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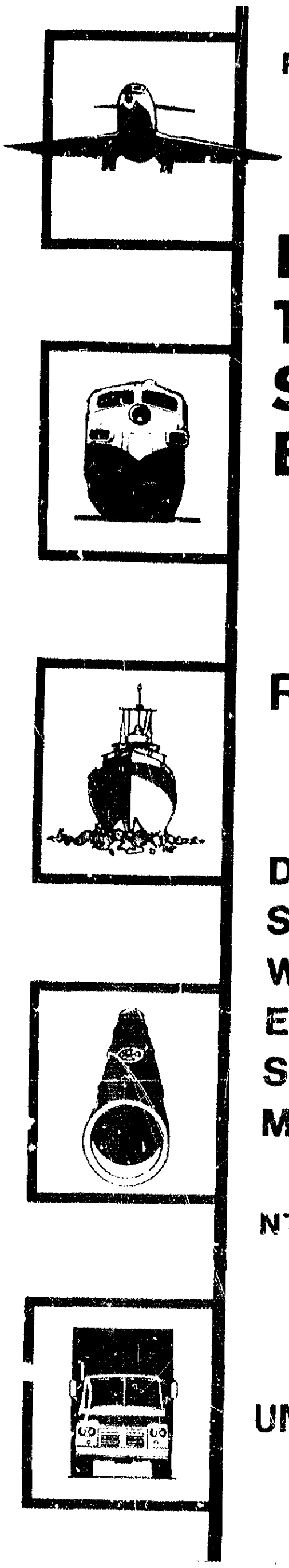

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT OF STEAM EXCURSION TRAIN NORFOLK AND WESTERN RAILWAY COMPANY TRAIN EXTRA 611 WEST SUFFOLK, VIRGINIA MAY 18, 1986

NTSB/RAR-87/05

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16. Abstract On May 18, 1986, 14 of the 23 passenger cars of a Norfolk and Western Railway Company (N&W) passenger excursion train powered by a steam locomotive derailed near Suffolk, Virginia. Of the approximately 1,000 train passengers, all of whom were N&W employees and their relatives and guests, 177 were injured; 19 of the injured were hospitalized. The estimated cost of damage was $231,530.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the Norfolk and Western Railway Company (N&W) to train its Maintenance of Way Department employees adequately in the inspection and repair of continuous welded rail, and the failure of the Maintenance-of-Way Department management to monitor the implementation of the N&W's maintenance-of-way practices by its employees. Contributing to the severity of the accident was the N&W's decision to use equipment without tightlock couplers and passenger cars with modified interiors having severe injury-producing mechanisms.

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EXECUTIVE SUMMARY

On May 18, 1986, 14 of the 23 passenger cars of a Norfolk and Western Railway Company (N&W) passenger excursion train powered by a steam locomotive derailed near Suffolk, Virginia. Of the approximately 1,000 train passengers, all of whom were N&W employees and their relatives and guests, 177 were injured; 19 of the injured were hospitalized. The estimated cost of damage was $231,530.

The safety issues discussed in this report include:

1. Identifying and correcting track maintenance problems;
2. Monitoring practices of extreme temperatures;
3. Requalification of track inspectors;
4. Procedures for inspecting multiple tracks;
5. Passenger cars without tightlock couplers;
6. Passenger cars without window glazing and safety glazing standards;
7. Securement of interior fixtures and appliances; and
8. Lack of toxicological testing following an accident.

Recommendations concerning these issues were made to the Norfolk and Western Railway Company, American Short Line Railroad Association, Association of American Railroads, National Railroad Historical Society, American Association of Private Railroad Car Owners, Inc., and the Federal Railroad Administration.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the Norfolk and Western Railway Company (N&W) to train its Maintenance of Way Department employees adequately in the inspection and repair of continuous welded rail, and the failure of the Maintenance-of-Way Department management to monitor the implementation of the N&W's maintenance-of-way practices by its employees. Contributing to the severity of the accident was the N&W's decision to use equipment without tightlock couplers and passenger cars with modified interiors having severe injury-producing mechanisms.

NATIONAL TRANSPORTATION SAFETY BOARD
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RAILROAD ACCIDENT REPORT

Adopted: September 15, 1987

DERAILMENT OF STEAM EXCURSION TRAIN NORFOLK AND WESTERN RAILWAY COMPANY TRAIN EXTRA 611 WEST SUFFOLK, VIRGINIA MAY 18, 1986

INVESTIGATION

The Accident

On May 18, 1986, the Norfolk and Western Railway Company (N&W), sponsored a train trip for approximately 1,000 persons, including employees of its Norfolk Terminal and their families and friends. The train, N&W Extra 611 West, was to operate from Norfolk, Virginia, to Petersburg, Virginia, and return. It consisted of a steam locomotive, a tender, an auxiliary tender, 3 office cars, a tool car, 17 coaches, a commissary car, and an observation car.

At 12:15 p.m. e.d.t., 1/ the engineer, the fireman, and the conductor for Extra 611 West reported for duty. The conductor called the dispatcher to check the temperature to determine if the train speed would be restricted because of heat. 2/ The dispatcher told the conductor the temperature was 86° F.

The system road foreman of engines-steam relieved the engineer of his operating duties and informed him that there would be no room for him in the cab of the locomotive and that it would be best for him to ride in the cars. The engineer informed the fireman of the change and both men took seats in the passenger cars. The conductor was not told of the changes.

Before departure the train was inspected and the brakes tested satisfactorily. The train departed Norfolk at 1:31 p.m. on the westbound main track. The chairman and chief executive officer (CCEO) of the Norfolk Southern Corporation (NS), the parent company of the N&W, was operating the locomotive; an operating fireman, 3/ the system road foreman of engines-steam, and three visitors also were in the cab. Shortly afterward, the CCEO made the required running brake test; he did not note any discrepancies. When the train cleared Bridge 7, the CCEO increased its speed to about 60 mph. (The permitted timetable speed was 60 mph.) (See figure 1.)

1/ All times herein are eastern daylight.
2/ A "heat wave" order is issued when the temperature reaches a specified threshold which in effect reduces the maximum timetable speed from 60 to 40 mph. The specified threshold on the Norfolk Division on May 18, 1986, was 90° F.
3/ The operating fireman was an employee of a service contractor and was permanently assigned to the NS steam operations.

LEGEND

Petersburg	N	84.4
Suffolk	N	22.7
Juniper	N	17.0
Derailment	N	16.0
Gilmerton	N	7.5
Bridge 7	N	6.6
Bridge 5	N	5.2
Lamberts Point	LP	0.0

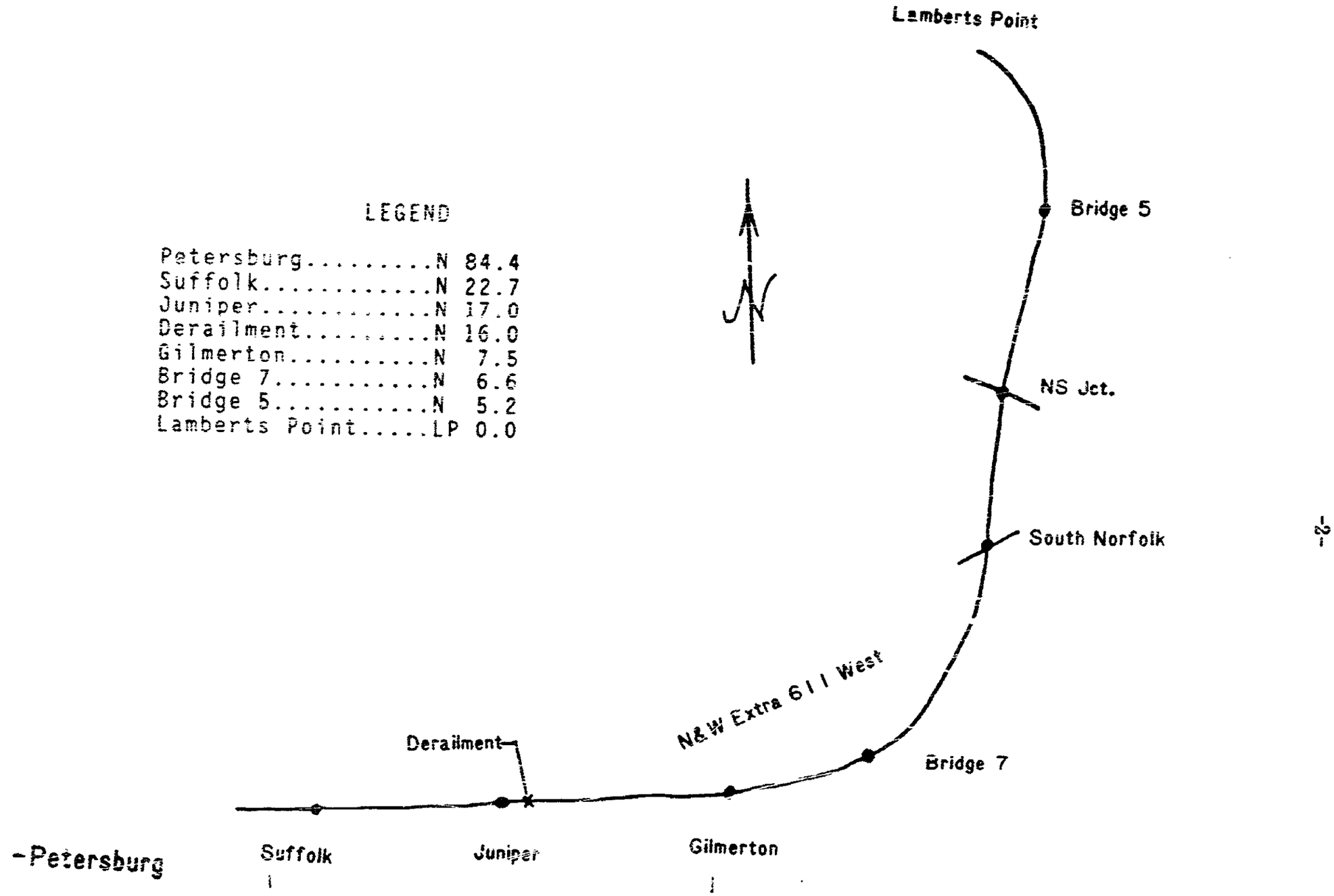

Figure 1.—Map of accident site from Norfolk to Suffolk.

About 16 miles west of Norfolk and 6 miles east of Suffolk, Virginia, the train approached a switch in the Great Dismal Swamp, designated as Juniper by the N&W. This switch enabled trains to be diverted from the westbound main track to a middle track. The CCEO said that the switch target was positioned for the main track, and the operating fireman said that the switch points 4/ were aligned for the main track. At 2:09 p.m., the locomotive passed over the turnout. 5/ The operating fireman stated that the turnout was rougher than it had been on the previous day when he had been on this engine on the same track. The CCEO said that he felt a lateral motion, but that he took no exception. The three visitors in the locomotive cab, who were not railroad employees, stated that they felt no unusual movement at the time.

Railroad employees riding as passengers in the cars immediately behind the locomotive stated they felt they had ridden over a track abnormality. A passenger in SOU 1-Virginian, the first car in the train (located just behind the auxiliary water tender), said that the auxiliary water tender rocked violently as if it had passed over a crossover. 6/ Passengers in NW 200, the third car, and tool car NW 1407, the fourth car, stated they experienced combinations of vertical, lateral, and rocking motions; they said that they felt the car ride up and then down. A passenger in car NW 1407 stated that his first indication of a problem was ". . . a jerk, side motion jerk, and to me it sounded like a loud explosion under the wheel . . . the sound of steel hitting steel." Another passenger in the same car stated that he ". . . heard sharp sound, cracking sound . . ." A road foreman of engines, who was riding in NW 1407, stated that he would have reported the switch because it was rough riding, but that he would not have placed any restrictions on its use.

The CCEO said that immediately after the locomotive passed over the turnout at 2:09 p.m. he felt slack movement, 7/ followed by an emergency brake application. He told Safety Board investigators that he reached up with both hands and shoved the throttle closed and that, simultaneously, the road foreman of engines-steam reached over to the engineer's side and depressed the independent brake valve handle to release the locomotive brake. The CCEO then climbed down from the locomotive cab and saw that the train had derailed. The train had parted between the 7th and 8th cars; 14 cars, the 8th through 21st cars, had derailed in the area of the turnout. The conductor, who was in the last passenger car, stated that he became aware of the derailment when the train brakes applied in emergency followed by two slack run-ins.

The lead truck (west end) of the eighth car, NW 531, had passed through the turnout correctly, but the trailing truck (east end) proceeded in the direction of the divergent route, skewing the car and breaking off the knuckle 8/ of the seventh car, TWC 1723. All derailed cars remained upright and together except for the 13th through 16th (NW 1069, SOU 1087, SOU 4061, and SOU 1070) which jackknifed and/or overturned. The 13th car (NW 1069) did not stay in line with the five preceding derailed cars. The last two cars of the train remained undamaged on the track. The derailed cars blocked the middle track and the eastbound main track. (See figures 2 and 3.)

4/ A switch point is a movable tapered track rail, the point of which is designed to fit against the stock rail.
5/ A turnout is an arrangement of rails, by means of which railroad cars may be diverted from one track to another.
6/ A crossover is two turnouts with the track between the frogs arranged to form a continuous passage between two nearby and generally parallel tracks.
7/ Slack is unrestrained free movement between cars in a train.
8/ A knuckle is the pivoting hook-like casting that fits into the head of a coupler and rotates about a vertical pin either to the open position or to the closed position.

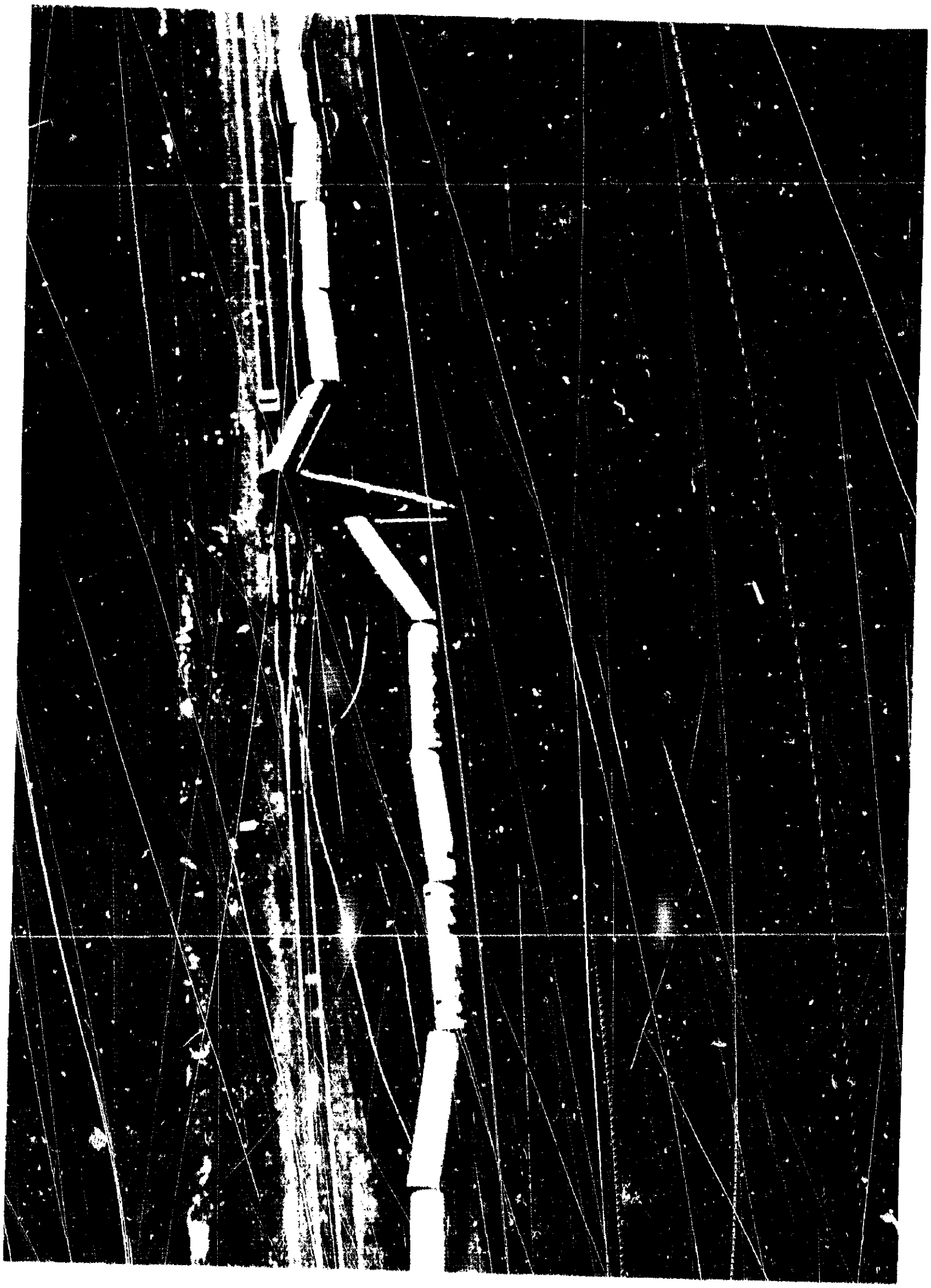

Figure 2.—Aerial view of accident.

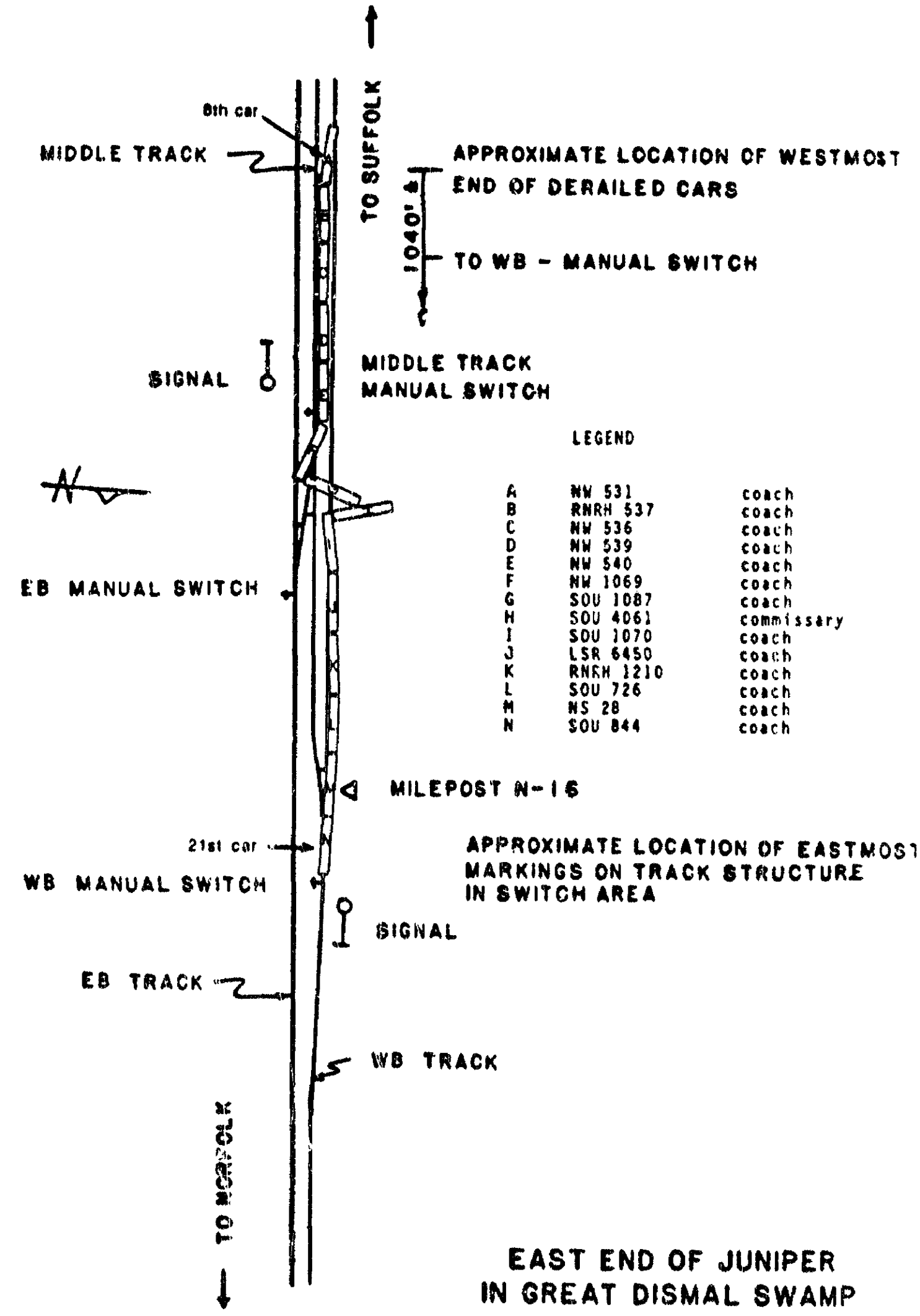

Figure 3.-- Derailment site.

