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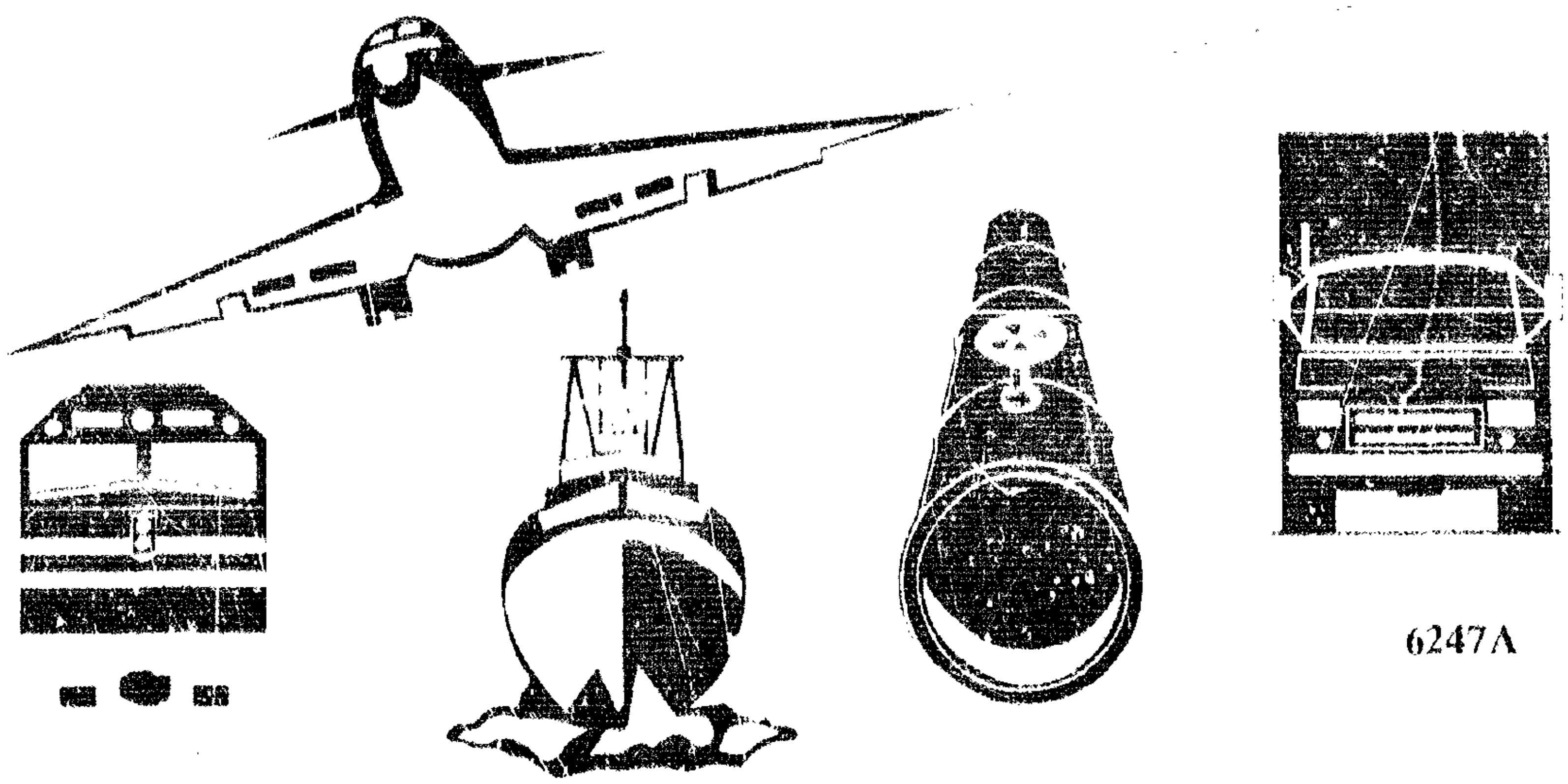
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

HEAD-ON COLLISION AND DERAILMENT OF
BURLINGTON NORTHERN FREIGHT TRAIN
WITH UNION PACIFIC FREIGHT TRAIN
KELSO, WASHINGTON
NOVEMBER 11, 1993



6247A

Abstract: On November 11, 1993, a Burlington Northern (BN) freight train collided head on with a Union Pacific freight train at BN milepost 102.8 south of the Longview Junction South interlocking near Kelso, Washington. As a result of the accident all five crewmembers from both trains were killed.

The major safety issues discussed in this report are positive train separation and the adequacy of wayside signals for capturing a train crew's attention. The report also discusses calling signals, event recorder crashworthiness, and locomotive crashworthiness.

As a result of its investigation of this accident, the Safety Board makes safety recommendations to the Federal Railroad Administration, the Burlington Northern Railroad, the Union Pacific Railroad, and the Association of American Railroads. The Safety Board also reiterates two safety recommendations to the Federal Railroad Administration.

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HEAD-ON COLLISION AND DERAILMENT OF BURLINGTON NORTHERN FREIGHT TRAIN WITH UNION PACIFIC FREIGHT TRAIN KELSO, WASHINGTON NOVEMBER 11, 1993

RAILROAD ACCIDENT REPORT

Adopted: November 15, 1994
Notation 6247A

NATIONAL
TRANSPORTATION
SAFETY BOARD

WASHINGTON, D.C. 20594

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Executive Summary

On November 11, 1993, about 12:24 a.m. Pacific standard time, a Burlington Northern (BN) freight train collided head on with a Union Pacific (UP) freight train at BN milepost 102.8 south of the Longview Junction South interlocking near Kelso, Washington. As a result of the accident all five crewmembers from both trains were killed.

The National Transportation Safety Board determines that the probable cause of this accident was (1) the failure of the Burlington Northern crewmembers, for unknown reasons, to see the intermediate signal that would have directed them to stop at the absolute signal and (2) the lack of redundancy in the centralized traffic control system. Contributing to the accident was the lack of a positive train separation control system.

The major safety issues discussed in this report are:

- adequacy of wayside signals for capturing a train crew's attention, and
- positive train separation.

The report also discusses calling signals, event recorder crashworthiness, and locomotive crashworthiness.

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INVESTIGATION

The Accident

On November 11, 1993, about 12:24 a.m.[1] southbound Burlington Northern (BN) freight train 01-111-10 (train 111) collided head on with northbound Union Pacific (UP) freight train NPSEZ-09 (train 09) near Kelso, Washington. The accident occurred on the BN Railroad between the Columbia River and Interstate 5. (The tracks are east of the river and west of the interstate.)

Train 111 had an engineer, a conductor, and a brakeman. Train 09 had an engineer and conductor. All five crewmembers were killed in the collision. The bodies of the train 111 engineer and conductor were located amidst the wreckage of the lead locomotive. The coroner's report states that the remains of the train 111 brakeman were located in the wreckage of the third locomotive. It appears likely that he was riding in that unit at the time of the accident. The bodies of the train 09 engineer and conductor were located under the wreckage within a few feet of one another.

Train 09 originated at North Platte, Nebraska, and was destined for Seattle, Washington. It moved north on UP tracks, with 3 locomotives and 83 cars, from Portland, Oregon, until it entered the BN Railroad at North Portland Junction. The train continued north to Vancouver, Washington. (See figure 1.) At Vancouver, the Seattle Subdivision of the Pacific Division begins at mile post (MP) 136.5, with the MPs decreasing to Tacoma, Washington. The train passed Vancouver Junction North at MP 132.5 about 11:42 p.m. As the train proceeded north on main track 2, it cleared the interlocking at MP 111 about 12:15 a.m.

There are two main tracks; one is designated main track 1 and the other, main track 2. (See figure 2.) The BN train dispatcher stated that about 12:11 a.m. he crossed train 111, which had 5 locomotives and 117 cars, from main track 1 to main track 2 at Ostrander interlocking (MP 93.4). He said he routed the train on main track 2 to allow it to pass a local freight train, UP DC-59 (train 59). Train 59 was working at Longview yard (MP 101.1) on main track number 1. (See figure 3.)

About 12:17 a.m., train 111 passed through Kelso South interlocking (MP 98.9). Shortly after passing through, a crewmember had a brief radio conversation (see appendix C) with the yard clerk at Longview yard. The clerk stated he was sure that the crewmember he spoke with was the conductor. A review of the radio and telephone voice tapes shows the radio conversation lasted from 12:17:46 until 12:18:38 a.m. When the conversation ended, the train was about 3/4 mile from the yard office. It passed the office less than 70 seconds later.

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[1]All times are Pacific standard time, reported in hours, minutes, and seconds for voice tape recorded or computer recorded events and in hours and minutes for all other events.

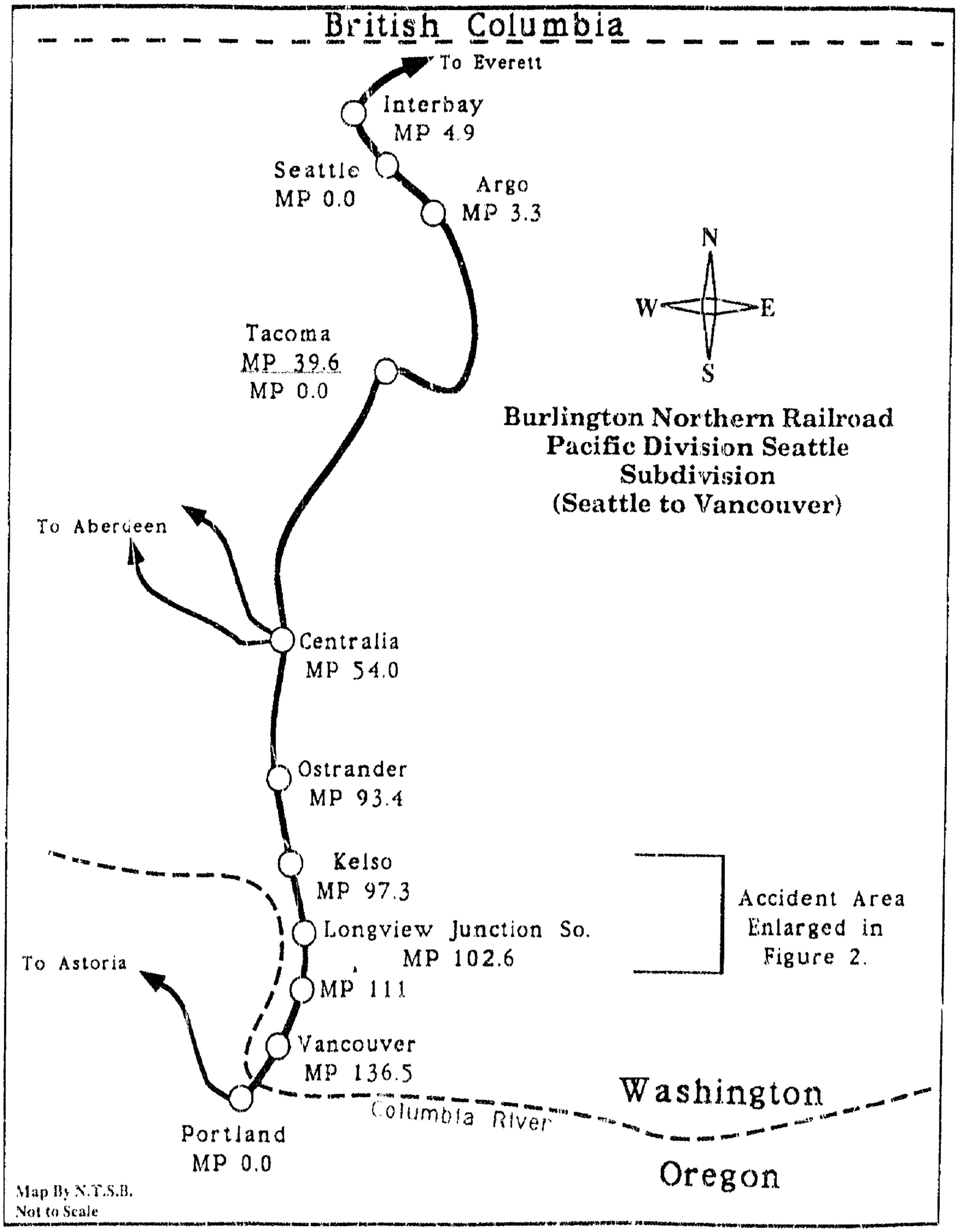


Figure 1.--Route between Interbay, Washington, and Portland, Oregon.

