilet were all on the lower level. Two dumbwaiters carried food to the upper level and the midcar maitre d's station, which had a soup warmer counter and two full-size refrigerators. All appliances were electric.

The Superliner sleeping cars had accommodations for a maximum of 44 passengers. The 14 economy rooms could accommodate 2 passengers each; the 5 deluxe rooms, 2 passengers each; a family room, 4 passengers; and a handicapped room, 2 passengers.

Superliner cars were equipped with a "standard" 24 x 66-inch window. A variety of standard and half-standard windows were found on the lower level, depending on car type. All midsection lower level exterior exit doors had a half-standard door window. Each car had four upper level windows designated as emergency exits. The next to the last windows from each end of the cars on one side, and the fourth from the end windows on the other side were designated as emergency exits. A minimum of one window in three was designated as an emergency exit on the lower level, depending on the car type.

The Superliner exteriors were a combination of flat and corrugated stainless steel sheeting.

In addition to the locomotive HEP, each car had a battery for emergency lights and short-term backup needs. Six types of service lighting were available in the Superliner cars, depending on the car type: fluorescent background cove, incandescent reading, aisle, rest room, ceiling, and car body end lights.

Each car had air conditioners in the lower level at both ends above the trucks. The cars were electrically heated using both overhead and floor heating units.

Postaccident Equipment Inspection

Car Inspections.--At the accident site, Safety Board investigators gave the eight derailed cars an initial visual inspection. The train had remained coupled throughout the derailment, and some coupler shanks[8] of the derailed cars were twisted.

The last four cars showed evidence of contacting or striking the empty gondola car that had been placed on an adjacent parallel siding. A corner of the gondola contained pieces of stainless steel from the passenger car side sheeting. All contact points on the gondola and the passenger cars matched according to height and other dimensional data. The gondola had been struck on the corner near the hand brake and was moved along the length of the siding until it struck a derail[9] near the switch stand. (See figure 4.)

The fourth car from the end, sleeping car No. 32064, received a slight crease about 18 feet long on the B end[10] and about 60 inches from the top of the track rail, where it contacted the gondola side's top rail lip. The next car, coach No. 31012, contacted the bottom edge of the gondola side sill, which ripped a continuous cut into the side sheet stainless steel sheathing of the passenger car about 3/4 of its length, then caught and bent the corrugation and step at the A end. The corner of

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[8]Coupler shank is that part of a coupler between the coupler head and the swivel pin.

[9]A track structure for derailing rolling stock in case of an emergency.

[10]Railroad car ends are designated "A" or "B" according to the position of the hand brake, which is normally located at the B end.

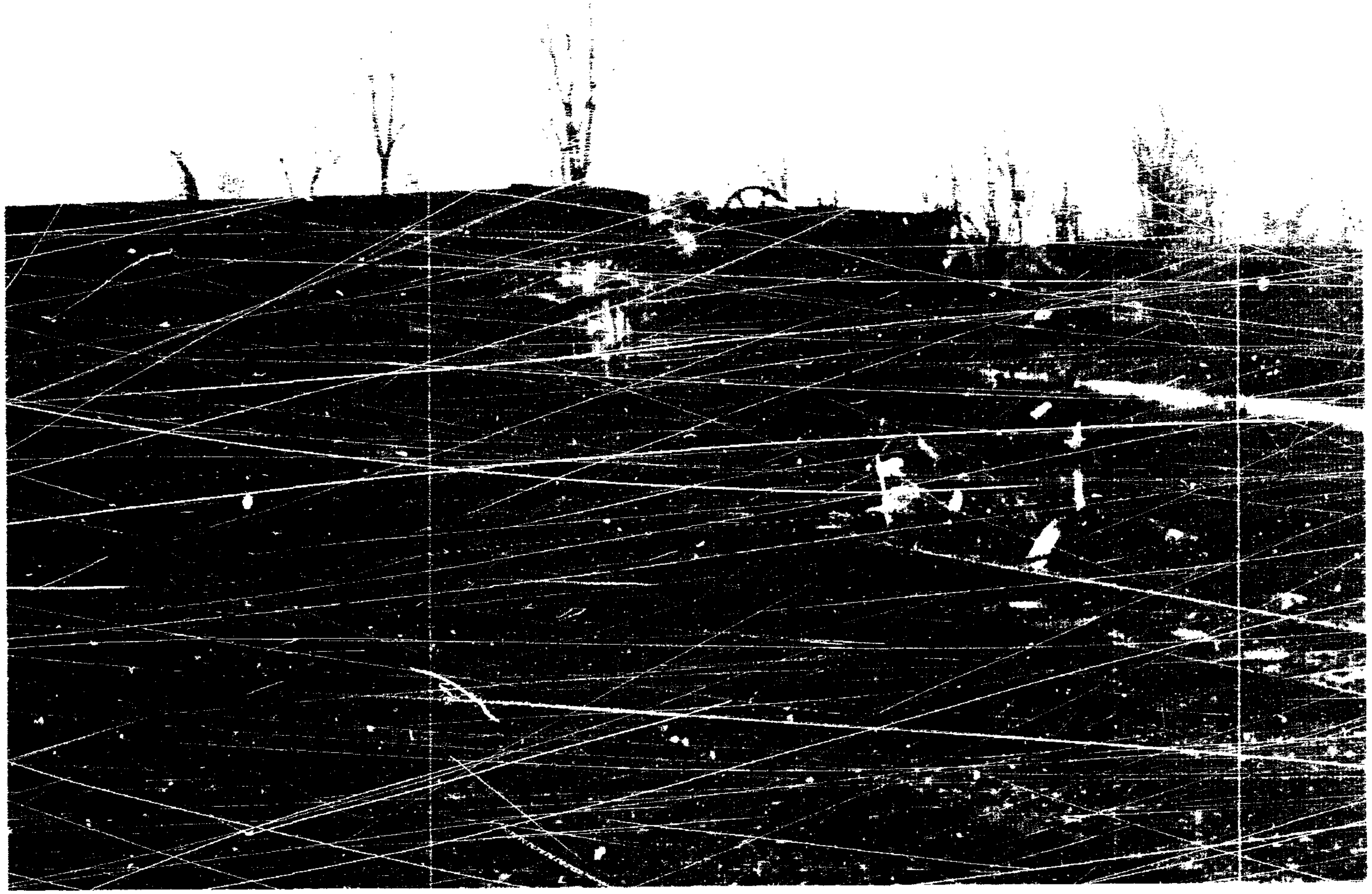

Figure 4.--Damage to gondola.

the gondola ripped large gashes in the trailing half of the last two cars on their south sides just below the top/lower deck separation. (See figure 5.).

These last two cars, coach No. 34001 and sleeping car No. 32046, had significant interior damage. Coach No. 34001 had interior and exterior wall damage from the upper level floor starting at seats 75-76 on the right (south) side and continuing to seats 83-84 at the end of the car. In sleeping car No. 32046, the interior and exterior walls of rooms 14 and 15 were destroyed, along with the car's stairwell.

All the derailed cars sustained damage to the equipment attached to the bottom of the cars' underframes. Components such as the electrical conduit and air brake piping, valves, and reservoirs were damaged when the derailed cars straddled rails and track parts while riding on the ballast and ties.

Wheel Inspection.--After workers rerailed the train's last eight cars, they were moved to Fairfield, Iowa, for more thorough inspection and preparation for movement to Amtrak's Beech Grove (Indianapolis), Indiana, shop for repair. Fifteen pairs of wheels were removed for replacement due to wheel flange or disk brake damage, suspected bearing damage, or other running equipment damage that might cause a derailment or endanger the damaged cars' continued movement.

Lounge car No. 33021 and dining car No. 38017, the 9th and 10th cars, had scrape marks along the outer edge of the wheel rim on the south wheels and scrapes on the inside of the north brake disks. However, neither one had to have wheels changed at Fairfield. No other car wheels displayed such marks.

All derailed cars had some wheel damage. The worst case was multiple strike marks in one area on a wheel of car No. 31012. The damaged part of the wheel was sent to an independent laboratory, Transportation Services Division of Transportation and Distribution Associates, Inc. (TSD, Inc.), Springfield, Missouri, for analysis.

Mechanical Records.--Safety Board investigators reviewed equipment maintenance records after the accident. Locomotive unit documents examined included: the FRA Locomotive Inspection and Repair Record (Form F6180-49A), Locomotive Daily Inspection Card (FRA Rule 203), and Amtrak maintenance forms. Investigators also reviewed computerized Amtrak passenger car maintenance histories and work sheets. They found no discrepancies in car or locomotive parts, or maintenance practices and inspections.

Signal Information

Train movements through Batavia are controlled by wayside signals as part of an automatic block signal (ABS) system, by track warrant control (TWC), and by centralized traffic control (CTC) on the subdivision where double track changes to single track. After the accident and before workers moved the wreckage, investigators examined the signal system. Beyond the immediate damage to the continuity of the track circuit system, investigators found no defects, and the signal system functioned as designed.

Track Information

General.--The derailment occurred on the second subdivision of the BN's Galesburg division. A segment of BN's mainline between Chicago and Denver, the

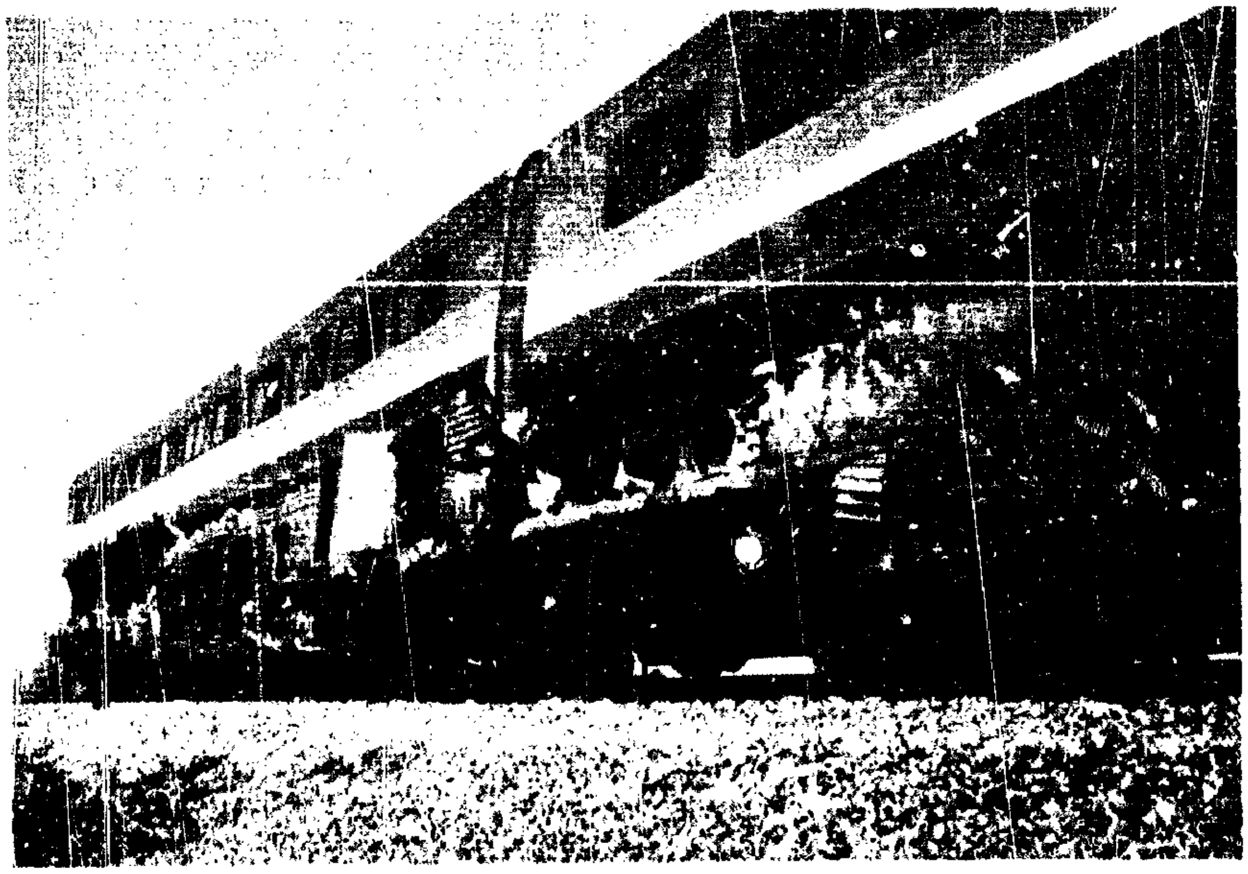

Figure 5.--Damage to coach and sleeping cars.

second subdivision runs east-west for 230.5 miles between Galesburg, Illinois, and Creston, Iowa. Originally built in 1864 as part of the Chicago, Burlington & Quincy Railroad, the subdivision is heavily traveled. According to BN, the subdivision moved approximately 38 million gross tons of freight in 1989, mostly in unit coal trains. More than 20 million gross tons of traffic passed through Batavia in the 5 1/2 months before the derailment.

Accident Site Information.--Two mainline tracks run through the south side of Batavia; the westbound (north) track is designated track No. 1, and the eastbound (south) track is designated track No. 2. From MP 266.2 to MP 265.8, the track grade profile through Batavia is in the bottom of a sag vertical curve.[11] East of Batavia, past MP 265.8 in the direction train No. 6 was heading, the track profile rises at 0.5 percent grade for the next 3/10 of a mile, levels off for a 1/2 mile and then climbs again at 0.54 percent for 1 1/4 miles into Agency City. West of Batavia, past MP 266.2, the grade profile rises at 0.5 percent for 1/10 of a mile and then increases to 0.66 percent for the next 1 1/10 miles after which the uphill grade profile gradually decreases toward Creston.

BN officials and track inspectors indicated that due to the shallow rising terrain on either side of Batavia, rail movement and track stability had not been a problem in the Batavia area. According to BN, when a railroad's grade, traffic, or both, are significant, gravity and the downhill braking of trains creates a tendency of rail to run or move toward the bottom of a sag.

County Road 43, a north-south public road, runs through Batavia and crosses the railroad at grade. The grade crossing has flashing warning lights. Just west of the road crossing, the railroad curves 1° 02' for about 1/4 mile, limiting sight distance east of the road crossing and through Batavia. A turnout for a track crossover from the eastbound No. 2 track to the westbound No. 1 track is about 400 feet east of the road crossing. Both railroad crossover turnouts are No. 11, 132-lb. R.E. rail with railbound manganese frogs[12]. A left hand turnout to a track siding is located at MP 266 and extends about 1/10 mile south and parallel to the eastbound No. 2 mainline track. (See figure 6.)

The railroad right-of-way through Batavia varies in width from 30 to 485 feet. Light agricultural industry is located on both sides. Just off the right-of-way near the east end of the derailment site are a few single-family homes.

Track Structure.--Mainline rail through Batavia from MP 266.7 to MP 273.1 is 129 lbs per yard of CWR. In the Batavia area, the distance between mainline track centers is about 14 feet. Rails lay on double-shouldered tie plates with two rail-holding spikes on the gage side (inside) and one rail-holding spike on the field side (outside). Tie plates are spiked to 7 inch x 9 inch x 8 feet 6 inch, grade No. 5 hardwood ties. Ties are spaced at 19 1/2 inches between centers. Track surface and alignment are maintained on crushed granite about 1 1/2 inches in size. In the undisturbed areas immediately east and west of the derailment area, the tie cribs were full and the shoulder ballast extended about 12 inches or more beyond the tie