The road foreman of engines-steam stated that he initially attempted to notify by radio the operator at Bridge 7 to protect any eastbound movements and then ordered the operating fireman to get a red flag and equipment and to go west to protect any eastbound movements. Before the operating fireman could carry out the order, the road foreman contacted the operator at Bridge 7 who assured the road foreman that he would provide protection. Meanwhile, the conductor had run to a wayside telephone and had notified the operator at Bridge 7 of the accident and requested emergency assistance. Immediately afterward, crewmembers and uninjured passengers assisted in the evacuation and care of the injured.

The west end of the last car to derail, SOU 844, was near the turnout frog; 9/ the east end of the car remained on the track with its wheels in the switch area. A member of the traincrew reported that the switch points were gapped and that neither switch point was against the stock rails. According to N&W maintenance-of-way officials, the switch stand 10/ was examined immediately after the accident and was found in the reverse position (diverging route into the middle track); the safety block in the stand had rotated 90° counterclockwise. The operating lever had rotated with the safety block remaining locked in its recess in the top collar portion of the safety block. The yellow disc target was facing the east-west direction indicating that it had reversed to show a diverging route into the middle track.

Injuries to Persons

Injuries	Passengers	Crewmembers	Total
Fatal	0	0	0
Injuries	177	0	177
None	823*	6	829
Total	1,000*	6	1,006

* Estimated number provided by the N&W.

Damage

Train.--The postaccident inspection of the locomotive, the tender, the auxiliary water tender and the undercarriage, trucks, wheels, and couplers of the first seven nonderailed cars did not reveal any damage, unusual or significant marks, or missing equipment.

NW 1069, SOU 1087, and SOU 4061, which jackknifed and/or overturned, were destroyed in the derailment. The first car to derail, NW 531, had a gouge approximately 1/16 inch deep and 3 to 4 inches long inside the leading wheel on the south side of the trailing truck on the back face of rim area. The gouge was preceded by chatter marks 11/ approximately 12 inches long. Both the gouge and the chatter marks proceeded from the outside of the wheel toward its center in a shallow curve. (See figure 4.) The side frame of the truck also had slide markings on the bottom of the frame. The 10 remaining derailed cars had markings resulting from the derailment. No deviations from normal conditions were found when investigators measured back-to-back wheel

9/ A frog is a track structure used at the intersection of two running rails to provide support for wheels and passageways for their flanges, thus permitting wheels on either rail to cross the other.
10/ A switch stand is a device for the manual operation of switches.
11/ Chatter marks are fine undulations formed on the surface of steel.

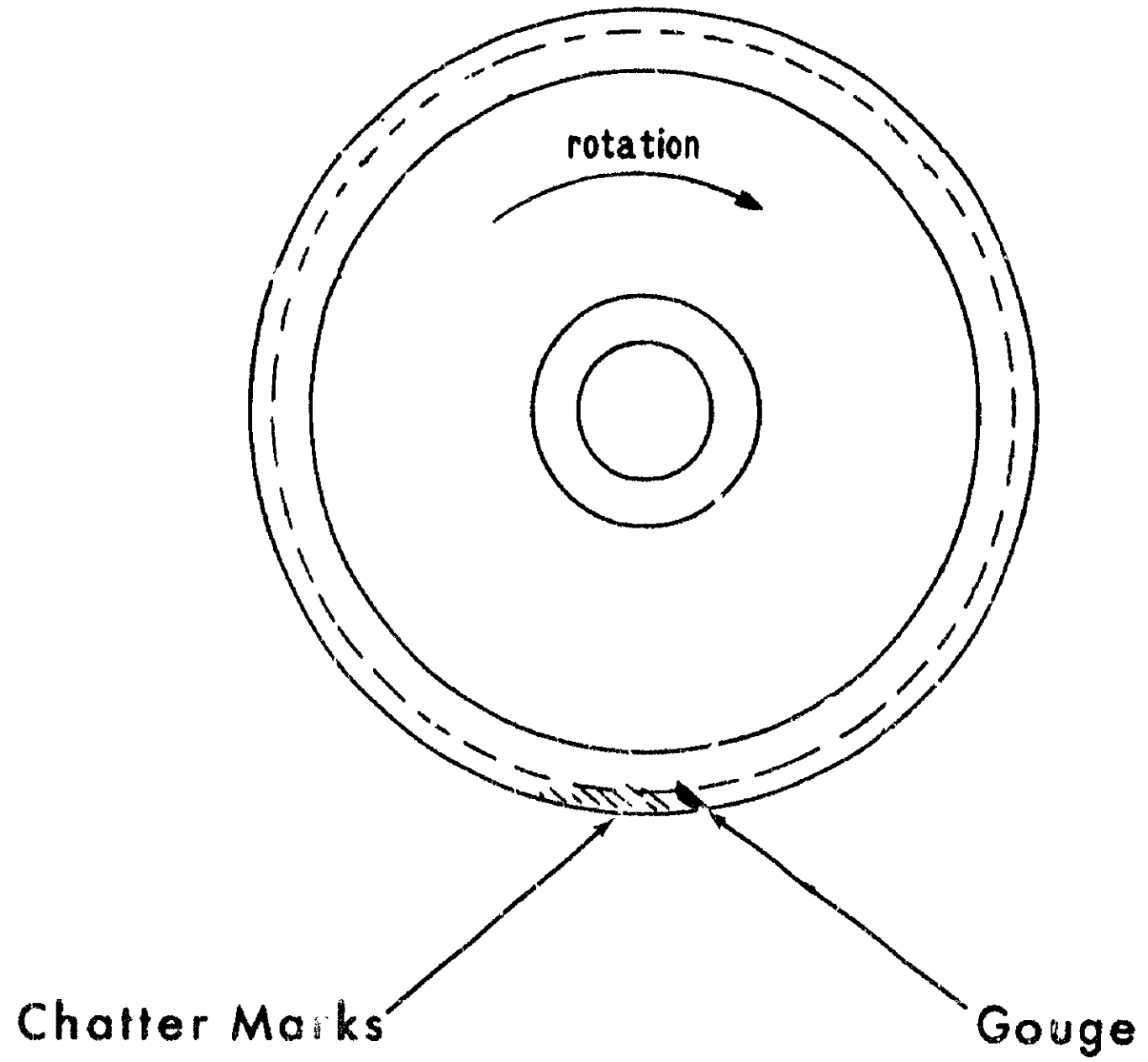

Figure 4.—Markings on southside of lead wheel, trailing truck on N&W 531.

distances and wheel flange thickness on the locomotive, the tender, the auxiliary water tender, and the first 12 passenger cars in the consist, and the last 4 derailed cars (RNRH 1210, SOU 726, NS 28, and SOU 844).

The N&W provided the following damage assessments for its equipment:

Equipment	Amount of Damage
NW 531	$ 5,258.70
RNRH 537	18,930.70
NW 536	10,501.05
NW 539	11,686.18
NW 540	16,655.20
NW 1069	34,687.00*
SOU 1087	977.00*
SOU 4061	17,397.00*
SOU 1070	14,224.52
LSR 6450	7,291.73
RNRH 1210	14,572.59
SOU 726	4,705.48
NS 28	2,649.35
SOU 844	713.78
	$160,250.28

* total loss

Track and Signal.—About 1,000 feet of the westbound main track, including the guard rail and frog area of the turnout, were destroyed from approximately 65 feet west of the point of switch. The middle track, including the turnout connecting the middle track to the eastbound main track, was destroyed from the westbound turnout westward for approximately 960 feet. Approximately 157 feet of the eastbound main track was moderately damaged. The N&W estimated that the cost of restoring the track and turnout to its original state was $106,341. However, the actual costs incurred were $70,780 because two turnouts and 330 feet of track were not replaced. (See figure 5.)

The N&W estimated the signal damage to be $500.

Estimated damage to equipment, track, and signals was as follows:

Equipment	$160,250.28
Track	70,780.00
Signal	500.00
Total	$231,530.28

Personnel Information

The operating fireman and the system road foreman of engines-steam were properly qualified for their respective positions in accordance with N&W requirements. (See appendix B.) The CCEO had last passed the N&W operating rules examination in 1984. Engineers are required to pass an annual rules examination or be held out of service until they pass the examination. The operating fireman had last passed the N&W operating rules examination in April 1986. The system road foreman of engines-steam had been promoted from road foreman of engines of the Norfolk Division. In his position, he had frequently been over the division with other engineers. He was responsible for performing efficiency checks on the engineers and for determining that they were current on the rules examination.

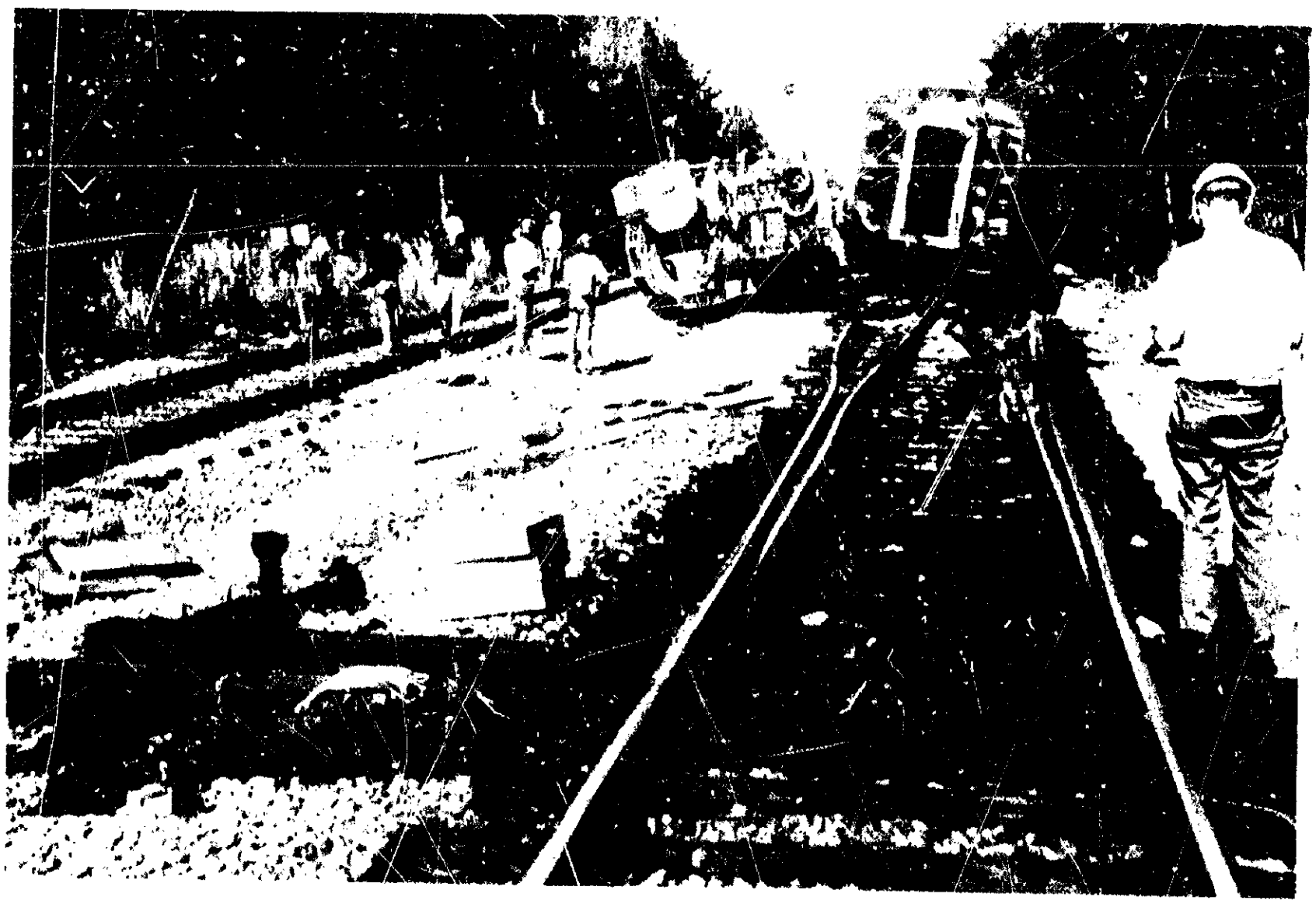

Figure 5.—Westbound turnout at Juniper.

Train Information

NS was operating the excursion train. The corporation had been arranging excursion trips through sponsors for about 20 years. The general manager of steam operations stated that excursion trains had been carrying approximately 1,000 to 1,200 people each weekend between April and November.

Locomotive No. 611 was built in 1950 by the N&W in its Roanoke Shops. 12/ The locomotive featured advanced engineering practices of that time, including roller bearings on axles, cadmium-plated side rods, and mechanically lubricated moving parts. The railroad reported that locomotive 611 was capable of pulling a 1,000-ton passenger train at more than 100 mph although it normally did not operate at that speed. In 1959, the locomotive was retired from passenger service; it was used for various excursions until it was turned over to the Roanoke Transportation Museum. In 1981, the locomotive was rebuilt by the Southern Railway 13/ steam shop and returned to serviceable condition for use in the NS steam program.

12/ No. 611 was a streamlined "Northern" (4-8-4 wheel arrangement) locomotive used to operate passenger trains.

13/ The N&W and Southern Railway are operating subsidiaries of Norfolk Southern Corporation.

The locomotive was equipped with a multichannel, battery-powered radio and permanently mounted speakers in the cab. Two handsets were provided for communicating with the traincrew, the dispatcher, the wayside operators, and other trains. Although the radio could be removed, it was not a portable radio. The locomotive did not have an event recorder.

The cars were pre-Amtrak (1970) passenger-type equipment, referred to as "historic" or "older" equipment. (See appendix C.) The passenger cars were individually owned by N&W, Southern Railway Company (SOU), Norfolk Southern (NS), the Tide Water Chapter (TWC) of the National Railroad Historical Society (NRHS), the Roanoke Chapter (RNRH) of the NRHS, and the Lake Shore Region (LSR) Historical Society. The destroyed cars, NW 1069, SOU 1087, and SOU 4061, were built between 1926-29, according to railroad damage records provided after repairs were made to the equipment.

During the service life of the equipment, some of it was modified by the previous owners; records of these modifications were not available. The tool car, NW 1407, originally built as a baggage car in 1927, was modified to carry tools for performing maintenance on the locomotive and to provide an area for enthusiasts to take sound recordings of the train. Cars NW 1069 and SOU 1070 had been modified as open window coaches with wood bench-type seats, and car SOU 4061, a baggage car, had been converted into a commissary car. SOU 1087 had been modified to an all-seat coach by removing restrooms from both ends.

On the night of May 17, 1986, and the morning of May 18, 1986, the equipment was serviced and inspected by Maintenance of Equipment Department personnel at Lamberts Point Yard in Norfolk. Air hoses were replaced between cars RNRH 1210 and LSR 6450; two cast-iron brakeshoes were replaced on TWC 1721. The carman who inspected the train stated that the brake test was made with 80 psi registered at the rear end. N&W later provided information that the feed valve setting on the locomotive was 100 psi as required by N&W operating rules.

The general foreman stated that he visually inspected the condition of the train and took no exception to its condition. He also said he received no complaints or exceptions concerning any unsafe conditions or defects from the carmen or supervisors who prepared the train.

The locomotive, the tender, the auxiliary tender, car NW 1407 (tool car), car NW 1069, car SOU 1087, car SOU 4061 (commissary car), and car SOU 1070 were equipped with standard type E couplers. The remaining cars were equipped with type F (interlocking), type T (early tightlock), or type H (tightlock) couplers. The tightlock coupler was designed specifically for passenger cars, was adopted as an Association of American Railroads (AAR) alternate standard in 1937, became standard in 1947, and became mandatory on new passenger equipment built after 1956. 14/ The derailed cars without tightlock or interlocking couplers jackknifed and/or overturned during the derailment. The general manager of steam stated that since the accident, locomotive 611 has continued in service for excursions, but without tool car NW 1407, because management decided to use only cars equipped with tightlock couplers.

The Equipment Maintenance Engineer/Mechanical Department of the NS told Safety Board investigators, "I wish [the equipment] had tightlock couplers. It appears to have kept the cars that had them in line in the derailment." When asked if tightlock

14/ The Car and Locomotive Cyclopedia, Sec. 9 -Couplers, 1980. Standard couplers of the Association of American Railroads (AAR).

couplers would have prevented the cars from jackknifing out of the train, he stated, "I don't know. I really don't. I'm judging from the configuration of the derailed cars after the derailment." When asked if he would recommend tightlock couplers, he stated, "I think that's reasonable, yes sir."

Track and Signal Information

The Norfolk Division, between milepost N-8 to the yard limits at Suffolk at milepost N-21, is straight double-track mainline designated eastbound and westbound with automatic block signaling. About milepost N-16, the east end of Juniper, the westbound main track shifts approximately 13 feet to the north to accommodate a middle track between the eastbound and westbound tracks. Juniper is approached from the east at an average gradient of 0.033 percent ascending westbound (6.1 feet rise in elevation in 3.5 miles) and then is level for approximately 3,000 feet west of milepost N-16. The turnout, at milepost N-16, to the middle track is on a 0.035-percent ascending grade. The transition from the westbound main track is through a 0°-20' curve to the right, with a 1/2-inch superelevation, for 330 feet beginning approximately 537.8 feet east of milepost N-16, exiting to a tangent track of approximately 372.45 feet. The tangent track includes the left-hand turnout to the middle track, followed by a 0°-24' curve to the left, with a 1/2-inch superelevation for 279 feet. The track is then tangent and parallel to the eastbound main and middle track. Track centers are approximately 13 feet center to center.

On November 19, 1985, the NS Track Geometry Car, 15/ NS-85, tested the westbound main track through the Juniper area for rail profile, gage, superelevation/crosslevel, alignment, twist, and rail surface. 16/ An anomaly on the chart, for superelevation/crosslevel, showed 1/2- to 3/4-inch crosslevel variation on the tangent track approaching the turnout at milepost N-16 and an approximate 1-inch crosslevel variation on the exiting side of the west end of the turnout. N&W maintenance-of-way track officials told Safety Board investigators that these same anomalies had appeared in four previous tests, performed at 6-month intervals, and that a 1/2-inch difference had been deliberately built into the tangent track to reduce truck hunting. 17/ However, test results were within the maintenance standards prescribed by the N&W Track Safety Standards. No maintenance was performed or programmed for the area as a result of the tests.