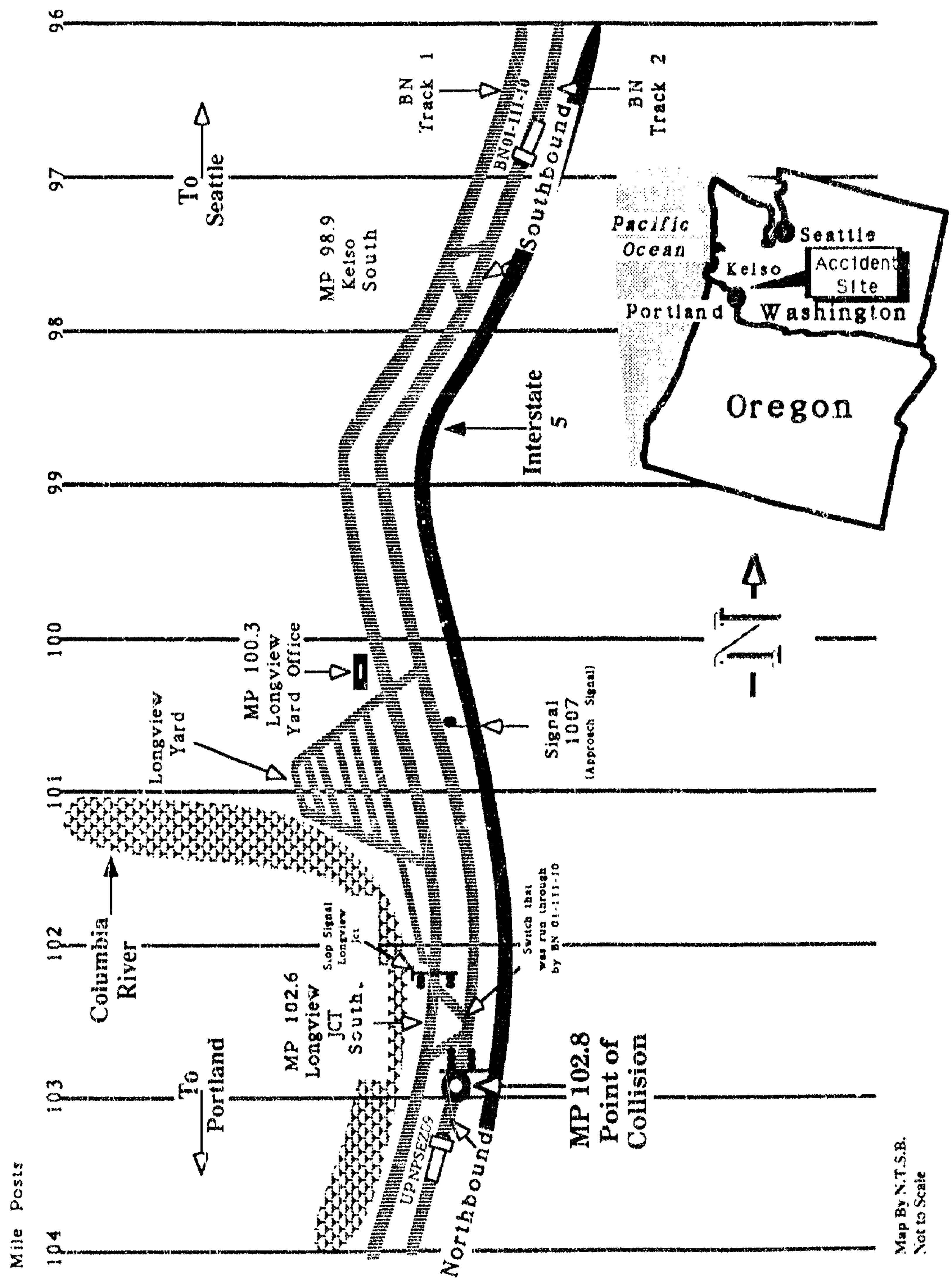


Figure 2.--Map of accident site.

The yard clerk stated that he was engaged in a telephone conversation when train 111 passed the yard office. The clerk further stated that although visibility was "maybe a couple of hundred feet" due to fog, he could discern the locomotives. He added that he could not see the positions of the crewmembers but he waved to the train because he waves to all the trains that go by. He said there had been instructions on his turnover when he arrived at work that evening saying that train 111 would not stop to work at the yard. He stated that on most of the trips, the train was on main track 1 and stopped to work in the yard. The pick-up was cancelled because the train had reached its tonnage capacity. He said that the instructions were from the trainmaster. He did not talk to the train crew about the instructions because he assumed that the crewmembers had already received them.

Shortly after 12:20 a.m., the conductor of train 59 walked to the manually operated switch at the north end of Longview yard. He said that the locomotives of train 111 had passed his location before he walked to the switch. He did say that he observed the rear portion of the train. He estimated the speed to be about 40 mph. While standing at the switch, he stated, he heard a rumbling sound, and "it sounded like thunder, just a rolling thunder."

BN dispatching records (see appendix D) indicate that train 111 passed the intermediate signal (MP 100.7) about 12:20 a.m. (See figure 2.) The intermediate signal is the approach signal to Longview Junction South interlocking. With the route that the dispatcher had lined up, the intermediate signal should have been displaying a yellow, or approach, indication. The dispatching record also indicates that about 12:24 a.m., the interlocking had a "power off" alarm.

The collision occurred at BN MP 102.8, south of the Longview Junction South interlocking (MP 102.6). All locomotives were either destroyed or severely damaged. Following the collision, a fire from punctured fuel tanks engulfed the derailed locomotives. In total, 8 cars were destroyed and 16 were damaged. (See figure 4.)

There were two eyewitnesses to the accident who were traveling north in separate vehicles on Interstate 5. Both described the weather as patchy fog along the highway but clear at the accident location. One stated he was traveling between 65 and 70 mph when he passed train 09, and he estimated that "the train was probably doing 55 mph." He described the collision as "a major explosion. It was unbelievable." The other witness stated he observed the headlight of train 111 coming at him. He was watching and waiting for the two trains to pass each other. He said they just ran into each other. He stated "there was just fire and devastation."

Injuries

INJURY TABLE

	Burlington Crew	Union Pacific Crew	Total
Fatal	3	2	5
Serious	0	0	0
Minor	0	0	0
None	0	0	0
Total	3	2	5

Damage

The BN and the UP provided the following damage estimates:

Locomotives	$2,977,000
Equipment	571,500
Track	388,700
Signal	11,500
Lading Damage	290,000
Environmental Cleanup	245,165
Miscellaneous	121,091
TOTAL	$4,604,956

Personnel Information

Safety Board staff members reviewed the personnel files of the two train crews and the dispatcher and examined their work records for the 60-day period before the accident. Each person was rested in compliance with the work/rest provisions of the Hours of Service Act. The train crews should have been familiar with the physical characteristics of the accident area. All crewmembers routinely worked on the Seattle to Portland territory, and each person had made at least 12 trips over that route within the past month.

Train 09 engineer.--The engineer started working for the UP in December 1980 as a laborer. He worked successively as an engine wiper and cleaner and as a carman apprentice before being furloughed in June 1982. He rejoined the UP in May 1988 as a brakeman. In August 1990, he became a fireman and 6 months later was promoted to engineer. He successfully completed an operating rules examination in December 1992. In the year before the accident, he had passed 36 efficiency tests, including 20 stop tests.

He had been at home on November 9, 2 days before the accident. At 9:45 p.m. that night, he began a trip from Seattle to Portland. He marked off duty in Portland at 5:00 a.m.

the next morning, November 10. The lodging register at the Portland hotel shows that he checked in at 5:35 a.m. on November 10. At 4:30 p.m., his wife stated, he had called home. UP crew dispatching records indicate that he was notified at 6:18 p.m. to report for train 09 at 8:15 p.m. The hotel clerk stated that about 7:15 p.m. she spoke with the engineer as he was returning from having pie and coffee with another UP engineer. She said that he appeared rested and, as always, in good spirits. In a separate interview, the other UP engineer confirmed the desk clerk's observations.

Train 09 conductor.--The UP initially hired him as a brakeman in March 1964. He was promoted to conductor in July 1974. In August 1988, he received a 31-day suspension for excessive speed in violation of BN track bulletin No. 9042; he was reinstated the following month. He had passed his most recent operating rules exam in October 1991. In the year preceding the accident, he had passed 38 efficiency tests, of which 18 were stop tests. His most recent stop test was in October 1993. A crew hauler, who had driven the engineer and conductor to train 09, stated that both men were in good spirits and seemed well rested and alert on the evening of November 10.

Train 111 engineer.--The engineer began employment with the BN as a yardman/brakeman in March 1979. In 1980 he took a leave of absence to enter a locomotive-engineer training program and was promoted to engineer in July 1980. He was a fireman from September 1982 to August 1985 and then, until the accident, an engineer. He successfully completed a BN rules exam in February 1991. He passed all 35 of his efficiency tests in 1993, including a stop test on October 22, 1993.

On November 8, 3 days before the accident, he completed a trip from Vancouver to his home terminal at Interbay, where he marked off duty at 9:50 p.m. He was then off duty for about 43 hours before reporting for train 111 on November 10 at 4:30 p.m.

Train 111 conductor.--The BN hired the conductor in July 1969. He alternated as brakeman and conductor until January 1990, when he assumed the conductor position that he held until the accident. BN service records show that he had been suspended for 10 days in 1978 for missing a call for work, for 30 days in 1979 for occupying a main line without authority, and for 4 days in 1980 for being discourteous/boisterous. In 1982 he was suspended twice, each time for 5 days. The first time he had violated rules about shoving cars, and the second time he had been discourteous\boisterous. In February 1990, he was dismissed for violation of Rule 564, a rule against being insubordinate or quarrelsome; he was reinstated in March 1990.

He passed his most recent rules exam in April 1993. During the year before the accident, he had had 73 efficiency tests, including 10 signal tests and 3 radio tests. He passed 70 tests. The three failures were for failing to follow a radio procedure, for not being in the controlling unit of the train, and for failing to wear proper eye protection. The radio procedure failure, for which he was retested and passed within 30 days, was for failing to conclude a radio conversation with the word *out*, thus for failing to let the employee he was talking to know that the transmission had been completed.

Train 111 brakeman.--The BN had employed the brakeman continuously for 29 years except during a 2-year leave of absence (1965-67) for military service. He started as a yardman/brakeman in April 1964 and had worked under the job title of brakeman since 1986. He successfully completed a rules exam in March 1993 and in September 1993 had passed two efficiency tests, one of which was a stop test. In March 1993, he was suspended for 5 days for failing to operate at or below maximum speed, a violation of *General Code of Operating Rules* A, B, D, 106, and 106A.

Dispatcher.--The dispatcher started work as a telegrapher for the BN in September 1977. He became a dispatcher in June 1980. In addition to occasionally working the Centralia South dispatcher district until 1982, he had worked that district as a regular assignment since September 1993. He had successfully completed a rules examination in December 1992 and had passed 18 efficiency tests in the 13 months preceding the accident.

Train Information

Train 09.--Train 09 originated at North Platte, Nebraska, on November 9 and was destined for Seattle, Washington. The crew reported for duty at 8:15 p.m. on November 10, 1993, in Portland, Oregon. The train consisted of 3 UP locomotives (UP 2475, 3388, and 3515), 79 loaded cars, and 4 empty cars and had 5,605 trailing tons. The train was 6,582 feet long and equipped with an operative end of train device, which had last been tested on October 21, 1993. Appropriate air brake tests were conducted according to the Federal Railroad Administration's (FRA's) power brake rules before the train departed Portland.

Representatives from the UP, the FRA, and the Safety Board did the postaccident mechanical inspection of the equipment. They did not find any defects. They examined the A-1 charging/cut-off pilot valves of locomotives UP 2475 and UP 3515 and the actuating piston. The piston position in each valve (up) indicated that the engineer had initiated an emergency application of the train brakes.

Train 111.--The crewmembers went on duty at Balmer yard in Interbay, Washington, on November 10 at 4:30 p.m. The train was a southbound freight train destined for Vancouver, Washington. The train consisted of 4 BN locomotives (BN 8160, 2255, 2729, 1954), 85 loaded cars, and 5 empty cars. The train passed an air test and car inspection which was performed by the crew of train 111 and car inspectors. The train departed Balmer yard at 5:45 p.m.

About 6:13 p.m., the train arrived in Stacy yard in Argo, Washington. The crew added 25 loaded cars and 2 empty ones to the train. After passing an air test, the train departed Argo at 7:05 p.m.

The train arrived in Tacoma, Washington, about 8:10 p.m., where a Montana Rail Link locomotive (MRL 305) was added as the lead unit. At 9:05 p.m., the train left. It was 7,639 feet long, had 13,195 trailing tons, and consisted of 5 locomotives, 110 loaded cars, and 7 empty cars.

Representatives of the Safety Board, the FRA, the BN, and the UP did the postaccident inspection of the equipment. They found and repaired two minor air leaks in the non-derailed cars before the train left the accident location. They found no other defects. The air leaks appeared to be the result of the collision since no air brake problems were noted after the last air test in Tacoma. They examined the mechanical records and reports of all accident locomotives and found that all inspections and tests required by the FRA had been conducted. They reviewed the maintenance records, which indicated normal maintenance patterns, and did not discover any maintenance trends that could be linked to the accident.

Lead locomotive.--The locomotive, Montana Rail Link (MRL) 305, was leased to the BN Railroad. The unit had been built by the Electro Motive Division of General Motors as an SD-45 and had subsequently been rebuilt by MRL with updated electronics to the SD-45-2 version.

Since the lead locomotive was destroyed in the collision, the investigators inspected a sister MRL locomotive. The engineer's seat was in the traditional position on the right side of the cab, and the seats for the head brakeman and/or conductor were on the left side. The control stand was along the engineer's left, extending from the cab heater to alongside the engineer's seat at about a 30-degree angle. The radio was recessed inside the control stand to the engineer's immediate left, with the hand set located adjacent to the radio in a holder on the end of the control stand. (See figure 5.)

Track and Signal Information

Track .--The BN designates the track through the accident area as FRA class 4. The FRA restricts freight trains on class 4 track to 60 mph. According to the BN timetable (No. 1, dated Friday, January 1, 1993), freight trains are restricted to 50 mph. The authorized speed through the crossover at Longview Junction is 35 mph.

Train 09 had no special timetable speed restrictions. However, train 111 did. It was restricted to 45 mph because it had about 112 tons per operative brake, and the special instruction in the timetable restricted trains with more than 100 tons per operative brake to 45 mph. The train would have been restricted to 25 mph through the crossover at Longview Junction South for the same reason.