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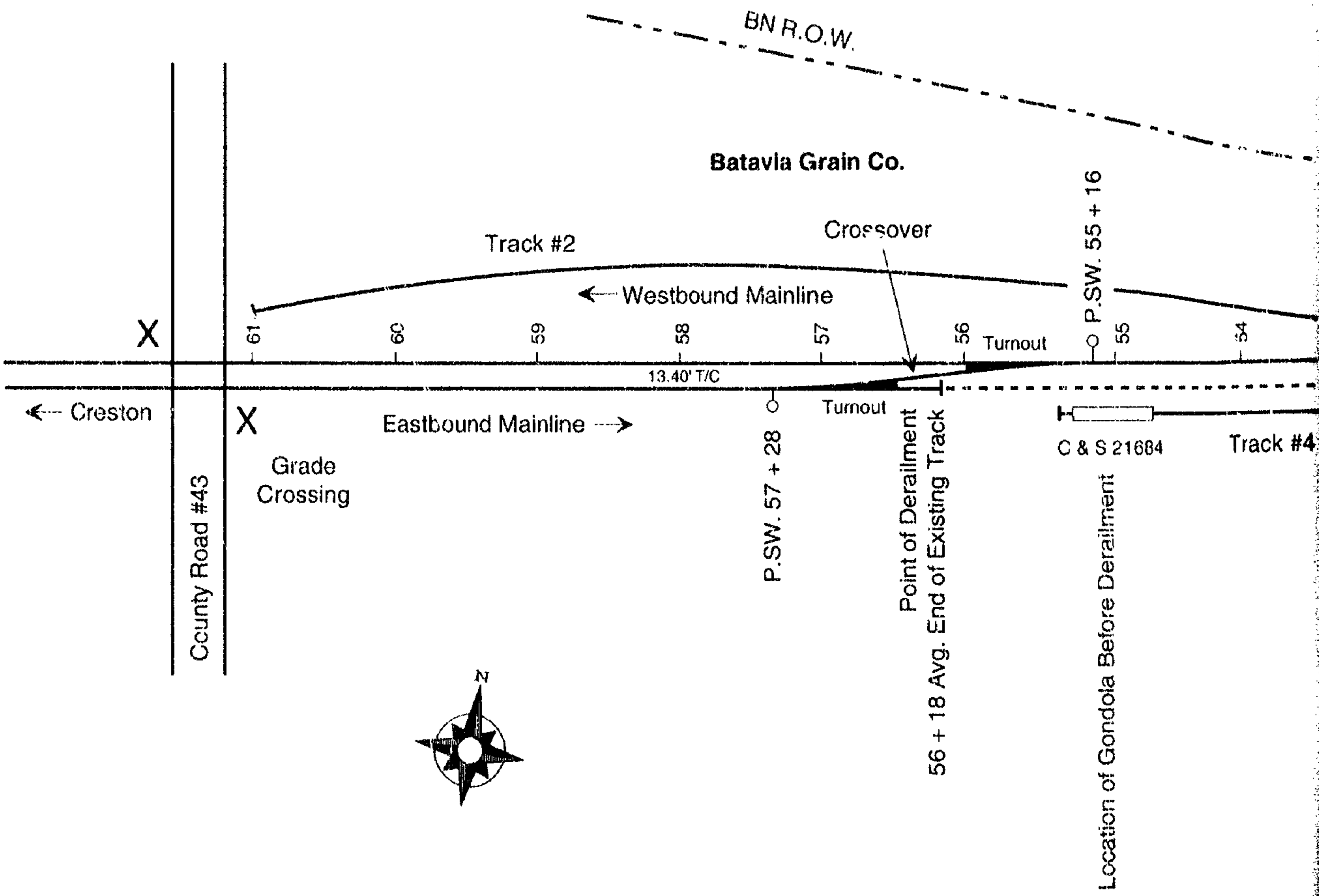
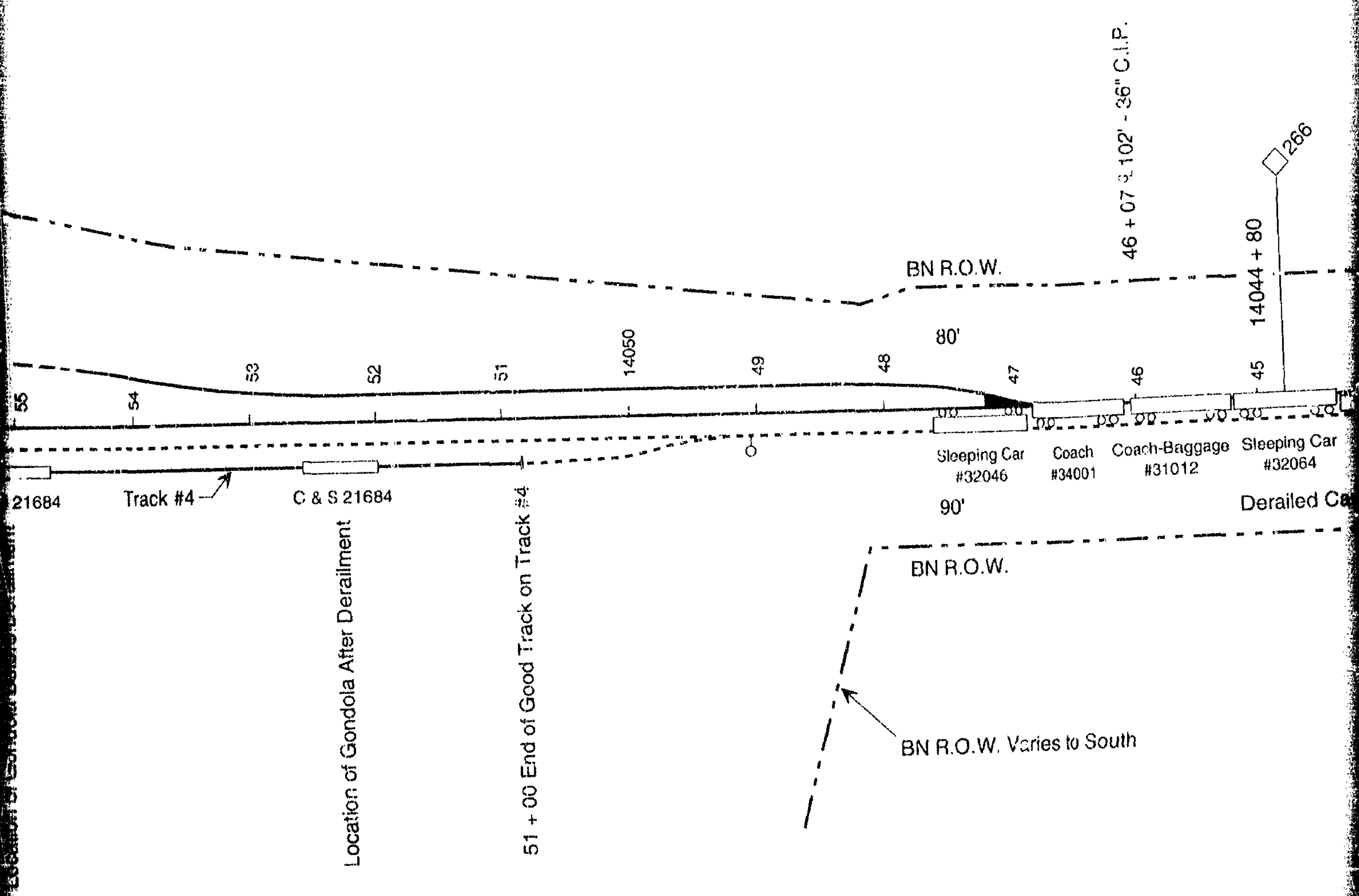
[11]A sag vertical curve is a vertical transition curve in the profile of a track to connect intersecting grade lines and permit the smooth and safe operation of trains over summits and across sags.

[12]A frog is a track structure used at the intersection of two running rails to provide support for wheels and passageway for their flanges, thus permitting wheels on either rail to cross the other.

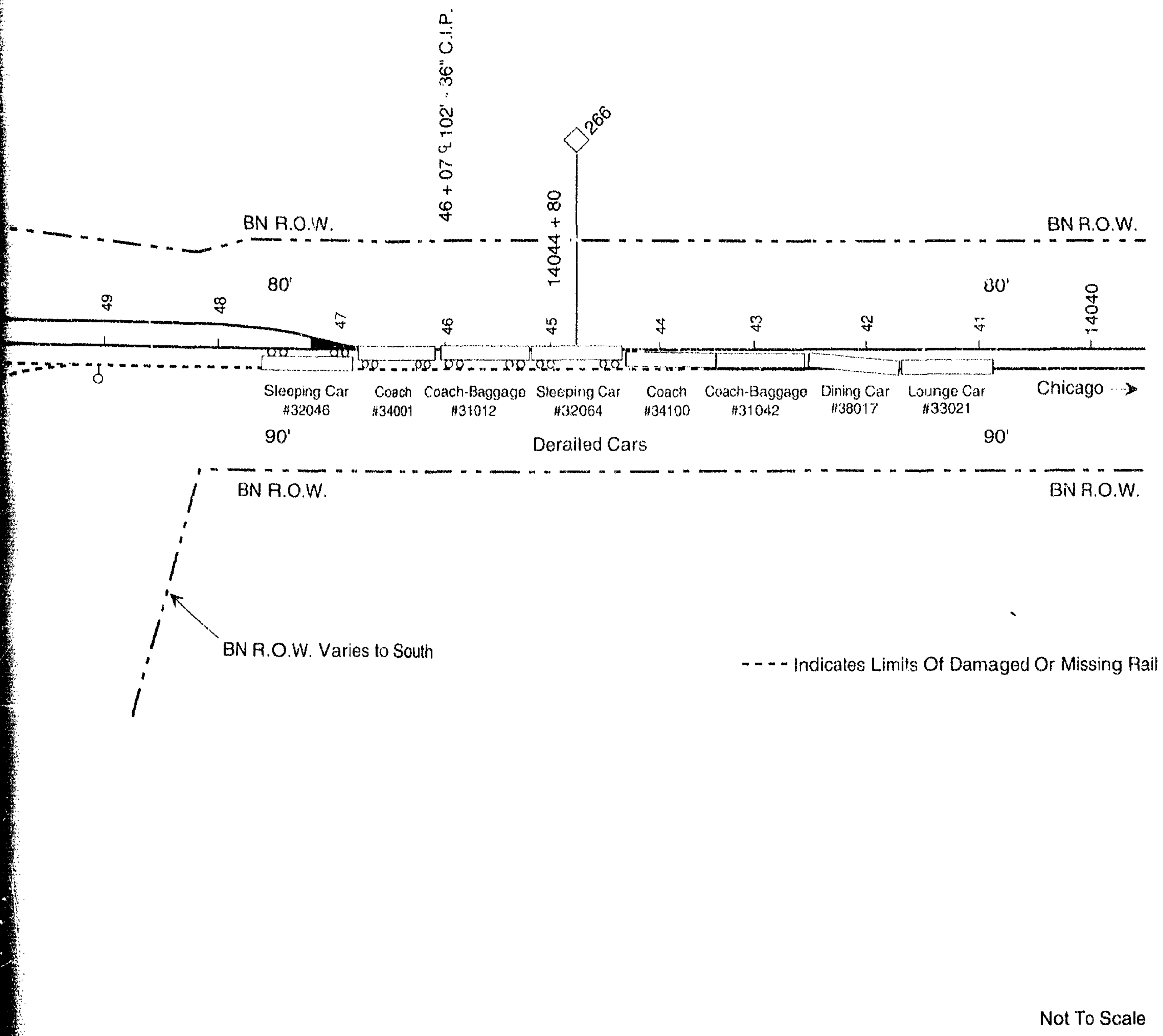


BN R.O.W.
Batavia Grain Co.
Track #2
Crossover
P.SW. 55 + 16
Westbound Mainline
X
61
60
59
58
57
56
Turnout
55
54
13.40' T/C
Creston
X
Eastbound Mainline
Turnout
C & S 21684
Track #4
Grade Crossing
County Road #43
P.SW. 57 + 28
Point of Derailment
56 + 18 Avg. End of Existing Track
Location of Gondola Before Derailment
N

Figure 6. --



e 6. -- Batavia, Iowa, track arrangement.



arrangement.

ends. All ties were box-anchored, that is, anchored on both sides of the tie, to prevent longitudinal movement of the rail in either direction for about 1,675 feet west of the accident site and 1,000 feet east of the accident site. Beyond these limits, every other tie was box-anchored.

The left hand turnout to the crossover, which the train passed just before derailment, was constructed of 132-pound rail with Pandrol rail fasteners. All mainline and closure rail joints in the turnout were field-welded. The stock rail was undercut to accommodate the 16 1/2-foot mainline rail Samson switch point.

Continuous Welded Rail.--CWR has no joints; joints are welded together either in a rail plant or in the field. The concept of welding rails together to eliminate the disadvantage of rail joints was conceived in the early 1930s. According to the AAR, about half of all jointed rail defects develop within the area enclosed by the joint bars. The inherent benefits of CWR are reduced track maintenance, reduced harmonic roll[13] and in-train forces, and stronger track structure. However, CWR is subject to mechanically induced outside forces when loaded and to thermally induced internal forces from expansion or contraction. CWR must therefore be longitudinally restrained to prevent rail movement caused by these mechanical and thermal forces. Although these forces are present in all railroad rail, they are much greater in CWR because the absence of joints eliminates gaps which accommodate the tendency to expand or contract and the resulting longitudinal rail forces.

Longitudinal restraint in CWR generally takes the form of additional rail anchors, shoulder ballast, or both; elastic clips in lieu of rail holding spikes; and possibly larger or heavier ties. When the longitudinal mechanical and thermal compressive forces in CWR build up to a point at which they exceed the ability of the track structure to restrain the forces, track buckling will occur. According to the American Railway Engineering Association (AREA), the MOW arm of the AAR, the magnitude of force that may be developed within CWR, independent of its length, is the product of the difference in temperature between the laying (anchoring) temperature and current rail temperature multiplied by the cross-sectional area of the rail and the factor of 195 psi.[14]

Track buckling is also referred to as a "sun kink," and usually takes two forms or shapes in straight track--an "S" shape with symmetrical lobes on each side of the track centerline or a "longhorns" shape that has a small lobe on each end of the buckle on one side and a large center lobe on the other. (See figure 7.)

Mechanically induced longitudinal rail forces develop as a result of the wave-like rolling motion created in the rail when it bends under the continuously moving weight of a train. Although this mechanical loading is usually not sufficient by itself to buckle track, it can produce longitudinal creep or movement of the rail. When this creep is restrained, as in the case of well-anchored CWR or at anchor points such as turnouts and grade crossings, longitudinal compressive forces build up within the rail.

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[13]Harmonic roll is the excessive lateral rocking of rail cars and locomotives, usually at slow speeds between 10 and 25 mph, associated with jointed rail. In extreme cases this phenomenon can result in wheels lifting off the rail and the train derailing.

[14]The internal stress of restrained rail is the product of the coefficient of expansion and the modulus of elasticity of the steel, times the change in temperature.

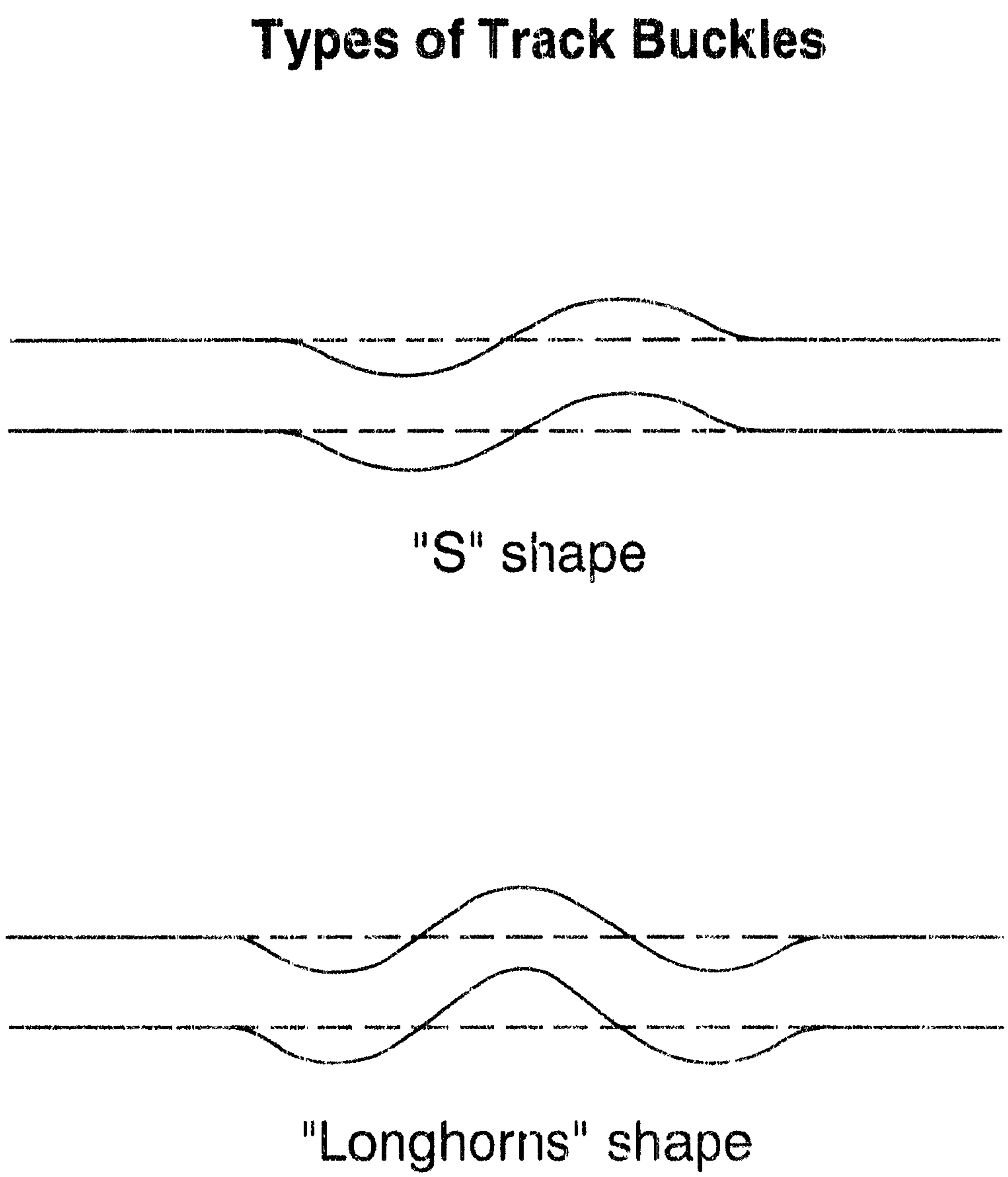

Figure 7.--Types of track buckles.

Thermally induced longitudinal rail forces result when restrained CWR seeks to expand or contract beyond its force-free or neutral temperature state. The neutral rail temperature is an estimate of the temperature of the steel rail under conditions free of internal forces due to thermal stress or strain. Thermal expansion causes the compressive longitudinal forces found in track buckling. Because a difference in rail temperature from the initial laying temperature (when the rail is anchored or restrained) determines the magnitude of the thermally induced internal longitudinal rail forces, the proper selection and control of CWR installation temperature is very important. Consequently, many railroads have well-defined installation temperatures for different geographical and climatic locations that are intended to minimize the thermally induced internal longitudinal rail forces throughout the range of seasonal temperature change. This installation temperature is commonly referred to as the neutral temperature. If the rail temperature is below the designated neutral temperature at the time of CWR installation, the rails are artificially heated to the neutral temperature and then immediately anchored. Conversely, if the rail temperature at the time of CWR installation is above the neutral rail temperature, the rail is cooled, usually by spraying with a coolant, and then anchored. Each railroad develops its own CWR standards, which can be customized to its geography and climates.

The same restrained mechanical and thermal forces that make up the longitudinal rail forces may also lead to permanent stresses and deformation in the CWR that build up over time, changing the neutral rail or installation temperature. This often occurs in conjunction with maintenance activities such as surfacing. Surfacing is the process of raising the track and leveling the roadbed on which it rests, aligning the track back into place. After such operations, the force-free or neutral temperature is no longer the same, and the CWR should be adjusted[15] to conform to the new conditions.

Track History and Maintenance.--During the 9 months before the accident, BN had performed a significant amount of track work in the Batavia area. In August 1989, the crossover between the eastbound and westbound mainline tracks had been moved about 200 feet west toward the grade crossing and reversed for the current westbound to eastbound movements. This also involved the replacement of one crossover turnout with a new prefabricated 132-pound rail turnout. Between June and November 1989, all rail joints in the eastbound mainline turnout of the crossover (on which the accident train traveled) were field-welded. Between August 30 and November 17, 1989, all the 129-pound jointed rail on the eastbound mainline between MP 250 and MP 266.3 was field-welded into CWR by BN welding gang No. 41 using Holland welding equipment.

On November 22, 1989, BN surfaced and lined the eastbound mainline through Batavia including the crossover turnout. To provide uniform compaction and minimize settlement of the ballast under traffic, BN used a tamping machine, which vibrated the ballast and raised the entire track structure an estimated 1/2 inch. From records obtained from nearby Ottumwa Airport, Safety Board investigators determined that on November 22, 1989, when BN surfaced the Batavia area track, the high ambient temperature was 33° F and the low was 22° F. After the track had

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[15]Rail is adjusted according to its temperature to minimize longitudinal forces, usually by removing rail anchors and adding or removing small sections of rail.

been surfaced and lined, BN made no follow-up adjustment of the rail to accommodate any change in the neutral rail temperature of the CWR.

Surfacing.--BN records show that the last time that the track in the Batavia area was disturbed before the accident was the week after gang No. 41 finished welding CWR. According to BN, surfacing was necessary to reestablish a smooth and uniform rail surface that was free of the humps or dips that can be created during the in-track electric flash butt-welding operation. The surfacing involved one or more of the following operations: lifting the track, aligning the track, and tamping the ballast.

According to the AREA, after surfacing is performed on CWR track, the rail should be adjusted (destressed). Once the bond between the tie and the ballast is broken, no restraint remains that will prevent the rail from contracting or expanding to a force free condition, a new neutral rail temperature. When this occurs, the new neutral rail temperature becomes whatever the rail temperature is when the ballast to tie bond is reestablished. Therefore, once surfacing is complete, the rail must be adjusted to the specified neutral rail temperature for the geographical zone by heating or cooling the rail before reanchoring. If not adjusted immediately, CWR should be closely monitored for rail movement if ambient temperatures begin to increase. The AAR also recommends that an adjusted track be closely monitored until the passage of tonnage trains establishes a new ballast and tie bond.