The rail in the westbound main track was 132-lb RE section 18/ continuous welded rail (CWR), manufactured in 1981 by Bethlehem Steel. The rail was laid in April 1982 on 8- by 14 3/4-inch, double-shoulder tie plates, atop 7-inch by 9-inch by 8-foot 6-inch treated crossties, on 19- to 21-inch centers, with 18- to 24-inch depth crushed rock ballast. There were two rail-holding spikes per tie plate. Rail anchors were

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15/ A specially equipped railroad car with optical laser, conventional feeler, or magnetic gauges linked to a computer for comparing geometry data to specified standards and identifying the locations with a printed record.
16/ Rail profile limits are established by individual railroads based on the amount of acceptable rail wear. Gage, superelevation/crosslevel, alignment, twist, and rail surface standards are prescribed requirements of 49 CFR 213 Subpart C.
17/ Truck hunting is an instability at high speed of a wheel set (truck), causing it to oscillate down the track, usually with the wheel flanges striking the rail.
18/ 132-lb RE section refers to rail that nominally weighs 132 pounds per linear yard and is a standard rail section recommended for use by the American Railway Engineering Association.

installed according to N&W standards of box-anchoring 19/ to every other tie, except at the track approaches to the turnout, where every tie for 160 ties was box-anchored. The westbound main track was designated by the N&W as class 4 track. 20/

The middle track was constructed similarly to the westbound main track, but the rail had been installed and artificially heated on February 10-11, 1986, to reach an initial rail-laying temperature of 90° F to 95° F. After installation, the middle track was routinely inspected as required by the FRA Track Safety Standards. The middle track was designated by the N&W as class 3 track.

The rail anchor pattern in the undamaged sections of the westbound main and middle track was according to the N&W Maintenance of Way Standards. Gaps between the face of the tie and rail anchors varied from zero to 1/4 inch for approximately 1/2 mile. The anchor pattern through the turnout and for approximately 1,000 feet to the west, on both the westbound main and the middle track, could not be determined because the track was destroyed in the derailment. However, the roadmaster had performed a semi-annual inspection of the turnout on April 25, 1986, and reported that the general condition of the rail anchor was standard.

The N&W Maintenance of Way Standards for ballast shoulder width is 6 inches on tangent track and 12 inches on curved track. The field side ballast shoulder width of the 0°-20' curve approaching Juniper from the east varied from 6 to 12 inches. The ballast shoulder width 1,000 feet west of the turnout, in the tangent track, was 6 inches. The ballast shoulder width in the derailment area could not be determined from the turnout to approximately 1,000 feet to the west.

The turnout in the westbound main track, at the east end of Juniper, to the middle track was a left-hand, No. 12 turnout, 21/ 132-lb RE rail, facing point westward, with a railbound manganese steel frog 22/; 22'-0" straight switch points with undercut stock rails; six pairs of Racor Security adjustable rail braces; Racor type C guard rails with two adjustable C-clamps each and one bolt at each end through the guard rail, end-filler block, and running rail. (See figure 6.) The switch stand was a Racor type 17-C with a high mast and one elliptical yellow target set parallel to the main track when the switch is positioned for the main track and to display the yellow elliptical disc when the switch is positioned for the middle track. The stand was located on the south side (fireman's side) on the westbound track. The lever arm of the stand was secured in its notch and protected with a Sargent-Greenleaf security lock. All rail and associated hardware in the turnout was replaced with new material when the turnout was rebuilt.

Although the N&W Maintenance of Way Standard plan for a 132-lb RE rail switch with 22'-0" switch points requires nine pairs of adjustable rail braces, this turnout had only six pairs (the fourth, seventh, and ninth pairs from the O-gage plate had not been installed when the turnout was rebuilt in a 1982 maintenance program). The chief engineer-line maintenance agreed that the number of adjustable switch brace plates was less than the N&W Maintenance of Way Standard of nine pairs, but stated it had been that way since its

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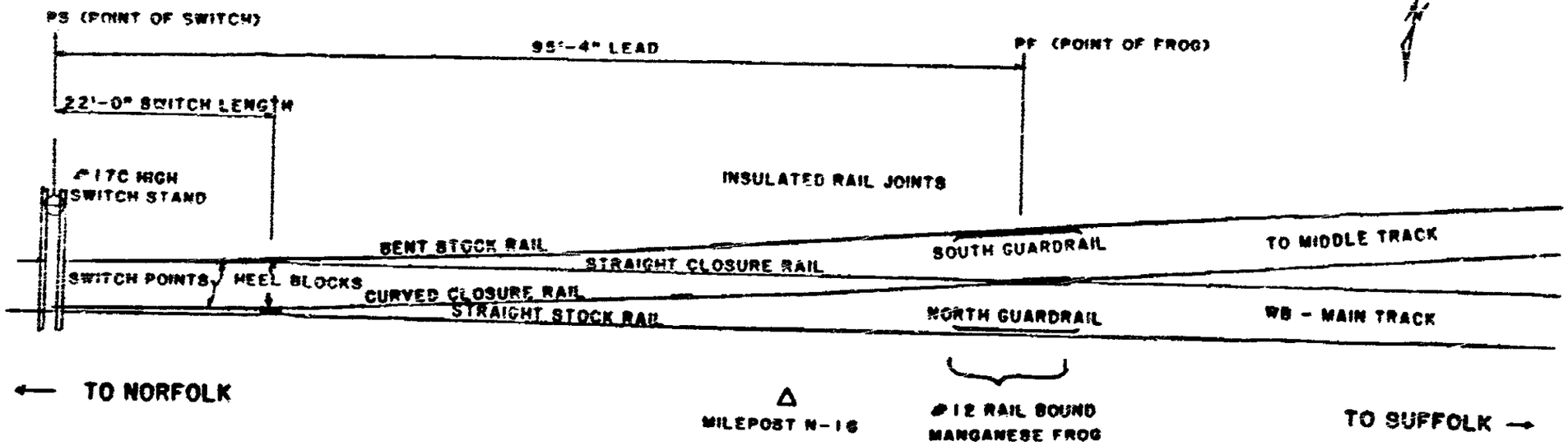
19/ Box-anchoring is the practice of setting rail anchors to bear against both sides of a tie to restrain rail longitudinal movement in both directions.
20/ Class of track defines, in accordance with the FRA Track Safety Standard, the speed, the track geometry, the track structure, and the inspection requirements for track.
21/ Turnout number corresponds to the frog number of the frog used in the turnout.
22/ A frog consisting essentially of a manganese steel body casting insert fitted between rolled rails and held together with bolts.



NO SCALE

Figure 6.—Schematic of No. 12 left-hand turnout.

installation in 1982 without any problems. He stated that, "The only reason I can offer is that apparently the person installing this at the time either looked at it as though it was a No. 10 turnout or thereabouts or he simply didn't put enough braces back on it. . . ." He further stated that the American Railway Engineering Association (AREA) recommends seven braces, with only one gage plate on the No. 1 tie, and the N&W Maintenance of Way Standards are very conservative. He stated that it is likely that the N&W Maintenance of Way standards will be changed to those of the AREA and Southern Railway as track standards are consolidated for the NS.

The east end of the westbound main track at Juniper is controlled by automatic block signaling. Westbound traffic movements are governed by a three-aspect automatic signal located approximately 51 feet east of the point of switch east of milepost N-16. The turnout was equipped with a track shunt circuit switch protection with a nonseries break-type circuit. 23/

Track Maintenance and Inspection

The track at the accident site was maintained in accordance with Federal Railroad Administration (FRA) class 4 standards, which permit a maximum allowable operating speed of 80 mph for passenger trains. NW Timetable No. 2, issued September 16, 1984, restricted the maximum speed to 60 mph through the Juniper area.

The last programmed maintenance on the westbound track in the area of the east-end Juniper turnout was performed between April 17-25, 1984, as an out-of-face 24/ operation to install ties and to surface track. On March 24, 1986, Sperry Rail Service performed an annual ultrasonic inspection of the rail for internal defects on the westbound main track; no exceptions were noted at Juniper.

Programmed maintenance of surfacing and tie renewal of the CWR installed on the middle track on February 10-11, 1986, took place in March and April of 1986. The chief engineer-line maintenance testified when asked about followup inspection on CWR installed at that time of the year, "Well, there is constant follow-up in that regard in checking-out what . . . you know, the track performance, how it performs after it has been laid and after it's been there awhile. But of course the main thing is that it's done properly to begin with and there's a lot of people checking that it's done properly to begin with. . . ." The roadmaster stated he had personally walked the middle track following the completion of the surfacing and tie replacement work, checking for rail anchors and spiking patterns.

N&W Maintenance of Way Standards for turnouts and rail anchors on CWR specify that sufficient rail anchors be applied to all rails in the turnout, that the rail anchors be inspected frequently, and that the rail anchors be adjusted when necessary. The inspection and adjustment of the rail anchors is the responsibility of the track inspectors while they are inspecting the track on hi-rail vehicles 25/ during regular inspection.

23/ A nonseries break-type circuit used for track shunt switch protection is an integral component of the electrical control circuit and is a by-path in an electrical circuit. This nullifies the fail-safe concept of the signal system when the shunt wire becomes disconnected.

24/ Out-of-face track work is work that proceeds completely and continuously over a given piece of track as distinguished from work at disconnected points.

25/ A hi-rail is a truck or automobile with retractable flanged wheels so it may be used on either the highway or the railroad track.

The chief engineer-line maintenance testified that many N&W officers are involved in track inspections. He stated that roadmasters or assistant roadmasters inspect the tracks on hi-rail vehicles weekly and that the division engineer inspects the track on hi-rail vehicles monthly. Also, a division officer conducts a monthly inspection from a train. However, the N&W officers are not required to complete any reports of track inspections. Various railroad officers testified that the westbound track is ". . . better than any Class 1 railroad in the United States . . . and that applies to the area where the derailment occurred at Juniper. . . "; ". . . no problem with it, it's an excellent riding piece of track. . . "; ". . . we don't have any trouble, really, on the westbound. . . . "

The N&W Standards and the FRA standards do not address track inspection of multiple tracks or the track the inspector must travel. The standards refer to the inspection being made on foot or over the track in a vehicle at a speed that allows the track inspector to visually inspect for compliance with the standards. The division engineer stated that the FRA track inspection requirements permit the inspection of three tracks when the middle track is between two main tracks. However, an FRA track inspector testified at the Safety Board's public hearing that ". . . under most circumstances, I would consider it pretty near impossible to see all three tracks from one. That would be a subjective interpretation of the standards, as to whether or not the inspector is in a position to see the track he's inspecting." (See appendixes D and E.)

The roadmaster stated that he knew the middle track was inspected once a week because it was required by N&W standards and FRA standards for class 3 track. The assistant roadmaster had inspected the middle track on a hi-rail vehicle following the installation of the CWR in February 1986. He said that he was sure the track inspectors inspected the middle track every time they were inspecting track.

The area covered by the regular track inspector was between Norfolk and Petersburg, milepost N-8 to milepost N-96, including a branch line. During May, up to the date of the derailment, the regular track inspector was off-duty for health reasons, and an N&W relief track inspector performed the twice-weekly inspections, as required by the N&W Track Safety Standards and the FRA Track Safety Standards for class 4 track. The westbound main track was the traveled track twice during this period and the eastbound main track was the traveled track three times.

The relief track inspector said he had been qualified for FRA track inspections by the N&W. He stated, however, that he had not performed track inspections since May 1977. During the review of track inspection reports at the public hearing, the relief track inspector stated that he could not determine from his reports the track he was traveling on and what switches he had inspected. When the relief track inspector was interviewed following the accident and asked what class of track is between milepost N-8 and N-96, he answered, "I think it's supposed to be 2 and 3" (referring to the FRA classification of track between mileposts N-8 and N-96). At the Safety Board's public hearing, he testified that it was class 4 track, but when asked what that means he stated, "Well, I'm not exact what it means. The speed is 60 miles an hour and that's how you tell the class."

Both the relief track inspector and the regular track inspector stated it was not difficult to inspect multiple tracks. They stated that they performed their inspections in accordance with the FRA Track Safety Standards and N&W Maintenance of Way Standards and that they are governed by the N&W timetable while on the track.

The regular track inspector was familiar with and had seen kinks 26/ in the rail, but had never had a major problem with them, but he had put slow orders on the track. The relief track inspector had observed a few kinks, but stated that he did not consider those kinks to have been abnormal or bad enough for a slow order. The relief track inspector could not describe a kink, but he also did not consider a 1/2-inch displacement of the track to be abnormal.

After achieving certain seniority and qualifications, railroad employees may bid on track inspector positions. According to the assistant roadmaster, once a track inspector becomes qualified for that position, it is a permanent qualification; the N&W has no provisions for requalifying or evaluation of performance. There are no formal procedures for supervisory evaluations of track inspectors except for a supervisor's discretionary inspection of the track. Inspectors normally work by themselves and are not regularly accompanied in their work by assistants or supervisors. When a track defect is noted, it is the inspector's responsibility to repair it or report it for repair. A followup inspection of reported defects is not required, but the regularly scheduled track inspection should indicate the defect exists until it is no longer considered a defect. There were no followup inspections or evaluations of the work done by the relief track inspector by his supervisors after he took over for the regular inspector.

There are no written requirements for medical or visual examination other than preemployment physicals. The roadmaster testified "There are no specific yearly checks, as far as I know, on eyesight." When questioned on the importance of eyesight he stated, ". . . if I knew one of my men had a problem, . . . then I would probably send him to a doctor. . . ."

On May 6, 1986, 12 days before the accident, employees of a contractor under the supervision of an N&W track foreman were operating a prototype shoulder ballast cleaner (see figure 7) in the accident area. This operation provided a testing track for evaluating and modifying the contractor's prototype equipment and, in return for providing the track, the N&W selected the areas of track for cleaning the shoulder ballast. The equipment, a two-car train, was operated by six men to remove, clean, and replace the ballast at the ends (shoulder) of the ties.

The track foreman who supervised the shoulder ballast cleaning operation stated that he received his instructions from the assistant roadmaster and the roadmaster before beginning the work. The assistant roadmaster stated that he discussed shoulder ballast specifications and slow orders, with the track foreman; he also stated that he instructed the track foreman to take no chances if the weather got hot. The assistant roadmaster stated he had not seen the shoulder ballast cleaning equipment operate, but had observed the shoulder ballast conditions after the equipment had been used.

The roadmaster stated that he instructed the track foreman to clean the areas that had been selected by the division engineer and to stay behind the equipment to ensure that a standard ballast shoulder was maintained. Although the roadmaster did not specifically instruct the track foreman, he expected that the track foreman would obtain temperatures and take all necessary precautions because the position of track foreman is a supervisory position by N&W Maintenance of Way Standards; the job position requires that he knows the procedures and requirements for maintenance of track.

26/ Kinks refer to irregularities in rail alignment which are caused by excessive compression in rails.

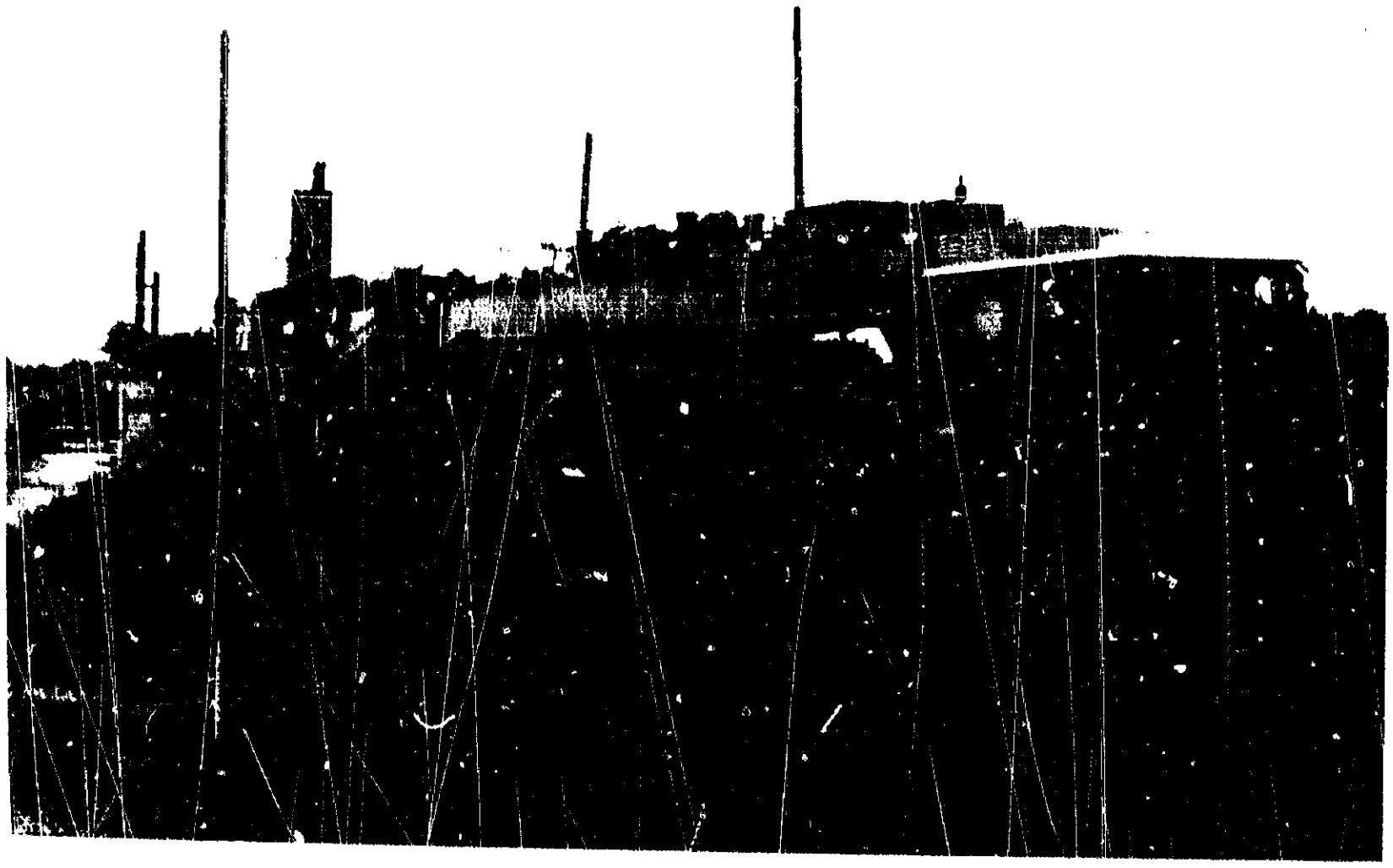


Figure 7.—Prototype shoulder ballast cleaner.

About 9:15 a.m., the shoulder ballast cleaner was westbound on the westbound main track when it struck the turnout at the east end of Juniper and damaged eight Morden adjustable brace plate bolts. The equipment operator stated that he had been removing the shoulder ballast down to about 6 to 8 inches below the ties. He said that about 30 to 40 feet from the turnout, the ballast scoop was raised to proceed past the turnout, but the rear leveler did not clear the adjustable brace plate bolts. Following the incident, so the equipment could be repaired, the shoulder ballast cleaner was moved west of the turnout while the track foreman arranged to repair the damages to the turnout.

The track foreman stated that he called for the assistant roadmaster on the radio to talk to the section foreman. The section foreman stated that he talked to the track foreman and then explained to the assistant roadmaster that the shoulder ballast cleaner had struck the turnout and clipped some bolts on the braces at the east switch at Juniper and that the track foreman needed some bolts to repair the switch. The assistant roadmaster then sent a relief foreman to get material and to assist the track foreman in repairing the switch. No other track problems were discussed, according to the assistant roadmaster and the section foreman.

The track foreman explained to Safety Board investigators that the replacement of the bolts on the adjustable brace plates near the switch points required the use of two track jacks to lift the running rails. The plates are continuous under both running rails and the switch point rails. The switch point rails are connected to each other with

insulated switch rods. 27/ Replacement of bolts on the remaining adjustable brace plates (those plates not adjacent to the switch points) required only one track jack. The track foreman stated that he had to lift up the rail about 1/2 inch, and slide the brace plates to one side to remove the broken bolts and install the new bolts. He also stated that he had pulled the rail holding spikes only on ties that had braces on them, that he plugged the spike holes, and that he respiked the plates. In doing this, 10 rail anchors were knocked off or fell off and were reinstalled.