The collision occurred on main track 2 in a curve that is, for a northbound train, a 1-degree 45-minute curve to the left. (See figure 6.) The track gradient is 0.06 percent ascending from south to north.

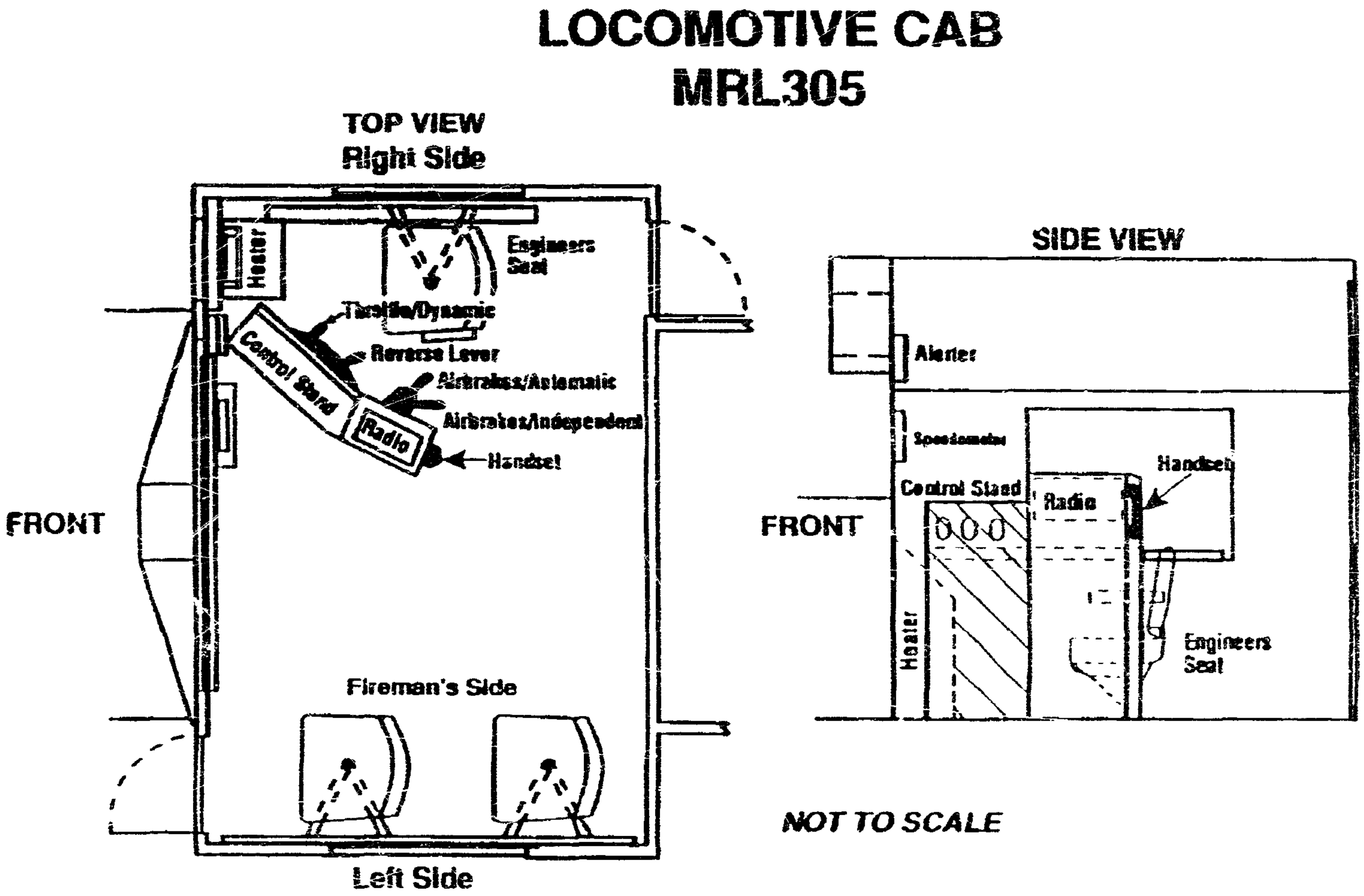
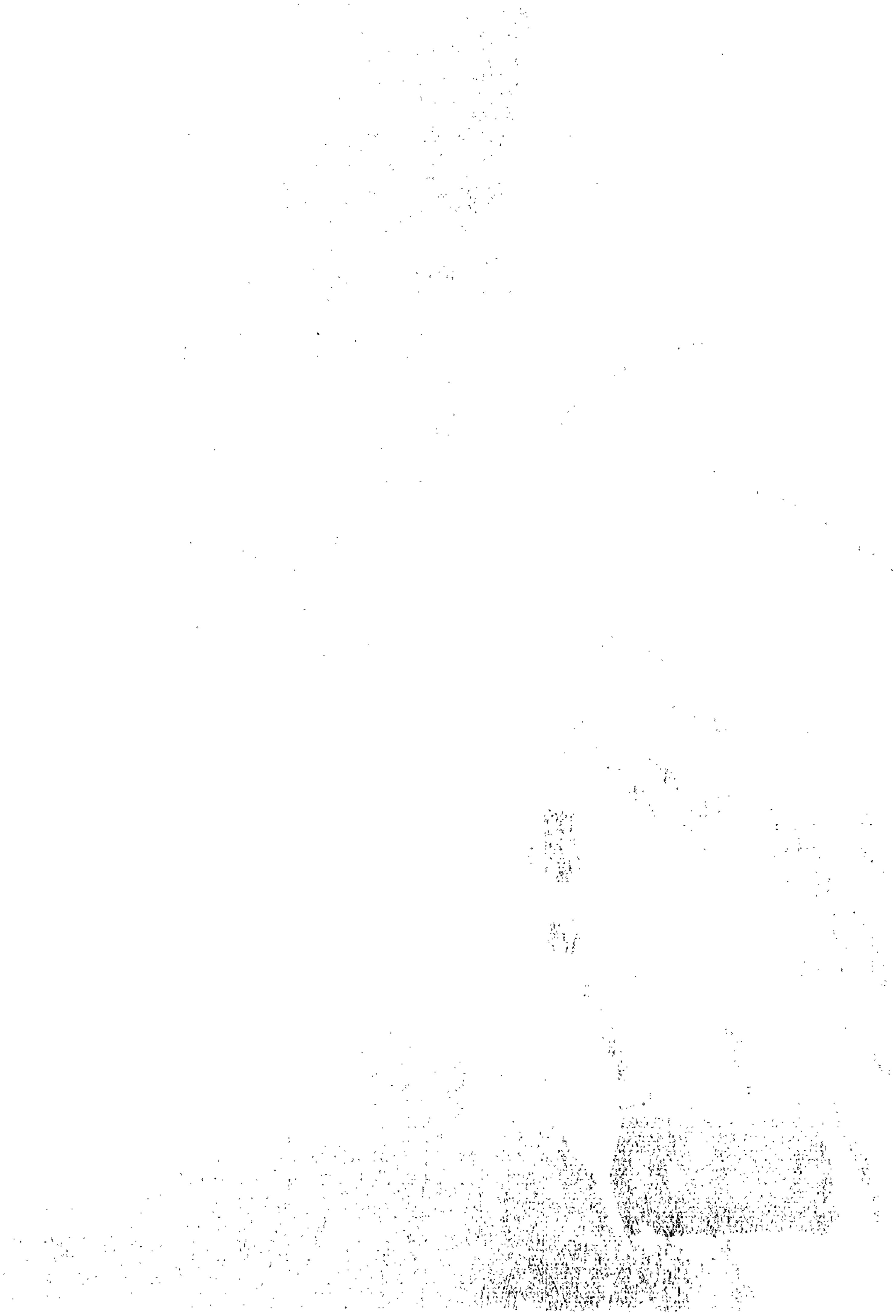


Figure 5.--Diagram of locomotive.



The interlocking at Longview Junction South, MP 102.54, consists of a double crossover. The south crossover permits trains to cross from main track 1 to main track 2, and the north crossover permits trains to cross from main track 2 to main track 1. (See figure 7.) Each turnout is electrically operated and remotely controlled by the dispatcher in Seattle.

Postaccident inspection of the switch points of the turnout on main track 2 of the north crossover revealed abrasive marks on the back side of the switch point rail, where the switch point would be against the stock rail when aligned for a diverging route. The switch point rails were aligned for a straight through train movement, with about a 1-inch gap between the straight stock rail and the curved switch point rail. The turnout switch point was chipped, and the throw rod was bent. (See figure 8.)

The last track geometry tests were performed on September 23, 1993, on track 2 and on September 27, 1993, on track 1. No FRA reportable defects were noted. The most recent maintenance on the north crossover was on the turnout; a track frog had been replaced in August 1993.

Signal.--The intermediate automatic block signal[2] (intermediate signal) has a number plate reading 1007 and is near MP 100.7 (see figure 9). The intermediate signal is about 9,006 feet north of the north absolute signal[3] for Longview Junction South interlocking and governs southward movements on main track 2 between itself and the absolute signal. The intermediate signal is approach activated[4] and is designed to display one of four aspects: clear, approach, approach medium, and restricted proceed. (See appendix E.)

The engineer of train 59 reported to investigators what he thought was a problem with the intermediate signal. He stated that on one of his trips after the accident, he had passed the signal. When he looked back at it, he noticed that it was not lit. He was expecting to see a red signal. After he reported the signal, its manufacturer, Harmon Industries, sent one of its field engineers to test the track circuit components and found that the system was operating in accordance with the specifications. A BN signal engineer stated that the intermediate signal is controlled by electronic coded track circuits (Electro Code Signal System). The signal is one of several automatic block signals on the BN system that are located within yard limits; and for many yard train activities, it is designed to display a signal indication only when required for the appropriate train movement and to remain unlighted at other times.

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[2]A general term applying to any signal device that operates automatically.

[3]A block or interlocking signal designated by an *A* marker or the absence of a number plate. An absolute block is a block in which no train is permitted to enter while it is occupied by another train, except as prescribed by the rules.

[4]Only lights up when a train is in that section of track that the signal controls. At all others times, the signal remains dark.

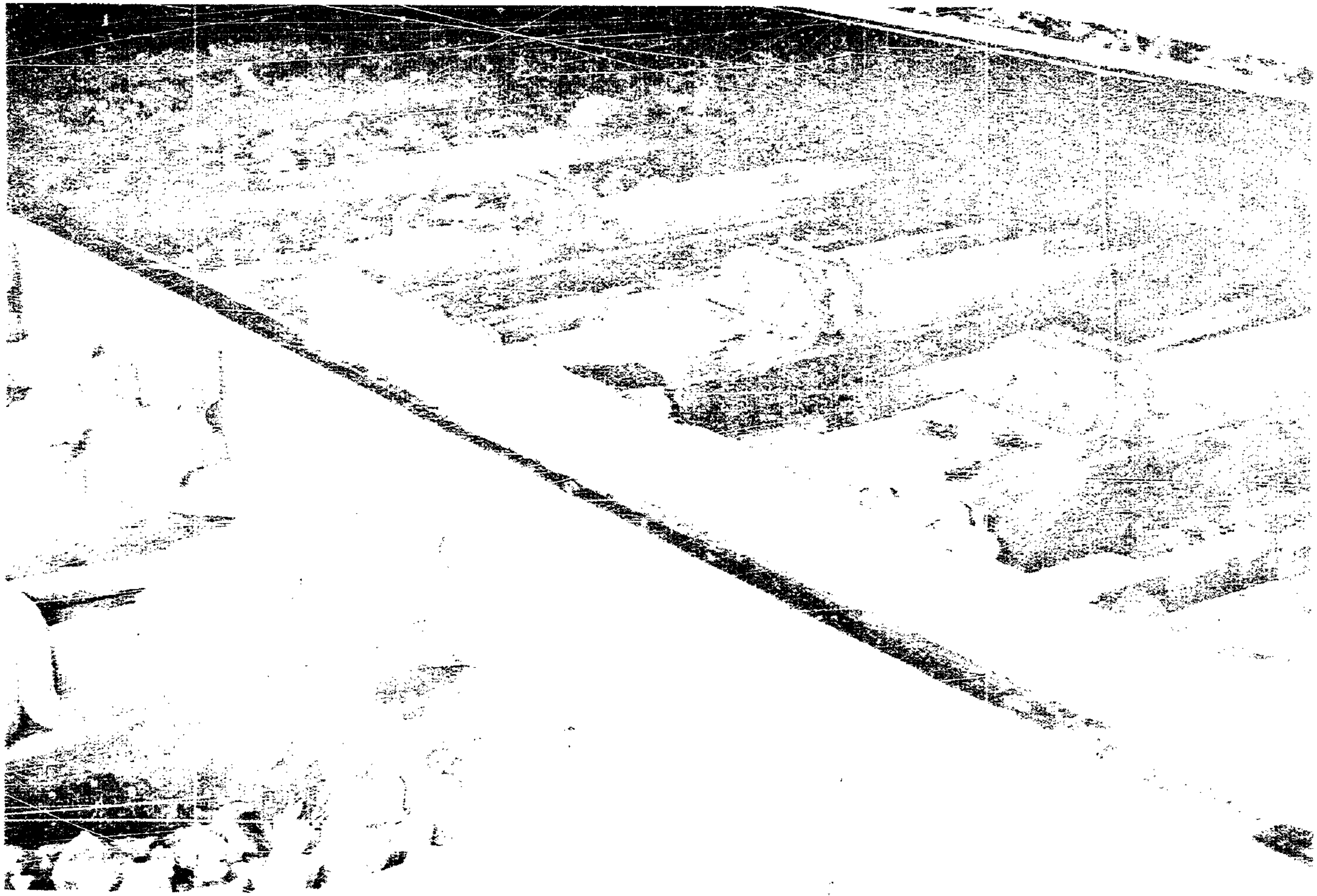

Figure 8.--Damaged switch point of turnout on main track 2 of the north crossover.