Appendix A, "Prevention of Track Buckling," in BN's MOW rules book contains the following instructions for installing concrete ties and maintaining CWR track:

> Concrete Tie Installation
>
> 2. At the completion of each day's work, a new neutral rail temperature is established. Undercutting and resurfacing behind also establishes a new neutral temperature.
>
> 4. Correction of existing neutral temperature to the desired neutral temperature as shown in M/W Circular 1, Pages 5 through 9, will be performed by destressing crews.
>
> Destressing Concrete Ties
>
> 2. During destressing, all rail clips will be removed and rail/track tension will be relieved through stretching, cropping, and heating, or a combination of these techniques. As with wood ties, care is to be exercised when releasing rail, cutting, and pulling around curves to avoid rail from moving in undesired directions. Equal stressing is to be achieved for both rails.
>
> Maintenance of Concrete Tie Track
>
> The following affect lateral resistance:
>
> 1. Neutral temperature. This is changed any time maintenance is performed (surfacing, joint elimination, and rail replacement).

With the exception of the above instructions for concrete tie installation, BN's MOW rules book does not specifically require adjustment of CWR track after surfacing. The MOW rules do advise that precautions should be taken when surfacing during periods of warm weather, that the rules do not contain precautions for cold weather. The rules also require that "any time track shows indications of tight rail or exhibits a track buckling tendency, the rail must be cut and stress relieved."

Preaccident Track Inspections.--BN had maintained the second subdivision in compliance with Federal Track Safety Standards (CFR 49, Part 213) for class 4[16] track with an 80-mph speed limit for passenger trains. These standards require the carrier to inspect the track twice weekly with an interval of at least one calendar day between inspections. BN inspectors examine the second subdivision mainline (230.3 miles) daily from a hi-rail vehicle and either report any defects or correct them on the spot. The track in the Batavia area was last inspected for compliance with FRA standards on March 6, 1990, by an Iowa Department of Transportation (IDOT) track inspector who found no defects between MP 232 and MP 278. In the 30 days before the accident, BN track inspectors found and corrected 15 FRA defects between MP 218 and MP 278. A BN inspector recorded the following defects at or near the accident site:

Date	Location	BN Description	Corrective Action and Date
3-06-90	Eastbound Mp 266.1	133.07	New Cotter Pins 3-06-90
3-06-90	Eastbound Mp 266.0	121.05	New Bolts, Repaired 3-06-90
3-14-90	Eastbound Mp 266.5	33.07	Filled in With Rock 3-14-90
3-15-90	Eastbound Mp 266.2	141.02	Welders Repaired 3-15-90
3-16-90	Eastbound Mp 266.4	Low Spot	Raised 3-16-90
3-23-90	Eastbound Mp 266.9	High X-plank	Renewed 3-23-90
4-16-90	Eastbound Mp 266.4	<2Bolts/rail end	Replaced and Tightened
4-23-90	Westbound Mp 263.5	121.07	Replaced Bolts, Tightened

A BN track geometry car[17] last evaluated the second subdivision on March 26, 1990. No defects were detected in the Batavia area between MP 254.5 and MP 268.8.

On the day of the accident, a BN track inspector had made a routine inspection of both mainline tracks as he passed through Batavia on the westbound main about 10:50 a.m. He did not stop at any of the turnouts, nor was he required by Federal or company regulations to do so. He took no exception to the condition of the track. This BN track inspector had been assigned to the second subdivision area for 7 days before the accident. He had been a qualified BN track inspector since November 1980.

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[16] The FRA classifies track into one of six classes. Track class determines the speed limits of trains; class 1 is the slowest and class 6 the fastest. Track class is determined by parameters such as track geometry tolerances, the number of defects allowed, and the physical strength of the track structure according to rail size and tie spacing.

[17] Track geometry cars measure irregular cross level, super elevation, gage, warp, alignment, and profile, as outlined in the FRA Track Safety Standards, CFR Part 213,C.

The local section foreman had also inspected the track on the day of the accident as he walked through the Batavia area while supervising the unloading of grade crossing material from a gondola. He indicated that he noted nothing unusual. The section foreman said in a postaccident interview that "Sunday (April 23, 1990) was the first warm day, somewhere between 80 degrees and 85."

Meteorological Information

On the day of the accident, the nearby Ottumwa Airport recorded a low temperature of 60° F at 5:50 a.m. and a high of 84° F at 4:50 p.m.[18] The recorded temperature was 79° F at 11:50 a.m. and 82° F at 12:50 p.m. Clouds were high and scattered. The temperature had risen 20 degrees in 5 hours, from 62° F at 7:50 a.m. to 82° F at 12:50 p.m. The air temperature remained between 82-84° F the rest of the afternoon past 5:50 p.m., when the IDOT inspector was at the accident site.

Records from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and Ottumwa Airport show that the area near Batavia had the following ambient high and low temperatures during April prior to the accident:

APRIL 1990

Date	High (F°)	Low (F°)	Date	High (F°)	Low (F°)
1	63	37	13	43	38
2	49	30	14	59	39
3	51	28	15	59	44
4	62	39	16	59	37
5	46	29	17	50	28
6	40	25	18	57	34
7	55	22	19	62	43
8	69	41	20	66	53
9	53	45	21	69	50
10	[illegible]	37	22	78	48
11	40	27	23	84	60
12	52	25			

The hourly temperatures recorded at Ottumwa Airport on the day before the accident and the day of the accident were as follows:

Time	April 23	April 22
0050	65	53
0150	63	52
0250	62	51
0350	61	50
0450	61	50
0550	60	48
0650	60	51
0750	62	52

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[18] Recorded temperatures are ambient "shade" temperatures.

Time	April 23	April 22
0850	66	56
0950	70	60
1050	75	66
1150	79	70
1250	82	74
1350	82	77
1450	83	78
1550	83	78
1650	84	78
1750	83	77
1850	--	74
1950	--	71
2050	--	70
2150	--	68
2250	--	67
2350	--	65

Postaccident Track Inspection.--About 3 hours after the derailment, an IDOT track inspector arrived at the accident site. He had been a State track inspector since 1974 and was familiar with the Batavia area. The IDOT inspector noted that the ties near the frog of the crossover turnout on the eastbound main were out of alignment and had been 12 inches further south before being pulled back toward their original position by the derailing train. This side movement included about 30 feet of track structure on either side of the frog. Based on this evidence, he concluded that the derailment had occurred underneath the train and that the force of the train's forward movement had tended to straighten the track back into alignment. (See figure 8.)

Suspecting a possible track buckle, the IDOT track inspector measured the rail temperature of both the eastbound and westbound mainline rails late in the afternoon using the local roadmaster's rail thermometer.[19] He found the westbound rails (No. 1 track) to be 98° F and the eastbound rails (No. 2 track) to be 94° F. The track inspector stated, "When I arrived, it was... mostly sunny, very few clouds in the sky, just light cloud...; this was the first hot day of the year, yes."

In an effort to reopen the mainline as soon as possible, nearby BN maintenance-of-way and wreck clearing forces began working before Safety Board investigators arrived. However, the IDOT track inspector photographed the accident site before it was disturbed. The westbound mainline track was out of alignment for 19 feet behind the point of the frog and extending west about 15 feet. The track was out of alignment to the south up to 18 inches at one point between the crossover frogs. (See figures 9 and 10.)

Safety Board investigators found no marks or abrasions on the track structure leading into the derailment site. The curve before the grade crossing was super-elevated. Geometry was within FRA standards for class 4 track. Rail

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[19]Rail temperature will be at or above the ambient temperature depending on the amount of sunshine on the rail.

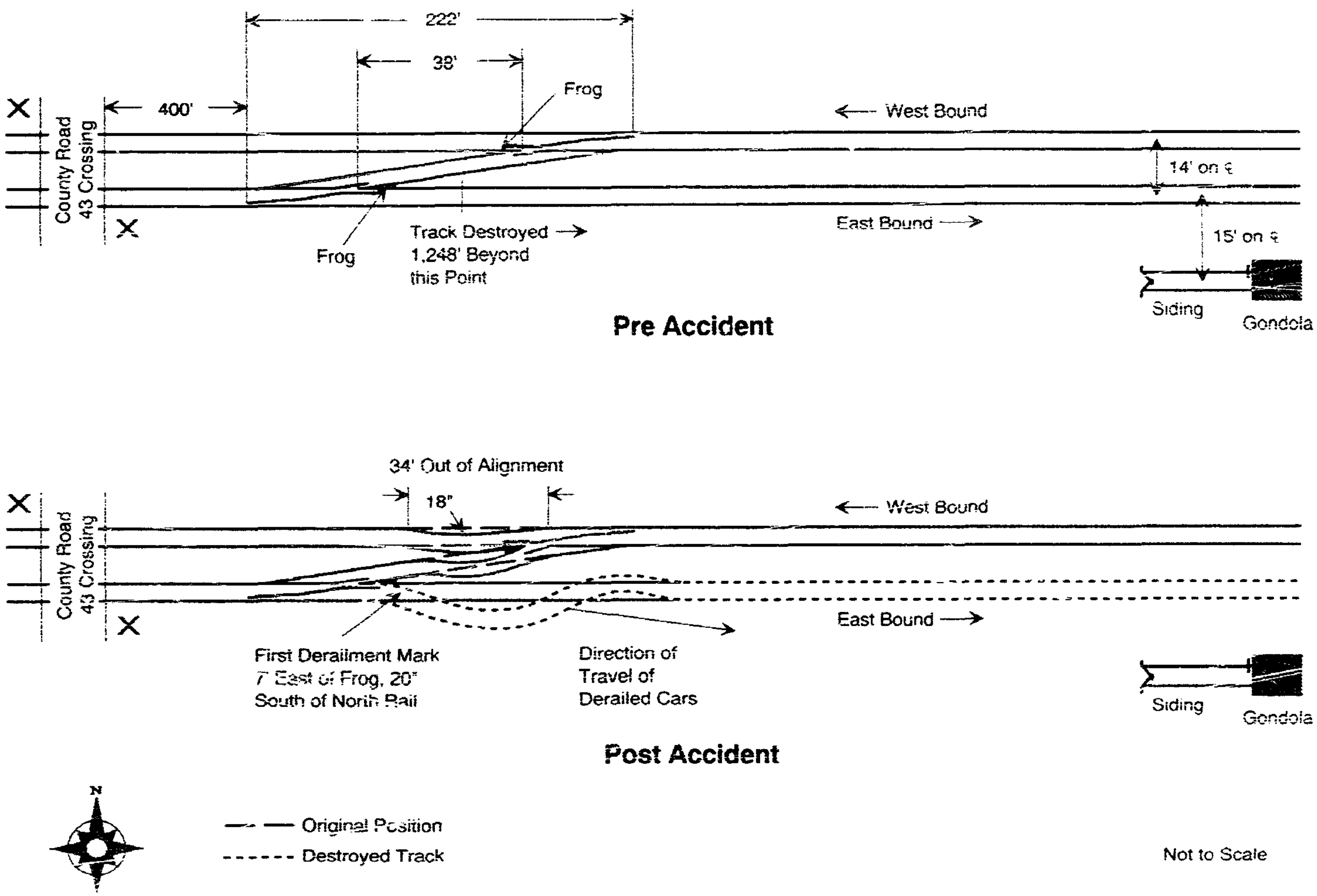

Figure 8.--Accident site track alignment.

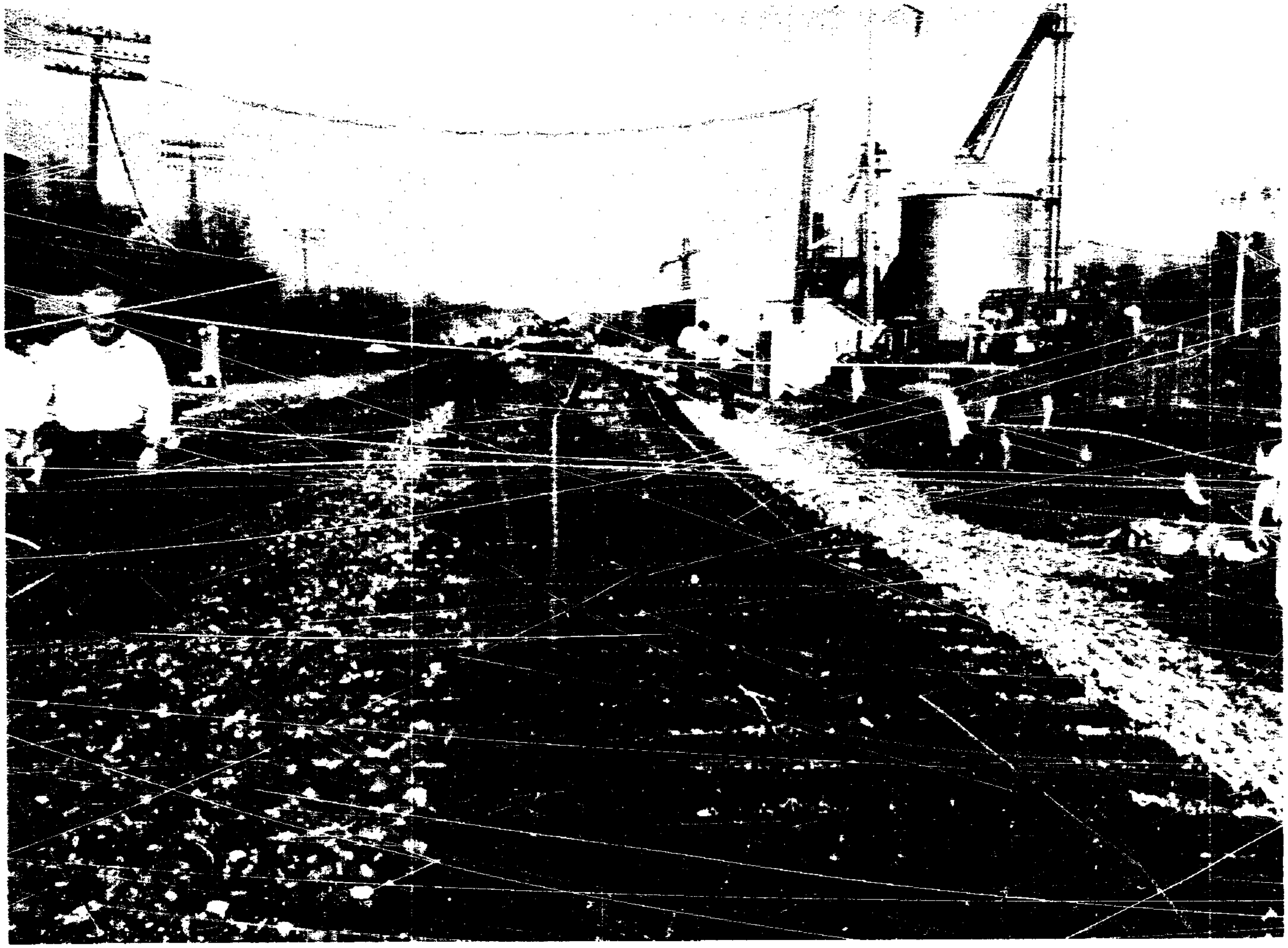

Figure 9.--Eastbound mainline track alignment.

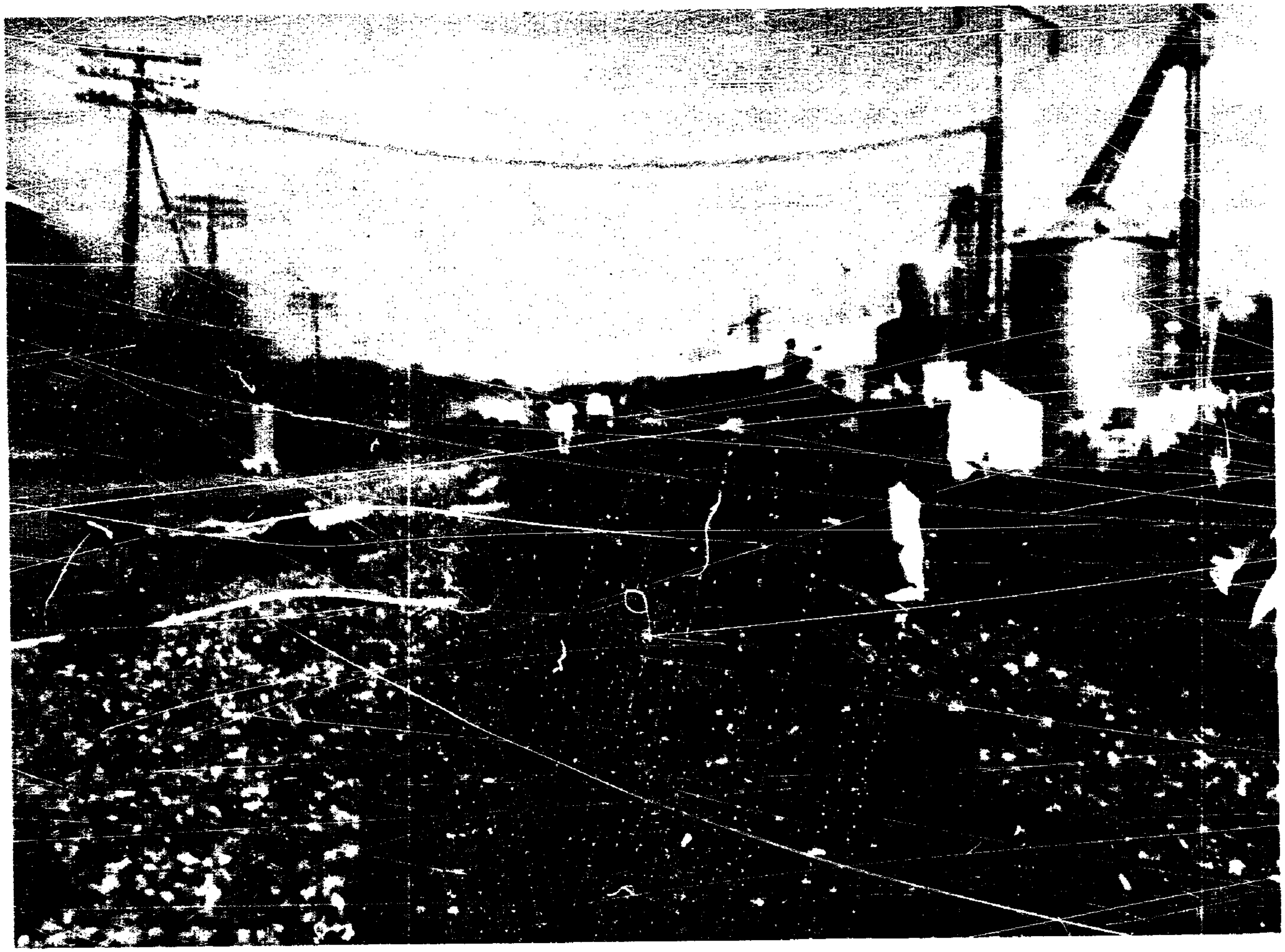

Figure 10.--Westbound mainline track alignment.

anchorwere tight and bearing hard against the west side of the ties. No evidence indicated that the rail had moved in either direction over the tie plates.