Near the switch points, a signal shunt wire was attached to a tie. The shunt wire was part of the circuitry of the signal system which indicated the position of the switch points. The track foreman told Safety Board investigators that, as far as he knew, the wire did not interfere with replacing the bolts and that he did not request a signal maintainer. The assistant roadmaster and division engineer also stated that they believed that it would not have been necessary to have a signal maintainer present. The roadmaster stated to Safety Board investigators that it was up to the foreman to decide, but that he would have had a signal maintainer check the signal shunt wire.

During the on-site investigation, neither the track foreman, the assistant roadmaster, nor the division engineer acknowledged any track alignment problems on the westbound track. Before the Safety Board's public hearing (see appendix A), the chief engineer-line maintenance informed Safety Board investigators that when the track foreman was notified he would be testifying at the hearing, the track foreman acknowledged that he had a track alignment problem after he had completed the repairs to the turnout.

At the public hearing, the track foreman testified that he completed the repairs about 2:30 p.m. and that he issued a 10-mph slow order through the dispatcher. He testified that he was concerned with the track alignment because of the shoulder ballast cleaning, but that ". . . the slow order was there to take care of whatever happened."

The N&W Maintenance of Way Standards for placing slow orders on CWR states, in part:

> When the track is disturbed to extent that lateral stability is appreciably affected, speed restriction of no more than 10 mph must be imposed until sufficient tonnage has passed to afford stabilization. Authorized speed may then be accomplished. . . after personal inspection. (Caution: Prior to permitting authorized speed, all ties throughout disturbed area must be securely tamped and standard ballast section restored.)

The track foreman testified that following the repair work he noticed an alignment problem in the track approaching the turnout from the east near the switch points. Approximately 5 to 8 feet east of the switch points, the track was misaligned to the south 1/2 to 1 inch for a length of 2 feet. The track foreman testified that he did not make any correction at the time because he had already issued a 10-mph slow order and ". . . put the order on so the heat wouldn't do any more damage. . . ." He said that he believed the temperature was near 90° F, but that he did not make any temperature checks. The track foreman stated that he did not discuss the alignment problem with either the assistant roadmaster or the roadmaster, but because the temperature was high and the track was out of line he asked his section foreman, later that day, to take a look at the track on the next day.

27/ Insulated switch rods are a device connecting the two switch points to maintain the relative distance between the points. Insulation is used to prevent the flow of electrical current from one rail to another.

The roadmaster said he was not informed of the track damage or alignment problem until May 7, the next day, when he found that a 10-mph slow order was still on the track. He also said he knew that the shoulder ballast cleaning operation was in that area, but that a 25-mph slow order was normally used after the shoulder ballast cleaning. The 25-mph slow order was removed after maintenance-of-way personnel had determined that the track was safe for normal train operations. He stated that he questioned the section foreman and was told only of the damage and repair of the switch brace bolts and of the track foreman's request for the 10-mph slow order. The roadmaster stated that he then instructed the section foreman to check the track, "make any necessary corrections, and get the slow order off." The roadmaster stated that he did not consider this to be a serious problem and that ". . . little things like this happen all time where a gang has to pull off a job they're on to make a minor correction somewhere and go back to work. I don't go immediately and check each thing that they've done. In hi-railing, making my normal inspections over track, I do remember all these things that have been done and take notice of them at that time." However, railroad records indicate that the roadmaster did not perform a hi-rail inspection following these repairs before the derailment. (See appendix F.)

The section foreman stated that he inspected the track at the east end of the switch about 9 a.m. on May 7 and found the track misaligned approximately 1/4 to 1/2 inch to the south. He placed track jacks against the south side of each rail, realigned the track, and filled the gaps made by the jacks with ballast. The section foreman also stated he guessed that the temperature at the time was about 75° F or 80° F. He told Safety Board investigators that it is not unusual for a slow order to be on the track for 24 hours if the track is damaged or if there is a lot of movement of the track. The section foreman said that after observing one train pass over the turnout, he notified the dispatcher to remove the 10-mph speed restriction. Between May 7 and the day of the derailment, normal train traffic, including a revenue passenger trip of locomotive 611 on May 17, traveled the same track without incident.

The signal supervisor and roadmaster had performed a semi-annual inspection of the turnout on April 25. No exceptions were noted for that inspection. According to N&W records, on May 6, the day the turnout at Juniper was damaged by the shoulder ballast cleaner, the relief track inspector performed a monthly inspection of the turnout at the time repairs were being made and did not report any damage, defects, or slow order. On May 14, the signal maintainer and section foreman performed a quarterly inspection of the turnout at the east end of Juniper as prescribed by N&W standards. No exceptions were noted in N&W records as a result of the inspection.

On the day of the derailment, May 18, the relief track inspector was assigned to perform a special inspection of the track ahead of Extra 611 West. The relief track inspector stated that he guessed the temperature to be between 70° F and 80° F and did not know of any "heat orders" being issued. He further stated that he put his hi-rail inspection vehicle on the westbound main track at 10:46 a.m. at milepost N-8, traveled to the east end of Juniper, inspected the switch, and proceeded to the west end of Juniper where he had to go onto the middle track to allow a westbound train of empty hopper cars that preceded Extra 611 West to pass. He stated that he then proceeded west on the eastbound main track, operating his vehicle at 25 mph during his inspection. At crossovers, he slowed to 5 mph, stopped, got out, ". . . took a glance at a lot of turnouts . . . " and finished his inspection at milepost N-96 about 2:45 p.m. He stated that during the inspection he noticed "little kinks" in the track, but that he did not feel the need to report them because he did not consider them unsafe.

Training

In 1979, the N&W established a program to train potential track foremen (apprentice foreman) on track maintenance practices and procedures. The program consisted of 4 weeks of classroom training and additional on-the-job training, which took place over a 1-year period. This program covered all aspects of track maintenance, inspection, and construction. An abbreviated program consisting of 2 weeks of classroom training was given to existing track foremen. In an approximate 4-year period, the N&W had trained nearly all of its potential and existing foremen.

The N&W apprentice foreman training program consisted of a 1-week classroom session for review of N&W rules, procedures, and standard plans. The classroom session was followed by on-the-job training for variable periods of time, depending on the progress of the individual foreman as evaluated by their immediate supervisor. Apprentice foremen then returned to the classroom for an additional week of review of rules, procedures, and standard plans. Completion of training indicated that the apprentice foremen were qualified to begin working in the field alone or accompanied by their immediate supervisors, depending on their performance evaluations.

Materials used in the program included the N&W Standard Procedures and portions of the Standard Plans. The Standard Procedures addressed a variety of maintenance procedures, such as fire protection at bridges, use of rail anchors, use of track spikes, laying CWR, curve characteristics, ballast maintenance, types of adjustments necessary to prevent thermal buckling of track, inspection procedures for CWR, implementation of slow orders and some procedures needed to repair track misalignments. The Standard Plan described the railroad construction requirements and specifications for track construction and their components for standardization and consistency in track maintenance and construction. The training information was retained by the foremen and updated as new standards or procedures were issued.

The FRA Track Safety Standards also were used in the training program. Where N&W standards were more restrictive than the FRA standards, the N&W standards were to be applied, otherwise the FRA standards applied. Track inspectors were required to pass a written test covering FRA and N&W Track Safety Standards as part of their qualifications. The N&W also required track inspectors, track foremen, and supervisors to pass annually an exam on their transportation department's operating rules as they apply to the use of track cars (hi-rail vehicles).

The track foreman assigned to the shoulder ballast cleaning operation on May 6, 1986, said he had taken the 2-week training course. The section foreman who realigned the track at the turnout following the damage from the shoulder ballast cleaner had been a foreman since 1969; however, he had not attended the training school. The regular track inspector stated that he had attended the school and that at the time of the accident he had passed the exam on the operating rules required by the N&W's transportation department for operating a track car. The relief track inspector stated that he had "... training through the Book of Rules, FRA, and I've been through the foreman's school and worked on the papers around foreman that have."

In 1983, the training program was discontinued because nearly all potential and existing foremen had been trained, and track maintenance personnel were reduced. According to N&W management, its training of track personnel is an ongoing program. In 1987, a new NS procedure for "Maintaining Track Stability" was issued to all track foremen and above.

The N&W has indicated that although classroom training is beneficial, "the real experience to inspect track comes from on-the-job training." It is the policy of the N&W that the performance of its track inspectors be constantly monitored by supervisory maintenance personnel through their frequent inspections of the track and through their joint inspections with track inspectors. The N&W/NS consolidation process eventually will provide an apprentice foreman training program at the NS Training Center at McDonough, Georgia. N&W currently has a 1-year management trainee program with 5 weeks of training under qualified maintenance supervisors.

Method of Operation

Trains are operated on the Norfolk District between Norfolk and Colley Avenue, milepost LP-1.9, under the authority of the general yardmaster at Lamberts Point Yard in accordance with Norfolk Division Timetable Rule 107(a). Between Colley Avenue and milepost N-8.4, trains operate on a double track system governed by signal indications of a traffic control system in accordance with NS Operating Rules 97 and 420, and Norfolk Division Timetable Rule 100. Between milepost N-8.4 and the east-end turnout at Juniper, milepost N-16, trains operate with the current of traffic and are governed by signal indications of an automatic block system in accordance with NS Operating Rules 97 and 251 and Norfolk Division Timetable Rule 100.

Trains departing Norfolk must have a copy of the current dispatcher's bulletin which contains current operating instructions, including temporary speed restrictions and other restrictive conditions as required by Norfolk Division Timetable Rule 2-A.

The maximum authorized speed for trains between milepost N-6.6 and N-22.1 is 60 mph in accordance with Norfolk Division Timetable Rule 4-A. There were no restrictions for train operations between milepost N-6.6 and the point of derailment on the day of the accident.

The system road foreman of engines-steam stated that he was actually the person in charge of the locomotive and responsible for the safety of the noncrewmembers in the locomotive cab. The CCEO had operated both steam and diesel locomotives on numerous occasions on both the N&W and SOU railroads. He said that he believed that the CCEO was qualified and well versed on the rules although he was not sure he had taken the exam. The CCEO testified that he receives a copy of the rules exam, decides if he wants to take it, and sends it to the rules officer. He stated he did not take the exam until after the accident and had last qualified on the rules exam in 1984.

According to NS operating rules, the conductor is in charge of the train and all crewmembers of that train. The conductor must consult with the engineer, when necessary, for assurance that all requirements are being met. He is responsible for the safe and proper management of the train, the protection and care of passengers and their property, the performance of duty by train employees, and the observance and enforcement of the rules and instructions. However, the conductor was not made aware that the CCEO was operating the locomotive and that the engineer and fireman were asked to ride with the passengers.

The N&W policy on the Norfolk Division required that whenever the temperature reached 90° F "heat wave" orders be issued and that train speeds be restricted to 40 mph because CWR track is subject to longitudinal expansion during periods of high

temperatures and is susceptible to shifting laterally (buckling or kinking 28/) ahead of, or under, a train. When "heat wave" orders are issued, bulletins are posted and trains already en route are notified by radio. The Maintenance of Way Department vehicles are equipped with radios so that operators can monitor the dispatcher's frequency for bulletins issued by radio. This is the only way that "heat wave" orders come to the attention of maintenance-of-way supervisors in the field. Track inspectors have been instructed that when they learn of the placement of "heat wave" orders they are to patrol their areas until the "heat wave" order is removed by the dispatcher.

On May 7, 1986, the dispatcher at Crewe, Virginia, issued a heat wave order at about 2:44 p.m. No other heat wave orders were issued up to the time of the derailment.

The superintendent of the Norfolk Division stated that the chief dispatcher in Crewe, checks temperatures four times a day, but ". . . in a case like the heat is coming up and they got thermometers at Norfolk, they've got thermometers at Crewe," and when the temperature is ". . . getting close to within five degrees, they start checking more periodically." He stated that the maximum temperature recorded by the dispatcher at Crewe was 83° F at 1 p.m. provided by the operator at Bridge 7 on the day of the accident.

The N&W manager-operating rules testified that the railroad has a uniform method of obtaining ambient temperatures through the dispatching points on the railroad. He stated that temperatures are recorded at midnight, 6 a.m., noon, and 6 p.m. from a thermometer at the dispatcher's office at Crewe, and that the dispatcher could also contact a wayside operator (if one was on duty), or the weather bureau, if he needed to determine a temperature at a location other than at his office.

During June 1986, the N&W reduced the threshold limiting temperature for issuing "heat wave" orders from 90° F to 85° F. The manager-operating rules stated that this was done as a result of a request made in April to the various divisions on the railroad to determine what threshold temperatures were in effect systemwide. The threshold temperature limit was not uniform systemwide, varying from 85° F to 90° F.

Meteorological Information

Surface weather observations provided by the National Weather Service (NWS) station at Norfolk for February 10-11, 1986 (the dates of construction of the middle track), recorded ambient temperatures in the mid 30's.

The NWS reports for March 1986 (the time of programmed surfacing and tie renewal on the middle track) showed that between the hours of 7 a.m. and 3 p.m. the ambient temperature varied from a low of 31° F to a high of 80° F with the average being approximately 52° F.

The NWS reports for May 6, 1986, recorded clear, sunny skies with ambient temperatures between 62° F and 88° F during daylight hours with the maximum temperature of 88° F occurring at 1:50 p.m. On May 7, 1986, the skies were cloudy with ambient temperatures between 70° F and 92° F during daylight hours with the maximum temperature of 92° F occurring between 1:50 p.m. and 3:50 p.m.

28/ Buckling of track is a major irregularity in track alignment which is caused by excessive compression in the rails which cause the track to shift laterally.

Weather information furnished by the NWS station at Lake Kilby (Suffolk) reported a temperature range of 41° F to 93° F between May 6-18, 1986, with the maximum temperature being recorded on May 7. The maximum temperature recorded on May 18 was 88° F.

Ambient hourly temperatures recorded by the NWS at Norfolk for May 7-18, 1986, showed that temperatures decreased from a high of 92° F on May 7 to a low of 46° F on May 11, followed by increasing temperatures, to a high of 89° F about the time of the derailment.

On May 18, 1986, before Extra 611 West departed Norfolk, the temperature reported to the conductor by the dispatcher at Crewe was 86° F. The NWS at Norfolk reported clear to partly cloudy, cumulus clouds, with minimum and maximum ambient temperatures between 67° F and 90° F during daylight hours with the maximum temperature of 90° F occurring between 2 p.m. and 4 p.m.

The following are hourly readings from the NWS at Norfolk for May 7 (the last day that a heat order was issued) and May 18, 1986:

Time	May 7, 1986 Temperature (° F)	May 18, 1986 Temperature (° F)
12:50 a.m.	71	71
1:50 a.m.	70	70
2:50 a.m.	70	69
3:50 a.m.	72	68
4:50 a.m.	70	67
5:50 a.m.	70	67
6:50 a.m.	72	70
7:50 a.m.	75	74
8:50 a.m.	79	78
9:50 a.m.	82	82
10:50 a.m.	84	85
11:50 a.m.	87	87
12:50 p.m.	90	87
1:50 p.m.	91	89
2:50 p.m.	91	88
3:50 p.m.	91	88
4:50 p.m.	84	85
5:50 p.m.	84	83
6:50 p.m.	79	81
7:50 p.m.	77	79
8:50 p.m.	73	76
9:50 p.m.	72	74
10:50 p.m.	71	73
11:50 p.m.	71	71

Medical and Pathological Information

Of the estimated 1,000 passengers on Extra 611 West, 177 were treated at local hospitals. Of the 177 injured passengers, 19 required hospitalization. Passengers who were treated and released had injuries consisting of fractures, strains, sprains, contusions, and lacerations. Five passengers had multiple trauma, one had unstable angina, and one had a closed head injury.

The most seriously injured passengers could not recall how their injuries were sustained. Less severely injured occupants stated that their injuries were caused by a variety of types of secondary impacts with the interior surfaces of the car. Passengers in SOU 1087 and SOU 4061 said that they felt the cars overturn and remembered being thrown about the cars and seeing others thrown; however, no one could recall specifically how they sustained their injuries.

Survival Aspects

Emergency Response.— Immediately after the accident, crewmembers, uninjured passengers, emergency medical technicians (EMT), and nurses aboard the train started to care for the injured. The EMTs had been hired by the Tidewater Chapter of the NRHS to ride the train on this trip. Passengers that were too injured to move stayed in the cars, attended by medical personnel or other passengers from the train, until rescue personnel arrived on the scene.

Following the derailment, about 2:12 p.m., the conductor went to a wayside telephone and called the Bridge 7 operator. The Bridge 7 operator stated that the conductor reported that the train had "wrecked" and requested ambulances. The Bridge 7 operator then telephoned the Lamberts Point Yard general yardmaster's office and reported the accident. The yardmaster stated that upon receiving the notification he telephoned the Norfolk Fire Department which referred him to the Chesapeake Fire Department. The yardmaster stated that he estimated completing the notification about 2:24 p.m.

Chesapeake Fire Station No. 8 received the alarm that a passenger train had derailed on the N&W tracks approximately 7 miles west of the Yadkin and Galberry Road crossing at the east entrance of the Great Dismal Swamp, in the city of Suffolk.

The first fire units arrived on scene about 2:25 p.m. They determined that additional units were required and requested special equipment, including a heavy hydraulic rescue tool to extricate passengers from the overturned cars. A command center was set up at the east end of the derailment. The operational medical director for Norfolk and Virginia Beach responded with portable cellular telephones that were used at the command post to communicate with area hospitals. A triage center was established at Galberry and Yadkin Roads due to the limited accessibility to the accident site. Access to the accident site was by way of a crushed stone driveway adjacent to the westbound main track and was confined on the north side by a deep trackside ditch. Two mobile cranes from the Norfolk Naval Base were dispatched by the U.S. Navy to assist at the accident site. However, the cranes became stuck in the stone driveway and blocked vehicular access from the east end.

Sixteen passengers were removed from the overturned cars. Helicopters from the U.S. Coast Guard, the U.S. Navy, and the Virginia State Police, and a medical evacuation helicopter from a local hospital, referred to as "Nightengale," assisted in removing the seriously injured. All arrived within minutes of notification. Because the area near the accident was determined to be too risky for landing the helicopters except for the Nightengale. A landing zone was set up at the Old Dominion Steel plant on Yadkin Road, approximately 1/4 mile east of the triage area. Five of the most critically injured passengers were transported via helicopter and two were transported via ambulance within 60 to 90 minutes after the accident to Norfolk General Hospital.

Railroad employees assisted in the evacuation of passengers who were uninjured or suffered only minor injuries. Two locomotives arrived at the east end of the derailment. One engine was immediately coupled to the last two cars, which did not derail and in which uninjured passengers were transported from the scene. The other locomotive brought three cabooses that also were used to transport uninjured passengers. The steam locomotive and the seven head-end cars that did not derail were used to transport minor injured and uninjured passengers to the Suffolk train depot where fire units, North Carolina EMTs, and buses were waiting; the injured passengers were then taken to Louise Obici Memorial and Southampton Memorial Hospitals.

The N&W superintendent arranged to have several buses rendezvous at the triage area to transport passengers with minor injuries to area hospitals and the uninjured to Lamberts Point train depot. Approximately 80 people were transported by bus to Chesapeake General and Maryview Hospitals. Fifty-six people were transported by bus and ambulance to Louise Obici Memorial Hospital.

The Chesapeake Fire Department estimated that 177 people were transported by ambulance, bus, or helicopter to six hospitals. The rescue operations involved approximately 29 emergency medical service (EMS) units, 89 EMS personnel, and 5 air Medivac units. In approximately 3 hours, 1,000 people were transported from the accident site.

Emergency Response Procedures.--The cities of Chesapeake and Suffolk both maintain emergency operations plans. In addition, the Tidewater Emergency Medical Services Council, Inc., publishes and issues Mass Casualty Procedural Guidelines, Emergency Communication Manuals, and Regional Medical Protocols which are used by hospitals and EMT units in various counties within its jurisdiction. Triage supplies, mobile life support units, communications equipment, training criteria, and operating procedures are standardized throughout the Tidewater Council region. In the Tidewater Council area, regional drills are held annually and EMS unit drills are conducted twice a year. Represented communities meet monthly.