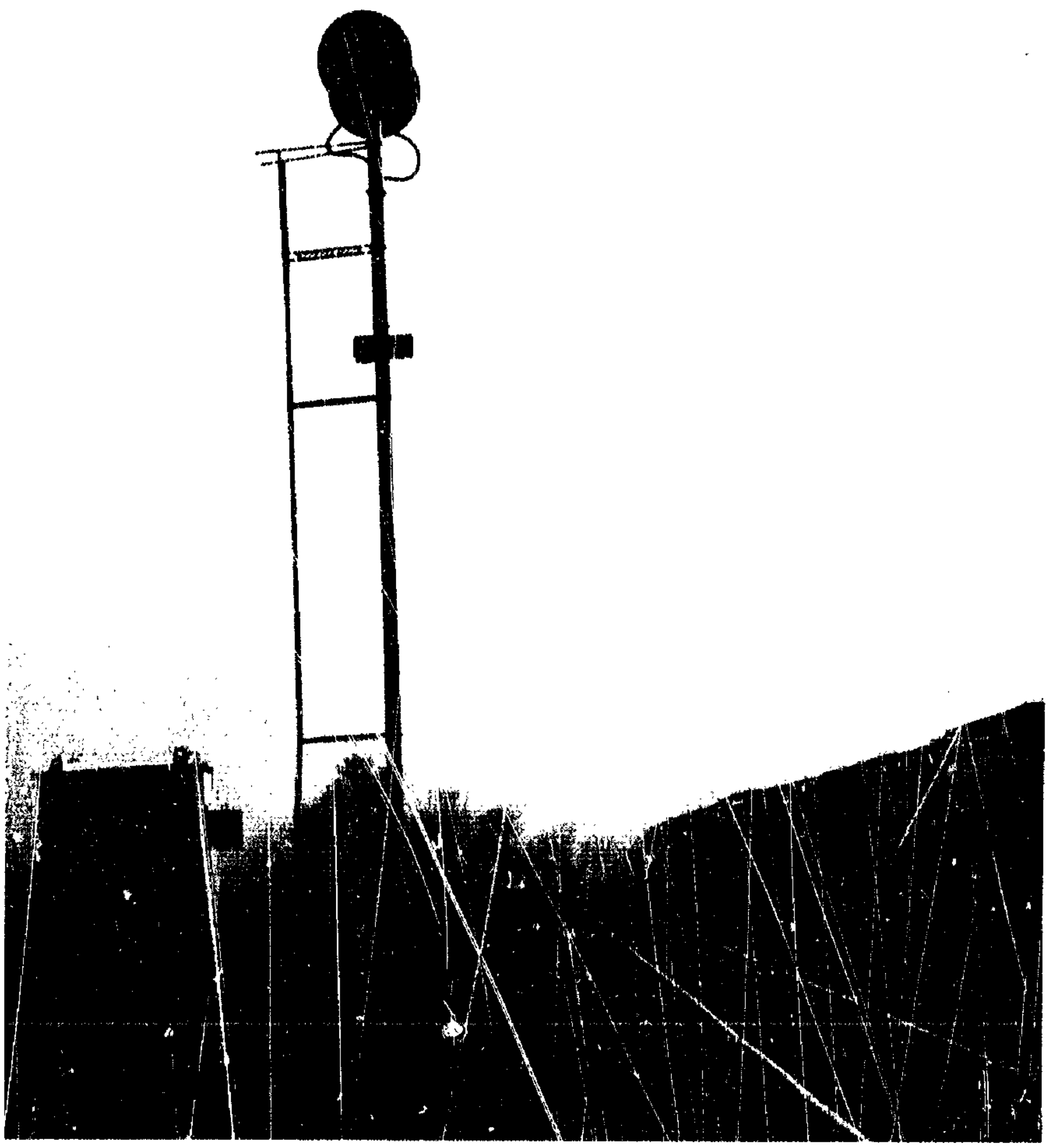

Figure 9.--Intermediate signal, looking south.

Safety Board investigators inspected the signal system, observed the track switches for proper alignment, and reviewed pertinent signal inspection reports. All FRA and BN signal appliance tests were up to date.

When signal department personnel arrived at the accident scene, it was noted that the crossover had been set (switches reversed) and train 111 had run through the switch at the south end of the crossover (track 2). The relays in the Longview Junction South signal box were in correspondence for a crossover move, indicating that the reversing of the crossover had been completed.

Operations Information

The collision occurred on the BN Railroad, Pacific Division, Seattle Subdivision. The movement of trains over this territory is governed by the *General Code of Operating Rules* dated October 29, 1989, and by timetable instructions. The territory where the accident occurred is within a centralized traffic control (CTC) system under the direction of the Centralia South BN train dispatcher in Seattle, Washington.

The Centralia South dispatcher who was on duty at the time of the accident stated that he had had both trains routed on main track 2 because train 59 was on main track 1. He said that his plan was to have train 111 and train 09 meet at Longview Junction South interlocking. The train dispatcher decided to let train 09 proceed through Longview Junction South ahead of train 111 because he thought that train 09 would be there first.

The train dispatcher then entered commands into the CTC system, via his computer, to route train 09 through the crossover from main track 2 to main track 1. The computer accepted the commands. The route was clear for a northbound crossover at 12:12:56 a.m. The train dispatcher stated that he had had no radio conversations with either train 111 or train 09 before the collision.

Meteorological Information

Official surface weather reports were taken for the Kelso-Longview Airport for November 11, 1993, one at 12:16 a.m. (8 minutes before the accident) and one at 12:36 a.m. (12 minutes after the accident). At 12:16 a.m., the temperature was 30 degrees F, with ceiling 500 feet overcast. The wind was 040 degrees at 4 knots, and visibility was 0.6 miles. At 12:36 a.m., the temperature was 31 degrees F, with ceiling 200 feet overcast. The wind was calm, and visibility was 0.2 miles.

Weather conditions on the night of the accident were also described by several witnesses. Two witnesses, who were traveling on Interstate 5, stated it was clear at the accident location. They also described the weather just north of the accident site as "really foggy, a half a mile up the road." Two railroad employees described the weather. The engineer of train 59 said it was foggy with visibility ranging from 1/16 to 1/4 mile and that there was about a 1- to 2-mile-an-hour south-southeast wind causing the fog conditions to vary. The conductor of train 59 stated he could see about 2 to 3 (rail) car lengths, or about 150 to 225 feet. Emergency response personnel reported dense fog at the accident location.

The conductor of train 59 testified that 3 months after the accident he was traveling south on main track 2 in conditions similar to those on the night of the accident. He stated that the intermediate signal "being high in the fog and looking out in the fog with the headlights shining, your visibility is greatly decreased. The block [signal] is visible for just a few brief moments."

Medical and Pathological Information

Fatalities.--The 40-year-old train 111 engineer died from blunt-impact head and chest injuries. The 56-year-old train 111 conductor died from massive blunt-force trauma of head and chest. The 49-year-old train 111 brakeman died from blunt-impact head injuries (basilar skull fracture). The 41-year-old train 09 engineer died of multiple fractures and internal injuries. The 50-year-old train 09 conductor died of massive blunt-force trauma of head and chest.

Toxicological testing.--Postmortem toxicological tests were performed on the five deceased crew members and on samples from the BN dispatcher. The tests required by the FRA found no evidence of drug or alcohol use by any of the personnel. Although the brain blood and brain specimens from the UP conductor were positive for ethanol (0.032 percent and 0.058 percent, respectively), the results were attributed to postmortem microbial ethanol production.[5]

Wreckage

Train 09.--The lead locomotive of train 09, UP 2475, upon collision overrode MRL 305, the lead locomotive of train 111. UP 2475 landed perpendicular to the track and upside down on the trailing two BN locomotives, crushing the engine compartment. The fuel tank and trucks were stripped off.

The second unit, UP 3388, followed the first UP unit, UP 2475, in a "pile-on" fashion, also landing upside down and partially on top of the front half of UP 2475. UP 3388 was also stripped of its trucks and fuel tank. A BN gondola from train 111 landed on top of UP 3388, which lay roughly parallel to the lead UP unit and also perpendicular to the track.

The third UP unit, UP 3515, was damaged on the left side and rear end.

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[5]Postmortem alcohol production levels exceeding 0.15 percent (150 mg/dL) have been reported in the forensic science literature, e.g. Canfield, D.V. Kupiec, T., and Huffine, E., "Postmortem Alcohol Production in Fatal Aircraft Accidents," *Journal of Forensic Sciences*, JFSCA, Vol. 38, No. 4, July 1993, pp. 914-917.

Train 111.--The cab of the lead locomotive was separated from the rest of the unit and was found off the east end of the deck of unit BN 2255. The locomotive lay in an "L" shape around a gondola car and half underneath UP 3388. A portion of MRL 305 was crushed between the wreckage of the second BN locomotive BN 8160, and the third UP unit, UP 3515. MRL 305 was totally destroyed, partially crushed, buried, and burned.

The second unit was BN 8160. The front right (engineer's) side had been crushed on the short hood of MRL 305 and UP 3515. BN 8160 lay with the cab in the direction of travel, slightly askew toward Interstate 5 and across main track 2. This unit had extensive superstructure crush damage above the electrical cabinet and on the right side of the diesel engine compartment.

The third unit was BN 2255. The deck (frame and floor) lay perpendicular and across the main track 2, stripped of all superstructure and the trucks but retaining the fuel tank.

The fourth and fifth BN units, BN 2729 and BN 1954, were also completely destroyed and burned. These units were broken up and partially buried under the lead UP locomotive, UP 2475.

Fire.--The impact ruptured the fuel tanks of six of the eight locomotives. There were fires among those six locomotives as a result of the spilled diesel fuel. An eyewitness to the accident described the collision as a "major explosion." Another eyewitness stated that "there was just fire and devastation." The first fire fighting unit that arrived on the scene, at about 12:36 a.m., initiated fire suppression activities in an attempt to knock down the flames surrounding the locomotives. The on-scene commander assessed the situation and concluded that there was no possibility of anyone surviving the fires, which were enveloping the locomotives. Therefore, in order to prevent further environmental damage from the leaking fuel tanks, the fires were allowed to burn themselves out. At 2:38 p.m., the last of the fires burned out because all of the diesel fuel had been burned up.

Survival Aspects

Emergency response.--About 12:24 a.m., the Cowlitz County, Washington, District 2 Fire and Rescue Communications Center received an emergency 911 telephone call from an unidentified caller. About 12:25 a.m., the first emergency unit was dispatched to the scene. It arrived at 12:35 a.m. and established a command post. The rest of the initially dispatched units arrived within minutes thereafter and began fire suppression activities. The following emergency vehicles were initially dispatched: two class A fire engines, one water tender (2,500 gallon), and one medical aid unit. About 12:36 a.m., the Communications Center asked for help from other companies. The total number of fire and rescue units responding to the accident included 9 class A fire engines, 12 water tenders, 4 medical aid units, 2 private ambulances, 5 mini pumpers, 6 command units, and 6 support vehicles.

The Battalion Chief of the Cowlitz District 2 Fire and Rescue was the designated incident commander throughout the course of the fire and rescue operations. A security zone was established to control all fire fighting and medical response activities, as well as to control the crowd.

Disaster preparedness.--The Cowlitz County Comprehensive Emergency Management Plan (Plan) was put into effect at 12:34 a.m. At that time an emergency operations center (EOC) was established by the County Emergency Management Agency at the Cowlitz County Hall of Justice. The implementation of the Plan entailed notifying all law enforcement agencies in the county, including the sheriff's department, as well as State and local police departments. In addition, local hospitals were notified of the accident and were put on emergency alert to be prepared to receive casualties. A hospital medical representative was dispatched to the EOC and directed all emergency medical operations, including notifying the surrounding jurisdictions of the need for mutual aid.

The Cowlitz County Fire Department had performed an emergency fire and rescue drill with the BN Railroad in June 1992. They also performed a disaster drill in June 1993, simulating a mass casualty disaster involving a school bus.

Tests and Research

Sight distance tests.--On November 14, 1993, the Safety Board conducted sight distance tests at the site of the accident from 2:15 a.m. until 5:00 a.m. The weather was clear, dry, and cold and did not restrict visibility.

Locomotive BN 2285 (GP38-2) was used to simulate train 111. Locomotive BN 1841 (GP-9) was used to simulate train 09. The locomotives were positioned short-hood end to short-hood end (the configuration of the trains involved in the collision) at the approximate point of impact.

The locomotives were moved away from each other, and seven distances were measured. Test results appear in appendix G. The results of the test indicate that the engineer on train 111 under clear conditions could first see the absolute signal when he was about 2,104 feet north of it. Also both engineers could have seen each other under clear conditions when they were about 1,536 feet apart. When they were 983 feet apart, they could have determined that they were on the same track.

Event recorders.--The event recorders that were recovered in this accident were the type that record data on an eight-track magnetic tape cartridge. Such recorders provide data about speed, distance, time, traction motor amperage, throttle position, locomotive and automatic brake application, and direction of travel.