Eastward, in the direction of the train's movement, the first evidence of derailment was two flange marks on the tops of ties between the rails on the eastbound mainline track. The first mark, a distinct and sharp groove on top of the ties, began 7 feet east of the turnout frog and 20 inches south of the north rail. The other flange mark began 14 1/2 feet east of the frog and 18 inches south of the north rail. The paths of both flange marks continued at a shallow angle southeast toward the parked gondola on the parallel siding. Each flange mark was distinct and had been made by a wheel from different wheel sets as indicated by distance and spacing. The second mark, a broad scuff mark, indicated when the wheel turned away from the direction of movement.

Inspection of the eastbound main turnout revealed no marks on the switch points, guard rail, or frog that suggested a track defect or dragging equipment. The frog was slightly chipped and bent but well within FRA specifications.[20]

Two pieces of welded rail, each about 600 feet long, were salvaged from the derailment and examined. They were sections from the north and south rails of the eastbound mainline between the crossover and the stub track. The rails showed few flange marks on the web and base except at the west end of the south rail, where some anchor marks were present on the bottom base of the rail for about 100 feet. A wheel running on the side of the sharp corners of the rail base had flattened the field side of the south rail base. This condition became more pronounced near the west end of the rail, which had been behind the crossover frog. The base of the north rail had similar deformations but only on the east half.

The south rail was also severely abraded and scuffed on the gage corner of the rail head. The mark began about 40 feet behind the heel of the frog and extended east about 45 feet. Some 400 feet behind the heel of the frog was a similar mark about 10 feet long. These and several other rails suffered heavy gage face gouging. (See figure 11.)

Operational Welding Procedures

Welding Gang No. 41.--A Holland welding gang had performed much of the rail welding in the Batavia area. The BN has one welding gang that performs in-field production welding of rail or creates CWR on-site. All other CWR installations on BN are done by "steel gangs" who only install or "lay" 1/4-mile lengths of rail. The Holland welding gang comprises a general foreman, two assistants (foremen), and 56 machine operators and laborers, who operate two Holland welding trucks and miscellaneous support machines. The gang is split into two duplicate groups that work simultaneously about 1/4 mile apart on each of the track rails. (See figure 12.)

In the accident area, the Holland welding gang converted conventional jointed 39-foot rail into CWR using an electric welding process. The gang created unbroken CWR without any gaps until they reached an "anchor point" or "set point" such as a turnout, grade crossing, bridge, or other permanent track fixture where the welding machine could not pick up the rail. At these points, the gang had to cut a gap in the

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[20]49 CFR 213.137.

Figure 11.--Heavy gage face gouging on one rail.

rail and then field-weld the two rails together using the chemical thermit[21] or the "Orgotherm" process. If the welding gang did not encounter a fixed point, they continued making uninterrupted CWR without regard to distance.

<u>The Holland Welding Process</u>.--According to the Holland Company, the welding gang used the "in-track electric flash butt-welding process" to create CWR. In the electric flash process, the two adjacent rail ends to be welded together are clamped and held firmly in the welding machine. Unlike the chemical thermit welding process, no gap is left between rail ends before welding. After the two rail ends are butted tightly together, they are heated by a process of electric flashing or quick electrical resistance heating. When the rail ends reach the proper temperature, the welding machine forces the two steel rail heads together. The combination of heat and pressure melds the rails together. As the rails fuse, some of the steel is "upset" and bulges out around the point of fusion. The length of rail that is lost through upsetting is about 1 1/2 inches at each weld. The excess upset is sheared away by the welding machine and dressed with a grinder.

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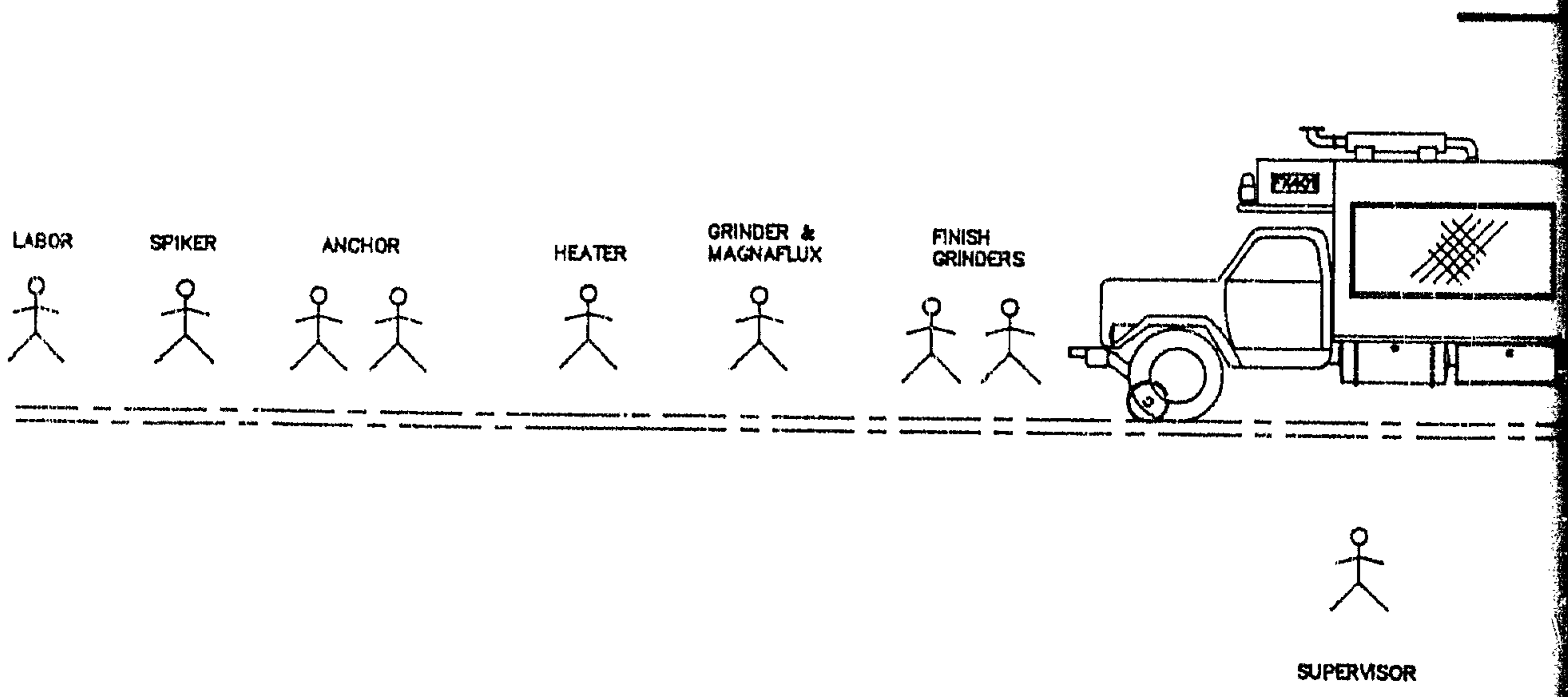
[21]Thermit is a trademark for a welding and incendiary mixture of fine aluminum powder with a metallic oxide of iron or chromium that produces an intense exothermic reaction when ignited. Thermit and other filler materials are placed in a portable crucible that welds the rail ends together when ignited.



TOLERANCES
UNLESS NOTE
FRACTIONS ±
TWO PLACES
THREE PLACES
ANGLES ± 1

EQUIPMENT LIST

PROFILE GRINDER
BASE GRINDER
WEB POLISHER
(2) SAW
BOLT MACHINE
SPEED SWING OR BURRO CRANE
SPIKE PULLER
RAIL HEATER
ANCHOR MACHINE
SPIKE DRIVER

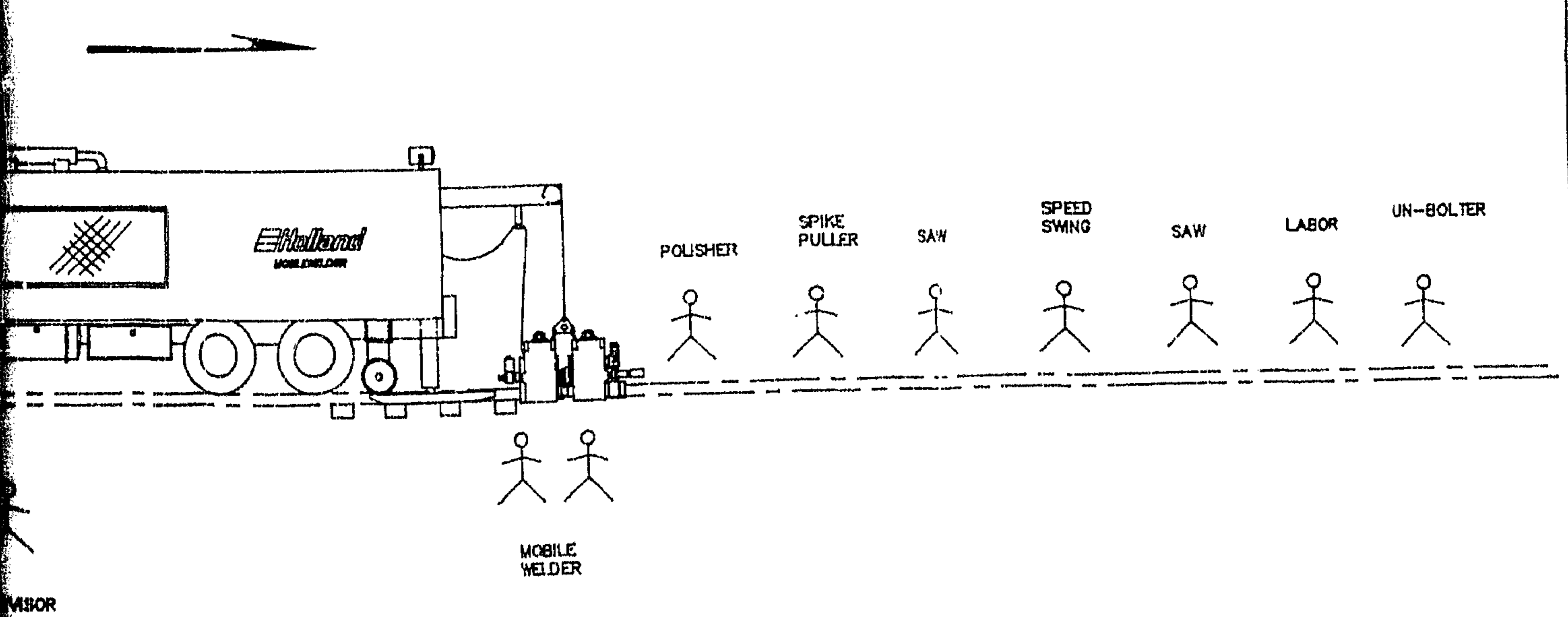


Figure 12. -- Holland welding gang.

TOLERANCES UNLESS NOTED FRACTIONS ± 1/16 TWO PLACES DEC. ± .03 THREE PLACES DEC. ± .010 ANGLES ± 1 °	REVISIONS	PROPERTY OF Holland Company	DR. JS CH. AP.	CROP AND WELD SYSTEM MOBILEWELDER SCALE / DATE 9/26/86 / DWG. NO. SB-19119

Rail renewal plants commonly use this electric flash butt-welding process. The in-track method that gangs use in the field involves other steps, such as removing joint bars and rail anchors, cutting off or "cropping" the rail ends with the joint holes before welding, and heating the rail, when necessary, to apply rail anchors after welding. In the field, rails must also be pulled while they remain on the tie plates to close the gaps left from cropping and removing the rail ends. Workers must insert an extra "seed," or closure rail, to fill the cumulative gaps created by rail cropping and upset.

<u>Temperature Control</u>.--According to BN, when anchoring newly created CWR, it is critical that the welding gang ensure that the rail temperature is as near as possible to the designated "neutral rail temperature." Neutral rail temperature is an estimate of the steel rail's temperature when it is free of internal stress. Currently, no industrywide standards exist for installing and controlling CWR temperature. Each railroad has developed its own empirical standards, to include neutral rail temperature guidelines. In Appendix A, "Prevention of Track Buckling," of its MOW rules, BN states that the best way to maintain CWR is to lay the rail "at the proper rail temperature." The MOW rules state that "If the rail temperature is above or below the designated neutral temperature, the rail should be adjusted to the theoretical neutral temperature, force-free condition during installation anchoring." According to the AAR, the purpose of adjusting rail temperature is to compensate for the compressive or tensile forces within the rail during seasonal temperature changes and to prevent excessive force buildup, which results in track buckling in the heat of summer or rail breaks in the cold of winter.

In most climates, once CWR has been laid at the neutral temperature, no other adjustment is needed until the rail or track is disturbed[22] for maintenance or after a predetermined number of seasonal cycles have elapsed. However, in areas of temperature extremes, such as the Dakotas, where summer highs are over 100° F and winter lows are below -30° F, additional seasonal adjustments may be required. BN has divided its railroad into three neutral rail temperature zones as outlined on page M6 of Standard Practice Circular 1 in the BN MOW rules. Each zone has a specified minimum rail laying temperature[23] that workers must maintain while laying CWR. Batavia is in zone B, which has a minimum rail laying temperature of 90° F. BN representatives testified that BN raised the zone B minimum rail laying temperature to 95° F sometime before gang No. 41 started the 1989 season. Although none of the BN representatives interviewed could produce a written standard confirming the increase to 95° F, they were uniform in their opinion that the standard had been changed to 95° F.

Page M5 of BN's MOW Rules Circular 1 contains the following guidelines in regard to laying welded rail:

> When laying welded rail, the application of rail anchors must not be done below the minimum laying temperatures for

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[22]Disturbed track is track that has had the bond between the ties and ballast broken, usually due to lifting the track in a maintenance operation, and has not yet had enough time or traffic to re-establish the bond.

[23]BN considers the specified minimum rail laying temperature to be the same as neutral rail temperature.

specified areas as shown on Exhibit "A." When rail laying temperatures are below the specified minimum rail temperatures, rail will be heated to the appropriate minimum temperatures or stretched using a hydraulic rail expander. When rail heaters are used, steps must be taken to ensure rail does not bind with tie plates or spikes. Just heating the rail to the desired temperature is not enough; the rail must expand the proper amount. While heating rail, it will be necessary to vibrate the rail or tap the tie plates to assist movement. Match marks will be placed on the base of the rail and tie plate every 9 rail lengths to ensure the rail has expanded the proper amount.

If the rail temperatures are below the designated neutral temperature, the rail temperature may be adjusted by slowly moving a propane rail heater over the rail to achieve the neutral rail temperature as the rail is anchored to prevent or minimize rail movement or creep. Match marks placed on a rail base and tie plate before the rail is heated can be used to determine whether the rail has been thoroughly heated by expanding it the proper length as set forth in matrix tables for that purpose. Since a rail heater may only superficially heat the rail, match marks are used to ensure that the rail has been thoroughly heated and expanded the proper distance as implied by the rail surface temperature of rail thermometer. The general foreman of welding gang No. 41 stated that they did not use match marks before the accident. BN's MOW rules, Circular No. 1, paragraph J, has a matrix table that can be used for match marks. The matrix table identifies expansion distance in inches using two variables--rail length and the temperature differential between neutral and pre-heat (cold) rail temperature. The general foreman added that the gang did not vibrate the rail or tap the tie plates.

If the ambient and rail temperatures are above the neutral rail temperature, BN's MOW rules provides no guidance or instruction for adjusting the CWR. The BN division superintendent of maintenance and engineering stated that laying rail above the neutral rail temperature only exposed the rail to the inconvenience of a rail break in winter, which was protected by the signal system and therefore not considered as serious as a rail buckle.

Welding Gang No. 41 Work Report.--At the close of each workday, the gang foreman filled out a daily work report that showed where the gang worked, how many men worked, track time, work delays, and the number of welds made. According to the general foreman, work progressed at a rate of about "1/2 mile a day." The work report also required that the actual rail temperature be recorded three times a day, at 8 a.m., noon, and 3:30 p.m. This information was reported daily by phone to the division headquarters, where it was kept on file. According to BN, 8 a.m. rail temperatures were sometimes recorded before anchoring actually began.

Before October 31, 1989, welding gang No. 41 heated rail at MP 256 on only one day, October 20, 1989. Records show numerous rail temperatures at the time the rail was anchored that were below the prescribed 95° F rail laying temperature for that zone. The Safety Board's audit of BN's *Daily Report for Holland In Track Welding Gang No. 41* shows that gang No. 41 worked 62 days on the second subdivision eastbound mainline, including Batavia. Of the 62 working days, excluding rain days (nonworking days), 48 had recorded rail temperatures, and 32 of the 48 were days on which no temperatures were recorded at or above the 95° F required neutral rail temperature. On October 17-19, no temperatures above 49° F were recorded. According to testimony, these ambient temperatures were the rail laying (anchoring) temperatures. When BN increased the minimum rail laying temperature to 95° F, the disparity between the actual laying temperature and the specified minimum rail laying temperature also increased, despite the constant availability of a rail heater. According to records and testimony, division MOW supervisors did not take exception to the low rail laying temperatures recorded and reported daily. When asked why gang No. 41 failed to heat the rail, the general foreman of gang No. 41 replied, "It wasn't a process that we felt like we had to do."

Between October 31 and November 17, 1989, the last 14 days that gang No. 41 worked in the Batavia area, no rail temperatures were recorded, although the rail heater was used during this time. The general foreman appointed a temporary[24] rail heater operator from another machine to run the rail heater. The rail heater operator had no previous experience running the heater and was trained on the job by the foreman. The rail heater operator took individual rail temperatures that the foreman only recorded as "adjusted to 95° F" or "same" in the temperature recording column of the daily work report. The general foreman also stated, "We would allow maybe 4 or 5 degrees variance." This period included work in the derailment area from MP 266 east to MP 263 from November 14 - 17, 1989.

Ambient temperatures measured at the Ottumwa, Iowa, Airport and the number of welds made for those days were:

DATE 1989	HIGH TEMP	LOW TEMP	AVE. TEMP	VAR-NORM	%SUN	WIND SPEED	WELDS
Nov. 14	55	39	47	+7	no recorded data		129
Nov. 15	44	24	34	-6	32	25 mph	113
Nov. 16	25	14	20	-19	93	20 mph	152
Nov. 17	41	12	27	-12	49	21 mph	45

A Safety Board investigator who visited welding gang No. 41 on April 30, 1990, discovered that gang members were not closely monitoring rail temperatures behind the rail heaters, they were not calculating differential rail temperatures, and they were not using match marks to determine the amount of rail movement. Surface rail temperatures taken at that time by the investigator indicated surface rail temperatures of 110 to 128° F.

<u>Supervisory Oversight</u>.--Gang No. 41's general foreman testified that "60 welds per truck per day was a goal." A welding gang foreman stated, "We really weren't laying welded rail; we were making welded rail."