The deputy fire chief in charge of the rescue effort stated that the N&W provided training to area fire departments for familiarization with trains and the functions of cars. He did not state whether or not the training included passenger cars or was confined to only certain types of freight cars. He believed the training his department had received could benefit all fire departments.

Car Interiors.--The most seriously injured passengers were riding in cars NW 1069, SOU 1087, and SOU 4061, which jackknifed and/or overturned. NW 1069 (see figure 8) had 20 double-width seats on each side. Each seat was constructed of a metal frame and a series of wood slats that were attached laterally across the frame members. At every fourth seat on each side of the car, a partition extended horizontally from the sidewall of the car to the aisle side of the seats and vertically from the floor almost to the luggage racks. The partition was constructed of metal framework and sheet metal at the lower half; the upper section consisted of transparent plastic sheeting that extended to the height of the top of the exterior window frame. Eleven window openings were located on each side. Ten window pairs measured approximately 5 feet horizontally by 3 feet vertically, and one pair measured 2 feet horizontally by 3 feet vertically. There was no window glazing in the window openings. NW 1069 was located ahead of the overturned cars and came to rest leaning at an angle of about 30° toward the north.

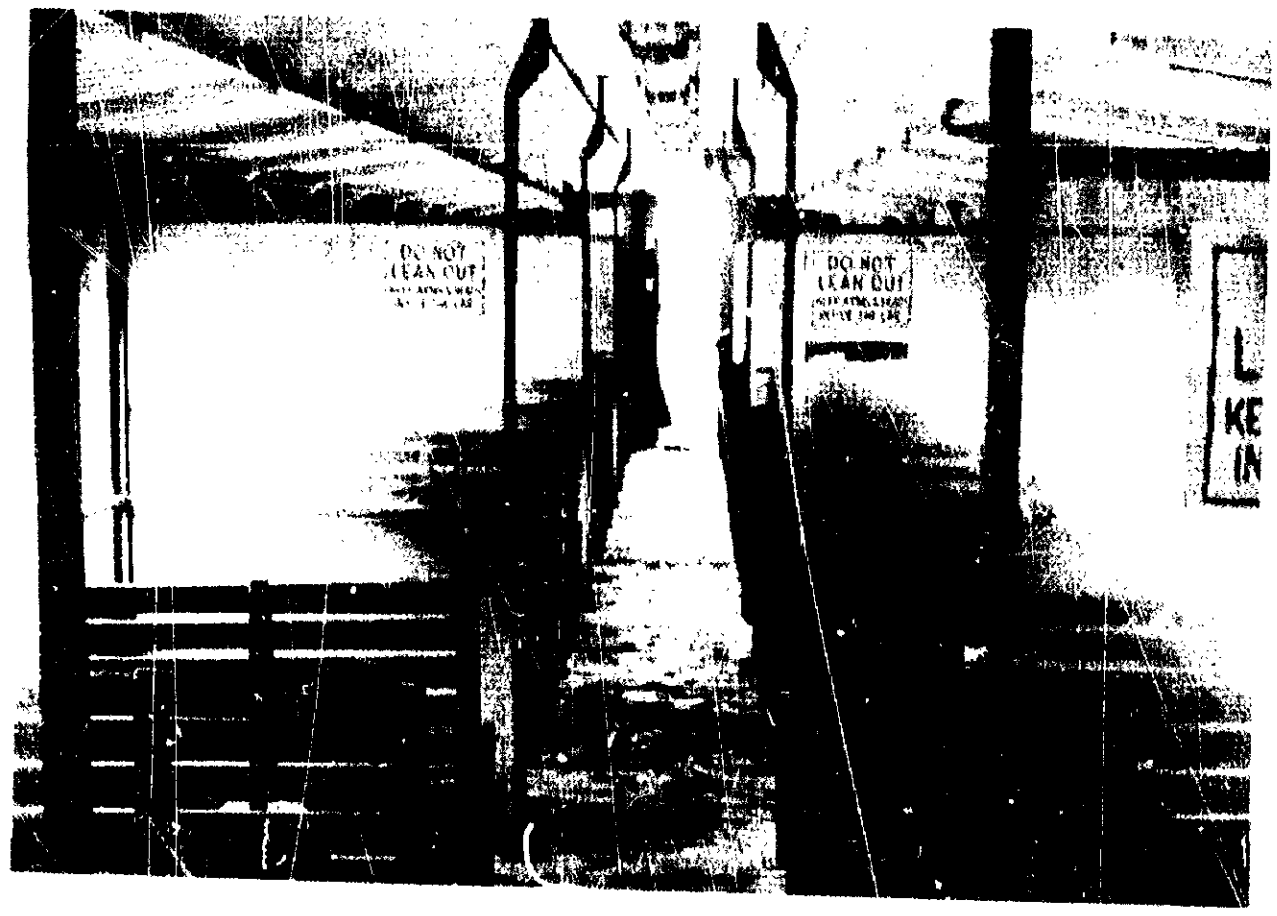


Figure 8.--Interior of car NW 1069.

Eighteen double-width seats were installed on each side of SOU 1087. (See figure 9.) The seats were equipped with an armrest at each end of the pair of seats and a center armrest which could be folded up into the seatback. Each pair of seats shared a common frame, but each seat had an individual seat pan. The seat unit was mounted on a center pedestal and could be rotated to face in either direction. In the derailment, several seats rotated and all seats on the north side were displaced toward the aisle approximately 6 inches. Overhead luggage storage racks were located on each sidewall over the seats for the full length of the compartment. They were constructed of exposed tubular metal and slanted downward approximately 20° to the outside wall. There were no doors or any type of restraining devices on the luggage racks. The car had no emergency exits. The east end of SOU 1087 was damaged and steps were missing on one side and crushed on the other side. The floor of the vestibule at the opposite end had been bent upward 2 feet, and the diaphragm 29/ and steps were missing on one side. A window on the south side near the middle of the car was broken while all windows on the north side were broken.

Figure 9.—Interior of car SOU 1087.

29/ A diaphragm is a rubber or canvas shield used to exclude dust and water from the passageway between two cars.

SOU 4061 (see figure 10) had been converted into a commissary car for food service. A wood counter about 2 feet wide extended half the length of the car. A gas stove, a commercial-type coffee maker, and a sink were mounted on the counter. Another counter about 10 feet long was mounted at the opposite end of the car. It did not have any appliances. Both counters were constructed of wood with plywood countertops and were fastened to the floor of the car with nails and 1/4-inch bolts. When SOU 4061 overturned, the counter with appliances separated from the floor and fell to the bottom of the car trapping an occupant under it. Hot coffee from the coffee maker spilled on the trapped occupant. Large wood cabinets and wood shelves were attached to the exterior wall behind the counters. Passengers and N&W employees stated that the car was equipped with loose, freestanding tables and chairs, although none were found during the postaccident equipment inspection. Many loose heavy objects were present, including cartons of soft drinks, a microwave oven, coolers, and a 55-gallon drum used as a trash container. Light switches, electrical conduits, electrical junction boxes, bare bolts, and exposed nails protruded from the walls.

The FRA minimum safety glazing standards required to protect railroad passengers and employees from injury as a result of objects striking the windows do not apply to passenger cars that are historical or antiquated and are used only for excursion, educational, recreational, or private transportation purposes. All other existing passenger cars, built or rebuilt before July 1, 1980, not meeting the glazing requirements were required to be equipped with certified glazing in all windows and have a minimum of four emergency windows. 30/

Figure 10.—Interior of commissary car SOU 4061.

30/ Title 49 CFR Part 223, Subparts A and B.

Toxicology

Toxicological Testing Requirements.—Upon notification of the accident at 3:20 p.m., on May 18, 1986, the Safety Board accident notification duty officer requested the N&W to perform toxicological testing. No persons involved with the accident were asked by the N&W nor did they provide specimens for toxicological testing. The passengers and crewmembers who were interviewed after the accident stated that they did not see any drug and/or alcohol use on the excursion train. Consistent with the objectives of the company-sponsored safety trip and the N&W's Rule G, the railroad provided nonalcoholic refreshments to passengers.

N&W's Rule G states:

> An employee who reports for duty under the influence of alcohol or other intoxicant, cannabis in any form, an amphetamine, a narcotic drug, a hallucinogenic drug, any controlled substance (as defined by Federal law) or a derivative or combination of any of these, or who uses any of the foregoing while on duty, will be dismissed. Possession of any of the foregoing while on duty, or possession, use, or being under the influence of any of the foregoing while on Company property or occupying facilities provided by the Company is prohibited.

FRA regulations under 49 CFR Part 219 provide the following:

1. prohibit employees from reporting to work when they are impaired by alcohol or drugs and prohibits on-the-job alcohol drug use (Subpart B);

2. mandate postaccident toxicological testing for major train accidents, impact accidents, and fatal train incidents (Subpart C);

3. authorize railroads to test employees for alcohol or drug impairment where there is reasonable cause for the administration of such test (Subpart D);

4. mandate pre-employment drug screening (Subpart E); and

5. require policies to promote early identification of problem drinkers or drug users (Subpart F).

Section 219.201(c) requires a railroad representative responding to the scene of the accident/incident:

> . . . to make reasonable inquiry into the facts as necessary to make such determinations. In making such inquiry, the railroad representative shall consider the need to obtain samples as soon as practical in order to determine the presence or absence of impairing substances reasonably contemporaneous with the accident/incident. The railroad representative satisfies the requirement of this section if, after making reasonable inquiry, the representative exercises good faith judgment in making the required determinations.

The president of the N&W stated that the N&W adopted Subpart C on March 1, 1986. These requirements apply to accidents that involve: a fatality; a release of a hazardous material accompanied by an evacuation or a reportable injury resulting from the hazardous material release; damage to railroad property of $500,000 or more; or collision resulting in a reportable injury and/or damage to railroad property of $50,000 or more.

The president of the N&W, who was not then at the site, stated that he was informed of the accident at 2:40 p.m. He said he contacted the N&W operation center in Roanoke for information about the accident. He said that based on the approximate dollar amount of damages and that since none of the other criteria of 49 CFR Part 219, Subpart C, had been met, he decided alcohol and drug tests were not necessary. He stated he made this decision sometime that afternoon. He also stated, ". . . I believe it was the following day in a telephone conversation with [the FRA associate administrator for safety] he agreed with me that none of these post accident testing mandatory rules came into play."

The superintendent of the Norfolk Division, the senior railroad officer on the division, testified that he made the decision to not perform toxicological tests, at about 6:30 p.m., based on his evaluation of the derailment.

The system road foreman of engines-steam stated that the senior operating official on scene was the operating engineer, the CCEO. The CCEO stated that he was aware of the FRA position on alcohol and drug tests, but that he was not familiar with the regulations to know whether postaccident toxicological tests were applicable following the derailment. He stated that there had not been any discussions regarding such tests at the accident site and that his concerns at the time was not for himself, but for the safety of his passengers. He also stated that, in retrospect, it would have been prudent for him to have taken the tests ". . . because it would have eliminated a lot of argument . . . "; he also stated that he didn't think it was necessary from his understanding of the rules. The CCEO testified that he had not consumed any alcoholic beverages before the train departed Norfolk, nor while on the train.

Toxicology Training Program.--The NS personnel department provides an 8- to 10-hour training class for supervisors to disseminate information on the FRA toxicological requirements. An area of instruction provided to all NS officers who supervise "covered employees" concerns the FRA regulations for control of alcohol and drug use. "Covered employees" refer to all those who perform services and duties under the Hours of Service Act (45 U.S.C. 61-64B). The Safety Board was provided a copy of the NS program syllabus developed by the NS and used for officer instruction. 31/ The NS syllabus closely parallels the FRA's Supervisory Training Syllabus on the signs and symptoms of drug and alcohol use and impairment. 32/ Both syllabuses provide descriptions of the types, effects, and possible reasons for drug and alcohol abuse. Both address 49 CFR Part 219 regarding control of alcohol and drug use and the criteria to use in deciding whether to conduct toxicological tests.

The NS syllabus departs from the FRA syllabus by elaborating on certain sections, such as a training program that allows local police departments to participate in the instructions for recognition of signs and symptoms of alcohol and drug usage, and an extensive discussion on toxicological testing procedures which comply with

31/ NS: FRA Regulations - Control of Alcohol and Drug Use, 1985.
32/ FRA: Field Manual for Control of Alcohol and Drug Use in Railroad Operations (undated); Course Syllabus and Instructional Material On The Signs and Symptoms of Drug and Alcohol Use and Impairment.

FRA requirements and are tailored to company policy. For example, the NS program discusses "reasonable suspicion" as cause for urine testing, but requires that the determination first be made jointly by two supervisors, one of whom has received training in recognizing the signs of drug use.

The NS program and FRA regulations both distinguish between "covered" and "noncovered" employees, the former who are required to submit to toxicological testing as a function of their employment and the associated clause of implied consent. "Covered employees" include: "All operating employees assigned as crewmembers of any train involved in an accident/incident . . ." and "Operator, dispatcher, signal maintainer, or other covered employee(s) directly and contemporaneously involved in the circumstances or the accident/incident." 33/

Tests and Research

Maintenance-of-way officials directed track maintenance employees to remove the switch stand from its position on the turnout ties and disassemble the stand at the accident site; the spindle was found separated from the base and the collar was found separated from the base casting. The roadmaster stated that a heating torch and hammer were used to free the spindle from the base. Notwithstanding the damage, the switchstand was in a condition which allowed for testing to be performed.

The switch stand from the east-end Juniper turnout was tested at the material yard of the N&W at Roanoke on July 1, 1986, in the presence of Safety Board investigators. A hydraulically operated jack with a pressure gauge was used to compare the pressure required to force the switch points to throw, or reverse, from a set position. A similar test was conducted on a new switch stand of the same design. The new switch stand required a force of 1,827 pounds, and the switch stand from the derailment site required a force of 2,692 pounds. The switch stand from the derailment was intentionally displaced 1/2 inch, with a 900-pound force, and the force was then released; the switch points did not reseat (return) to the stock rail 34/ when the force was released.

The chief engineer line-maintenance testified that at Roanoke he tested the switch stand using a standard 1/4-inch shim. The procedure is prescribed by N&W Maintenance of Way Standards to determine proper functioning of the stand and positioning of the switch points against the stock rails, for ensuring that the switch points do not gap. He stated that he used the procedure to determine if the broken collar around the spindle would have allowed the switch points to gap and he found that it was not possible to lock the switch stand with the 1/4-inch shim in place and have the switch points gap.

Examination of the operating lever recess revealed moderate wear on the adjacent corners of the quadrant collar between the northeast and northwest recesses, and no other wear. Examination of the switch stand components showed that the springs, plungers, and rollers were intact, but contained a substantial amount of foreign material. The rollers were fouled with rust and did not rotate freely on their axles. The stand showed no evidence of lubrication.

The turnout and its components were removed from the track for reassembly at the Lamberts Point Yard at Norfolk. Approximately 40 ties from the switch points westward were recovered for repositioning in the location they occupied in the turnout. The turnout was reassembled at Lamberts Point Yard and again at the maintenance yard in Roanoke.

33/ NS: Control of Alcohol and Drug Use.
34/ The stock rail is a running rail against which the switch point operates.

No provisions were made by the N&W to reassemble the turnout at the derailment site or to protect it from additional damage in handling or transporting to the reassembly sites. The curved closure rail 35/ was bent laterally to the north approximately 5 to 6 feet west of the heel block. 36/ Eleven of approximately 74 rail anchors were attached to the rail. There were markings on the base of the rail, but the source of the marks could not be established. The insulated joint had been struck on the gage side (south side) by rolling equipment and was torn and bent with four of six joint bolts broken.

The straight closure rail of the turnout was bent laterally to the north approximately 5 to 6 feet west of the heel block. Eight of approximately 74 rail anchors were on the base of the rail near the heel block. There were markings on the base of the rail, but again the source of the marks could not be established. The rail anchors that remained did not fit tightly against the ties. The surface of the rail had a light wheel flange mark beginning approximately 6 to 8 feet west of the heel block and continuing for approximately 18 to 25 feet before leading off to the field side (south side) of the rail. The surface of the rail had heavy rub marks.

The straight closure rail of the turnout was field welded to the wing rail of the frog in 1982. The bolt holes, where the straight closure rail was bolted to the heel block, were slightly elongated and deformed. The bolted joint of the curved closure rail to the right-hand wing rail was separated.

The frog assembly was destroyed in the derailment. The manganese insert had multiple wheel flange marks from the westbound main track side to the middle track side, across the top of the insert, west of the frog point. The side of the manganese insert had marks where wheel flanges impacted the reinforcing bars between the manganese insert and wing rails. The frog point was battered toward the south approximately 6 inches west of the frog point. The throat of the frog was severely deformed and torn. (See figure 11.)

The bent stock rail (south rail) leading to the middle track was severely bowed in the area of the south guard rail. The base of the rail, from the left-hand switch point to the area of the guard rail, had approximately 50 percent of the required number of rail anchors remaining. The clear spacing between remaining rail anchors varied from 10 to 14 inches.

The straight stock rail (north rail) of the westbound main track showed a lateral bend, toward the north, approximately 5 to 6 feet west of the right-hand heel block. Wheel flange marks on the tie plates and spike heads on the gage side began approximately 18 to 25 feet west of the heel block. The spike heads on the gage side also showed marks where the base of the rail had flattened a portion of the head of the spikes. Less than 50 percent of the required number of rail anchors remained on the rail. The clear spacing between rail anchors measured approximately 11 inches. The right (north) guard rail had impact marks on the east end opposite the marks on the straight closure rail and was separated from the straight stock rail.

35/ The closure rail is the rail between the parts of any special trackwork layout, as the rails between the switch and the frog in a turnout (sometimes called lead rails or connecting rails).

36/ The heel block is a steel block through which bolt holes are drilled which is placed between the heel end of a switch point rail and the closure rail.

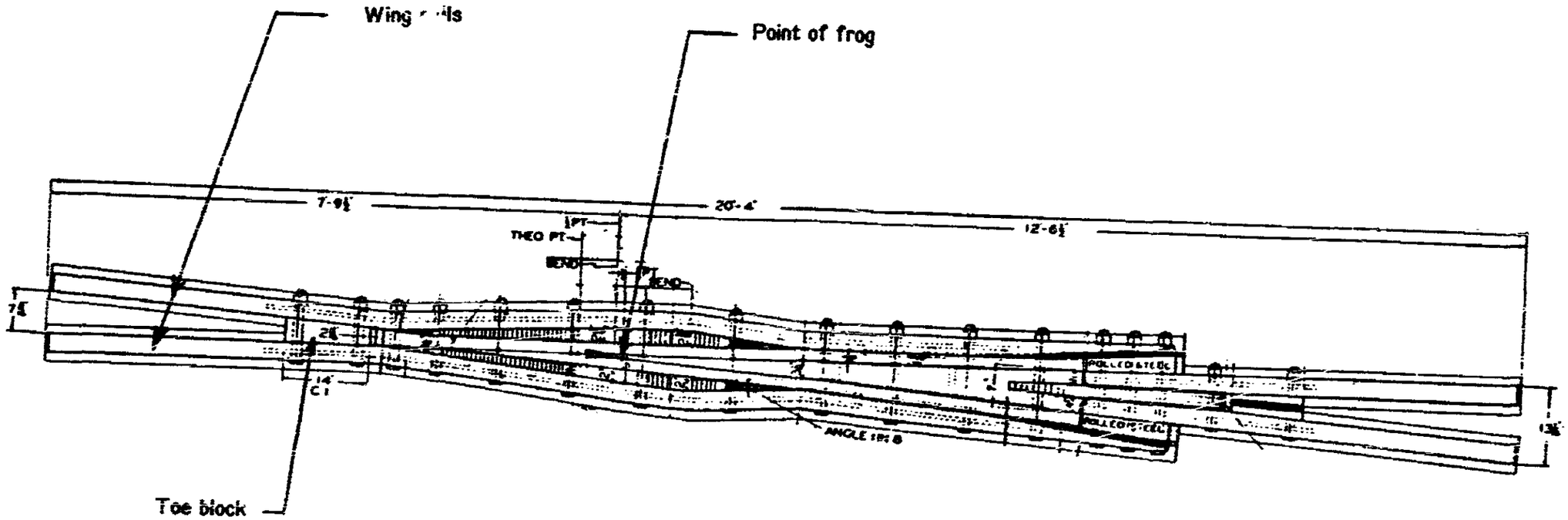


Figure 11.—No. 12 railbound manganese frog.