All three of the train 09 locomotives were equipped with event recorders. The one from the lead unit, UP 2475, was not found and was presumed to have burned. The one from the second unit, UP 3388, was found in the wreckage but had been so damaged by the fire that the data pack and internal components of the recorder had melted. The one from the third unit, UP 3515, was in good condition, but no data pack was installed in the recorder. As a result of the fire damage to two of the event recorders and the lack of recording media in the third, no event recorder data is available for train 09.

Four of the five train 111 units were equipped with event recorders, but only two survived the postaccident fire. They were from the lead unit, MRL 305, and the second unit, BN 8160. The event recorders from the third and fourth units, BN 2729 and BN 2255, respectively, were not found and were presumed to have burned. (The fifth unit, BN 1954, was not equipped with an event recorder.)

Although the data pack from the lead unit was recovered, its tape had separated from the data pack into multiple pieces, the remains of which had sustained significant tears and punctures, as well as dirt, diesel fuel, and fire fighting fluid contamination. The tape was so damaged that the Safety Board lab did not attempt to recover data from it.

The event recorder from the second unit was in good condition and was initially read out by the BN, both on the scene and at its facility in Overland Park, Kansas. The Safety Board lab performed a train movement study from the data pack and determined the following:

Train 111 passed the intermediate signal about 12:20:27 a.m. at a speed of 39 mph with the throttle in position number 3 and all brakes released. The throttle position began increasing approximately 10 seconds after the lead unit passed the signal. The throttle position then progressively increased to number 7 about 12:22:30 a.m. at some point near MP 102.10.

According to the train movement study, about 12:22:42 a.m., the train was near MP 102.23 and going 40 mph. The throttle was at position number 7. Less than 10 seconds later, when the train was near MP 102.29, the throttle had been reduced to position idle/1/2. About 12:23:05 a.m., near MP 102.49, an automatic brake application was initiated. This application reached a total of 18 psi about 12:23:16 near MP 102.61.

The train movement study indicates that the lead unit of train 111 passed the absolute signal at approximately 12:23:02 a.m. at a speed between 39 and 40 mph. The train brakes went into emergency braking about 12:23:28 a.m. near MP 102.73. The study showed that train 111 hit train 09 at approximately 12:23:34 at MP 102.80 at a speed of 35 mph. A simulation run was conducted for train 111 to determine the stop distances. The stopping distance from 40 mph for train 111 was 2,112 feet after an emergency brake application.

The Safety Board could not determine the speed of train 09 since no event recorder information was available.

ANALYSIS

General

The Safety Board concludes that the train equipment, the track, and the signal system functioned as designed and that the train dispatcher's activities were normal. Nothing in the predeparture tests, the postaccident equipment inspection, or the event recorder data indicated any equipment failure. Also, no mechanical problems were reported by the train crew while the train was en route. Pre- and postaccident track inspection and measurements showed no defects or any deviations from FRA track safety standards. Pre- and postaccident inspection of the signal system indicated it functioned as designed. A review of the pertinent signal-inspection reports showed no deficiencies that would prevent proper operation of the signal system. Observations and tests indicated that the signals and the switches functioned properly. In a submission to the Safety Board, the Brotherhood of Locomotive Engineers raised the issue that the signal system may have been worked on before the FRA and Safety Board investigators arrived on the scene. The Safety Board has absolutely no evidence to indicate that the signal system was tampered with after the accident. There was also no evidence of any failure of the signal system itself. All tests conducted on the signal system and an analysis of the dispatcher's actions and the physical evidence--the run-through switch--indicate that the signal system worked as designed. As confirmed by the centralized traffic control computerized log, the train dispatcher experienced no difficulty in requesting and receiving the route for train 09. The train dispatcher demonstrated sufficient knowledge of centralized traffic control procedures and dispatching duties.

The Safety Board concludes that neither the dispatcher nor any crewmember of either train was impaired by alcohol or drugs. Their toxicological test results were negative. A review of the crewmembers' work records and interviews with family members, co-workers, and supervisory personnel provided no evidence of fatigue. The event recorder tape recovered from train 111 shows that the engineer was actively controlling his train as he approached the intermediate signal. The transcript of a radio tape recording shows the train 111 conductor holding a conversation with the yard clerk less than 2 minutes before the train passed the intermediate signal. Each member of both train crews had had the necessary training and experience to competently perform his duties. Each member had passed BN or UP physical and visual examinations and rules tests and had been observed and tested on stop signal and operational train movements.

The Accident

Train 111 passed the intermediate signal without the train crewmembers taking any action to reduce speed. It continued south on main track 2 past the absolute signal and struck train 09 head on. Train 09 had been given a clear signal to cross from main track 2 to main track 1 at Longview Junction South interlocking. The portion of track on which the collision occurred did not have a positive train separation control system. There was no automatic back-up control system in place to stop train 111 short of the absolute signal in the event that the locomotive engineer and crew did not respond to the restrictive signals.

The Safety Board examined two major safety issues: (1) the adequacy of wayside signals for capturing a train crew's attention, and (2) positive train separation. In addition, the Board looked at the survivability and crashworthiness of event recorders and locomotives and at calling signals..

Adequacy of Wayside Signals for Capturing a Train Crew's Attention

Control actions of train 111 engineer.--As train 111 proceeded southward past the yard office, the intermediate signal was displaying an approach aspect. That aspect required the engineer to be prepared to stop his train at the next signal and, if he was exceeding 35 mph, to immediately reduce to that speed (Rule 236). The event recorder data established that train 111 passed the intermediate signal at 39 to 40 mph with the engines in throttle position 3. About 10 seconds after the head end of the train passed the signal, the throttle was progressively increased and at MP 102.10 reached position 7. The throttle increases are consistent with what an engineer should do if he thinks he is proceeding on a clear signal. However, increasing the throttle position is the opposite of what an engineer should do if he realizes he has just passed an approach signal at a speed exceeding 35 mph and has to immediately reduce to that speed. The Safety Board concludes that the crew did not see the intermediate signal.

As part of their qualification procedures, locomotive engineers are required to know the location of each wayside signal. If they are unable to determine the signal aspect because of the absence of a light (burned-out bulb), a failure of the signal system, or poor visibility, they must take action. They are required to regard the signal as the most restrictive indication that can be given by that signal. Absence of a light at the intermediate signal would have required that the crew slow the train to restricted speed (not exceeding 20 mph), a speed that permits the train to be stopped within one-half the range of the engineer's vision, thus short of a train or other obstruction.

Sight distance tests established that when train 111 reached MP 102.10, the engineer would have been able to see the absolute signal had the weather been clear. Yet the engineer took no action to slow the train until he initiated a rapid throttle decrease to idle/1/2 about MP 102.23. His action was most likely because he had seen the stop signal ahead of him. He was then about 1/4 mile from the absolute signal (MP 102.46), a distance consistent with the reports of reduced visibility that night. Since the stopping distance for his train from 40 mph was 2,112 feet (0.4 miles), it was already too late to stop the train short of the absolute signal.

At that point, train 09 would not have been in sight even in clear weather. Thus, the train 111 engineer probably did not realize the urgency of the situation; otherwise he would have immediately gone to an emergency brake application. Instead, he initiated an automatic brake application within ±200 feet of the absolute signal, with the brake pipe pressure reduction reaching 18 psi about MP 102.60. He might have interpreted the situation as a dropped signal.[6] Although Rule 304, "Change of Indication," required him to stop the train at once, he may have intended to allow for gradual slack adjustment[7] so that he could stop the train safely.

The train 111 engineer put his train into emergency braking somewhere between MP 102.67 and 102.73. As confirmed by postaccident sight distance tests, it was at this point that the engineer could first have seen that train 09 was on the same track. The Safety Board concludes that the crewmembers of train 111 did not control their train to comply with the intermediate signal and did not take timely action to stop at the absolute signal, which was displaying a stop indication.

The Safety Board examined a number of factors to attempt to determine why the crew of train 111 did not comply with the approach aspect of the intermediate signal and consequently was unable to stop at the absolute signal. The subsequent analysis is made from two perspectives. First, an analysis is made of some possible sources of distraction for the train crew. Second, because this accident has parallels with numerous train collisions that the Safety Board has investigated, an analysis is made of a systemic safety issue--the adequacy of passive wayside light signals to reliably capture a train crew's attention in the face of competing sources of attention.

Reduced conspicuity of the intermediate signal due to fog.--A sight distance test done at night in clear weather determined that the intermediate signal is visible from a southbound train at a distance of 1,997 feet. The weather on the night of the accident, however, was described by several witnesses as very foggy.

In clear weather, the intermediate signal first becomes visible immediately after a southbound train passes the yard office (which is 2,059 feet north of the signal). The engineer of train 59, which was in the Longview yard when train 111 passed, testified that visibility at the time of the accident varied from 1/16 to 1/4 mile (330 to 1,320 feet) because of the fog. The conductor of train 59 testified that he had commented to his brakeman that night on how dense the fog was. The conductor told Safety Board staff that "you could only see about 2 or 3 [rail] car lengths" (about 150 to 225 feet).

After the accident, the conductor of train 59 traveled down main track 2 in conditions which he described as being similar to those on the night of the accident. He stated that the intermediate signal "being high in the fog and looking out in the fog with the headlights shining, your visibility is greatly decreased. The block is visible for just a few brief moments."

Train 111 was traveling at 40 mph when it passed the yard office. Thus, the intermediate signal would have been in view for a maximum of about 34 seconds in clear

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[6]A signal that unexpectedly changes to a less favorable aspect.

[7]See Rule 302A, "Slack Control," in appendix B.

weather and for as little as 6 seconds if fog had reduced visibility to 1/16 mile. The Safety Board concludes that the crew of train 111 did not see the intermediate signal. Fog may have reduced the viewing distance and consequently the amount of time in which the crew could have seen the signal. However, the crew was qualified and familiar with the territory and should have been alert for the signal.

Distraction from the radio conversation.--Between 12:17:46 and 12:18:38 a.m., the BN conductor initiated and maintained a radio conversation with a clerk at the Longview yard office. (See appendix C.)

At a postaccident deposition proceeding, the BN Director of Operating Rules and Practices was asked whether the conversation could be considered proper radio procedure. He responded:

> No identification of who they're talking to. You don't know when the conversations are done or when they begin. So no identification. No use of "over." The operator does once, I think, say "over" in here [referring to the communication transcript]. There's more wrong than right. It really doesn't have anything to do with the railroad operation. There's not very much that was done correctly.

General Code of Operating Rules 502, 506, 507, 510, and 511 are applicable to this radio conversation and are listed in appendix B. The investigation determined that the conversation was unnecessary.

The yard clerk testified that he recognized the voice on the radio as the train 111 conductor ("I'd know his voice anywhere") and that the conductor always knew who was working on any given night. The clerk added that he usually waved to the conductor when the train went by.

When the conversation ended, train 111 was about 3/4 mile from the yard office. About 70 seconds later, the engines passed the office, which is to the right of the track at MP 100.31. The unnecessary radio communication may have been the subject of continuing discussion among the train crewmembers and drawn their attention to the right as they looked for the clerk to wave from his office.

The radio conversation may have increased in another way the likelihood of the crew missing the signal. The conductor would have had to get out of his seat to pick up the radio handset (see figure 5). Had he remained standing after the conversation, his ability to see signals ahead would have been restricted by the height of the windshield, and his body may have partially obstructed the engineer's view of the left side of the track, where the intermediate signal was.

Other sources of distraction.--As train 111 was passing the Longview yard, train 59 was moving northward up through the yard to the right of the main tracks. This movement may have contributed to drawing the attention of the crewmembers away from maintaining a visual search for the intermediate signal, which was ahead and to their left.

Vigilance for signals.--The concept that wayside signal systems will safely control train movements is founded upon the belief that train crews will unfailingly observe and properly respond to those signals. That belief is codified in an extensive set of operating rules.[8] Among the rules relevant to signals is Rule 7(A), "Vigilance for Signals," which states that "all employees must keep a vigilant lookout for signals and act upon them strictly in accordance with the rules." Rule 34, "Observe and Call Signals," requires that all crewmembers in the control compartment of an engine observe and communicate signal aspects to one another and stop the train if the engineer or conductor fails to take action. Even unusual circumstances, such as the restricted visibility due to fog at the time of the Kelso accident, are addressed by the rules. Rule 101, "Precautions Account Unusual Conditions," states that "when conditions exist which may impair visibility...speed must be regulated to ensure safe passage and to ensure observance and compliance with signal indications."

The crew of train 111 was familiar with these and the other rules of the *General Code of Operating Rules*. They had all successfully completed rules examinations within the mandated period of time and, during the 2 months preceding the accident, had passed one or more unannounced tests of their compliance with signals. The crewmembers knew that adherence to the rules was necessary to safeguard their lives and their livelihood since Rule A states that "Obedience to the rules is essential to safety and remaining in service." Yet, the investigation determined that the crewmembers demonstrated a lack of vigilance that probably contributed to their demise. The repeated finding that crews are not attending to wayside signals suggests that a reevaluation is needed of the current system, which relies exclusively on a crew's vigilance regardless of the conditions existing at the time.

The belief that the human operator will infallibly see and respond to light signals is not well founded. An abundance of empirical data demonstrate that sustained vigilance is one of mankind's less reliable abilities. Mackworth[9] conducted an extensive series of laboratory vigilance tests. He consistently found that an operator's reliability in detecting a visual signal declined significantly within the first hour of performing the task. More than a decade later, Buckner and McGrath[10] replicated Mackworth's findings. In addition, Buckner and McGrath

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[8]In the Kelso accident, the BN and UP crews were operating under the *General Code of Operating Rules*, 2nd ed., effective October 29, 1989.