The general foreman stated that his immediate supervisor, the manager of gangs, visited gang No. 41 "probably once a week." The division superintendent of maintenance and engineering visited "from time to time." Neither the manager of gangs nor the division superintendent took exception to gang No. 41's operating procedures or to the failure to use the rail heater until October 31, 1989, well after ambient temperatures were below freezing. Although division headquarters received daily work reports from gang No. 41 that listed temperatures below the

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[24]Operators can be appointed under union contract temporarily for up to 30 days while the position is bid by seniority.

neutral or minimum rail laying temperature, no action was taken nor were any exceptions noted.

Although BN's *Prevention of Track Buckling* pamphlet dated April 1, 1989, does not specifically address the Holland welding operation, it does include a paragraph under "Rail Relay" that states:

> If for any reason the rail is laid at less than the minimum rail temperature, it must be adjusted to the prescribed rail temperature for the geographic area at a later date. This may be done by natural means or with a hydraulic expander. Regardless of how the adjustment is done, it must be accomplished on or before the first warm day after laying.

After gang No. 41 finished its work at Batavia, a surfacing gang surfaced the newly created CWR in accordance with BN policy. However, no supervisor ensured that the track was subsequently adjusted to accommodate any unintentional change in neutral rail temperature caused by the track disturbance.

Maintenance-of-Way Rules Book CWR Instructions.--BN issued a MOW rules book, Form 15125, effective October 29, 1989, to all its MOW and engineering employees; the book also includes instructions for CWR in the following paragraphs in Circular No. 1:

F- Replacement of Defective Rail or Welds and Field Welding to Eliminate Joints in CWR Territory;
G- Turnout Installation in CWR Territory;
J- Laying Welded Rail; and in
Appendix A, Prevention of Track Buckling;
Appendix B, Engineering Policy Letters,
  Page B-5, Use of Rail Thermometers, and
  Page B-6, Cold Temperature Field Welding.

In the back of the book are several sections that contain specific instructions for the installation and temperature measurement of traditional CWR, that is, 1/4-mile long strings of CWR. The MOW rules book has no instructions for the Holland type process.

A table in Circular No. 1, paragraph J, provides the match mark-distance relationship for temperature differentials between the current rail temperature and the specified rail laying temperature. Exhibit B in paragraph J provides instructions and an example for the amount of gap to be allowed when the minimum rail laying temperature cannot be reached. Because the matrix tables in Circular No. 1 are for conventional CWR laying and maintenance operations, they are based on standard 39-foot rail lengths of factory-welded ribbon rail brought to a field installation site.

The division superintendent of maintenance and engineering stated that the tables are primarily "for a steel gang which comes out and has a piece of rail laying on the side of the track for a known length...the table is made for that." BN's position is that the tables can be used in Holland operations. Because the Holland operation is a continuous process involving varying rail lengths and distances, the tables must be interpolated to be used for that purpose. The unit of distance (length) in one table is rail length (39 feet); the unit of distance is feet in the other table. The minimum distances listed in the expansion tables is nine 39-foot rail lengths (351 feet) in one table and 400 feet in the other. These minimum distances are more than the one or two rail lengths between the rail heater and the anchoring machine described by the gang No. 41 general foreman. Therefore, the general foreman must calculate fractions of rail distances to determine rail expansion distances in inches. (See appendix D.)

Use of matrix expansion tables is particularly important at anchor, points where rail must be precut before being heated and anchored. During his deposition testimony, the general foreman testified concerning use of matrix tables to determine rail gap at fixed points. The FRA asked him if the temperature of the cold rail was taken in order to determine the proper temperature differential between the cold and neutral rail temperatures. The general foreman said, "We never measured the cold rail to see what the cold rail was." By definition, temperature differential cannot be determined without knowing the cold rail temperature.

The table in paragraph J, Circular No. 1, of BN's MOW rules does not cover the full range of temperature differentials experienced by the Holland welding gang. On November 16, 1989, when gang No. 41 was in the Batavia area, the average ambient temperature was 20° F. According to a track expert[25], the cold rail temperature under such conditions would be about the same. Therefore, the temperature differential would have been 75° F (95° F neutral temperature minus 20° F cold rail temperature). The Circular No. 1 table stops at 70° F.

Burlington Northern Maintenance of Way Supervisor Training.--During deposition proceedings, the director of maintenance testified that BN provided training for prevention of track buckling to BN front line supervisors, roadmasters, maintenance engineers, and track inspectors. He stated that the company used the "cascade" method of training, under which persons attending the track buckling seminar were expected to pass the information on to subordinates, as appropriate. The director said he and another instructor presented the track buckling seminars annually in a series of 1-day classes throughout the BN system. He also stated that he personally taught the seminar sessions pertaining to track buckling and temperature adjustment during rail welding and that the time allotted for this information was 2 to 3 hours. BN had no followup system or method to determine how effective the director's training was or how much participants had learned.

The director described the content of the block of instruction on track buckling and temperature adjustment. He began his presentation with a 30-minute videotape, "Rails That Grow," which he believed depicted all the concepts that BN was trying to convey in its education program on the track buckling prevention. He indicated that he was very proud of the tape, which was originally produced by another class I railroad. The tape describes the general principles and importance of proper temperature control and adjustment and shows conventional steel gang and CWR maintenance operations. The tape does not show a Holland welding-type operation.

The director of maintenance testified that he also used other audiovisual materials in his presentations, including slides that show derailments caused by track buckles on BN and a film on laying rail. None of these other audiovisual materials illustrated Holland in-track welding operations. He identified MOW Circular No. 1 as

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[25]Kerr, Arnold D., Professor, University of Delaware.

the source for detailed information on temperature adjustment during rail welding operations.

The director said that the seminar focused on new rail installation. Although he did not specifically address the Holland operation in the seminar, the director believed that the subject matter presented should also cover procedures involving the Holland welding operations. He stated that a representative from the Holland Company was in charge of the vehicle at the field site and that BN organized the gang. He later said that the only on-site role of the Holland representative was to ensure the performance of the welding machine and to troubleshoot any problems with it.

The director identified the general foreman of gang No. 41 as a two-time attendee of his annual seminar, most recently in March 1990. He also stated that he had known the general foreman for about 3 years. The director said that he did not provide any special instructions on Holland equipment or the Holland operation in the March 1990 seminar. He thought that his instruction universally applied to any CWR welding or installation operation. He recognized both the seminar and the "track buckling pamphlet" as the primary training sources on track buckling. The director also pointed out that Appendix 2 of the MOW rules book contained the same information that was in MOW Circular No. 1.

During deposition testimony, the general foreman stated that he received his "training" on temperature control adjustment "just from maintenance-of-way circulars." He recalled attending two track buckling seminars but said that they presented no new information to him. He referred to the seminars as "refresher" training. The general foreman did not recall any information from the seminars about heating rail. He said that his foreman and assistant foremen from gang No. 41 had attended the same track buckling seminars that he did.

Operations Information

Method of Operation.--Operation of the railroad was governed by the GCOR, second edition, effective October 1, 1989, and timetable No. 2 which became effective at 00:01 a.m. central standard time, Sunday October 29, 1989. The derailment occurred on track designated by the timetable as ABS territory between "W. Burlington," MP 209.3, and "ISU Switch," MP 289.1. Each of the two main tracks is signaled for only one direction. The No. 1 track is designated and signaled for westbound movement; the No. 2 track is signaled for eastbound movement. At the time of the derailment, Amtrak train No. 6 was running with the current of traffic by signal indication on the No. 2 eastbound track.

Authorization for a train to occupy the main line and for its movement was by track warrant(s), which were provided in hard copy form at stops or over the radio from one of the dispatchers at Galesburg, Illinois, or Lincoln, Nebraska. GCOR rules govern TWC movement. Temporary conditions that may affect the safe movement of trains, such as track work, weather conditions, speed restrictions, or traffic, were governed by bulletins or issued via radio by the dispatchers.

On April 23, 1989, TWC No. 731 authorized train No. 6 to occupy and move on the eastward mainline between the east yard limits at Ottumwa and the CTC at Burlington, Iowa. The dispatcher had issued the TWC by radio and the fireman received it at MP 293. The dispatcher confirmed it at 12:59 p.m. after the fireman repeated it.

Maximum authorized speed for passenger trains was 79 mph, according to the special instructions in timetable No. 2. No other bulletins or verbal instructions restricted train speed. The crew testified that they were moving at 79 mph, which they observed on the speedometer on the right side of the cab. According to the engineer, who was seated on the left side of the cab, his speedometer was 3 mph slow and indicated a speed of 76 mph. The event recorder printout showed a speed of 77 mph at the time of the derailment. Amtrak requires its engineers to perform a speedometer accuracy check by timing a designated measured mile along their route. According to FRA requirements in 49 CFR 229.117(a)(1), a speedometer must be accurate within 3 mph at actual speeds of 10 to 30 mph and within 5 mph at speeds above 30 mph. The engineer performed the required speedometer check soon after leaving Lincoln, Nebraska, and found speedometers on both sides of the cab to be within FRA requirements.

Neither the engineer nor the fireman took any exception to the response of the train. The event recorder printout showed that both men controlled the speed and slack of the train through throttle modulation. The locomotive crew stated that they felt no slack action until the locomotives "lunged and jerked" when the derailment occurred. Under the supervision of a Safety Board investigator, BN conducted a computer simulation of the trip following the accident. The simulation demonstrated negligible buff and draft forces[26] before the derailment.

Traincrew Efficiency Testing and Management Oversight.--BN and Amtrak independently monitor traincrew performance, particularly train handling by engineers, through efficiency testing, cab rides by railroad officials, and review of speed tapes and event recorders. The efficiency tests are specifically designed to demonstrate a working knowledge of the more critical operating rules and to test knowledge of current bulletins and special instructions.

Effective April 1, 1990, Amtrak required that its operating first-line supervisors make 100 efficiency checks and cab rides of operating crews each month. The program was set up to test every Amtrak operating employee at least once every 90 days. Amtrak road foremen of engines were also required to evaluate and make a speed check on each engineer under their supervision at least once every 90 days during a cab ride. Amtrak records showed that the engineer had been tested or evaluated 21 times since 1988, the fireman 30 times, the conductor and head-end assistant conductor 21 times each, and the rear assistant conductor 17 times. The results of these tests were satisfactory and resulted in no discipline or remedial action for any of the operating crew.

BN did not require its operating officers to make a fixed number of efficiency tests, checks, or evaluations per month. All operating employees, including Amtrak employees, were to be tested at least once every 6 months. Test results are compiled by computer. BN operating officers are also required to make at least eight cab rides per month. Records show that the engineer of train No. 6 had been tested three times since 1988. Results of these the performance inspections were satisfactory.

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[26]Terms used to describe coupler forces in compression or tension, respectively.

Medical, Pathological, and Toxicological Information

Medical.--Six area hospitals treated passengers and employees from the derailment. Sixty-six were treated and released and 20 were admitted. Of the admitted patients, all had what were considered minor injuries except one, who had a comminuted fracture of the right humerus and radius, which was considered serious.

Toxicological.--In accordance with FRA regulations, BN directed the postaccident collection of toxicological samples from all five members of the operating crew. These blood and urine samples were sent to CompuChem Laboratories of Sacramento, California. In addition, in accordance with BN operating procedures, a second set of samples was collected and forwarded to a contract facility, which in this case was also the CompuChem facility in Sacramento. The samples for all five crewmembers were negative for drugs and alcohol.

Survival Aspects

Emergency Response.--At 1:26 p.m., the BN East Ottumwa dispatcher received a radio transmission from the Amtrak train No. 6 fireman: "Yea, dispatcher, this is 1006. We're in emergency at Ottumwa... We're right about half a mile east of Batavia. We got cars over, on the ground, sideways, dispatcher."

The dispatcher acknowledged the radio call, stated that he would get help there as soon as he could, and called emergency services. At 1:28 p.m. the fireman called for medical assistance for those in the passenger cars; the dispatcher said he would send assistance.

A Batavia resident who lived near the accident site telephoned the Fairfield Police/Fire Department dispatcher at 1:29 p.m. and notified him of the derailment. The Fairfield dispatcher responded by sending a sheriff's department unit and a Jefferson County ambulance to the scene.

At 1:35 p.m., the Fairfield police notified Iowa State Police Post 13 in Mt. Pleasant and Post 14 in Ottumwa, who both sent units to the derailment site. The State police helped secure the scene and set up a mobile command post using one of the State police units.

The first of two Jefferson County ambulances arrived at 1:40 p.m. and called for mutual aid. A paramedic aboard the first ambulance was the medical incident commander. Upon his arrival, he entered the derailed cars and walked their length to determine the amount of medical assistance needed. Additional emergency response agencies arrived at intervals within 45 minutes and assisted by bearing stretchers, directing passengers to the Batavia Community Center, arranging bus transportation, and unloading baggage.

During the derailment, passengers had been thrown from their seats, striking floors, walls, tables, and other passengers. Paramedics performed triage in an area near the derailed cars and inside the cars for more seriously injured passengers. By 2:30 p.m., rescue personnel had removed all passengers from the derailed cars, and by 3:30 p.m., ambulances had taken all injured passengers to six area hospitals. An "Air Care" helicopter and a "Mercy Air Life" helicopter each transported one patient to area hospitals.

Hospital Response.--Of the six hospitals involved in the medical treatment and examination of passengers, only one activated its disaster plan. According to the hospital's director of quality assurance, most of the passengers were treated for minor injuries and released.

Disaster Preparedness--Because the number and severity of injuries resulting from the derailment were not great, Jefferson County did not activate its disaster plan. The director of Jefferson County's ambulance service stated that neighboring counties had a mutual aid agreement, which they put into effect. At 1:45 p.m., about 20 minutes after the derailment, the Iowa State disaster coordinator was advised of the derailment. At 2 p.m., the Governor's office was notified. The State offered additional disaster assistance to Jefferson County, but the Jefferson County disaster coordinator declined further State help.

Seat Rotation and Seat Locks.--After the accident, Safety Board investigators inspected all the passenger car interiors at the accident site for damage and sources of injury. Safety Board investigators noted that several seats in each coach were unlocked and in some cases rotated. Inadvertent seat rotation during a derailment can lead to injury. Some seats with serviceable locks were found unlocked. One Trison lock from car 34001 appeared to be defective and was removed for further tests. The Safety Board mailed 116 questionnaires to passengers involved in the accident. Of 72 responses received, 12 (16 percent) said their seats had swiveled or shifted in the accident. Passengers responding to the questionnaire attributed their injuries to striking the seat in front of them, the floor, or luggage.

On September 12, 1990, Safety Board investigators examined an Amtrak train at Omaha, Nebraska, without prior notice. Several seats in each coach were found to be unlocked, although the locks were mechanically sound. The car seats had both Trison and AMI seat locks. From conversations with passengers and on-board service personnel, investigators determined that passengers frequently depress the locking pedal under the seat in the mistaken impression that the pedal is for some other purpose, such as reclining the seat, rather than unlocking and rotating the seat. Consequently, seats are inadvertently unlocked. On-board service personnel, such as the car attendants, have no specific instructions to check and ensure that seats are locked after the train leaves its point of origin.

Tests and Research

Wheel Tests.--In the Safety Board's postaccident inspection, multiple strike marks on a wheel of coach-baggage car No. 31012 were the most severe example of passenger car wheel damage. The damaged portion of the wheel was sent to the metallurgy laboratory of TSD, Inc., for detailed analysis. Their report concluded:

> The damage induced on this submitted wheel's flange was the result of irregular sliding motion of the wheel on its flange, after the wheel stopped normal rotation and the truck containing this wheel had twisted into an unnatural angular position. It is probable that the damage in this wheel's flange was induced by sliding along the top edge of a rail. The wheel was damaged by action of an ongoing derailment rather than being the cause of the derailment.

Rail Tests.--The metallurgical laboratory of TSD, Inc., examined five broken rails recovered from the accident site and found that four of the fractures were stress breaks resulting from the postderailment damage. TSD, Inc., indicated that a rail base defect caused the other break, but concluded, because of its location in the track, that this break did not cause the derailment.

Train Simulations.--BN conducted Train Dynamics Analyzer simulations of the Amtrak train through Batavia using the train handling information from the event recorders. The simulations showed no excessive in-train forces[27] for coupler buff or draft, unusual air brake phenomenon, or sudden speed variations between vehicles.

Seat Lock Examination.--On October 30, 1990, the Safety Board laboratory examined the Trison, Inc., lock that had been removed from seats 73-74 of car 34001 to determine the cause of the lock's failure. Accident investigation representatives, including Trison, attended the examination. The lock had been found in the unlocked position with the pin stuck and retracted in the surrounding cylinder, a condition that would allow the seat to rotate. (See figure 13.)

After taking measurements and conducting experiments, investigators determined that the lock's cylinder walls had been pinched together, preventing the pin from sliding in the cylinder. Because the pin could not return to its locked position, the seat was free to rotate. No evidence indicated that this had occurred in service, and investigators concluded that it may have occurred either during installation or in manufacture. Participants in the examination agreed that to prevent the cylinder walls from pinching together, cylinder wall spacing should be more positively assured by use of a spacer plug and outside bracing of the cylinder walls to the base plate. They also thought that a stronger return spring would help. In a letter dated November 23, 1990, Trison notified the Safety Board that it had made the recommended changes to its seat locks. (See appendix E.)

Event Recorder Examination.--A BN trainmaster recovered multievent recorder data packs (eight-track tape cartridges) from the lead and last locomotive units in the consist at the accident site. A paper speed tape was recovered from the middle unit, No. 262. These were given to the BN director of safety and rules, who in turn gave them to the Safety Board for analysis at the Safety Board laboratory in Washington, D.C. Wheel diameter was recorded on each data pack for accurate printout.

The Safety Board laboratory made reel-to-reel copies of the data packs and used them to generate "expanded" paper charts of the train's trip and the accident sequence. The paper strip chart from the last locomotive unit, No. 343, failed to print the bottom two graphs, which included automatic and independent (locomotive) brake application, throttle position, and dynamic brake application. The laboratory determined that this failure was due to the failure of those components of the locomotive's recording equipment that operated intermittently 4 hours before the accident. Such a failure would not have been known to the traincrew or maintenance forces until a tape was played or the recorder tested. All other features of the multievent recorder printout charts and the paper speed tape matched without anomaly.

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[27]A term used to describe the dynamic motion and forces that result from the interaction of the vehicles coupled into a train that are responding to track, terrain, and weather conditions; train mass distribution; and train handling.