The wing rails 37/ had multiple wheel flange and abrasion marks from derailed car truck frames sliding on the rail. Several bolt holes were elongated on the west end of the right-hand wing rail with small chips broken out at the edges. A depression in the base of the right-hand wing rail was found in the area of the connection to the cast steel toe block. 38/ Recovered bolts and nuts from the frog were examined by the Safety Board's materials laboratory in Washington, D.C. With one exception, the laboratory found that all bolts had separated through the thread immediately adjacent to the shank. The exception was a bolt with a break flush with the rail side surface of the nut, approximately midway in the threaded length. Several bolts broke in an overstress condition, and some bolts showed overstress fracture features extending from a fatigue region. The nuts showed evidence of mechanical deformation, as if the nuts were struck by another object. The laboratory found that the location of the deformation on the nuts was consistent with the direction of the respective fracturing load, as if the blow on the nut produced the fracture on the bolt. The frog bolt nuts were located on the middle track side (southside) of the frog.

Heel block bolts recovered from the accident site were examined in the Safety Board's materials laboratory and were found to have deformation consisting of single-direction bends in the shanks of the four bolts that connected the closure rails to the respective heel blocks. The bolts were not broken, but showed varying amounts of wear and deformation on the shank. The remaining four bolts appeared to be straight where the switch points were connected to the heel blocks.

The left-hand switch point was examined by metallurgists from the Safety Board at the Alexandria, Virginia, Research and Test Laboratory of the NS Corporation. Near the middle of the switch point a contact mark was noted on the field-side surface of the rail head. This mark ran continuously from the midpoint of the switch point for a length of approximately 6 feet 2 inches toward the heel block. The contact mark had a series of slightly curved, but mainly vertical parallel scratches within the mark. At the end of the mark farthest from the switch point, the mark moved to the upper surface of the rail head and ran partially across the rail head surface at approximately 30°. On the rail head, the contact mark had a gouge that cut into the surface of the rail. Within the gouge region another series of parallel scratches were visible; however, these scratches were parallel to the rail. Visual examination by a Safety Board metallurgist revealed a "fish-scale" pattern on the machined surface of the tapered portion of the switch point. A portion of the "fish-scale" pattern was worn away by polishing while the switch point was in service in the turnout.

The chief engineer-line maintenance testified from his observations at the derailment site that ". . . There was no damage to the points themselves . . . nothing had really hit the points at any speed or with any force whatsoever. . . . "

The wheel and axle from the lead axle of the trailing truck of NW 531, the eighth car in the train consist, were also examined by Safety Board metallurgists at the NS Research and Test Laboratory. The leading wheel from the south side of the trailing truck was mechanically damaged on the inside flange surface of the wheel at the outer diameter. The mechanical action of the damage had removed metal from the wheel and left an undulating pattern through a portion of the damaged region. At one point, the damage cut significantly into the flange. Curled metal folding at this point established the relative direction of the wheel when the cut was made.

37/ Wing rails are rolled rails that are drilled and bolted to both sides of a casted insert frog forming a railbound frog.
38/ The toe block is a cast steel block through which bolt holes are drilled; the toe block placed at the end of a frog nearest the switch.

Offset measurements were provided by the N&W Maintenance of Way Department. The measurements were based on a tangent line, using the field side of the south rail east of the switch, to measure the change in alignment at the turnout following the derailment. The measurements were as follows:

Station	Offset (feet)	
4+10	0.01	Right (north)
4+20	0.03	
4+30	0.04	
4+40	0.04	
4+50	0.06	
4+60	0.08	
4+70	0.10	
4+80	0.20	
4+90	0.39	
5+00	0.68	point of switch
5+10	1.23	
5+20	1.64	
5+30	2.15	
5+40	2.85	
5+50	3.55	
5+60	4.20	
5+66	4.60	end of rail

ANALYSIS

General

The operating fireman and the system road foreman of engines-steam were properly qualified for their respective positions in accordance with N&W requirements; however, the CCEO, although otherwise qualified, was not current on the rules examination. The signal system was inspected with no exceptions noted that would have contributed to the accident. Also, there were no mechanical defects on the locomotive or passenger cars that would have been causal to the accident.

The Derailment

The locomotive crew did not report seeing anything unusual as they approached the turnout at Juniper. The CCEO said that the switch target was positioned for the main track, and the operating fireman said that the switch points were correctly positioned for the train. However, the operating fireman stated that compared to his trip on the same track the previous day, the turnout seemed rough as Extra 611 West passed over it. The CCEO said that he felt a lateral motion, but that he took no exception.

Many passengers on this train were employees of the N&W's Norfolk Division; therefore, their experiences and observations provided knowledgeable descriptions. Passengers in the lead cars preceding the derailed cars described the effects of riding over a track abnormality; they observed the auxiliary water tender rocking, as if it had gone through a crossover; and they experienced combinations of vertical, lateral, and rocking motions as their cars went up and then down. The passengers described hearing a sharp, steel-on-steel cracking sound, such as the sound made when a wheel flange drops

back inside the track gage after being forced to the head (top) of the rail. The road foreman of engines' statement that he would have reported the rough switch and passengers' statements that described a rough ride indicate a rapidly deteriorating track condition.

The absence of derailment-induced marks on the locomotive and the seven nonderailed cars on the head end of the train indicated that the derailed cars, beginning with the eighth car, derailed as they passed over a progressive track abnormality.

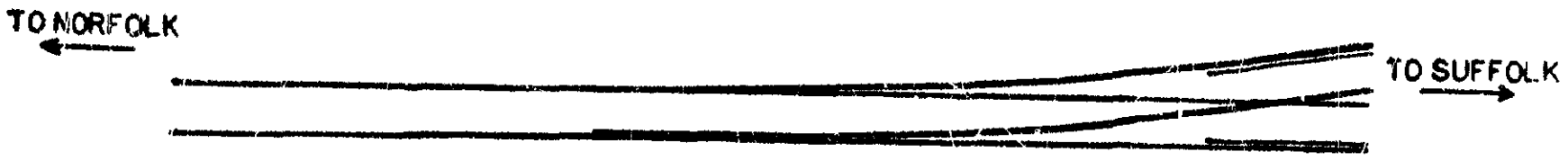
The bend in the closure rails of the turnout 5 to 6 feet west of the heel block and the bent heel block bolts connected to the closure rails indicated that some force laterally displaced the track. The location of the wheel flange marks indicated that a wheel rode onto the top of the straight closure rail 6 to 8 feet west of the heel block and continued for 18 to 25 feet before dropping off to the field side of the rail. The gouge and chatter marks on the inside of the lead wheel on the south side of the trailing truck of NW 531 indicated that the wheel was rotating when it contacted the rail. The wheel flange marks and heavy rub marks on the surface of the straight closure rail are consistent with the marks found on the side frame of the derailed truck of NW 531. The impact marks on the east end of the right (north) guard rail coincided with the location where the wheels left the rail.

This physical evidence and the testimony of the crew and passengers suggest strongly that as the train approached the turnout on the westbound track, it passed over track, which was already laterally displaced somewhat. The force of the train on the track increased the lateral displacement. Lateral displacement of the track is a condition which can progressively increase with the passage of cars over the displaced track. The cars following the locomotive experienced increased vertical and lateral movement, or both, until the severity of the displacement allowed a wheel flange to be forced on top of the rail head. Some wheel flanges returned to the gauge side of the rail head and those cars remained on the track. Finally, however, a wheel flange dropped to the field side (lead wheel of the trailing truck on NW 531) and the car derailed.

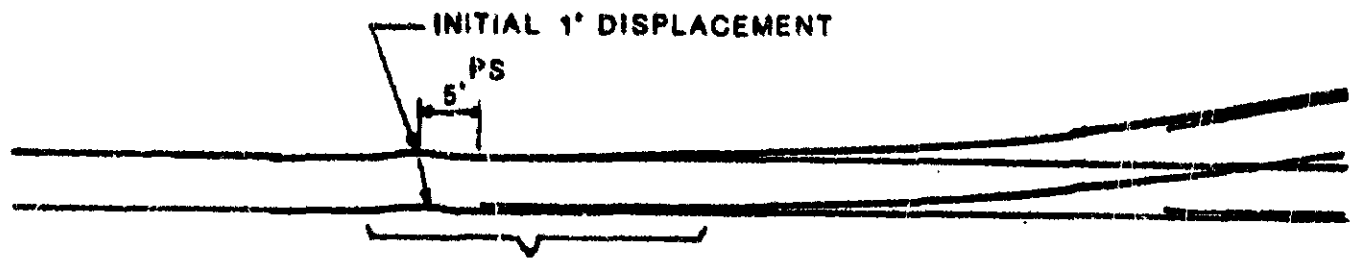
The Safety Board believes that the lateral displacement which precipitated the derailment resulted when the disturbed track could no longer restrain the compressive forces imposed on the turnout from the effects of the rising temperatures on the improperly adjusted approach track and the middle track.

Multiple wheel flange marks across the back of the frog indicated that derailed cars crossed over the south running rail. The frog bolt nuts were fractured as the result of impacts while they were in place in the frog, indicating that the frog was initially intact and began to separate when it was struck by derailing cars. The Safety Board concludes that the 13th car did not follow the path of the five preceding cars because the frog was destroyed by them.

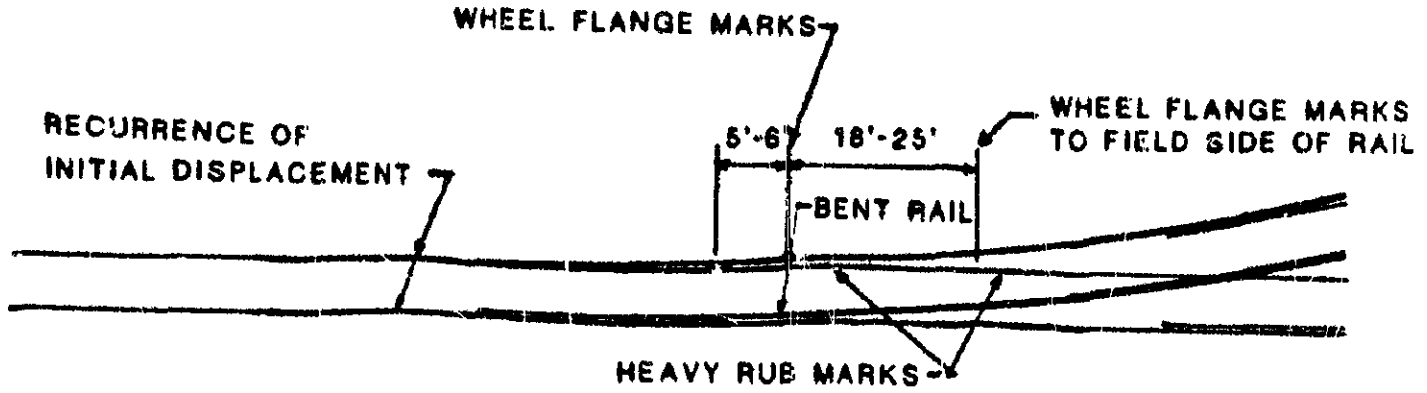
The offset measurements at the turnout showed that the point of switch shifted approximately 8 inches (0.68 foot) toward the north from its original location, and at a point 60 feet west toward the frog, the track had shifted approximately 50 inches (4.2 feet) to the north. This track shift from the switch area westward may have resulted from derailing cars shoving the track in the direction that they derailed. The derailing action of the last cars to derail increased the offset until the rails separated from the ties. (See figure 12.)



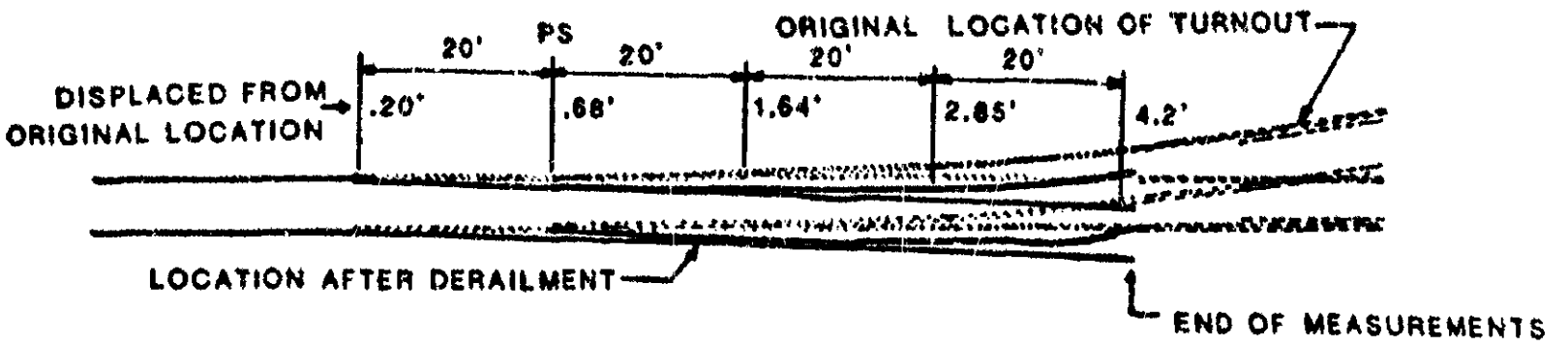
EASTBOUND JUNIPER NO. 12 TURNOUT



TURNOUT FOLLOWING REPAIRS MAY 6, 1986



TURNOUT TRACK DISPLACEMENT UNDER TRAIN
IN611 WEST MAY 18, 1986



TURNOUT AFTER DERAILMENT MAY 18, 1986

NOT TO SCALE

Figure 12.—Stages of track displacement.

Track Maintenance

Lateral displacement of the turnout occurred when the approach rails and the middle track rails expanded due to the increasing temperatures and moved laterally because this was the path of least resistance to relieve the increased internal stresses. Lateral displacement can result when track is subjected to increasing temperatures under one or more of the following conditions: (1) improperly adjusted rail; (2) insufficient anchors; (3) insufficient ballast; (4) disturbed track; or (5) alignment defects. The passage of a train, even at normal train operating conditions, can exacerbate conditions conducive to lateral displacement and produce such a lateral displacement of the track when none would have occurred otherwise. The Safety Board believes that the conditions of improperly adjusted rail, disturbed track and alignment defects were present in the turnout area, the turnout-side middle track, and the approach track before the accident.

The undamaged sections of westbound main track met the minimum requirements for the FRA Track Safety Standards of class 4 track, and the rail anchor pattern and ballast section of the undamaged track generally complied with the N&W Maintenance of Way Standards. However, postaccident reconstruction of the turnout showed that in at least one way the turnout did not comply with the N&W Maintenance of Way Standards. The number and location of adjustable rail braces did not meet the N&W standards. This condition of the turnout, which had existed since it was rebuilt in 1982, had been accepted by railroad management when it was initially rebuilt, had been inspected monthly by the track inspectors, and had been inspected annually by the roadmaster without correction. None of the inspections revealed that track maintenance operations had failed to meet the N&W Maintenance of Way Standards. The Safety Board thus concludes that, although this lesser number of adjustable rail braces did not contribute to this accident, the failure of inspectors to detect this condition clearly indicates that the N&W inspection program was inadequate in this respect.

The Safety Board also concludes that improper maintenance of the track did contribute to the accident. The process of replacing the bolts in the adjustable rail braces at the switch on May 6, 1986, resulted in a track disturbance because the track foreman failed to remove the rail-holding spikes from the adjacent ties causing 10 rail anchors to fall off. By not removing the adjacent rail-holding spikes, the adjacent ties were lifted as the rail was raised by the jacks to replace the bolts. The track foreman stated that he had to jack up the rail about 1/2 inch to slide the plates to one side to replace the bolts. A track jack is designed to lift in 1/2-inch increments. However, with the restraint of the adjacent ties in the ballast, the weight and rigidity of the attached rail, and the compression of the base of the jack into the ballast, it would be extremely difficult to limit the lift to 1/2 inch. The Safety Board believes that during the process the track was jacked up sufficiently to cause the tie/ballast interface to be disturbed. This reduced the ability of the track structure at the turnout to resist the forces in the rail created by the increasing temperatures on May 6. These forces caused the track to shift laterally when it was replaced.

The track foreman indicated at the public hearing that after completing the repair work at approximately 2:30 p.m., he noted a 1/2- to 1-inch misalignment over a length of 2 feet approximately 5 to 8 feet east of the switch and that he then placed a 10-mph "slow order" on the track. He did this because he felt that the condition would worsen due to the hot weather, although he did not know the temperature at the time. The NWS recorded a maximum ambient temperature of 88°F at Norfolk at 1:50 p.m. The track foreman's concern for the misalignment was justified because of the disturbed track condition. However, he did not repair the misalignment. Instead, he notified his section foreman that afternoon and asked that he look at the track the next day.

When the section foreman looked at the track about 9 a.m. on May 7, 1986, the ambient temperature recorded by the NWS at Norfolk was 79° F. The lower overnight and morning ambient temperatures would have had a cooling effect on the rail resulting in a smaller (1/4 - to 1/2 -inch) track misalignment than that experienced by the track foreman. Although, according to the section foreman, the track misalignment was only 1/4 to 1/2 inch, he removed the misalignment by jacking the track. However, it would be quite unusual for a misalignment this small to be corrected by maintenance personnel. Further, the section foreman was fully aware that following shoulder ballast cleaning a slow order of 25 mph was normally used and that a slow order of 10 mph was used when track had been disturbed. The section foreman said he did not consider it unusual to leave a 10 mph "slow order" in place for 24 hours when track has been damaged or when there has been a lot of movement of the track.

The Safety Board believes that the misalignment on May 6 and 7 was probably greater than that reported by either foreman. The misalignment on May 6 probably was greater than 1 inch. An alignment defect of 1 to 2 inches would provide a path of least resistance for internal rail stresses to be relieved by laterally displacing the track. Further, the method used by the section foreman, to realign the track with the track jacks, would not have relieved the rail stresses that caused the misalignment. The Safety Board believes that on the day of the accident the track misalignment recurred when the temperatures increased and the resultant rail stresses could no longer be resisted by the track structure.

When he questioned the section foreman about the slow order, the roadmaster should have explored the possibility of a disturbed track condition at the turnout because the track foreman had issued the 10-mph slow order instead of the 25-mph slow order. The 10-mph slow order, which reflected the track foreman's concern for the lateral stability of the track, was in accordance with the N&W's Maintenance of Way Standards for issuance of slow orders when performing track maintenance on CWR. However, the roadmaster did not consider the damage and the repair to the switch brace bolts to be a serious problem, and he did not inquire further into the conditions that resulted in the 10-mph slow order. At the least, the roadmaster should have promptly followed up by inspecting the track. This failure to inspect the track or to inquire further about the placement of a slow order that is used after track maintenance should prompt the N&W management to review its maintenance and inspection procedures, and its oversight of first-line supervisors to determine if these procedures are adequate to support its policy regarding constant monitoring of track maintenance and inspection by its supervisory personnel. The Safety Board believes that vigilant track inspection and effective communications are especially important for track that has had misalignment problems and for track that has had maintenance especially during the winter and spring months.