[9]Mackworth, N. H. (1950) *Researches on the measurement of human performance*. Medical Research Council Special Report Series No. 268. London: HM Stationery Office.

[10]Buckner, D. N., and McGrath, J. J. (1963) A comparison of performance on single and dual sensory mode vigilance tasks. In D. N. Buckner and J. J. McGrath (Eds.), *Vigilance: A Symposium*. New York: McGraw-Hill.

found that although an operator is more reliable in detecting an auditory signal than a visual one, and even more reliable in detecting paired visual and auditory signals, his performance is never 100 percent reliable and declines sharply within an hour.

In an operational setting, there is evidence that people simply may not spend as much time "looking" as is expected of them. Hermann[11] found that operating bridge look-outs at sea typically spent only 48 minutes of each hour on duty actually watching the sea. A look-out who was distracted by the presence of a superior officer spent as little as 32 minutes an hour watching the sea. While the studies presented above provide strong evidence that human vigilance is unreliable, investigation of railroad collisions provides compelling evidence that wayside signals are at times inadequate for gaining human attention.

Previous train collisions attributed to a lack of vigilance for wayside signals.--The Safety Board has investigated numerous train collisions in which the probable or contributing cause was a train crew's inattention to wayside signals. The accidents have disturbing parallels with one another and with the Kelso accident. A partial list of the accident reports is given in appendix F. The listing is not intended to be complete, but rather, to characterize the systemic nature of the problem.

On first inspection of the list, the accidents appear to be a diverse lot. They are separated in time (1986-1993) but have occurred relentlessly year after year. They are also widely separated in place, quite literally, across the length and breadth of this country--from Massachusetts (NTSB/RAR-87/02) to California (NTSB/RAR-91/03) and from Indiana (NTSB/RAR-92/02/SUM-93/03) to Georgia (NTSB/RAR-91/02). In part correlated with that geographic diversity, the involved trains were operated by eight different carriers. Therefore, the accidents cannot be attributed to the management oversight, operating rules, or training practices of a particular company.

One-third of the reports in appendix F are of collisions involving commuter or passenger trains (NTSB/RAR-87/02, -88/01, and -93/03). Those three accidents accounted for a disproportionate share of the total numbers of people killed or injured in the nine accidents: 62 percent of the 36 fatalities and 96 percent of the 438 people injured. These data do not minimize the tragic consequences of the six other collisions that involved freight trains exclusively. Each of the latter instances resulted in the death or injury of one or more crewmembers and, in the aggregate, damages in excess of $17 million. Regardless of whether the collisions involve passenger trains or freight trains, the continuing societal consequences are significant.

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[11]Hermann, R. (1977) Two studies for optimizing operating bridges and their application in inland and sea navigation. In D. Anderson, H. Instance and J. Spencer (Eds.), *Human factors in the design and operation of ships*. London: Taylor and Francis, pp. 58-68.

The common thread among these accidents was, ostensibly, the causal role of a failure to observe signals. The specific cause of the inattention varied among accidents. The Chase, Maryland, report (NTSB/RAR-88/01) cited the engineer's impairment from marijuana. In the case of the Yuma, Arizona, head-on collision (NTSB/RAR-88/02), it was determined that the engineer was under the influence of alcohol. The investigation of the Corona, California, collision (NTSB/RAR-91/03) determined that the members of one of the train crews were probably asleep. The several other collisions were attributed variously to the crews' fatigue, lack of vigilance, inattention, or a combination of those factors. In all cases it was found that the signal system "functioned as designed."

In retrospect, it is time now to address the systemic cause of these accidents. The railroad industry needs to recognize that there are limits to human vigilance. Further, it needs to recognize that although wayside signal systems may work electrically and mechanically as designed, the systems do not work as intended--that is, they do not ensure safe train operations. The Safety Board concludes that passive wayside light signals are not wholly adequate because they do not always capture a train crew's attention or provide any safety redundancy or back-up when crewmembers misinterpret, disregard, or fail to pay attention to a signal. The Safety Board continues to believe that advanced control systems that provide positive train separation are necessary to actively ensure safety in train operations.

Positive Train Separation

Introduction.--The Safety Board has long been an advocate of advanced train control systems that have the capability to provide positive train separation (PTS). PTS control systems automatically intercede in the operation of a train to prevent trains from colliding.

About 80 percent of the railroad accidents the Safety Board has investigated over the past 10 years are the result of human error. Train crewmembers are continuously trained, drilled o\n the operating rules, and provided with all the equipment needed to do their jobs. Training, however, is not a guarantee that an individual will take the correct action. Highly trained people still have accidents. PTS control systems provide a back-up to the engineer that ensures that a train is properly controlled.

The Safety Board's objective in recommending PTS is to provide an automatic means of supporting the actions of the train crew. A PTS control system will monitor the engineer's performance as he approaches the limits of his authority or a restricting signal. If he fails to react by not braking the train, the control system will take over, automatically applying the brakes and stopping the train.

The Safety Board has investigated a number of accidents that could have been prevented had a PTS control system been in place.

On August 30, 1991, two BN freight trains collided head on near Ledger, Montana. Both trains were routed over a nonsignaled single track line. A dispatcher in Seattle, Washington, controlled the train's movements by issuing track warrants through a computerized track warrant control system.

The two trains collided head on at a combined speed of 87 mph. Nine locomotives and 22 cars were destroyed, and 9 cars were damaged. Track damage, equipment replacement, and clean up costs were estimated at $19 million. Three crewmen suffered fatal injuries, and four others were severely injured.

The Safety Board investigation found that a read-back error by the train crew not caught by the dispatcher resulted in overlapping authority on a section of track. If a PTS control system had been in place, the position and the authorities of the two trains would have been closely monitored. The trains would have been stopped before they exceeded their authority, and the collision would have been prevented.

On January 18, 1993, two Northern Indiana Commuter Transit District trains collided head on near a gauntlet bridge in Gary, Indiana. The operator of the eastbound train failed to stop his train short of a stop signal. The train stopped in a position where the train fouled the westbound gauntlet track. A westbound train struck the stationary eastbound train head on. Seven passengers died, and 95 people sustained injuries.

The Safety Board determined that the cause of the accident was the inattentiveness of the engineer on the eastbound train, resulting in his passing a stop signal and partially blocking the westbound track. Had a PTS control system been in place, the system would not have allowed him to approach the stop signal at such a high speed. The system would have taken control of the train and stopped it short of the red signal.

The crewmembers of train 111 in the Kelso accident failed to stop the train short of a stop signal. If a PTS control system had been in place, the system would have slowed the train as soon as it passed the approach signal and stopped the train short of the absolute signal. The Safety Board concludes that this accident would have been prevented had the trains been controlled by a fully implemented positive train separation control system.

The list of accidents that might have been prevented by PTS does not end with Kelso. The Safety Board is currently investigating several more, all of which happened after Kelso.

On February 10, 1994, two Kansas City Southern freight trains collided head on near Anderson, Missouri. Four locomotives and five cars were derailed. Three crewmen suffered serious injuries. The accident occurred on a single main track in centralized traffic control territory.

On February 26, 1994, a head-on collision occurred on the Illinois Central (IC) Railroad in Flora, Mississippi. A northbound IC freight train collided with a southbound IC freight train on a 1-degree 30-minute curve. The members of both crews jumped from the lead locomotives just before the collision. The engineer of the northbound train was seriously injured as a result of the jump and died about 7 hours after the accident. The remaining three crewmembers were seriously injured.

As a result of the collision, all four locomotives of the two trains were destroyed. Additionally, the 15 head cars of the northbound train and the 8 head cars of the southbound train were derailed. The evidence indicates that the northbound train did not stop at the meet location designated in the track permit.

On June 8, 1994, the Safety Board investigated a collision involving three BN freight trains near Thedford, Nebraska. An eastbound coal train collided with the rear of a standing coal train. The wreckage from the two eastbound coal trains fouled the westbound track. An empty westbound coal train collided with the derailed locomotives about 10 to 15 seconds after the initial collision.

The engineer and conductor of the striking eastbound train were fatally injured. The engineer and conductor of the westbound train jumped from the locomotive just before the accident. The evidence indicates that the eastbound train did not reduce speed to comply with the restricted proceed signal, which was 2,000 feet from the collision site.

The Safety Board is investigating yet another collision, a head-on one between two Southern Pacific freight trains on July 25, 1994, near Marathon, Texas. Twelve locomotives derailed and caught fire as a result of the accident. All four crewmembers (two per train) were killed.

The eastbound train ran past a stop signal, through a switch, and into the westbound train. The accident occurred in centralized traffic control territory, and all signals had been set to stop the eastbound train so that the westbound train could move into a siding and clear the main track.

In all of these accidents, the trains were unprotected by a redundant back-up system. PTS control systems provide the redundancy that is needed to achieve safe train operations.

Safety Board's position on PTS.--The Safety Board first made recommendations about preventing collisions after a fatal head-on collision in Darien, Connecticut, between two Penn Central commuter trains. The accident occurred on August 20, 1969. Four persons were killed, and about 43 were injured.

As a result of the Darien accident, the Safety Board recommended that:

> The Federal Railroad Administration, if it receives additional statutory authority under legislation now in progress, study the feasibility of requiring a form of

automatic train control at points where passenger trains are required to meet other trains. (R-70-20)

In response to Safety Recommendation R-70-20, the FRA funded a special study at the Department of Transportation's Systems Center. The results indicated that the best system would appear to be a hybrid, composed of both present and proposed levels of mechanical control. However, because of the costs and necessary extensive installation, it did not appear possible at the present time. On August 20, 1975, the recommendation was classified "Closed--Acceptable Action."

After its investigation of a May 1986 rear-end train collision at Brighton, Massachusetts, the Safety Board issued Safety Recommendation R-87-16 to the FRA:

> Promulgate Federal standards to require the installation and operation of a train control system on main line tracks that will provide for positive separation of all trains.

Currently, the recommendation is classified "Open--Acceptable Response." The Safety Board included PTS on its list of most wanted transportation safety improvements in 1990.

Additional accidents that were related to PTS occurred in Chicago, Illinois, on October 30, 1972; New York, New York, on January 2, 1975; Meeker, Louisiana, May 30, 1975; Seabrook, Maryland, on June 9, 1978; North Platte, Nebraska, on July 10, 1986; and Chase, Maryland, on January 4, 1987. Each investigation resulted in recommending that the railroads involved provide automatic train control to back up the engineer in the event that he fails to react. Additional recommendations on automatic train control were made as a result of accidents in Boston, Massachusetts, on November 12, 1987; in Sugar Valley, Georgia, on August 9, 1990; and most recently in Ledger, Montana, on August 30, 1991.

After its investigation of an August 9, 1990, collision and derailment of two Norfolk Southern freight trains at Sugar Valley, Georgia, the Safety Board issued Safety Recommendation R-91-25 to the FRA:

> In conjunction with the Association of American Railroads and the Railway Progress Institute, expand the effort now being made to develop and install advanced train control systems for the purpose of positive train separation.

Currently, the recommendation is classified "Open--Acceptable Response." The Safety Board believes that the FRA's train control report to Congress and the pilot test by the BN and the UP deserve recognition. Based on the level of effort underway, the Safety Board has classified Safety Recommendation R-91-25 "Closed--Acceptable Action."

On July 29, 1993, as a result of the Ledger, Montana, accident investigation, the Safety Board issued Safety Recommendation R-93-12 to the FRA:

> In conjunction with the Association of American Railroads and the Railway Progress Institute, establish a firm timetable that includes at a minimum, dates for final development of required advanced train control system hardware, dates for a implementation of a fully developed advanced train control system, and a commitment to a date for having the advanced train control system ready for installation on the general railroad system.

The recommendation was classified "Open--Acceptable Response" after the FRA took a proactive position with the railroad industry by seeking final system definition, development migration path, and a timetable by the end of 1994.

The Ledger, Montana, recommendation resulted from years of frustration with the response of the industry to the Safety Board's prior recommendations. The Safety Board acknowledged the research and testing that has been conducted on PTS hardware, but it was the Safety Board's view that development work on a practical PTS control system was not progressing as quickly as it should. Member railroads of the Association of American Railroads (AAR) had been testing components of an advanced train control system for years. The AAR, however, has yet to demonstrate a fully implemented system that provides PTS.

Until fall 1992, there were two projects on advanced train control. The BN had a working PTS control system that was called ARES (advanced railroad electronics system). The AAR had a program to develop a land-based transponder PTS control system known as advanced train control system or ATCS.

The BN's ARES system was based on satellite-based communications. Train locations were determined by using the Global Positioning Satellite (GPS) network. The BN demonstrated ARES on a 300-mile loop of track on the Iron Range in Minnesota. The BN equipped its locomotives with ARES equipment and used the system to control trains. ARES had the ability to locate trains with respect to the track profile. An onboard computer used the signals to calculate the specific location of the train. The location was transmitted by the railroad's voice (VHF) radio system to a central office. The location of trains could be determined to an accuracy of about 150 feet. If an engineer failed to slow for a signal, ARES first warned him of the upcoming signal. If he still did not take action, ARES took over and stopped the train.

ARES made a lasting impression on many in the railroad industry. The National Railroad Passenger Corporation (Amtrak) attempted to obtain funding so that ARES could be installed on that portion of the BN on which Amtrak passenger trains operate. Amtrak also wanted ARES installed on its own tracks between Porter, Indiana, and Kalamazoo, Michigan. It was a setback in the progress toward prevention of train collisions when the BN decided to abandon the advanced, field-tested, and field-demonstrated technology of ARES in fall 1992.