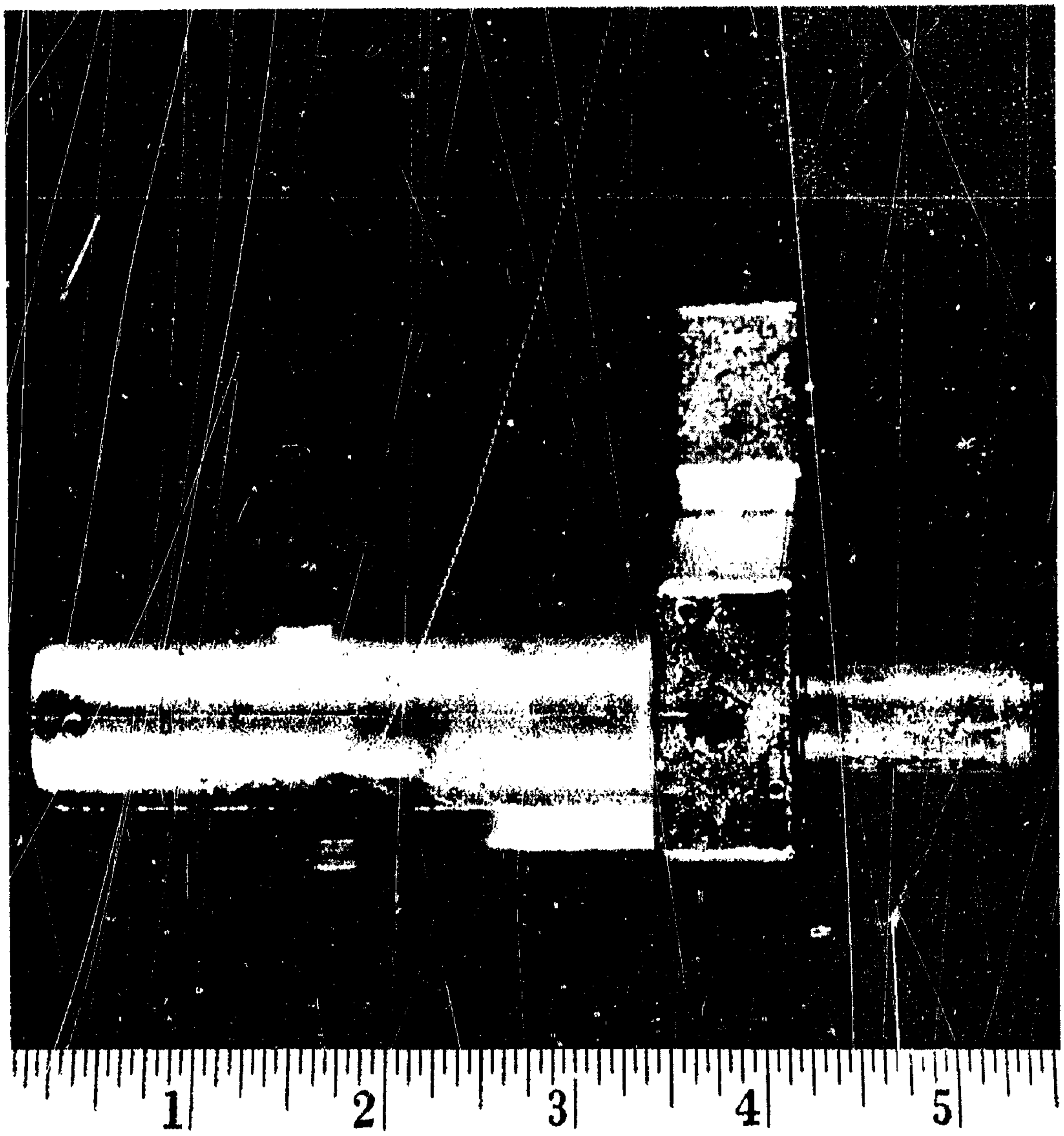

Figure 13.--Trison, Inc., seat lock.

Other Information

To date no reliable technique is available for the accurate measurement of longitudinal forces in rail. Therefore, neutral rail temperature, an important parameter in buckling prevention, could not be determined, but only estimated. The FRA has evaluated eight or more techniques as part of its track safety research program to develop a rail-force measuring technique or device. However, they have identified the following limitations and shortcomings for practical application:

- o An inability to measure absolute forces without cutting and destressing the rail.
- o Sensitivity to rail microstructure, residual stresses, and rail surface conditions.

The AAR, in cooperation with the FRA, has developed a rail uplift method to measure longitudinal rail force that could be integrated into CWR installation procedures without the above disadvantages. However, the device and its technique are still undergoing advanced development and field tests.

Association of American Railroads Investigation Report.--In November, 1980, the AAR published Report R-454, *An Investigation of Railroad Maintenance Practices to Prevent Track Buckling*. The report compares the maintenance and laying practices of 10 major North American railroads with the recommended practice of the AREA, the track and MOW arm of the AAR. The report also includes two surveys of railroad track buckling incidents. The first survey was an examination of 479 internally reported track buckling occurrences on one major class I[28] railroad. Of the 479 occurrences, 53 had resulted in derailments that were also examined and studied. The second survey was a study of derailments attributed to track buckling that occurred on seven North American railroads. Of these second survey derailments, 65 were studied and examined.

The AAR prepared its report following the more than 100 derailments each year reported to the FRA from 1976 through 1979 that were attributed to buckled track. Moreover, for every track buckle that had resulted in a derailment, maintenance forces had corrected an average of more than 10 cases of buckled track, that precluded a derailment.

Significant findings in the AAR report are:

1. Seasonal Temperature--More than 80 percent of the 479 track buckles occurred during May, June, and July; over 47 percent occurred in May alone. According to the report, these data suggested "that maintenance-of-way forces should be alert for buckles during the spring and early summer, specifically the first hot days of the season following the winter period." More than 75 percent of the track buckles occurred in an ambient temperature range of 85° F to 100° F.

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[28]The Interstate Commerce Commission (ICC) categorizes or classifies railroads according to their annual revenue, which is generally indicative of a railroad's size and economic importance to the Nation. In 1990, a Class I railroad was defined as having an annual revenue of $93.5 million or more.

2. New Installation--The AAR found that 56 percent of the buckles took place during the first two years after installation. The report attributed this to "a change in the force-free temperature during this time, early failure of improperly laid rail, or increased resistance of the track with time."

3. Track Condition and Maintenance--The report found "in 39 percent of the reported cases, ballast condition was not good. In almost 30 percent of the cases, the ballast section was nonstandard, with inadequate shoulder or crib." Maintenance activities, such as tie replacement or surfacing, also decreased lateral and longitudinal resistance and showed some correlation with buckling. Nonetheless, maintenance had been performed on less than 10 percent of the buckles within 1 week before the buckling occurrence. The report concluded, "Any maintenance operation which reduces lateral resistance, such as surfacing or tie renewal, must be carefully controlled."

4. Anchor Points--The report stated, "The effect of an adjacent structure in the build up of mechanical compressive forces and the corresponding change in free-force temperature can be significant." Fifty-five percent of the buckles occurred within 1,000 feet of an anchor point.

5. Seasonal Installation--Of 199 buckling incidents, 45 percent occurred in CWR that had been laid in October, November, or December. According to the AAR report, this indicated "that proper adjustments for laying temperature, which is very important in cold weather, were not consistently maintained." More than 90 percent of the locations where buckles took place did not have any pull-aparts nearby, suggesting "that the effective laying temperature in those areas might have been too low."

6. Time of Day--Of the 65 derailments examined in the second survey, 89 percent occurred between noon and 6 p.m., when the air temperature was generally in the 80°F to 100°F range.

7. Derailment Location in the Train and Train Handling--The second survey also found that "90 percent of the derailments occurred under the tenth car or further back in the consist, with a large percentage in the rear half of the train. ...Only 22 percent of the cases reported any braking or other action prior to the derailment, with 77 percent reporting normal train operations. Thus, it appears in many of these cases that the passage of the train, under normal operating conditions, was a factor in the buckling event."

8. Heavy Rail--The first survey found that heavier rail sections, in particular the 131 to 140 lb sections, showed an increased tendency to buckle. Results of the second survey of derailments indicated that heavier rail sections accounted for 47 percent of the derailments. The remaining 53 percent of the

> buckling derailments were distributed proportionally according to rail weight (size).

The report determined that track buckles that did not involve a train resulted from thermal compressive longitudinal forces "combined with a geometric imperfection or strength weakness," while compressive forces in the rail from the passing train were also a factor in train derailments.

The report concluded, "Proper control of the rail laying temperature requires a well-defined and consistent rail laying procedure. While most railroads have a formal procedure, there are variations, even on a given railroad, as to the consistent application of this procedure. This consistency is especially important for installation in periods of cold weather."

<u>Burlington Northern Continuous Weld Rail Followup</u>.--On April 27, 1990, for informational purposes, BN track forces cut an undisturbed rail at MP 266.30 at Batavia and another undisturbed rail at MP 264.78, about 1.2 miles east of Batavia. They recorded rail temperatures of 56° F and 62° F, respectively. When cut, each rail at MP 264.78 pulled apart 1/2 inch. At MP 266.30, one rail pulled apart 1/4 inch and the other 5/8 inch. The BN reports do not indicate where anchors were removed to enable the rail to move. The division's superintendent of maintenance and engineering concluded that since the rails pulled apart, the tests "indicated that the neutral temperature was higher (than the specified 95° F)."

As a result of the accident, BN made the following changes in its Holland welding gang for the balance of the 1990 season and thereafter:

1 An individual has been dedicated full time to record and monitor rail temperature.

2 Match marks are now used to ensure proper rail expansion and thorough rail heating when using the rail heater.

3 The neutral rail temperature for the Batavia zone has been raised to 105° F.

ANALYSIS

General

Before the derailment, the train received two initial inspections and two en route 1,000-mile inspections during which inspectors found no significant defects or problems. The contract inspectors at Omaha determined that the wheel flat spot reported by the section man was minor in nature and well within the prescribed AAR limits. Both the engineer and fireman testified that they followed normal train handling procedures throughout the trip and did not discern anything unusual in the train's movement or handling. Wayside sensors (hotbox and dragging equipment detectors) did not report or record any problems. Postaccident investigation of FRA and Amtrak inspection and repair documents revealed no discrepancies in maintenance procedures or inspections.

Train No. 6's engineer and fireman were experienced and knowledgeable in train operation. The engineer had almost 30 years of operating experience and had successfully completed his annual examinations on the GCOR and Amtrak rules less than six months before the derailment. The fireman had 12 years operating experience and was qualified by Amtrak and BN to operate the train. Both testified that they were well rested before departing Lincoln, that they were working their regular schedule, and that they were familiar with the route. The engineer and fireman had received their annual company physicals less than 2 weeks before the derailment and had been certified as fit for duty by the examining physician. According to toxicological tests taken after the accident and observations by on-scene FRA personnel shortly after the accident, none of the operating crew were impaired by drugs or alcohol.

After the derailment, examination of the wayside signals that controlled train movement through Batavia showed that the signal system functioned properly without defect or failure.

Based on the findings outlined above, the Safety Board concludes that the following were not causal or contributory factors in this accident: the train's mechanical condition; the physical/medical condition of train No. 6's operating crew; qualifications and competency of the crew; chemical impairment; or the wayside signal system.

Investigation of the physical track evidence at the accident site, weather conditions at the time of the accident, research of previous track work records, and deposition testimony by track maintenance forces, revealed several factors indicating a track failure. Therefore, the Safety Board investigators examined: in-track electric flash butt-welding procedures and temperature control of CWR; the efficacy of BN's MOW rules; supervisory oversight of Holland welding gang operations; and the FRA's regulatory role in the installation and maintenance of CWR. In addition, the Safety Board examined the emergency response effort and the adequacy of anti-rotation seat locks.

The Accident

On the day of the derailment, the ambient air temperature was approximately 80° F, up 20 degrees from an overnight low of 60° F. Clouds were high and scattered, which allowed the sun to warm exposed surfaces. The mainline track through Batavia was 129-lb. CWR that a BN Holland welding gang had begun installing in the fall of 1989 and finished that December. As Amtrak train No. 6 proceeded through Batavia, the passenger train began a slight descent into a vertical curve (sag). The fireman was at the controls of the train which was traveling at 77 mph, 2 mph less than the maximum authorized passenger train speed in the timetable. The fireman testified that about 1/8 mile before the derailment site he released a minimum brake application and had the throttle in 4th notch (approximately medium power). The engineer said he felt a "pretty hard jerk" from the train. The fireman and engineer immediately looked in the rear view mirrors at the trailing passenger cars and saw a cloud of dust. The last eight cars were moving erratically on the ground.

Postaccident on-site evidence indicated that as train No. 6 passed through Batavia, the track on the eastbound mainline buckled underneath the train beyond the frog, derailing the last eight cars. Physical indicators of a track buckle included the distance the mainline tracks shifted, the face gouging of the rail, the ambient weather conditions, and the location of the track near anchor points.

At the accident site, the IDOT inspector found that the suspected track buckle on the eastbound mainline had caused an 18-inch kink in the westbound mainline between the crossover frogs. Because the crossover connected the eastbound and westbound parallel mainlines, one track could not have shifted without some movement in the other. Under most circumstances, passenger cars do not generate the dynamic forces during derailment necessary to shift an adjacent parallel track more than a foot out of alignment. A misalignment of such magnitude is more commonly the result of a track buckle. Also, the much greater magnitude of the track disturbance on the eastbound track indicates that the buckle occurred on the eastbound track and was transferred through the crossover, resulting in a smaller disturbance on the westbound track. According to Dr. Kerr, this phenomenon is typical of force transfer between parallel connected tracks where the initial force on one track is only partially transferred to the other track due to the flexibility of the track structure and the resistance of the ballast. The difference in the relative sizes of the track disturbances of the east and westbound tracks leads the Safety Board to conclude that although some buckling force was transferred to the parallel westbound track, the buckle was initiated on the eastbound track.

Safety Board investigators found "heavy gage face gouging" of the accident area rail. Although heavy face gouging is not an absolute requisite of a track buckle, such a condition is certainly an indicator of a track buckle. The large number of factors and circumstances involved in each track buckle derailment are generally unique and may fail to fall into any specific category. However, the Safety Board believes such evidence in this accident strongly supports the track buckling scenario. (See figure 11, page 30, for a photograph of heavy gage face gouging.)

Witness testimony describing the day of the accident as the first "hot" day of the year is somewhat subjective. However, weather records obtained by Safety Board investigators show the temperature in the Batavia area was within the ambient temperature zone (80-100° F) cited in the AAR studies on track buckling. Ambient temperatures at the time of the accident together with the sun radiating on the rail could have produced rail temperatures that could subject CWR to a track buckle, particularly CWR laid in cold weather without consistent procedures or thorough temperature controls. Even the IDOT track inspector's late afternoon measurement (4:20 p.m.) of rail temperatures at the derailment site (94° F-98° F) fits the AAR's temperature buckle zone; moreover, earlier afternoon temperatures were probably higher.

On April 27, 1990, less than one week after the accident, BN track crews cut the rail for informational purposes at mile posts 264.78 and 266.30. The BN superintendent indicated that the results of this cutting showed that the neutral rail temperature was even higher than the specified 95° F, which implied that the temperature control procedures of gang No. 41 were sufficient. The rail cutting procedure BN used to determine the change in rail length requires removal of the rail anchors to allow the rail to move. However, there was no record of the number or for what distance rail anchors were removed. The procedure and location of BN's rail cutting renders any attempt to interpret the result questionable if not meaningless. In order to interpret the expansion or contraction of the cut rail, it is necessary to know the length of the free unanchored rail. In addition, the derailment would have alleviated the rail stress. Therefore, cutting the rail to determine the rail stress near the accident site would result in questionable findings. The Safety Board is also concerned that BN performed this operation without the participation or prior knowledge of any of the other parties to the accident or Safety Board investigators.

According to track experts who have published papers and articles[29] in the American Railway Engineering Association Bulletin on "thermal rail buckling," a track buckle can occur within the relatively short sections of track, especially between anchor points, much like the 600 feet section of the accident area. The dynamic force added by a passing train can cause the track to buckle at less force and at a lower temperature.

The Safety Board does not believe that the passing of the Amtrak train was the sole cause of the track buckle since the track buckle was not there prior to the passing of the train. No one noticed any evidence of a track buckle or impending track buckle in the Batavia area on the day of the derailment; not the track section foreman who was working in the vicinity, not the BN track inspector on routine inspection, and not the train crew as they approached and started through Batavia. The Safety Board does believe that the train was a trigger to a preexisting condition. Track structure by its very nature and function should be able to withstand the normal dynamic forces of passing trains without ill effect. No evidence exists to suggest that the passing of the Amtrak train was anything but a normal expected occurrence. The track structure in this case failed in its function to absorb the dynamic forces of the passing train.

Safety Board investigators noted that the Batavia derailment matched many of the characteristics of a track buckle as defined in the AAR study on track buckling to include:

- The derailment occurred in late spring/early summer (late April) on the first hot day of the year;

- the track was a relatively new installation involving jointed rail that was welded into CWR "in place" and laid approximately 6 months before the accident (56 percent of the buckles in the AAR study occurred within the first 2 years of installation);

- the track had recently undergone extensive maintenance activity and related disturbance, including surfacing, without follow-up adjustment;

- the derailment occurred near the anchor point of the road crossing (55 percent of the buckles in the AAR study occurred within 1000 feet of an anchor point);

- the installation of the CWR had taken place during the cold weather of the previous November (45 percent of the buckles in the AAR study occurred in CWR that was laid in October, November, or December);

29Kerr, Arnold D., *Thermal Buckling of Straight Tracks; Fundamentals, Analyses, and Preventive Measures*, American Railway Engineering Association Bulletin 669, 1978. Fastenrath, Fritz, *Railroad Track - Theory and Practice*, Fredrick Ungar Publishing Co., New York, pp. 337-338.

- the derailment occurred in the afternoon when the sun had begun to have its greatest effect (89 percent of the buckles in the AAR study of derailments occurred between noon and 6 pm);
- the derailment occurred approximately halfway back in the train at the ninth car where the mechanical stress of the passing train on the rail would have a contributory effect on the longitudinal forces in the rail (90 percent of the AAR study derailments occurred at the 10th car or further back with 77 percent reporting normal train operations); and
- the track involved heavy rail (129 lb), which is most affected by temperature change and which involved almost half of all track buckle derailments (47 percent of the derailments in the AAR study involved heavy rail).

Four months had gone by without mishap since the track had last been disturbed during surfacing. This does not necessarily mean the track was stable. The 4 months was during the cold part of the year when rail contraction (pull aparts) and not expansion would have been the problem. Also the frozen condition of the soil and ballast lent itself to a stronger more rigid track structure. The Batavia area had no pull-aparts that winter. As the AAR study found, over 90 percent of the locations where buckles took place had no nearby pull-aparts which suggested that the effective laying (anchoring) temperatures in those areas might have been too low.

Because the Batavia derailment displayed the characteristics of a track buckle identified in the AAR report, and the postaccident physical evidence indicated a track buckle, the Safety Board concludes that a track buckle occurred under Amtrak Train No. 6 as it moved through Batavia. The Safety Board also concludes that the longitudinal mechanical forces that accompanied the movement of the train acted as the trigger for the track buckle.