The expectation that regular track inspections, or that other indications of poor track performance would reveal a problem or the assumption that the installation was properly done is not a substitute for careful followup inspection by supervisory personnel. For example, a careful followup inspection should have revealed that the rebuilt turnout did not have the proper number of adjustable rail braces required by N&W Maintenance of Way Standards.

The CWR in the middle track was artificially heated when installed in February 1986 to achieve an initial rail-laying temperature 39/ of 90° F to 95° F when the average ambient temperature was in the mid 30's as reported by the NWS at Norfolk.

39/ Initial rail-laying temperature is the rail temperature when installed. It can be up to 10 percent above the ambient average annual temperature. It is sometimes referred to as adjusted rail temperature. Usually it is the temperature at which rail is laid, spiked, and anchored.

Artificially applied heat is a common practice in the railroad industry, but it is difficult to achieve uniform rail temperatures throughout such an installation process. Thus, careful followup inspection is necessary when ambient temperatures increase because the rail may need to be adjusted as a result of nonuniform rail-laying temperatures--the rail anchors may require repositioning. The N&W could not establish that followup inspections were performed on the middle track.

When tie replacement and surfacing work was done on the middle track during March and April 1986, the average temperature varied from 31° F to 80° F during the day, with the average temperature being 52° F. This could have resulted in the rail being secured at a temperature lower than that to which it was artificially heated when installed. The rail temperature can empirically be expected to be 15° F to 30° F greater than the ambient air temperature at the time it is resecured. 40/ The AAR, after a review of track stability problems, noted that when the ambient temperature increases about 35° F to 55° F above the rail-laying temperature the rail stresses increased to the point that track buckling is likely to occur. 41/ The N&W could not establish whether followup adjustments to the rail and rail anchors were made as a result of the maintenance performed during this period. The Safety Board believes that such followup adjustments were not made. The Safety Board concludes that the maintenance activities on the middle track (surfacing and tie replacement) and the increasing ambient temperatures created conditions that, in effect, altered the initial rail-laying temperature, resulting in rail which was no longer adjusted to resist the higher temperatures to which it was going to be exposed. Thus increasing temperatures would create greater longitudinal forces in the rail than would have been created had the rail been properly adjusted. Because of these increased forces, the rail would tend to elongate and eventually the turnout would not be able to resist this.

The longitudinal expansion or contraction of unrestrained steel rail can be calculated by the formula: $\Delta L = 0.0000065\ \Delta t$. 42/ Using this formula, unrestrained rail would expand or contract 4.1 inches per mile for each 10° F change in temperature. The decrease in the temperature at which the rail was resecured in March and April (the low 50's) from the artificially heated low 90's in February may have resulted in as much as 8 inches or more longitudinal expansion to be resisted by the track structure when the temperature increased in May over what would have occurred had the track been artificially heated to the low 90's when the work was done in March and April.

It is possible that compressive stresses of this magnitude were generated on the afternoon of the accident causing significant force to be applied by the middle track to the turnout, resulting in rotational forces being applied at the heel block through the rails increasing the lateral displacement of the track. This situation would have exacerbated the problem created by the misalignment in the approach track east of the turnout, and may have contributed to the derailment.

40/ AAR Report R-454, "An Investigation of Railroad Maintenance Practices to Prevent Track Buckling," November 1980; and William W. Hay, Railroad Engineering, Second Edition, 1982.

41/ AAR Report R-454.

42/ Hay, Railroad Engineering. In the equation ΔL equals the change in rail length per unit length and Δt reflects the change in rail temperature. The number 0.0000065 is the coefficient of expansion for length per degree change (i.e., $\Delta L = 0.0000065 \times 10°\ F \times 5{,}280$ feet per mile x 12 inches per foot = 4.1 inches per mile).

The Safety Board has noted in other accidents the problems with the installation, maintenance, and inspection practices of CWR. 43/ The Safety Board believes that the railroad industry needs to promote the importance of proper procedures to the employees responsible for these areas for CWR.

The track foreman assigned to the shoulder ballast cleaning operation on May 6 received minimal instructions from his supervisors concerning the operation of the equipment and the precautions he should exercise, even though the prototype equipment was being used for the first time on the N&W. Neither the roadmaster nor the assistant roadmaster had seen the equipment operate before and could not provide any guidance to the track foreman regarding proper use of the equipment. Because of this, the roadmaster should have been present when the equipment was being used. The roadmaster may not have been able to prevent the damage to the turnout, but he may have (and certainly should have) done the repair work properly.

The N&W Maintenance of Way Standards state that track foremen, who are responsible for the proper inspection and safe condition of the track under their charge, are supervisors. The Safety Board is concerned that although the track foreman was given the authority to make supervisory decisions, he was not provided sufficient information about the operation of the prototype equipment. The track foreman did not check the temperature, as expected by the roadmaster. Also, he failed to notify the Signal Department that track work was being performed in the area of the shunt wires of the turnout's track shunt circuit switch protection. Although no failure of the signal system was noted during the regular monthly test 8 days after the repairs, the Signal Department should have been notified of the track work because it could have affected the signal system.

On November 28, 1981, an N&W freight train, after receiving a clear signal indicating a clear main track route, entered a misaligned crossover and sideswiped coal-laden hopper cars and then caromed into a freight train on the adjacent track. 44/ The Safety Board investigation of the accident indicated that:

> . . . the west switch of the crossover revealed that the right-hand switch point and its mating stock rail had been recently renewed. The Safety Board also noted that the stock rail had not been drilled to accept the rail connectors for the shunt wires leading to the switch circuit controller. The shunt wires and rail connectors were found lying unconnected in the ballast under the stock rail. The rail connector studs were bent over and the stud ends exhibited fracture surfaces which were covered with rust. Even though the Safety Board believes that the section foreman may have requested the services of a signal maintainer, the Board believes that a signal maintainer was not present during the replacement of the switch point and stock rail. A qualified and experienced signal maintainer would not have broken off the connector studs in a manner that rendered them unfit for reuse and would not have left the shunt wires unconnected to the new stock rail.

43/ Railroad Accident Reports--"Derailment of Amtrak Train No. 21 (The Eagle) on the Missouri Pacific Railroad, Woodlawn, Texas, November 12, 1983" (NTSB/RAR-85/01); "Derailment of St. Louis Southwestern Railway Company (Cotton Belt) Freight Train Extra 4835 North and Release of Hazardous Materials near Pine Bluff, Arkansas, June 9, 1985" (NTSB/RAR-86/04).

44/ Railroad Accident Report--"Side Collision and Derailment of Norfolk and Western Railway Company Trains Nos. 6BS78, Yard Shifter, and 67HNP, Crewe, Virginia, November 28, 1981" (NTSB-RAR-82-3).

As a result of the investigation, the Safety Board recommended that the N&W:

R-82-44

Establish effective coordination procedures in the Maintenance of Way and Signal and Communications Department, to make certain that Maintenance of Way work which involves the signal system will not result in improper functioning of the signal system.

The N&W responded that instructions were reissued to N&W's Maintenance of Way and Signal and Communications Department employees that any work involving the signal system must be performed as a joint effort and/or with full protection of signal apparatus. On August 18, 1983, the Safety Board placed the recommendation in a "Closed—Acceptable Action" status.

The track foreman's work did not do so, but it could have resulted in the failure of the signal system to provide a correct aspect, thereby causing an accident. The Safety Board believes that a track foreman's judgment is not an adequate substitute for a signal maintainer's expertise in signal system appliances. The roadmaster was aware of the N&W's policy resulting from the Safety Board's recommendation, but he did not become aware of the work until the following day. The roadmaster did say that he would have called for a signal maintainer. The differing opinions of the roadmaster, the assistant roadmaster, and the division engineer about when compliance with the policy of notifying the signal department is necessary, indicates that the N&W should review its written procedures on notifying the signal department and then make these procedures clear to all pertinent employees. Further, it is difficult to understand how N&W maintenance employees could be properly trained about this important matter when it is so unclear to supervisors what the procedures require.

Track Inspection

The Safety Board is concerned about N&W's policy of inspecting multiple tracks while traveling one track. The division engineer's statement that the FRA track inspection requirements permit the inspection of three tracks when the middle track is between two main tracks conflicted with the interpretation by an FRA track inspector. The FRA track inspector testified that it is "... pretty near impossible to see all three tracks from one..." and "... would be a subjective interpretation of the standards...." The N&W's policy in this regard resulted in the roadmaster and the assistant roadmaster believing that the middle track was being inspected each time the main tracks were inspected. The Safety Board believes that multiple tracks cannot be inspected properly while the track inspector is traveling only one of the tracks.

The FRA Track Safety Standards, as detailed in 49 CFR 213.233, do not address the number of tracks that can be inspected nor the track on which the track inspector must perform his inspection. The permitted speed of the inspection vehicle is that which permits visual inspection of the track for compliance with the regulations. The vehicle speed for inspection of turnouts and crossings by the N&W timetable and FRA Track Safety Standards is limited to 5 mph. Track inspection speed in other areas is limited only by traffic, track conditions, and the timetable requirement of a maximum speed of 35 mph for the hi-rail type of inspection vehicle.

The relief track inspector was responsible for performing the FRA required track inspections of the westbound, eastbound, and middle tracks in the derailment area during May 1986. However, he had not formally performed these track inspections for 9 years.

Despite this lengthy period of time in which the relief track inspector had performed such inspections, on May 6, 1986, the day the turnout was damaged and subsequently repaired, his inspection forms indicated that he performed both a daily and a monthly inspection of the turnout. Further, the relief track inspector was not aware of the damage or repairs or that a slow order had been issued for the track conditions. Had he known about these situations, he would have had a better opportunity to look for, and perhaps recognize, the misalignment in the approach to the westbound track approaching Juniper.

Although it was apparently the N&W's policy to have constant supervisory monitoring of the work of its track inspectors, the N&W had no formal procedures for supervisory evaluation of track inspectors, no medical or visual requirements, and no requisite for requalification. Thus, it had no system to determine that its track inspectors were actually physically fit and that they could perform a proper inspection. The FRA Track Safety Standards do not address physical ability or fitness of track inspectors. There are also no FRA standards for the requalification of relief track inspectors or for the retraining of track inspectors who need such training.

The N&W had no method of assuring that the relief track inspector was following N&W Maintenance of Way Standards to determine if the kinks he observed were unsafe or worth reporting. The roadmaster and assistant roadmaster were responsible for the condition of the track, but they had not accompanied the relief track inspector or otherwise evaluated the quality of his work, despite the N&W's policy that this be done.

The difficulty the relief inspector experienced at the Safety Board public hearing in identifying from his reports which track he traveled or the switches he inspected and identifying the class of track and its meaning indicates that the relief track inspector lacked familiarity with his duties. The Safety Board believes that this demonstrates the inadequacy of the training received by the track inspector and the need for periodic retraining and requalification. The Safety Board also believes that N&W maintenance-of-way management did not exercise prudent judgment when they assigned the track inspection tasks to the relief inspector.

The N&W Maintenance of Way Standards for turnouts and rail anchors on CWR specified frequent inspection and adjustment, and the inspection and adjustment of anchors was the responsibility of the track inspector while inspecting the track on a hi-rail vehicle. Usually, indications of anchors moving away from the tie (which can result in the longitudinal movement of the rail) can be seen during such an inspection. However, the track inspector will not see small variations unless the hi-rail vehicle is traveling slowly. Further, the track inspector may not see even excessive variations when inspecting multiple tracks at any speed.

The N&W officers and supervisors who traveled the railroad before the accident implied that they considered these to be inspection trips. The Safety Board believes that although they may have been able to observe obstructions or major track problems, they were not performing FRA-required inspections. Further, the absence of reports or inspection records also suggests that the inspections were not the thorough type of inspections required by the FRA. The railroad officers repeatedly expressed their belief at the Safety Board's public hearing that the track through the derailment area was the best track on the railroad. This belief may have contributed to a less vigilant inspection of the track by those assigned the responsibility for inspection as well as those that were to oversee the quality of the inspections.

Heat Wave Orders

Lateral displacements of track occur more often in the early spring and early summer months as ambient temperatures increase and with wide variations occurring in daily temperatures. An AAR report 45/ showed that the greatest number of lateral track displacements were reported in May, June, and July with May having more than June or July. The report also noted that the ambient temperature range of 85° F to 100° F accounted for a majority of incidents. The wide variations in ambient temperatures from the high of 91° F on May 7 to a low of 46° F on May 11 followed by the high temperatures on the day of the derailment were significant because the changes in temperature created increases in the rail stresses that had to be resisted by the turnout.

In May 1986, the CWR on the middle and westbound main tracks was subject to variations in temperature which could produce tensile and compressive rail stresses. An increase in temperature could cause compressive stresses that could readily produce a lateral track displacement. A signal system usually is not affected by a lateral displacement of the track and thus it will not provide a warning of lateral track displacement. Therefore, constant visual inspection is necessary.

Compressive rail stresses normally are contained by properly maintained rail anchors and ballast section. Train operation creates additional compressive stresses in the rail, and combined with the effects of increased temperature and disturbed track conditions, the train exacerbates the effects with the possible result of laterally displaced track. The issuance of a "heat wave" order is one method to reduce the effects of the train on the track. A slow moving train is less likely to contribute to the displacement of track than one that is moving rapidly; further, if a track problem develops, the consequences will be lessened.

On May 7, 1986, the day following the repairs to the turnout and the track misalignment, the ambient temperature recorded by the NWS at Norfolk was 79° F when the section foreman realigned the track and removed the slow order. However, a "heat wave" order was issued by the dispatcher the same day, about 2:44 p.m., after the temperature went above the 90° F threshold, effectively reducing the effects of a train on the track. The NWS at Norfolk recorded a temperature of 91° F at 1:50 p.m.

The dispatcher at Crewe reported a temperature of 85° F to the conductor of Extra 611 West between the time the conductor reported for duty at 12:15 p.m. and the time the train departed at 1:31 p.m. At 1:50 p.m., the NWS at Norfolk recorded a temperature of 89° F. N&W officials testified that the threshold limit was not uniform throughout the NS system before the derailment, but in June 1986 the threshold was standardized at 85° F. The Safety Board believes that had the threshold limitation been standardized at 85° F earlier a "heat wave" order would have been issued on May 18, 1986, and may have prevented or lessened the effects of the accident.

The N&W's method of obtaining ambient temperatures at midnight, 6 a.m., noon, and 6 p.m. is a standard procedure throughout the railroad industry. Wayside operators normally report the weather conditions at their location to the dispatcher at these time intervals. However, 6 a.m., midnight, and 6 p.m. are not periods of maximum temperatures. On May 7, 1986, the maximum temperature occurred at 1:50 p.m. On the day of the accident, the maximum temperature occurred between the hours of 2 p.m. and

45/ AAR Report R-454.

4 p.m. The Safety Board believes that the effects of temperature changes on CWR requires that the times for monitoring temperatures needs to be modified to include the occurrences of maximum temperatures.

Training

The N&W's training program was intended to provide trainee foremen with the knowledge and skills required for performing their jobs effectively using the railroad Maintenance of Way Standards for track maintenance and the FRA Track Safety Standards. However, the accident and events preceding it indicate a discrepancy between the objectives of the program and the actual results. For a training program to be effective, participants should not only understand the subject matter taught, but they must also understand the program's objectives; that is, they should understand the goals of the program and the knowledge and skills they should acquire as a result of their participation. Performance evaluations, when conducted by the employees' supervisor, may help to determine weakness in the employees' training and areas that must be improved in the program.

The track foreman assigned to the shoulder ballast cleaning operation on May 6 said that he had taken the training program. Yet, when he performed the repair work on the turnout damage by the shoulder ballast cleaning equipment, he failed to remove the rail holding spikes before lifting the rail when he replaced the bolts in the adjustable brace plates. This omission indicates he did not fully appreciate correct maintenance procedures and it reflects a potential inadequacy in N&W training.

The section foreman who realigned the approach track at the turnout on May 7 following the repairs to the turnout by the track foreman, had been a foreman since 1969, but had not taken the training program. When he repaired the approach track, he failed to recognize that the misaligned approach track to the turnout required him to readjust the rail. He may not have fully understood the characteristics of CWR and thus the consequences of his actions on this type of rail. The section foreman's judgment of what action was needed may have been the result of his not receiving training in this area.

The track foreman and the section foreman may not have recognized that the manner in which they performed their work would have an effect on the lateral stability of the CWR through the turnout area; thus, they did not inform their supervisor of the alignment problem when it occurred. Had they done so, the roadmaster would have been in a position to take corrective action for the misaligned track. Also, the track foreman and section foreman may not have previously received constructive feedback by way of proper supervisory evaluations.

The relief track inspector had attended the training program, but his failure to appreciate the potential consequences of the kinks he noted on the day of the accident and his failure to understand the FRA standard classes of track suggests too that he may not have had adequate training. Although he had not inspected track formally for 9 years, the N&W exercised poor judgment in expecting him to do so without retraining and with limited supervisory oversight. Thus, he apparently did not consider the kinks to be abnormal in CWR during high temperatures, and he may have disregarded them, possibly because he did not understand or had forgotten the importance of such kinks. He was not aware that there had been a misalignment problem on the approach track of the westbound turnout at Juniper so he had no reason to suspect that the track had the potential to shift laterally; had he known of the problem he may have been more observant. Nevertheless, had he been properly trained to do his job, he should have known the importance of kinks on CWR.

In 1986, another railroad recognized the need to educate track maintenance employees and management on track buckling, including the effects of kinks on CWR and how compliance with certain procedures can prevent buckling. That railroad setup a 1/2-day seminar to provide technical training and a mechanism to improve communications between track maintenance personnel and track inspectors for identifying and correcting track buckling problems.

The existing N&W Maintenance of Way Standards address CWR installation and inspection procedures and methods to adjust and anchor CWR for different temperatures to prevent track buckling. The Safety Board believes that the N&W should complement its training program with technical training for maintenance of way forces and supervisory personnel to improve communication in identifying and correcting track maintenance problems associated with CWR.

Switch Stand

The statement by the railroad employee that both switch points were gapped following the derailment and the statements by railroad officials that the switch stand target was in the reverse position raised questions as to whether the switch may have contributed to the derailment.

The contact mark near the middle of the left-hand switch point appeared to have been made by a rotating object, not a sliding object. The "fish scale" pattern on the tapered portion of the switch point appeared to have been the result of original manufacture of the switch point. Thus, there was no visible evidence of damage on the switch points. To have the switch lever rotate in its stand with the switch lock still in place would require an external force on the switch rails to reverse the switch points, which could have occurred only during the passage of the train over the switch. However, the lack of visible damage or impact marks on the switch points indicates that the reversing of the switch must have occurred almost instantaneously after the initial derailment.

The switch points probably reversed when the first cars that derailed from the laterally displaced track struck the frog with sufficient force to destroy it, and the reaction of this force was transmitted through the rails causing the switch points to reverse. Testing of the switch stand showed that a force applied at the switch points of 2,692 pounds would reverse the switch. The forces created by the first cars which derailed impacting the frog would have been capable of producing an instantaneous force sufficient to cause a rapid reversal of the switch points. The Safety Board believes that the switch stand did not contribute to the cause of the accident.

Train Equipment

The Safety Board is concerned about the use of historic or older equipment for excursions on the general railroad system. It was no coincidence that, of the 14 cars to derail, the cars that jackknifed and/or overturned were not equipped with tightlock couplers. The railroad industry has long recognized that tightlock couplers prevent vertical disengagement of couplers during derailments, thus resisting cars overturning and telescoping in collisions. Tightlock couplers have been a mandatory standard of the AAR on railroad passenger equipment built since 1956. The N&W management had the responsibility and authority to accept or reject equipment or to impose restrictions as necessary. The Safety Board believes that the N&W management should not have permitted passenger equipment without tightlock couplers to be used in a train.

As a result of its investigation of a train derailment at Sound View, Connecticut, on October 2, 1970, 46/ the Safety Board recommended on December 22, 1971, that the FRA:

R-72-2

Promulgate regulations requiring interlocking couplers on all passenger-carrying equipment including the passenger locomotive.