The AAR had sponsored ATCS since the early 1980s. The ATCS approach was very similar to the ARES approach regarding wayside, locomotive, and dispatcher control. The

ATCS method, however, used land-based transponders to determine train location rather than signals from NAVSTAR global positioning satellites.

In December 1993, the Safety Board discussed PTS in detail during its meeting about the Gary, Indiana, accident. The Board expressed concern about the lack of progress in developing a PTS control system. Shortly after, however, the FRA Administrator began addressing the subject in round-table discussions with industry, and the program began to move forward.

These round-table discussions resulted from the Safety Board's recommendations and the Railroad Safety Act of 1992. The FRA was directed by Congress to investigate the status of ATCS and review the potential for ATCS to provide PTS that would be compatible nationwide.

Talks with the AAR and railroad industry representatives resulted in some basic decisions. The participants in the meeting identified PTS and speed control as essential safety elements in an advanced train control system. PTS would prevent collisions, and speed control would automatically ensure compliance with speed restrictions for track geometry or temporary slow orders.

This past spring, the BN and the UP announced their intention to establish a positive train control (PTC)[12] demonstration project on 750 miles of UP and BN track in the northwestern United States. The demonstration area will include the site of the Kelso accident. The system will contain both PTS and speed control features. Some sections of track will use satellite-based communications and global positioning satellites to locate and record train positions. Other sections of track will be controlled using ground-based transponders and communications.

Specifications for the BN/UP PTC system are currently being developed and will be issued for bid soon. The PTC test bed should provide answers to many of the questions about advanced train control systems and will better define the parameters associated with the ATCS program. Meanwhile, the AAR's core ATCS program is also moving forward. Additional testing of components is being conducted on Conrail and Amtrak.

FRA report to Congress.--On July 13, 1994, the FRA released *Railroad Communications and Train Control.*[13] The report discusses PTC in detail. The FRA suggests using risk assessment to determine which rail corridors could benefit the most from PTC. It has committed to monitoring and providing technical support for the PTC test bed in the northwest United States. It has also indicated that it will support Amtrak's activities on the northeast corridor to

[12]The FRA uses the term *PTC* to refer to the application of technology to the next generation of train control systems that intervene to prevent trains from operating at a speed in excess of the maximum allowed, from moving past any point of known obstruction or hazard, and from moving beyond the limits authorized.

[13]U.S. Department of Transportation, FRA. *Railroad Communications and Train Control.* Report to Congress, July 1994.

upgrade signal systems for 150-mph operation and will promote and develop PTC technologies as an element of high speed rail technologies.

The Safety Board recognizes the efforts of the FRA, the AAR, and the railroad industry in developing the report, and the Board supports its essence. However, the Board remains concerned about the future of PTS in the United States.

The Safety Board has long believed that PTS has advantages beyond safety that should be considered. Increase in rail line efficiency and utilization, savings in fuel use, reduced wear and tear on equipment through train pacing, and maintenance savings from eliminating pole lines and outdated signal equipment are a few of the business benefits.

The Manager for Train Control Technology for the AAR stated in his presentation on advanced train control systems to the International Association of Railway Operating Officers in 1993 that "rarely has a technology offered as broad a range of benefits to the railroad industry."

In the report to Congress entitled *Railroad Communications and Train Control*, the cost of a universal PTC system for the nation's railroads is estimated as between $859 million and $1.1 billion; however, safety is named as the only quantifiable benefit of PTC. The FRA alludes to the existence of business benefits from PTC but includes safety savings of only $34.5 million per year. Clearly the benefits of a PTS control system go well beyond safety, but if safety remains the only identified benefit, PTS control systems will never be economically justified.

The safety savings of $34.5 million per year seem vastly understated in view of the large amounts recently awarded to victims of transportation accidents in litigation suits. Any single serious passenger train accident involving fatalities and/or serious injuries would probably quickly exceed the $34.5 million per year figure.

The FRA issued a press release with its report to Congress that stated:

> To further advance positive train control, FRA, over the next 4 years, will identify high risk rail corridors on which PTC installation could be justifiable based on cost/benefit analysis. Upon a favorable finding, FRA would require installation on specific high risk corridors.

The Safety Board is concerned that without a full assessment of all of the benefits of PTS, including a more reasonable estimate of the true safety savings (including those resulting from preventing litigation), there may never be a favorable finding by the FRA.

The Safety Board believes that the business benefits associated with PTS are real and need to be included in the cost benefit analysis. If safety is the only criteria for justifying PTS, then the growth of PTS will be very slow. Lack of understanding of the business benefits of

PTS may be used as an excuse to label PTS control systems as too costly. The Federal Government and the railroad industry must know the true benefits of PTS control systems before they can make the proper decision regarding its application.

The Safety Board believes that the FRA and the AAR should identify and evaluate all of the potential benefits of PTS and include them in any cost benefit analysis conducted on PTS control systems. The Safety Board concludes that all potential benefits of PTS need to be identified and included in any cost benefit analysis of PTS control systems.

The Safety Board also believes that the FRA, the BN, and the UP should identify and evaluate all potential safety and business benefits of the PTC system currently proposed for the northwest region of the United States. The value of these benefits should be considered in the overall assessment of the system.

PTS control systems require specific information about the train speed and location to perform their functions. The control system also requires a data link communications platform to share the information with traffic control centers to ensure safe operation and to avoid conflicts with other trains in the vicinity. Once this information is made available to the PTS control system, it may be possible to use the information for other safety functions. For example, once a train's speed, direction, and exact location are known, it may be possible to provide information to motor vehicles waiting at grade crossings. Information could be displayed on an electronic display installed at the crossing. The display could be used to advise the motorists of such things as the presence of two trains converging at a double track crossing.

During the Rail Safety Summit sponsored by the Department of Transportation on September 30, 1994, panelists mentioned the possibility of using a PTS control system to send train movement information directly to individual motor vehicles. This possibility was also mentioned in the FRA's report to Congress. The ability to communicate information to individual vehicles could be incorporated in the Department of Transportation's Intelligent Transportation System (ITS) program (formally The Intelligent Vehicle Highway System). The Safety Board concludes that PTS data and information may be useful in enhancing grade crossing safety.

The Safety Board believes that the FRA should identify some of the possible uses for PTS data and information and conduct a study to identify ways in which this information can be used to enhance safety. Such a feasibility study would complement the FRA's current activities on PTS and the ITS program.

The Safety Board continues to be extremely interested in PTS control system development and technology. The Board is pleased that the FRA has issued its report *Railroad Communications and Train Control*. The Safety Board wants the FRA to continue serious involvement in PTS to ensure that railroads begin installing it on their main lines.

The need for PTS ultimately goes beyond the economic benefits of accident avoidance. It is impossible to fully assess the impact of fatalities, serious injury, property damage, environmental damage, or damages awarded through litigation on railroad employees, railroad passengers, or members of the general public. As railroad traffic increases, the risk of major accidents involving passenger trains and freight trains also increases. Public sentiment demands that the railroads be safe. The risk of injuring or killing train crewmembers and passengers or members of the general public, as well as the risk of environmental damage caused by hazardous material spills, is unacceptable to the public. Using PTS control systems is one way that the railroads can act to prevent a great number of human performance or human error accidents.

Therefore, the Safety Board reiterates Safety Recommendation R-87-16 from the Brighton, Massachusetts, accident report and Safety Recommendation R-93-12 from the Ledger, Montana, accident report. The Safety Board intends to monitor the progress made on this important issue and will continue to discuss the benefits of PTS in all reports of accidents in which PTS could have played a role.

Calling Signals

PTS is the long-term answer to preventing train collisions. The final development and installation of PTS will, however, take some time. In the meantime, the Safety Board believes, interim measures may need to be taken to increase the attentiveness of crewmembers.

According to BN operating rules, the conductor and the locomotive engineer are responsible for the safety and protection of their train and the observance of the rules; and under conditions not addressed by the rules, they must take every precaution for protection.

BN Rule 34 requires that train crews observe and call signals:

> Crewmembers in the control compartment of engine must be alert for and communicate to each other in a clear and audible manner, the name or aspect of each signal affecting the movement of their train as soon as it becomes visible or audible. They must continue to observe signals and call any change of aspect until passed.
>
> If prompt action is not taken to respect signal, other crewmembers must remind engineer and/or conductor of rule requirement, and if no response, or engineer is incapacitated, other crewmembers must take immediate action to ensure safety, using emergency brake valve to stop the train if necessary.

The BN Director of Operating Rules and Practices stated that "crewmembers call signals verbally within the cab." The BN rules do not require crews to use the radio to announce signal indications. He said the only system available to monitor crews' compliance with Rule 34 is to have supervisors ride the trains. He also stated that there currently is a pilot project going on in Memphis, Tennessee, in which crewmembers are not calling signals but announcing the signals over the radio when they pass them. Because these transmissions are recorded, the railroad can review the recording to monitor compliance with Rule 34.

Event Recorder Crashworthiness

Only two event recorder tapes, both from the BN train, were recovered from the eight locomotives. Four event recorders and/or tapes were burned or destroyed to the point that the data were not recoverable.

In the head-on collision between BN freight trains 602 and 603 near Ledger, Montana, on August 30, 1991, which involved nine locomotives, only three event recorders were recovered. Although all the locomotives had been equipped with recorders and tapes, the other six recorders and tapes were burned.

At the derailment of Amtrak train No. 2 at Big Bayou Canot, near Mobile, Alabama, on September 22, 1993, the lead locomotive was equipped with a state-of-the-art solid-state event recorder. The two trailing locomotives were equipped with paper/stylus tape recorders. All three recorders were submerged in the bayou as a result of the accident. Because the solid-state recorder was not waterproof, much valuable information, including the accident data, was lost due to electrolysis. The paper tapes were also relatively unprotected; however they were salvaged with great care and offered limited information since only speed, time, and distance data are recorded.

There are currently no crashworthiness standards for railroad event recorders to reasonably ensure the survival of recorded information in the event of an accident. Unlike aviation industry flight data recorders, railroad event recorders have no standards of crashworthiness and survivability for fire, water, or other liquids, such as diesel fuel and fire fighting fluids, common to railroad accident environments.

The Safety Board determines that the FRA needs to develop requirements for crash-, water-, and fire-resistant event recorders similar to the requirements used for aircraft recorders. The Safety Board will work with the FRA to determine appropriate standards. The new FRA regulations, CFR 49 Part 229.135 (a), effective January 16, 1995, require only the lead or controlling locomotive to be equipped with an event recorder, which makes its protection particularly important and critical.

The Safety Board, in its comments to the FRA's 1991 event recorder Notice of Proposed Rulemaking (NPRM), advised the FRA of its concern that event recorders and their data were being destroyed in accidents by fire or impact forces.[14] When the FRA issued its final rule in 1993,[15] the FRA, indicated that it would be consulting with the Safety Board on the development of standards for survivability of event recorders. Since then, Safety Board staff have had numerous discussions with staff from the FRA, the event recorder industry, the railroad industry, and the flight data recorder industry concerning the development of these standards. The Safety Board expects to provide the FRA with input concerning the development of standards for fire/crashworthy event recorders shortly.

Locomotive Crashworthiness

The magnitude of the dynamic forces generated in this crash exceeded the current capabilities of locomotive cabs to maintain a state of crashworthiness that would allow their occupants to survive. The subject of locomotive cab crashworthiness continues to be of utmost concern to the Safety Board. As already mentioned, the Board is currently investigating other railroad accidents that occurred after the Kelso accident. One involved the collision of an Amtrak passenger train with a CSX freight near Selma, North Carolina, resulting in the death of an Amtrak crewmember in the lead locomotive. Although the Amtrak locomotive was not severely damaged, the crewmember suffered fatal injuries when the locomotive derailed and overturned. Consequently, the Safety Board will thoroughly examine all aspects of locomotive crashworthiness in the Selma accident (and in all future railroad accidents).

Emergency Response

The Safety Board concludes that the response from the local and surrounding area fire and rescue units to this accident was both timely and effective. The fires that erupted from the locomotive fuel tanks that ruptured were extinguished by 2:38 p.m. The local and State police units were very effective in securing the area to facilitate a smooth flow of traffic past the accident site.

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[14]On June 18, 1991, the FRA issued an NPRM entitled "Event Recorders" in response to Section 10 of the Rail Safety Improvement Act of 1988. Section 10 specifies that the Secretary of Transportation will issue rules and regulations by December 22, 1990, requiring that trains be equipped with event recorders by June 22, 1991.

[15]On July 8, 1993, the FRA issued a final rule entitled "Event Recorders" with an effective date of November 5, 1993.

CONCLUSIONS

Findings

1. The train equipment, the track, and the signal system functioned as designed, and the train dispatcher's activities were normal. Neither the dispatcher nor any member of either train crew was impaired by alcohol, drugs, or fatigue. The members of both train crews had the necessary training and experience to competently perform their duties.

2. The crew of train 111 did not see the intermediate signal. Fog may have reduced the viewing distance and thus the amount of time in which the crew could have seen the signal.

3. The crew did not take emergency action to stop at the absolute signal.

4. Passive wayside light signals are not wholly adequate for preventing accidents because they do not always capture a train crew's attention or provide any safety redundancy or back-up when crewmembers misinterpret, disregard, or fail to pay attention to a signal.