Surfacing

The Safety Board examined the track maintenance factors that could have contributed to a track buckle. When BN surfaced the track in the Batavia area on November 22, 1989, the ambient temperature was between 29° F and 31° F from 5 a.m. to 5 p.m. At that time of year, heat from the sun would have a minimal effect on the rail temperature. The CWR was free to contract and assume a lower neutral rail temperature that would approach the ambient temperature when the surfacing operation disturbed the tie to ballast bond. The failure of BN supervisors to adjust the surfaced CWR in the Batavia area before warm weather arrived was the last opportunity to reestablish BN's neutral rail temperature for the area and avoid a track buckle. This failure resulted in a sufficient temperature differential and excessive longitudinal forces that the restraint system of the track could not absorb. The combination of these excessive longitudinal forces with the dynamic forces of the passing Amtrak train aggravated the condition, resulting in a track buckle.

Temperature Control

Track buckling results from heat expansion in the rail beyond the ability of the track structure to restrain the longitudinal forces. It is imperative not only that MOW personnel adjust the rail temperature after maintenance operations, but that welding gangs perform proper temperature control when they install CWR. AAR reports show that improper temperature control of CWR during installation is the major cause of track buckling. Safety Board investigators reviewed the procedures that the Holland welding gang followed while installing CWR in the accident area and the quality review measures of BN supervisors and found practices lacking in proper temperature control measures.

Although gang No. 41 had a rail heater on-site when they were in the Batavia area, they integrated the rail heater late into the production line, during their last 2 weeks of work. In addition, the inexperience of the new operator raises concerns as to the quality of work performed. The new rail heater operator testified he took rail temperatures and reported the rail temperature to his direct supervisor, the foreman. However, recordkeeping also became lax when rail temperatures were no longer recorded, just "adjusted to 95° F, plus or minus 5 degrees." Most importantly, the gang did not use match marks to ensure that the rail had been thoroughly and properly heated, or any other procedures, such as vibrating the rail, to ensure that the rail had free movement as it expanded.

The lack of recommended temperature control procedures was most evident at anchor points. The gang's general foreman testified that he determined gap distance at anchor points based on his experience as opposed to taking cold rail temperatures. This made correct determination of proper temperature differential and rail expansion gap improbable. Such a practice, where fractions of an inch in rail length can cause tons of excessive longitudinal rail force, is not sufficient to ensure a safe track structure.

The gang's installation procedures could have been facilitated if they had been able to use a reliable measurement device to determine longitudinal stress in the rail. Currently, the FRA and the AAR are funding research development and prototype testing of a device that may be used to determine actual longitudinal rail stress and predict when excessive stress will occur. To date, no reliable device exists. The Safety Board believes that the FRA and AAR should continue to provide funding for such a measurement device which would enable crews to alleviate the guesswork in their temperature control measures.

The BN Holland track welding form used by the Holland gang to record rail temperatures during installation has a column showing three times, "0800, 1200, and 1530." All of the Holland welding gang supervisors involved in this accident testified that the column implies that rail-anchoring temperatures should be recorded at these specified times. However, the superintendent of maintenance and engineering stated that some 8 a.m. rail temperatures were recorded before anchoring actually began. This contradicts the understanding that the column is for recording anchoring temperatures. The Safety Board believes the BN Holland track welding form should be modified to specify anchoring temperatures to avoid misuse or misunderstanding of the form's purpose which is to document sample rail temperatures at specified anchoring times. The Safety Board encourages BN to monitor the implementation of the revised form to ensure that it is used correctly.

<u>Rail Heating Training</u>.--The Safety Board received contradictory testimony which raised questions as to the adequacy of the rail heating training that gang No. 41 received for its Holland welding operation. According to the director of maintenance, he felt he personally addressed the subject sufficiently in his track buckling seminars. However, gang No. 41's general foreman did not recall any information pertaining to rail heating from the seminars he had attended. He

stated rather that he used maintenance-of-way circulars as his information source. In addition, the investigation determined that the general foreman relied upon his experience to assess rail expansion. Consequently, the Safety Board concludes that the rail heating training presented in the track buckling seminars could not readily be applied in the Holland operation or was sufficiently meaningful to the general foreman and his subordinates.

<u>Maintenance of Way Rules</u>.--The matrix tables for temperature/rail expansion in BN's MOW rules address only more traditional maintenance and ribbon rail CWR operations. The MOW rules do not mention the Holland production line process in which CWR is both made and laid in the same operation. Holland welding operation supervisors were generally left to interpret and interpolate the MOW rules as best they could to fit their unique operation.

Although rail length expansion as a function of temperature variation can be estimated using the matrix tables, the process is awkward. The tables list rail in conventional 39-foot or 1/4-mile lengths rather than in shorter lengths that would be more flexible and useful for the constantly moving Holland process. Another table lists rail lengths in increments of 400 feet which are generally too long to be of practical use in the Holland operation, particularly near anchor points. The Safety Board concludes that the MOW rules book for use by in-track welding operations is too generic and awkward to be effective. Therefore, the Safety Board believes BN should simplify and enlarge the thermal expansion tables in the MOW rules book to facilitate use and understanding by the Holland operation.

The standard practice circulars of BN's MOW rules book, including the appendixes, need to be updated and reorganized into a comprehensive set of instructions. In several instances, instructions applicable to a variety of operations are addressed in only one category. For example, BN supervisors testified that they recognized the importance of adjusting CWR after performing out-of-face operations such as surfacing. However, the MOW rules book does not mention any requirements for adjusting the rail after performing such work until Appendix A of Standard Practice Circular 1 under the subsection for concrete tie installation. Moreover, these guidelines for adjusting the rail do not specifically refer to CWR. The relevancy is implied because concrete ties are traditionally used for heavier rail which CWR is considered. Many rules in the circulars only address warm weather operations. These guidelines should also discuss the importance of temperature differential and the effects of cold weather operations.

<u>Supervisory Oversight</u>.--Examination of in-field and upper-management practices show that BN's supervisors placed greater emphasis on the quantity of rail laid rather than the quality of installation. In the field, first-line supervisors did not insist on quality control measures that might interrupt the gang's progress. For example, the welding gang No. 41 consistently failed to record actual rail anchoring temperatures and rarely used match marks to determine actual neutral rail temperature. Information from interviews and depositions showed that mid-level supervisors visited gang No. 41 too infrequently to ensure that the gang maintained proper temperature control or to ensure that the gang members had a complete understanding of proper procedures.

BN's upper-level supervision should have recognized from the daily reports that they received from the field that the Holland gang was laying rail at less than the specified (neutral) rail temperature and taken steps to correct the problem.

Even if all levels of management overlooked the potential problems in the initial installation, the track supervisors could have rectified the situation by requiring that the track be adjusted/destressed after surfacing. Supervision failed to assure that the track in the Batavia area was adjusted after surfacing operations and before warm weather arrived. The Safety Board believes that if BN supervisors had taken steps to ensure that the track in the Batavia area was adjusted after surfacing, the track buckle might have been averted despite the improper procedures of gang No. 41.

<u>FRA Standards for CWR Operations</u>.--Currently no Federal standards exist specifically for CWR. On March 29, 1982, the Safety Board sent a letter to the FRA in response to a Notice of Proposed Rule Making (NPRM), "Track Safety Standards; Miscellaneous Amendments," Docket No. RST-3, No. 3, which was published at 47 FR 7275 on February 18, 1982. A portion of the letter addressed the proposal to drop Section 213.119, Continuous Welded Rail from the FRA track safety standards, which read:

49 CFR Part 213.119 Continuous welded rail.

(a) When continuous welded rail is being installed, it must be installed at, or adjusted for, a rail temperature range that should not result in compressive or tensile forces that will produce lateral displacement of the track, or pulling apart of rail ends or welds.

(b) After continuous welded rail has been installed, it should not be disturbed at rail temperatures higher than its installation or adjusted installation temperature.

The Safety Board responded in part:

> This section should be retained, strengthened, and enforced because rail temperature is an important safety consideration. Even the subject rulemaking proposal acknowledges the importance of controlling thermal stress in continuous welded rail; but fails to propose action for accomplishing needed controls.

In 1982, the FRA removed the CWR section from their safety standards because they stated that the individual railroads already had adequate rules and practices in place to ensure a safe CWR track structure. The FRA also held that the regulation was unenforceable because no accurate means existed for measuring longitudinal rail force.

Recently both the U.S. House of Representatives and the Senate have drafted specific legislation to enhance rail safety by: providing positive incentives for railroads to improve their safety records; beefing up inspection and enforcement activities; and asking the FRA to update some of its current regulations to reflect changing technology and new knowledge. A portion of House Bill H.R. 2607 deals specifically with CWR.

Currently Congressional Bill H.R. 2607, dated September 1991, proposes to amend 49 CFR Part 202(s)(2), directing the Secretary of Transportation to conduct a review of track safety standards to include as a minimum:

(A) an evaluation of procedures associated with maintaining and installing continuous welded rail and its attendant structure;

(B) an evaluation of the need for revisions to rules with respect to track subject to exception from track safety standards;

In previous investigations of railroad accidents, the Safety Board has addressed the importance of temperature control of CWR and its ability to absorb the dynamic forces of trains in order that railroad operations may be conducted safely. Although much information has been developed from the research of the behavior of CWR, much of the present thinking about track structure capabilities and limitations is still supposition because of the wide variety of factors that affect neutral rail temperature such as ambient temperature, location, maintenance, and rail traffic. Standards relating to track structure should include a safety margin sufficient to reflect the inability to predict, with reasonable accuracy, the effects of operating conditions upon safety. Therefore, the Safety Board believes that the FRA should reinstate and expand Section 213.119 to ensure proper temperature control procedures for installing and maintaining CWR.

Emergency Response

The Safety Board believes that the emergency response of the Jefferson County ambulance, fire, and police units was timely and well organized. Neighboring volunteer aid departments dispatched an adequate number of units in a timely manner. Considering notification and travel time, arrival by ambulances within 15 minutes of the derailment was exceptional. By providing transportation, telephones, and assisting with luggage, volunteers from the Fairfield and Batavia communities greatly contributed to the emotional well being of injured and uninjured passengers which allowed emergency response personnel to concentrate on providing medical aid.

The traincrew's performance immediately after the derailment was commendable. The engineer quickly notified the dispatcher about the accident and stood by the locomotive radio to coordinate and communicate with railroad and others as needed. The traincrew aided passengers and directed emergency service personnel to the more serious cases when they arrived.

The Jefferson County disaster coordinator rapidly gained control of the emergency situation, determined the magnitude of the effort needed, and notified other necessary state agencies and officials in a timely manner.

Seat Locks

After Safety Board investigations of accidents involving Amtrak passenger trains at Russell, Iowa,[30] and Stockton, California,[31] Amtrak undertook a program of

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[30]Railroad Accident Report--Collision and Derailment of Amtrak Train 6 on the Burlington Northern Railroad, Russell, Iowa, October 12, 1987 (NTSB/RAR-88/04).

[31]Railroad/Highway Accident Report--Collision of Amtrak Passenger Train No.708 on the Atchison, Topeka, and Santa Fe Railway with TAB Warehouse and Distribution Co. Tractor-SemiTrailer, Stockton, California, December 19, 1989 (NTSB/RHR-90/01).

anti-rotation seat lock replacement and inspection. The replacement of AMI seat locks with Trison and new style Coach & Car locks is now 70 percent complete. When investigators examined the seat locks on the last eight cars of the accident train, they found only the one Trison lock to be defective. Since this accident, Amtrak has inspected all seat locks for defects. A spokesman said that Amtrak has used up its current stock of Trison locks, is now using Coach & Car locks in its seat lock replacement program due to cost, and anticipates no further use of the Trison lock. Since this accident, the Trison company has gone out of business.

After the Stockton, California, accident, the Safety Board recommended that Amtrak:

> R-90-49
>
> Establish systemwide procedures to ensure that all seatlocks are engaged in the locked position before offering the equipment for revenue service.

Amtrak has instituted an initial terminal inspection program for seat locks at locations where trains are originated, in this case Oakland, California. As a result, on August 21, 1991, Safety Recommendation R-90-49 was classified as "Closed--Acceptable Action." However, as Safety Board investigators discovered at Omaha, Nebraska, in September, 1990, seat locks may become inadvertently unlocked by passengers en route. Therefore, the Safety Board believes that Amtrak car attendants should check seats for unlocked or malfunctioning seat locks en route to ensure seats are secure in the event of an accident/derailment, and to prevent unexpected rotation and injury during normal operations.

CONCLUSIONS

Findings

1. The train crew was fit for duty and qualified to perform their duties. Train handling did not cause or contribute to the accident. No mechanical equipment failures or defects, or in-train forces caused or contributed to the accident.

2. The dynamic mechanical forces of National Railroad Passenger Corporation (Amtrak) train No. 6 triggered an incipient thermally-induced track buckle beneath the train.

3. Burlington Northern management failed to provide adequate oversight and quality control of the maintenance-of-way process by ensuring that crews used proper rail temperature control techniques.

4. The Burlington Northern Holland in-track welding form does not clearly stipulate that rail anchoring temperatures should be recorded in the temperature column.

5. Instructions in Burlington Northern's Maintenance of Way rules book do specifically address the in-field continuous welded rail operation nor can existing instructions for laying standard rail be readily interpolated in the Holland operation. In addition, Burlington Northern's annual track buckling seminar does not address Holland in-track welding procedures.

6. Currently, no Federal or industry standards exist for continuous welded rail installation and temperature control; each railroad develops its own CWR standards.

7. No reliable measurement device and/or technique exists for accurately measuring longitudinal rail forces while in the field.

8. A Trison seat lock in car No. 34001 failed to return to its locked position because the locking pin was stuck between the surrounding pinched cylinder walls.

9. The National Railroad Passenger Corporation's (Amtrak's) current procedures do not require that on-board service personnel periodically to check en route to ensure that passengers have not unlocked their seat locks.

10. The emergency response to this accident was timely and well organized.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was improper rail installation during cold weather operations resulting from ineffective training programs, inadequate supervisory oversight and quality control measures, and an ineffective data collection system. Also causal to the accident was the failure of Burlington Northern procedures to require that crews readjust/destress continuous welded rail (CRW) after the track had been disturbed, which resulted in a track buckle under Amtrak train No. 6.

RECOMMENDATIONS

As a result of its investigation, the National Transportation Safety Board made the following recommendations:

--to the Federal Railroad Administration:

> Conduct a review of track safety standards to include as a minimum an evaluation of procedures associated with maintaining and installing continuous welded rail and its attendant structure. (Class II, Priority Action) (R-91-65)
>
> Continue to provide funding for on-going research development and prototype testing for a reliable device that can be used to determine actual longitudinal rail stress and predict when excessive longitudinal rail stress will occur, and upon adoption and implementation of such a device, assist railroads to implement and/or modify continuous welded rail standards to more effectively prevent track buckling. (Class II, Priority Action) (R-91-66)

--to the Burlington Northern Railroad:

> Establish supervisory oversight procedures to ensure compliance with existing Burlington and Northern maintenance-of-way standards for all continuous welded rail operations. (Class II, Priority Action) (R-91-67)

Revise the Holland track welding form to specify that only actual rail anchoring temperatures be recorded. (Class II, Priority Action) (R-91-68)

Revise the Maintenance of Way Rules book to make it applicable for the Holland welding operation by simplifying and expanding the thermal expansion (contraction) tables to facilitate use and understanding. (Class II, Priority Action) (R-91-69)

Revise the Burlington and Northern annual track buckling seminar to specifically address in-track welding procedures. (Class II, Priority Action) (R-91-70)

--to the National Railroad Passenger Corporation (Amtrak):

Implement procedures for on-board-service personnel to periodically check passenger seats en route for unlocked antirotational devices and take action to ensure seats are functional. (Class II, Priority Action) (R-91-71)

Inspect all Trison seat locks to ensure that all are functional. (Class II, Priority Action) (R-91-72)

-- to the Association of American Railroads:

Cooperate with the Federal Railroad Administration in continuing to provide support for on-going research, development, and prototype testing for a reliable device that can be used to determine actual longitudinal rail stress and predict when excessive longitudinal rail stress will occur. Upon adoption and implementation of such a device, assist railroads to implement and/or modify continuous welded rail standards to more effectively prevent track buckling. (Class II, Priority Action) (R-91-73)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
Chairman

/s/ Susan M. Coughlin
Vice Chairman

/s/ John K. Lauber
Member

/s/ Christopher A. Hart
Member

/s/ John A. Hammerschmidt
Member

December 10, 1991

APPENDIXES

APPENDIX A

INVESTIGATION

Investigation

The Safety Board was notified of the accident at 3 p.m., on April 23, 1990, and immediately dispatched investigators from the Chicago Regional Office to the scene. The Safety Board Vice Chairman, the investigator-in-charge, and other members of the investigative team were also dispatched from Washington, D.C. Investigative groups were established for operational, track, mechanical, human performance, and survival factors.

Deposition/Hearing

The Safety Board convened two 1-day deposition proceedings as part of its investigation. The first was held on September 11, 1990, at Des Moines, Iowa. A follow-up deposition proceeding was held October 30, 1990, at Safety Board headquarters in Washington, D.C. Parties to the depositions included the National Passenger Corporation, the Burlington Northern Railroad, the Brotherhood of Maintenance of Way Employees, the Brotherhood of Locomotive Engineers, the Federal Railroad Administration, and Trison Associates, Inc.

APPENDIX B

PERSONNEL DATA

MAINTENANCE-OF-WAY

General Foreman

Darrell G. Collard was hired by Burlington Northern Railroad (BN) as a Maintenance of Way worker (MOW). He became a foreman in 1976 and also worked as a track inspector from 1976 to 1988. In 1985, he began the first foreman of the newly created "Holland"[1] welding gang and supervised the gang in 1985 and 1986. In 1988, he formally became part of BN management with his promotion to general foreman. He attended management training and "track buckling school" in 1988 and 1989. In 1989, he was again assigned to Holland welding gang No. 41 as general foreman, having overall on-site responsibility and control.

Foreman

Jack D. Ellis was hired as a BN MOW worker in June 1971 and became a foreman in December 1973. Since that time, he had worked as a foreman and track inspector. He worked as a Holland welding gang foreman in 1988 and 1989 and during those years, had attended the annual track buckling seminar along with the general foreman.

Manager of Gangs

Joseph L. Thornburg was hired by BN in June 1973 as a track laborer. He later worked as a welder, foreman, and track inspector. In July 1976, he entered management as a roadmaster. Thornburg, was promoted to district and then general roadmaster before becoming manager of gangs in October 1988. In addition to about 10 weeks of track technical training and 15 weeks of management training, since 1987, he had attended the annual track buckling seminars given by the director of maintenance.

Superintendent of Maintenance and Engineering

Les H. Bahls received an undergraduate degree in civil engineering from the University of Minnesota in 1977. Upon graduation, he was hired by BN as a management trainee in the MOW engineering department. After completion of program training, he served in various MOW positions, advancing into positions of greater responsibility until becoming superintendent in October 1988.

[1] BN uses Holland in-track welding equipment for field welding of CWR, therefore, BN workers refer to the welding gang as "the Holland welding gang."

Director of Maintenance

Darrell D. Cantrell was hired by the St. Louis and San Francisco Railroad in 1963 as a laborer. He was successively promoted to foreman, roadmaster, division engineer, regional maintenance engineer, and director of maintenance. As maintenance director, he had been presenting the 1-day track buckling seminars annually throughout the BN system for the past 5 years.