At the NTSB/FRA quarterly meeting of April 17, 1979, a discussion of interlocking couplers on passenger-carrying equipment centered on an FRA letter of July 14, 1978, which cited the cost of retrofitting older passenger equipment with interlocking couplers. FRA personnel advised the Safety Board staff that these cars were in commuter service and in the process of being retired. In addition, the National Railroad Passenger Corporation (Amtrak), the primary intercity rail passenger carrier, had equipped all of its passenger cars and locomotives with interlocking couplers.

The Safety Board believed that the recommendation was valid at the time of issuance, but based on the information from the FRA that all passenger cars were now equipped with interlocking couplers, except for a small number soon to be retired, Safety Recommendation R-72-2 was classified as "Closed--No Longer Applicable" on March 10, 1981. However, with the emergence of these cars in excursion service, the Safety Board believes that there is now a need to address this issue. The FRA should require interlocking couplers on all passenger-carrying equipment, including historic or older equipment and passenger locomotive units.

Survival Aspects

The Safety Board is aware that much of the modification and restoration of historic equipment is performed by members of railroad historical societies and associations who take pride in restoring the equipment to its original condition. However, the Safety Board believes that when this historic equipment is used on the general railroad system, the public has a right to expect that the historic equipment will not jeopardize its safety.

The FRA exempts historic or older equipment used for excursions on the general railroad system from complying with Federal requirements for safety glazing standards and emergency exits. However, in this accident, windows in the derailed passenger cars were broken either as a result of the derailment or by evacuation of passengers. More injuries, possibly even fatal injuries, could have resulted had car NW 1069 overturned and slid, like cars SOU 1087 and SOU 4061, which had no glazing in the window openings to keep occupants from being ejected from the car. The Safety Board believes that with the increasing number of excursion trips on the general railroad system, no passenger car should be exempt from compliance with the recognized safety standards that are intended to provide the safest equipment for the public.

In evaluating the interiors of the jackknifed and/or overturned cars, it is apparent that the conversions and modifications were done with little consideration for crashworthiness. Service counters in SOU 4061 were inadequately fastened to the floor and separated from the floor when the car overturned, trapping one passenger. The loose, free-standing appliances, furniture, and other objects became missiles during the derailment and may well have caused some of the more serious injuries. Protruding

46/ Railroad Accident Report--"Penn Central Transportation Company Freight Train Derailment, Passenger Train Collision with Hazardous Material Car, Sound View, Connecticut, October 8, 1970" (NTSB-RAR-72-01).

objects, such as light switches, junction boxes, bare bolt ends, and nails in the walls should be relocated or eliminated. The seats in NW 1069 were hard and unyielding, incorporating no injury-reducing features. Had this car overturned and had the passengers experienced the same forces as the passengers in the following car, SOU 4061, the injuries would have been at least as severe and in all likelihood, more severe than those in the cars which overturned.

The Safety Board believes that the train went into an emergency brake application as a result of an air hose separation during the derailment, rather than a manual application, since the CCEO stated he did not make a brake application. On the basis of the evidence and passenger statements, it is most likely that the brakes activated fairly early in the derailment sequence before SOU 1087 and SOU 4061 derailed and overturned. It would have been useful to know at what point in the derailment sequence the train went into emergency braking. However, the steam locomotive lacked an event recorder. Knowing the deceleration rate of the train and the approximate speed of the cars that jackknifed and/or overturned could have provided information as to the magnitude and duration of impact forces sustained by the passengers.

Despite difficulties caused by the remote location of the accident site as well as topographical limitations for access by emergency forces, the emergency response was timely and efficient. It is probable that much of the effectiveness of the emergency response was due to the quality and standardization of equipment, training, and procedures used by the Tidewater Emergency Medical Services Council. Frequent drills and integrated emergency management procedures also contributed to the effectiveness. It is especially noteworthy that such training and procedures were developed exclusive of city and county jurisdictional boundaries.

Toxicology

Although there was no evidence to suggest that alcohol and drugs were involved in the accident, the Safety Board believes that toxicological testing should consistently and routinely be performed following all major railroad accidents. Toxicological testing can eliminate doubts and speculation or confirm use of intoxicants.

Toxicological testing was not performed following the derailment on May 18, 1986, because according to NS, the criteria for testing were not met. As it turned out, it appears that this accident did not meet the FRA criteria for toxicological testing. A decision to not conduct toxicological testing was made by the president of the N&W who was not on the scene. The decision by the railroad superintendent on the scene was not made, however, until 4 hours after the derailment. Also, when the various NS investigators and officials arrived at the accident site, there was confusion as to the identity of the appropriate senior official entrusted with the decision on whether or not to test. Under other circumstances, for instance when testing criteria are met, such confusion may result in a failure to test or a delay in testing. The delay in deciding whether or not to test would seriously compromise the value of tests. The value of the NS testing program ultimately depends on its consistent application, as a matter of standard and routine practice.

The Safety Board approves of NS' effort to develop a comprehensive syllabus for instruction of management supervisory personnel on the control of alcohol and drug use. However, as demonstated by the confusion that arose at the accident site, clarification of duties of senior officials responding to an accident is needed. Also, the program needs to address the instance when a member of management or the executive division becomes the "covered employee."

Title 49 CFR Part 219, Subpart C states that the determination to conduct toxicological testing is left to the railroad representative responding to the scene of the accident/incident. This representative is responsible for making reasonable inquiry into the facts as necessary to make a decision. The regulations state that the railroad representative satisfies the requirements if, after making a reasonable inquiry, he exercises good faith judgment in making his decision. The Safety Board believes that the senior officers of the N&W failed to take advantage of an excellent opportunity to demonstrate to its employees the importance it places on its toxicological testing program and the FRA's toxicological testing program and that the N&W management not only supported such training, but would participate in such testing if they were involved in an accident. The Safety Board believes that the FRA should amend 49 CFR 219, Subpart C to require toxicological testing of all applicable employees in the event of a passenger train accident involving reportable injuries.

CONCLUSIONS

Findings

1. The operation of the train was not a causal factor in the derailment.

2. The signal system was not a causal factor in the derailment.

3. The effects of a progressive lateral displacement of the track under the train was confirmed by the statements of passengers in the cars that passed over the turnout and did not derail.

4. The reconstruction of the turnout disclosed deformed closure rails and heel block bolts. Derailment marks on the closure rails were consistent with derailment marks on the lead truck of the first car to derail.

5. Impact marks on the frog assembly bolt nuts indicated that the frog was intact before the train derailed and that it was destroyed by the impact from derailing wheels.

6. The maintenance activities in March on the middle track, combined with increasing temperatures, created conditions that resulted in improperly adjusted rail.

7. The track foreman responsible for the shoulder ballast cleaning received minimal instructions for the operation, and he was delegated supervisory responsibilities to implement the standard procedures of the Maintenance of Way Department without a clear understanding of what was expected.

8. The repairs to replace the switch brace bolts damaged by the shoulder ballast cleaner created a track disturbance resulting in a misalignment of the track approaching the turnout.

9. The Signal Department was not notified as required by Maintenance of Way Department standard procedures of track work being performed at a switch that had a track shunt circuit switch protection.

10. Failure to relieve the rail stresses when realigning the approach track to the turnout combined with the track maintenance on the middle track contributed to increased rail stresses in the turnout.

11. The offset measurements at the approach track and switch included the effects of the laterally displaced track and derailment action.

12. The relief track inspector had not performed FRA-type compliance inspections for 9 years and was not aware of the repairs and resultant track alignment problem at the turnout. His failure to know the class of track inspected, his inability to interpret his reports, and his perception of kinks in the track was a reflection of his lack of qualifications and training.

13. There is no requirement for track inspectors to be requalified on the FRA Track Safety Standards or the N&W Maintenance of Way Standards.

14. The N&W's interpretation of the FRA Track Safety Standards for track inspection resulted in the inspection of two and three tracks at one time with no prescribed procedure for traveling each track during the inspection cycle.

15. The FRA Track Safety Standards do not address the number of tracks that can be inspected from one track nor on which track the inspector must be traveling to perform the inspection.

16. The N&W does not require regular medical and/or visual examinations of track inspectors.

17. The roadmaster and assistant roadmaster believed that track inspections were being performed, as required, because the standards had prescribed inspection schedules and procedures. However, no systematic performance evaluations were in effect to establish competency in track inspection.

18. The track foreman and section foreman did not notify their supervisors of any track misalignment problem in the derailment area before the train derailed.

19. The switch stand did not contribute to the cause of the accident.

20. Contributing to the major injury-producing forces was the overturning of passenger cars without tightlock couplers and the hard, unyielding surfaces and loose objects in those cars.

21. The interior features of the commissary car and unsecured equipment in that car contributed to passenger injuries.

22. Toxicological testing should have been performed to demonstrate the N&W's support for toxicological testing following an accident.

23. The timely, effective, and professional response to the emergency was a result of the preparedness and training of the Tidewater Emergency Medical Services Council and the familiarization training provided by the N&W.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the Norfolk and Western Railway Company (N&W) to train its Maintenance of Way Department employees adequately in the inspection and repair of continuous welded rail, and the failure of the Maintenance of Way Department

management to monitor the implementation of the N&W's maintenance-of-way practices by its employees. Contributing to the severity of the accident was the N&W's decision to use equipment without tightlock couplers and passenger cars with modified interiors having severe injury-producing mechanisms.

RECOMMENDATIONS

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

--to the Norfolk and Western Railway Company:

Develop and implement a program to provide maintenance-of-way forces and supervisory personnel with technical training for identifying and correcting track maintenance problems associated with continuous-welded rail. (Class II, Priority Action) (R-87-24)

Review the written procedures in the Maintenance of Way Department and instruct all pertinent employees of the requirement to notify the Signal and Communication Department when maintenance-of-way work involves the signal system. (Class II, Priority Action) (R-87-25)

Require that all cars in the consist of a passenger-carrying train be equipped with interlocking (tightlock) couplers and certified window glazing. (Class II, Priority Action) (R-87-26)

Require that the interior fixtures and appliances of any passenger-carrying car be secure and that the interiors of cars do not have the injury-producing features identified in the accident involving train Extra 611 West at Suffolk, Virginia, on May 18, 1986. (Class II, Priority Action) (R-87-27)

Review the toxicology training program and revise, as necessary, to clarify the duties of company officials responding to the scene of an accident. (Class II, Priority Action) (R-87-28)

Revise, to reflect the occurrences of the maximum changes in ambient temperatures, the times at which such temperatures are obtained for the purpose of placing slow orders on continuous-welded rail track. (Class II, Priority Action) (R-87-29)

—to the American Short Line Railroad Association, the Association of American Railroads, the National Railroad Historical Society, and the American Association of Private Car Owners, Inc.,:

Inform its membership of the facts and circumstances of the train accident at Suffolk, Virginia, on May 18, 1986, and recommend that its members require all cars in the consist of a passenger-carrying train on the general railroad system to be equipped with interlocking (tightlock) couplers and certified window glazing. (Class II, Priority Action) (R-87-30)

Recommend to its membership that the interior fixtures and appliances of any passenger-carrying car be secure and that the interiors of cars do not have the injury-producing features identified in the accident involving train Extra 611 West at Suffolk, Virginia, on May 18, 1986. (Class II, Priority Action) (R-87-31)

—to the American Short Line Railroad Association and the Association of American Railroads:

Instruct its membership to revise, to reflect the occurrences of the maximum changes in ambient temperatures, the times at which such temperatures are obtained for the purpose of placing slow orders on continuous-welded rail track. (Class II, Priority Action) (R-87-32)

--to the Federal Railroad Administration:

Amend the Track Safety Standards, 49 CFR 213.7, to require periodic requalification of persons for supervising certain renewals and inspection of track. (Class II, Priority Action) (R-87-33)

Amend 49 CFR 213.233(b) and (c) to establish procedures for inspection of track in multiple track areas and to define the maximum speed for riding over the track in a track inspection vehicle. (Class II, Priority Action) (R-87-34)

Amend the Safety Glazing Standards in 49 CFR Part 223 to include the requirement that windows of historic or older equipment used for excursion purposes on the general railroad system be equipped with certified glazing. (Class II, Priority Action) (R-87-35)

Promulgate regulations to require that interlocking (tightlock) couplers be installed on all passenger-carrying equipment, including historic or older equipment and passenger locomotive units. (Class II, Priority Action) (R-87-36)

Amend 49 CFR Part 219 to require toxicological testing of all applicable employees in the event of a passenger train accident involving reportable injuries. (Class II, Priority Action) (R-87-37)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ JOSEPH T. NALL
Member

/s/ JAMES L. KOLSTAD
Member

JOHN K. LAUBER, Member, did not participate.

September 15, 1987

APPENDIXES

APPENDIX A

INVESTIGATION

1. Investigation

The National Transportation Safety Board was notified at 3:20 p.m. on May 18, 1986, that a westbound Norfolk and Western Railway Company passenger excursion train had derailed at Suffolk, Virginia. The investigator-in-charge and other members of the investigative team were dispatched from the Washington, D.C. office. Investigative groups were established for operations, mechanical, track, human performance, and survival factors.

2. Hearing

The Safety Board conducted a public hearing as part of its investigation of the accident on August 13-14, 1986, at Norfolk, Virginia. Parties to this proceeding included the Norfolk and Western Railway Company, the Brotherhood of Maintenance of Way Employees, and the Federal Railroad Administration. Twenty-seven witnesses testified.

APPENDIX B

PERSONNEL INFORMATION

Operating Engineer, and Chairman and Chief Executive Officer, Robert B. Claytor

Operating engineer Robert B. Claytor, 64, began his employment at N&W as a solicitor in the law department on September 15, 1951. He became vice president-law in 1964. In 1968, he was elected as director and appointed senior vice president. In 1970, he was elected executive vice president, and became president and chief executive officer in 1980. When the Norfolk Southern Corporation was formed in 1982, he became chairman and chief executive officer.

His experience with steam locomotives began in the early 1950's as on-the-job training and operation with regular engineers. He last passed an examination on the N&W operating rules in 1984.

Operating Fireman, D. A. Browning

Operating fireman D. A. Browning, 31, was employed by Industrial Electrical and Engineering under a service contract in 1982 to the Southern Railway, now Norfolk Southern Corporation, as a fireman/mechanic. He has been the fireman on locomotive 611 for 2 years. He was qualified in April 1986 on the Southern Railway and Norfolk and Western Railway operating rules.

System Road Foreman of Engines-Steam, Frank W. Collins

Road foreman Frank W. Collins was employed as a locomotive fireman in January 1947 by the N&W. He was promoted to locomotive engineer on steam engines in November 1954. He operated steam locomotives on the Radford Division from 1954 until 1958. In 1969, he was promoted to division road foreman-engine on the Scioto, Pittsburgh, Muncie, and Radford Divisions, and in 1970 on the Norfolk Division. In June 1986, he was promoted to system road foreman of engines-steam for the Norfolk Southern Corporation, permanently assigned to the steam program. He last passed an examination on the N&W operating rules in April 1986.

Track Foreman, Robert Sadaslaus Moore

Track foreman Robert Sadaslaus Moore, 56, was employed by the Norfolk and Western Railway in 1951 as a laborer. He has been a foreman and assistant foreman since 1976.

Section Foreman, Ralph William Leonard

Section foreman Ralph William Leonard, 51, was employed by the Norfolk and Western Railway in 1946. In 1966, he became an assistant foreman, and in 1969, a foreman.

Relief Track Inspector, William A. Peace

Relief track inspector William A. Peace, 41, was employed by the Norfolk and Western Railway in 1972 as a section laborer. In 1973, he became a track machine operator. In 1977, he became an assistant foreman, and in 1978 a section foreman. He has been an assistant foreman since 1983. He began performing relief track inspector's duties on May 1, 1986.

APPENDIX C

EXCURSION TRAIN EXTRA 611 WEST CONSIST FOR MAY 18, 1986

Equipment	Description	Coupler Type	
NW 611	steam engine	E	
NW 220165	tender	E	
NW 220166	auxillary tender	E	
SOU 1	office car	F	
SOU 1A	office car	F	
NW 200	office car	F	
NW 1407	tool car	E	
TWC 1730	coach	T	
TWC 1721	coach	T	
TWC 1723	coach	T	
NW 531	coach	H	
RNRH 537	coach	H	
NW 536	coach	H	
NW 539	coach	H	
NW 540	coach	H	
NW 1069	coach	E	open window
SOU 1087	coach	E	
SOU 4061	commissary	E	
SOU 1070	coach	E	open window
LSR 6450	coach	H	
RNRH 1210	coach	H	
SOU 726	coach	H	
NS 28	coach	H	
SOU 844	coach	H	
SOU 841	coach	H	
RNRH 3305	observation	H	

Abbreviations:

SOU	Southern Railway
NW	Norfolk and Western Railway
TWC	Tide Water Chapter NRHS
RNRH	Roanoke Chapter NRHS
LSR	Lake Shore Region NRHS
NS	Norfolk Southern Corporation

Coupler types: E - Standard
F - Interlocking
T - Early tightlock
H - Tightlock

APPENDIX D

EXCERPTS FROM N&W TRACK SAFETY STANDARDS

SUBPART F - INSPECTION

§ 213.231 Scope.

This subpart prescribes requirements for the frequency and manner of inspecting track to detect deviations from the standards prescribed in this part.

§ 213.233 Track inspections.

(a) All track must be inspected in accordance with the schedule prescribed in paragraph (c) of this section by a person designated under §213.7.

(b) Each inspection must be made on foot or by riding over the track in a vehicle at a speed that allows the person making the inspection to visually inspect the track structure for compliance with this part. However, mechanical or electrical inspection devices may be used to supplement visual inspection. If a vehicle is used for visual inspection, the speed of the vehicle may not be more than 5 miles per hour when passing over track crossings, highway crossings, or switches.

(c) Each track inspection must be made in accordance with the following schedule:

Class of track	Type of track	Required frequency
1,2,3.....	Main track and sidings.	Weekly with a least 3 calendar days interval between inspection, or before use, if the track is used less than once a week, or twice weekly with at least 1 calendar day interval between inspections, if the track carries passenger trains or more than 10 million gross tons of traffic during the preceding calendar year.
1,2,3.....	Other than main track and sidings.	Monthly with at least 20 calendar days interval between inspections.
4,5,6.....		Twice weekly with at least 1 calendar day interval between inspection.

(d) If the person making the inspection finds a deviation from the requirements of this part, he shall immediately initiate remedial action.

APPENDIX E

EXCERPTS FROM FRA TRACK SAFETY STANDARDS 49 CFR PART 123

Subpart F—Inspection

§ 213.231 Scope.

This subpart prescribes requirements for the frequency and manner of inspecting track to detect deviations from the standards prescribed in this part.

§ 213.233 Track inspections.

(a) All track must be inspected in accordance with the schedule prescribed in paragraph (c) of this section by a person designated under § 213.7.

(b) Each inspection must be made on foot or by riding over the track in a vehicle at a speed that allows the person making the inspection to visually inspect the track structure for compliance with this part. However, mechanical, electrical and other track inspection devices may be used to supplement visual inspection. If a vehicle is used for visual inspection, the speed of the vehicle may not be more than 5 miles per hour when passing over track crossings, highway crossings, or switches.

(c) Each track inspection must be made in accordance with the following schedule:

Class of track	Type of track	Required frequency
1, 2, 3	Main track and sidings.	Weekly with at least 3 calendar days interval between inspections, or *Before use*, if the track is used less than once a week, or *Twice weekly* with at least 1 calendar day interval between inspections, if the track carries passenger trains or more than 10 million gross tons of traffic during the preceding calendar year.
1, 2, 3	Other than main track and sidings.	Monthly with at least 20 calendar days interval between inspections.
4, 5, 6		Twice weekly with at least 1 calendar day interval between inspections.

§ 213.235

(d) If the person making the inspection finds a deviation from the requirements of this part, he shall immediately initiate remedial action.

[36 FR 20336, Oct. 20, 1971, as amended at 40 FR 8558, Feb. 28, 1975]

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