5. This accident could have been prevented had the trains been controlled by a fully implemented positive train separation control system.

6. The response from the local and surrounding area fire and rescue units to this accident was both timely and effective.

7. All potential benefits of positive train separation need to be identified and included in any cost benefit analysis of positive train separation control systems.

8. Positive train separation data and information may be useful in enhancing grade crossing safety.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was (1) the failure of the Burlington Northern crewmembers, for unknown reasons, to see the intermediate signal that would have directed them to stop at the absolute signal and (2) the lack of redundancy in the centralized traffic control system. Contributing to the accident was the lack of a positive train separation control system.

RECOMMENDATIONS

As a result of its investigation, the National Transportation Safety Board reiterates Safety Recommendations R-87-16 and R-93-12 made to the Federal Railroad Administration on May 19, 1987, and on July 29, 1993, respectively:

> Promulgate Federal standards to require the installation and operation of a train control system on main line tracks that will provide for positive separation of all trains. (R-87-16).
>
> In conjunction with the Association of American Railroads and the Railway Progress Institute, establish a firm timetable that includes at a minimum, dates for final development of required advanced train control system hardware, dates for implementation of a fully developed advanced train control system, and a commitment to a date for having the advanced train control system ready for installation on the general railroad system. (R-93-12)

Also as a result of this investigation, the National Transportation Safety Board makes the following recommendations:

-- to the Federal Railroad Administration:

As part of your monitoring and oversight activities on the Burlington Northern and Union Pacific Railroad's train control demonstration project, identify and evaluate all potential safety and business benefits of the positive train control system currently proposed for the northwest region of the United States. Consider the value of these benefits in your overall assessment of the system. (Class II, Priority Action) (R-94-13)

In conjunction with the Association of American Railroads, identify and evaluate all of the potential benefits of positive train separation and include them in any cost benefit analysis conducted on positive train separation control systems. (Class II, Priority Action) (R-94-14)

Identify possible uses for positive train separation control systems data and information and conduct a study to identify ways in which this information can be used to enhance grade crossing safety. (Class II, Priority Action) (R-94-15)

-- to the Association of American Railroads

In conjunction with the Federal Railroad Administration, identify and evaluate all of the potential benefits of positive train separation and include them in any cost benefit analysis conducted on positive train separation control systems. (Class II, Priority Action) (R-94-16)

-- to the Burlington Northern Railroad:

In conjunction with the Union Pacific Railroad, identify and evaluate all potential safety and business benefits of the positive train control system currently proposed for the northwest region of the United States. Consider the value of these benefits in your overall assessment of the system. (Class II, Priority Action) (R-9417)

-- to the Union Pacific Railroad:

In conjunction with the Burlington Northern Railroad, identify and evaluate all potential safety and business benefits of the positive train control system currently proposed for the northwest region of the United States. Consider the value of these benefits in your overall assessment of the system. (Class II, Priority Action) (R-94-18)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JAMES E. HALL
Chairman

JOHN K. LAUBER
Member

JOHN A. HAMMERSCHMIDT
Member

November 15, 1994

APPENDIXES

APPENDIX A

Investigation and Hearing

Investigation

The National Transportation Safety Board was notified at 6:16 a.m., eastern standard time, on November 11, 1993, of a collision and derailment of a Burlington Northern freight train with a Union Pacific freight train. The investigator-in-charge and other members of the Safety Board investigative team were dispatched from the Washington, D. C. office and from the Chicago, Illinois field office. Investigative groups were established to study operations, track, signals, mechanical, survival factors, and human performance.

The Safety Board was assisted in the investigation by the Federal Railroad Administration, Burlington Northern Railroad, Union Pacific Railroad, Brotherhood of Locomotive Engineers, United Transportation Union, Washington Utilities and Transportation Commission, Cowlitz County Fire Department, and Washington State Police.

Hearing/Deposition

The Safety Board staff conducted a deposition proceeding as part of its investigation of this accident on February 23, 1994, at Kelso, Washington. Eleven witnesses testified.

APPENDIX B

Rules Applicable to this Report

This report refers to several rules listed in the *General Code of Operating Rules* and the BN *Air Brake and Train Handling Rules*, which are quoted here in full:

General Rules

A: Safety is of the first importance in the discharge of duty.

Obedience to the rules is essential to safety and to remaining in service.

The service demands the faithful, intelligent and courteous discharge of duty.

Rule 7 (A)

Vigilance For Signals: All employees must keep a vigilant lookout for signals, and act upon them strictly in accordance with the rules.

The utmost care must be exercised by employees to avoid acting upon signals that are not understood, or that may be intended for other trains or engines. In case of doubt, understanding must be reached before movement is made.

Rule 34

Observe and Call Signals: Crew members in control compartment of engine must be alert for and communicate to each other in a clear and audible manner, the name or aspect of each signal affecting the movement of their train as soon as it becomes visible or audible. They must continue to observe signals and call any change of aspect until passed.

If prompt action is not taken to respect signal, other crew members must remind engineer and/or conductor of the rule requirement, and if no response, or engineer is incapacitated, other crew members must take immediate action to ensure safety, using emergency brake valve to stop the train if necessary.

Rule 101

Precautions Account Unusual Conditions: Trains and engines must be protected against any known condition which may interfere with their safety.

When conditions exist which may impair visibility or affect condition of track or structure, speed must be regulated to ensure safe passage and to ensure observance and compliance with signal indication.

In case of unusually heavy rain, storm or high water, trains and engines must approach bridges, culverts and other points likely to be affected, prepared to stop. If unable to proceed safely, movement must be stopped and not resumed until safe to do so.

The train dispatcher must be advised of such conditions by the first available means of communication.

Rule 236 — **Name of Signal:** Approach
Indication: Proceed prepared to stop at next signal, trains exceeding 35 MPH immediately reduce to that speed

Rule 302A — **Slack Control:** Except in an emergency, any changes in train speed as determined by throttle, braking handle position or air brakes must be made slowly. Sufficient time must be allowed for train slack to adjust gradually.

Rule 304 — **Change Of Indication:** If a signal indication permitting a train to proceed changes, before it is reached, to an indication which requires train to stop, stop must be made at once. Such occurrence must be reported to the train dispatcher.

Rule 502 — **Prohibited Transmissions:** No employee shall knowingly transmit any false emergency communication, any unnecessary, irrelevant or unidentified communication, nor utter any obscene, indecent, or profane language via radio. No employee shall divulge or publish the existence, contents, purport, effect or meaning of any communications (emergency communications excluded) except to the person for whom the communication is intended or to another employee of the railroad whose duties may require knowledge of the communication. The above applies either to communications received direct or to any that may be intercepted.

Rule 506 — **Transmitting:** Before transmitting, any employee operating a radio must listen a sufficient interval to be sure the channel is not already in use, then give required identification, and listen for acknowledgement from the employee for whom the transmission is intended and must not proceed with transmission until such acknowledgment is secured.

Rule 507 — **Identification:** Employees transmitting or acknowledging a radio communication must begin with the required identification, and must include the following in the order listed below:

(1) Base or wayside stations;
- **(a)** Name or initials of the railroad
- **(b)** Name and location or other unique designation of office or

station.

(2) Mobile units;

(a) Name or initials of the railroad,

(b) Train name (number), engine number, or words that identify the precise mobile unit.

If an exchange of communication continues without substantial interruption, identification must be repeated each 15 minutes.

After positive identification has been made in connection with switching, classification and similar operations wholly within a yard, fixed and mobile units may use short identification after the initial transmission and acknowledgement.

Rule 510 **Over:** To indicate to the receiving employee the transmission is ended and that a response is expected, the transmitting employee must say the word "over."

Rule 511 **Out:** To indicate to the receiving employee the exchange of transmissions is complete and that no response is expected, the transmitting employee must state his identification followed by the word "out."

APPENDIX C

Radio Conversation Between BN Train and Longview Junction Yard

BN 111:	(12:17.46)	Hi There Longview. Goodbye Longview.
BN 111:	(12:17.54)	Hey, Longview.
BN 111:	(12:18.13)	Hey, Randy, Good Night.
LV JCT:	(12:18.24)	Hello, Did Somebody Call Longview Jct? Over.
BN 111:	(12:18:26)	Well, Hi There. Goodbye.
LV JCT:		Hi and Goodbye, Where Are You?
BN 111:	(12:18:38)	Don't Sneeze, You'll Miss Me.

APPENDIX D

Signal Changes

The sequence of signal and switch events at Longview Jct South are as follows:

12:12:23	UP train occupied track #2 northward approach to Longview Jct South.
12:12:30	Dispatcher requested #2 crossover at Longview Jct. South to be reversed.
12:12:31	Dispatcher requested 2E signal at Longview Jct. South to clear for diverging route to track #1.
12:12:39	Crossover switches at Longview Jct. South moving to reverse position.
12:12:43	Southbound BN train 001-111-10 enters approach to Kelso on track #2 after crossing over from track #1 to track #2 at Ostrander.
12:12:45	Dispatcher requested signal 3E clear at Longview Jct. South (northbound signal on track #1).
12:12:50	Crossover #2 lined and locked for crossover movement and signal 2E cleared for diverging route northbound from track #2 to track #1 at Longview Jct. South. Dispatcher requested signal 1E at Kelso to clear for northward movement on track #1.
12:12:56	Route clear for northbound UP train from track #2 to track #1 through the entire interlocking at Longview Jct. South.
12:13:02	Signal 1E cleared for northbound UP train at Kelso.
12:15:18	UP train cleared "OS" at M.P. 111.
12:16:03	Dispatcher placed stack request; #1 crossover reverse, #2 crossover normal and signal 2W clear. This request would automatically be placed after the UP train had cleared the Longview Jct South interlocking limits.
12:17:58	BN train occupied first of two approach sections to Longview Jct. South.
12:19:16	UP train occupied the approach to Longview Jct. South.
12:20:27	BN train occupied second approach section to Longview Jct. South.

12:22:29	BN train released first approach section (unoccupied).
12:23:02	OS shown on track #2 and signal 2E goes to stop.
12:23:40	Track #1 approach to signal 1E shows occupied.
12:23:54	OS shown on over switch #3.
12:23:55	Switch #3 out of correspondence and "power-off" at Longview Jct. South.
12:24:00	Approach to signal 3W shows occupied.

APPENDIX E

Signal Indications

Color	**Name**	**Indication**
Green	Clear	Proceed
Yellow	Approach	Proceed prepared to stop at next signal, trains exceeding 35 mph immediately reduce to that speed.
Flashing Yellow	Approach Medium	Proceed prepared to pass next signal not exceeding 35 mph.
Red	Restricted Proceed	Proceed at restricted speed.

The CTC computer log was not designed to record the position of intermediate block signals.

APPENDIX F

Accident Reports of Train Collisions Attributed to the Train Crews' Inattention to Restricting Wayside Signals

Railroad Accident Report--*Rear End Collision Between Boston and Maine Corporation Commuter Train No. 5324 and Consolidated Rail Corporation Train TV-14, Brighton, Massachusetts, May 7, 1986* (NTSB/RAR-87/02).

Railroad Accident Report--*Rear End Collision and Derailment of Two Union Pacific Freight Trains near North Platte, Nebraska on July 10, 1986* (NTSB/RAR-87/03).

Railroad Accident Report--*Rear-End Collision of Amtrak Passenger Train 94, The Colonial, and Consolidated Rail Corporation Freight Train ENS-121 on the Northeast Corridor, Chase, Maryland, January 4, 1987* (NTSB/RAR-88/01).

Railroad Accident Report--*Head-on Collision of Southern Pacific Transportation Company Freight Trains, Yuma, Arizona, June 15, 1987* (NTSB/RAR-88/02).

Railroad Accident Report--*Head-end Collision of Consolidated Rail Corporation Freight Trains UBT-506 and TV-61 near Thompsontown, Pennsylvania, January 14, 1988* (NTSB/RAR-89/02)

Railroad Accident Report--*Collision and Derailment of Norfolk Southern Train 188 with Norfolk Southern Train G-38 at Sugar Valley, Georgia, August 9, 1990* (NTSB/RAR-91/02).

Railroad Accident Report--*Atchison, Topeka and Santa Fe Railway Company (ATSF) Freight Trains ATSF 818 and ATSF 891 on the ATSF Railway, Corona, California, November 7, 1990* (NTSB/RAR-91/03).

Railroad Accident/Incident Summary Report--*Head-on Collision of Norfolk Southern Freight Trains 277 and 629, Knox, Indiana, September 17, 1991* (NTSB/RAR-92/02/SUM).

Railroad Accident Report--*Collision Between Northern Indiana Commuter Transportation District Eastbound Train 7 and Westbound Train 12 near Gary, Indiana, January 18, 1993* (NTSB/RAR-93/03).

APPENDIX G

Sight/Distance Test Results

1. 1463 feet - distance at which both the engineer on train 111 and fireman on train 09 lost sight of the other locomotive.

2. 1536 feet - distance at which both the engineer and fireman on both locomotives lost sight of the other locomotive.

3. 983 feet - distance at which the engineer on train 111 and the engineer on train 09 first could determine that the locomotives were on the same track. Neither fireman could make this determination at this time.

4. 2104 feet - distance at which the engineer on BN train 111 could first see the absolute signal at Longview Jct South.

5. 2194 feet - distance at which the fireman on BN train 111 could first see the absolute signal at Longview Jct South.

6. 1997 feet - distance at which the engineer on BN train 111 could first see the approach indication on the intermediate signal.

7. 1958 feet - distance at which the fireman on BN train 111 could first see the approach indication on the intermediate signal.