APPENDIX C

REGULATIONS PERTAINING TO BRAKE TESTS

than 15 pounds above the maximum brake-pipe pressure fixed by the rules of the carrier and will not stop the compressor until the reservoir pressure has increased not less than 10 pounds.

(k) The communicating signal system on locomotives when used in passenger service must be tested and known to be in a safe and suitable condition for service before each trip.

(l) Enginemen when taking charge of locomotives must know that the brakes are in operative condition.

(m) In freezing weather drain cocks on air compressors of steam locomotives must be left open while compressors are shut off.

(n) Air pressure regulating devices must be adjusted for the following pressures:

Locomotives	Pounds
(1) Minimum brake pipe air pressure.	
Road Service	70
Switch Service	60
(2) Minimum differential between brake pipe and main reservoir air pressures, with brake valve in running position	15
(3) Safety valve for straight air brake	30-55
(4) Safety valve for LT, ET, No. 8-EL, No. 14 EL, No. 6-DS, No. 6-BL and No. 6-SL equipment	30-68
(5) Safety valve for HSC and No. 24-RL equipment	30-75
(6) Reducing valve for independent or straight air brake	30-50
(7) Self-lapping portion for electro-pneumatic brake (minimum full application pressure)	50
(8) Self-lapping portion for independent air brake (full application pressure)	30-50
(9) Reducing valve for air signal	40-60
(10) Reducing valve for high-speed brake (minimum)	50

Cars	Pounds
(11) Reducing valve for high-speed brake	58-62
(12) Safety valve for PS, LN, UC, AML, AMU and AB-1-B air brakes	58-62
(13) Safety valve for HSC air brake	58-77
(14) Governor valve for water raising system	60
(15) Reducing valve for water raising system	20-30

§ 232.11 Train air brake system tests.

(a) Supervisors are jointly responsible with inspectors, enginemen and trainmen for condition of air brake and air signal equipment on motive power and cars to the extent that it is possible to detect defective equipment by required air tests.

(b) Communicating signal system on passenger equipment trains must be tested and known to be in a suitable condition for service before leaving terminal.

(c) Each train must have the air brakes in effective operating condition, and at no time shall the number and location of operative air brakes be less than permitted by Federal requirements. When piston travel is in excess of 10½ inches, the air brake cannot be considered in effective operating condition.

(d) Condensation must be blown from the pipe from which air is taken before connecting yard line or motive power to train.

[33 FR 19679, Dec. 25, 1968, as amended at 47 FR 36794, Aug. 23, 1982]

§ 232.12 Initial terminal road train airbrake tests.

(a)(1) Each train must be inspected and tested as specified in this section by a qualified person at points—

(i) Where the train is originally made up (initial terminal);

(ii) Where train consist is changed, other than by adding or removing a solid block of cars, and the train brake system remains charged; and

(iii) Where the train is received in interchange if the train consist is changed other than by—

(A) Removing a solid block of cars from the head end or rear end of the train;

(B) Changing motive power;

(C) Removing or changing the caboose; or

(D) Any combination of the changes listed in (A), (B), and (C) of this subparagraph.

Where a carman is to perform the inspection and test under existing or future collective bargaining agreement, in these circumstances a carman alone will be considered a qualified person.

(2) A qualified person participating in the test and inspection or who has knowledge that it was made shall notify the engineer that the initial terminal road train air brake test has been satisfactorily performed. The

qualified person shall provide the notification in writing if the road crew will report for duty after the qualified person goes off duty. The qualified person also shall provide the notification in writing if the train that has been inspected is to be moved in excess of 500 miles without being subjected to another test pursuant to either this section or § 232.13 of this part.

(Approved by the Office of Management and Budget under OMB control number 2130-0008)

(b) Each carrier shall designate additional inspection points not more than 1,000 miles apart where intermediate inspection will be made to determine that—

(1) Brake pipe pressure leakage does not exceed five pounds per minute;

(2) Brakes apply on each car in response to a 20-pound service brake pipe pressure reduction; and

(3) Brake rigging is properly secured and does not bind or foul.

(c) Train airbrake system must be charged to required air pressure, angle cocks and cutout cocks must be properly positioned, air hose must be properly coupled and must be in condition for service. An examination must be made for leaks and necessary repairs made to reduce leakage to a minimum. Retaining valves and retaining valve pipes must be inspected and known to be in condition for service. If train is to be operated in electropneumatic brake operation, brake circuit cables must be properly connected.

(d)(1) After the airbrake system on a freight train is charged to within 15 pounds of the setting of the feed valve on the locomotive, but to not less than 60 pounds, as indicated by an accurate gauge at rear end of train, and on a passenger train when charged to not less than 70 pounds, and upon receiving the signal to apply brakes for test, a 15-pound brake pipe service reduction must be made in automatic brake operations, the brake valve lapped, and the number of pounds of brake pipe leakage per minute noted as indicated by brake pipe guage, after which brake pipe reduction must be increased to full service. Inspection of the train brakes must be made to determine that angle cocks are properly positioned, that the brakes are applied on each car, that piston travel is correct, that brake rigging does not bind or foul, and that all parts of the brake equipment are properly secured. When this inspection has been completed, the release signal must be given and brakes released and each brake inspected to see that all have released.

(2) When a passenger train is to be operated in electropneumatic brake operation and after completion of test of brakes as prescribed by paragraph (d)(1) of this section the brake system must be recharged to not less than 90 pounds air pressure, and upon receiving the signal to apply brakes for test, a minimum 20 pounds electropneumatic brake application must be made as indicated by the brake cylinder gage. Inspection of the train brakes must then be made to determine if brakes are applied on each car. When this inspection has been completed, the release signal must be given and brakes released and each brake inspected to see that all have released.

(3) When the locomotive used to haul the train is provided with means for maintaining brake pipe pressure at a constant level during service application of the train brakes, this feature must be cut out during train airbrake tests.

(e) Brake pipe leakage must not exceed 5 pounds per minute.

(f)(1) At initial terminal piston travel of body-mounted brake cylinders which is less than 7 inches or more than 9 inches must be adjusted to nominally 7 inches.

(2) Minimum brake cylinder piston travel of truck-mounted brake cylinders must be sufficient to provide proper brake shoe clearance when brakes are released. Maximum piston travel must not exceed 6 inches.

(3) Piston travel of brake cylinders on freight cars equipped with other than standard single capacity brake, must be adjusted as indicated on badge plate or stenciling on car located in a conspicuous place near brake cylinder.

(g) When test of airbrakes has been completed the engineman and conductor must be advised that train is in proper condition to proceed.

(h) During standing test, brakes must not be applied or released until proper signal is given.

(i)(1) When train airbrake system is tested from a yard test plant, an engineer's brake valve or a suitable test device must be used to provide increase and reduction of brake pipe air pressure or electropneumatic brake application and release at the same or a slower rate as with engineer's brake valve and yard test plant must be connected to the end which will be nearest to the hauling road locomotive.

(2) When yard test plant is used, the train airbrakes system must be charged and tested as prescribed by paragraphs (c) to (g) of this section inclusive, and when practicable should be kept charged until road motive power is coupled to train, after which, an automatic brake application and release test of airbrakes on rear car must be made. If train is to be operated in electropneumatic brake operation, this test must also be made in electropneumatic brake operation before proceeding.

(3) If after testing the brakes as prescribed in paragraph (i)(2) of this section the train is not kept charged until road motive power is attached, the brakes must be tested as prescribed by paragraph (d)(1) of this section and if train is to be operated in electropneumatic brake operation as prescribed by paragraph (d)(2) of this section.

(j) Before adjusting piston travel or working on brake rigging, cutout cock in brake pipe branch must be closed and air reservoirs must be drained. When cutout cocks are provided in brake cylinder pipes, these cutout cocks only may be closed and air reservoirs need not be drained.

(49 CFR 1.49(c))

[37 FR 12236, June 21, 1972, as amended at 47 FR 30795, Aug. 23, 1982; 47 FR 40807, Sept. 16, 1982]

§ 232.13 Road train and intermediate terminal train air brake tests.

(a) *Passenger trains:* Before motive power is detached or angle cocks are closed on a passenger train operated in either automatic or electro-pneumatic brake operation, except when closing angle cocks for cutting off one or more cars from the rear end of train, automatic air brake must be applied. After recoupling, brake system must be recharged to required air pressure and before proceeding and upon receipt of proper request or signal, application and release tests of brakes on rear car must be made from locomotive in automatic brake operation. If train is to be operated in electro-pneumatic brake operation, this test must also be made in electro-pneumatic brake operation before proceeding. Inspector or trainman must determine if brakes on rear car of train properly apply and release.

(b) *Freight trains:* Before motive power is detached or angle cocks are closed on a freight train, brakes must be applied with not less than a 20-pound brake pipe reduction. After recoupling, and after angle cocks are opened, it must be known that brake pipe air pressure is being restored as indicated by a rear car gauge or device. In the absence of a rear car gauge or device, an air brake test must be made to determine that the brakes on the rear car apply and release.

(c)(1) At a point other than an initial terminal where a locomotive or caboose is changed, or where one or more consecutive cars are cut off from the rear end or head end of a train with the consist otherwise remaining intact, after the train brake system is charged to within 15 pounds of the feed valve setting on the locomotive, but not less than 60 pounds as indicated at the rear of a freight train and 70 pounds on a passenger train, a 20-pound brake pipe reduction must be made and it must be determined that the brakes on the rear car apply and release. As an alternative to the rear car brake application and release test, it shall be determined that brake pipe pressure of the train is being reduced as indicated by a rear car gauge or device and then that brake pipe pressure of the train is being restored as indicated by a rear car gauge or device.

(2) Before proceeding it must be known that brake pipe pressure as indicated at rear of freight train is being restored.

(3) On trains operating with electropneumatic brakes, with brake system charged to not less than 70 pounds, test must be made to determine that

rear brakes apply and release properly from a minimum 20 pounds electro-pneumatic brake application as indicated by brake cylinder gauge.

(d)(1) At a point other than a terminal where one or more cars are added to a train, after the train brake system is charged to not less than 60 pounds as indicated by a gauge or device at the rear of a freight train and 70 pounds on a passenger train, a brake test must be made to determine that brake pipe leakage does not exceed five (5) pounds per minute as indicated by the brake pipe gauge after a 20-pound brake pipe reduction. After this test is completed, it must be determined that the brakes on each of these cars and on the rear car of the train apply and release. As an alternative to the rear car brake application and release portion of the test, it shall be determined that brake pipe pressure of the train is being reduced as indicated by a rear car gauge or device and then that brake pipe pressure of the train is being restored as indicated by a rear car gauge or device. Cars added to a train that have not been inspected in accordance with § 232.12 (c) through (j) must be so inspected and tested at the next terminal where facilities are available for such attention.

(2)(i) At a terminal where a solid block of cars, which has been previously charged and tested as prescribed by § 232.13 (c) through (j), is added to a train, it must be determined that the brakes on the rear car of the train apply and release. As an alternative to the rear car application and release test, it shall be determined that brake pipe pressure of the train is being reduced as indicated by a rear car gauge or device and then that brake pipe pressure of the train is being restored as indicated by a rear car gauge or device.

(ii) When cars which have not been previously charged and tested as prescribed by § 232.12 (c) through (j) are added to a train, such cars may either be given inspection and tests in accordance with § 232.12 (c) through (j), or tested as prescribed by paragraph (d)(1) of this section prior to departure in which case these cars must be inspected and tested in accordance with § 232.12 (c) through (j) at next terminal.

(3) Before proceeding it must be known that the brake pipe pressure at the rear of freight train is being restored.

(e)(1) Transfer train and yard train movements not exceeding 20 miles, must have the air brake hose coupled between all cars, and after the brake system is charged to not less than 60 pounds, a 15 pound service brake pipe reduction must be made to determine that the brakes are applied on each car before releasing and proceeding.

(2) Transfer train and yard train movements exceeding 20 miles must have brake inspection in accordance with § 232.12 (c)-(j).

(f) The automatic air brake must not be depended upon to hold a locomotive, cars or train, when standing on a grade, whether locomotive is attached or detached from cars or train. When required, a sufficient number of hand brakes must be applied to hold train, before air brakes are released. When ready to start, hand brakes must not be released until it is known that the air brake system is properly charged.

(g) As used in this section, "device" means a system of components designed and inspected in accordance with § 232.19.

(h) When a device is used to comply with any test requirement in this section, the phrase "brake pipe pressure of the train is being reduced" means a pressure reduction of at least five pounds and the phrase "brake pipe pressure of the train is being restored" means a pressure increase of at least five pounds.

[33 FR 19679, Dec. 25, 1968, as amended at 37 FR 12237, June 21, 1972; 51 FR 17303, May 9, 1986]

§ 232.14 Inbound brake equipment inspection.

(a) At points where inspectors are employed to make a general inspection of trains upon arrival at terminals, visual inspection must be made of retaining valves and retaining valve pipes, release valves and rods, brake rigging, safety supports, hand brakes, hose and position of angle cocks and make necessary repairs or mark for

APPENDIX D

TABLE 1 AND PARAGRAPH J FROM CIRCULAR 1 MAINTENANCE OF WAY RULES BOOK

TABLE 1

SHORTENING OF CWR FOR TEMPERATURE CHANGE

Rail Temp. Differential Degrees F	400'	600'	800'	1000'	1200'	1440'	1600'
5°	0"	1/4"	3/8"	3/8"	1/2"	1/2"	5/8"
10°	1/4"	1/2"	5/8"	3/4"	7/8"	1"	1 1/4"
15°	1/2"	3/4"	1"	1 1/4"	1 1/2"	1 3/4"	1 7/8"
20°	5/8"	7/8"	1 1/4"	1 1/2"	1 7/8"	2 1/4"	2 1/2"
25°	3/4"	1 1/4"	1 5/8"	2"	2 3/8"	2 3/4"	3 1/8"
30°	1"	1 3/8"	1 7/8"	2 3/8"	2 3/4"	3 3/8"	3 3/4"
35°	1"	1 5/8"	2 1/4"	2 3/4"	3 1/4"	3 7/8"	4 3/8"
40°	1 1/4"	1 7/8"	2 1/2"	3 1/8"	3 3/4"	4 1/2"	5"
45°	1 1/2"	2 1/8"	2 7/8"	3 1/2"	4 1/4"	5"	5 5/8"
50°	1 3/4"	2 3/8"	3 1/8"	3 7/8"	4 3/4"	5 5/8"	6 1/4"
55°	1 3/4"	2 5/8"	3 1/2"	4 3/8"	5 1/8"	6 3/16"	6 7/8"
60°	2"	2 3/4"	3 3/4"	4 5/8"	5 5/8"	6 3/4"	7 1/2"
65°	2"	3"	4 1/8"	5 1/8"	6 1/8"	7 3/8"	8 1/8"
70°	2 1/4"	3 3/8"	4 3/8"	5 1/2"	6 1/2"	7 7/8"	8 3/4"
75°	2 1/4"	3 1/2"	4 5/8"	5 7/8"	7"	8 3/8"	9 3/8"
80°	2 1/2"	3 3/4"	5"	6 1/4"	7 1/2"	9"	10"
85°	2 5/8"	4"	5 1/4"	6 5/8"	7 3/4"	9 1/2"	10 1/2"
90°	2 7/8"	4 1/4"	5 3/4"	7"	8 1/2"	10 1/4"	11 3/8"
95°	3"	4 1/2"	6"	7 1/2"	9"	10 3/4"	12"
100°	3 1/8"	4 3/4"	6 1/4"	8"	9 3/8"	11 1/4"	12 1/2"

NOTE: The above amounts do not include the gap (1") required for immediate field welding.

Formula for determining proper adjustment cut or laying gap:

0000065 X TD X L X 12

TD = Temperature differential below desired rail laying temperature

L = One-half the total length of the two adjacent strings if rail is being stretched or total length of the string if being adjusted after laying.

J - LAYING WELDED RAIL:

When laying welded rail, the application of rail anchors must not be done below the minimum laying temperatures for specific areas as shown on Exhibit "A". When rail laying temperatures are below the specified minimum rail temperatures, rail will be heated to the appropriate minimum temperatures or stretched using a hydraulic rail expander (Rail Stretching Instructions - Exhibit "B"). When rail heaters are used steps must be taken to insure rail does not bind with tie plates or spikes. Just heating the rail to the desired temperature is not enough; the rail must expand the proper amount. While heating the rail, it will be necessary to vibrate the rail or tap the tie plates to assist rail movement. The following chart shows the desired expansion for every nine rail lengths of CWR for assigned temperature differentials. Match marks will be placed on the base of the rail and tie plate every 9 rail lengths to ensure the rail has expanded the proper amount. Make sure tie plates with match marks are not allowed to move during the expansion process.

CONTINUOUS WELDED RAIL EXPANSION SEGMENTS (INCHES)

TEMPERATURE DIFFERENTIAL DEGREES F	NUMBER OF 39-FOOT RAIL LENGTHS			
	9	18	27	36
5	9/64	9/32	27/64	9/16
10	9/32	9/16	27/32	1-1/8
15	27/64	27/32	1-17/64	1-11/16
20	9/16	1-1/8	1-11/16	2-1/4
25	45/64	1-13/32	2-7/64	2-13/16
30	27/32	1-11/16	2-17/32	3-3/8
35	63/64	1-31/32	2-61/64	3-15/16
40	1-1/8	2-1/4	3-3/8	4-1/2
45	1-17/64	2-17/32	3-51/64	5-1/16
50	1-13/32	2-13/16	4-7/32	5-5/8
55	1-35/64	3-3/32	4-41/64	6-3/16
60	1-11/16	3-3/8	5-1/16	6-3/4
65	1-53/64	3-21/32	5-31/64	7-5/16
70	1-31/32	3-15/16	5-21/32	7-7/8

APPENDIX E

CORRESPONDENCE FROM TRISON ASSOCIATES, INC.

SPECIALISTS IN REPLACEMENT PARTS FOR MASS TRANSPORTATION TRISON ASSOCIATES INCORPORATED

801 W. STREET ROAD, SUITE 1
FEASTERVILLE, PA 19047
(215) 357-9150
FACSIMILE: (215) 357-9163

September 21, 1990

Mr. David Watson
Chief Regional Investigation Branch
National Transportation Safety Board
800 Independence Ave. S.W., ST-33
Washington, DC 20594

Dear Mr. Watson:

Enclosed please find our installation manual for your report. Please note, it is imperative that locks are installed with our fixtures and in accordance with our instructions. To date, we have provided two sets of fixtures, yet there are currently as Mr. Laurello alluded to, four installation locations.

Regarding a concern in the tube area, we would like to meet with you and examine the jammed lock as you had suggested. We will submit our complete drawing at that time. Meanwhile I have enclosed drawing #2678-60 which provides detail of the lock frame. Regardless of the cause of the problem, whether due to installation or manufacturing, we are currently modifying the pattern by adding ribs to the outside of the tube. This will prevent any further problems. I have also have informed AMTRAK that the installation must be completed in accordance with our installation manual.

Please advise when it is convenient for you to meet for further discussion.

Sincerely,

Joseph T. Egan
President

JTE/ah