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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

**REAR-END COLLISION OF TWO
GREATER CLEVELAND
REGIONAL TRANSIT AUTHORITY
RED LINE RAPID TRANSIT TRAINS
NEAR THE 98TH STREET STATION
CLEVELAND, OHIO
JULY 10, 1985**

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UNITED STATES GOVERNMENT



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16. Abstract About 8:12 a.m., eastern daylight time, July 10, 1985, eastbound two-car train No. 6601 struck the rear of three-car train No. 6614, which was standing inoperative on the eastbound main track of the Greater Cleveland Regional Transit Authority (GCRTA) Red Rapid Transit Line. Train No. 6614 was stuck in a reverse curve about 900 feet west of the West 98th Street Station in Cleveland, Ohio. The operators and conductors of both trains and a total of 46 of the approximately 400 passengers on the trains were transported to nearby hospitals. Two days after the accident, another passenger was admitted to the hospital for a cervical spine injury; the train crewmembers and the other passengers received outpatient treatment for minor injuries. The rear car of train No. 6614 was derailed and sustained rear end structural damage as a result of the collision impact.			
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The National Transportation Safety Board determines that the probable cause of this accident was the failure of the operator of train No. 6601 to comply with the signal aspects displayed and to monitor properly the track ahead and react in time to safely stop the train, and the failure of the Greater Cleveland Regional Transit Authority to enforce strict compliance with operating rules, to maintain its signal system, to adopt unambiguous operating rules, and to monitor adequately the performance of its train operators, thereby creating a permissive block operation. Contributing to the accident was the failure of the GCRTA to prevent vegetation from blocking visibility in areas of critical sight distance.

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EXECUTIVE SUMMARY

About 8:12 a.m., eastern daylight time, July 10, 1985, eastbound two-car train No. 6601 struck the rear of three-car train No. 6614, which was standing inoperative on the eastbound main track of the Greater Cleveland Regional Transit Authority (GCRTA) Red Rapid Transit Line. Train No. 6614 was stuck in a reverse curve about 900 feet west of the West 98th Street station in Cleveland, Ohio. The operators and conductors of both trains and a total of 46 of the approximately 400 passengers on the trains were transported to nearby hospitals. Two days after the accident, another passenger was admitted to the hospital for a cervical spine injury; the train crewmembers and the other passengers received outpatient treatment for minor injuries. The rear car of train No. 6614 was derailed and sustained rear end structural damage as a result of the collision impact.

From 1975 until this accident, the Safety Board had conducted in-depth major investigations of GCRTA (two accidents, one in 1976 and one in 1977) and field investigations of four accidents (in 1977, 1982, 1984, and 1985). The investigation of these accidents revealed a number of deficiencies in the manner in which the GCRTA operated its rail rapid transit system. These deficiencies included the failure to maintain its system adequately and the failure to provide adequate backup when it permitted trains to be operated into occupied blocks, in essence defeating the protective features of its automatic train stop signal system.

The Safety Board conducted a major investigation of this accident because of the number of accidents the GCRTA had experienced in its 10-year history of operating its rail rapid transit system and because of the issues uncovered during the Safety Board's investigation of six of the accidents.

The major safety issues in this accident concern the manner in which the GCRTA operated the Red Line, and the effect this and other factors may have had on the failure of the operator of train No. 6601 to stop his train before it collided with train No. 6614. The specific issues include

1. GCRTA's maintenance of its signal system and the line of sight provided for its train operators.
2. GCRTA's enforcement of its operating rules.
3. The adequacy of the GCRTA operating rules.
4. The adequacy of GCRTA's training of its operating personnel.
5. Compliance with the operating rules by the operator of train No. 6601.

6. The ability of the operator of train No. 6601 to stop the train without a collision.
7. The adequacy of the safety oversight of GCRTA operation of its rail rapid transit system.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the operator of train No. 6601 to comply with the signal aspects displayed and to monitor properly the track ahead and react in time to safely stop the train, and the failure of the Greater Cleveland Regional Transit Authority to enforce strict compliance with operating rules, to maintain its signal system, to adopt unambiguous operating rules, and to monitor adequately the performance of its train operators, thereby creating a permissive block operation. Contributing to the accident was the failure of the GCRTA to prevent vegetation from blocking visibility in areas of critical sight distance.

As a result of its investigation, the Safety Board issued safety recommendations to the GCRTA to modify its operating and radio rules to improve the safety of its operations when its automatic train stop or control systems are not functioning, or when other hazards exist; to improve its internal safety oversight; to improve the maintenance of its system; to post speed restriction signs in areas of limited sight distance; and to improve training to service and supervisory employees. The Safety Board also issued a safety recommendation to the Governor of the State of Ohio to provide for State oversight of rail rapid transit systems within the State of Ohio.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

Adopted: April 14, 1987

REAR-END COLLISION
OF TWO GREATER CLEVELAND REGIONAL TRANSIT AUTHORITY
RED LINE RAPID TRANSIT TRAINS
NEAR THE WEST 98TH STREET STATION
CLEVELAND, OHIO
JULY 10, 1985

INVESTIGATION

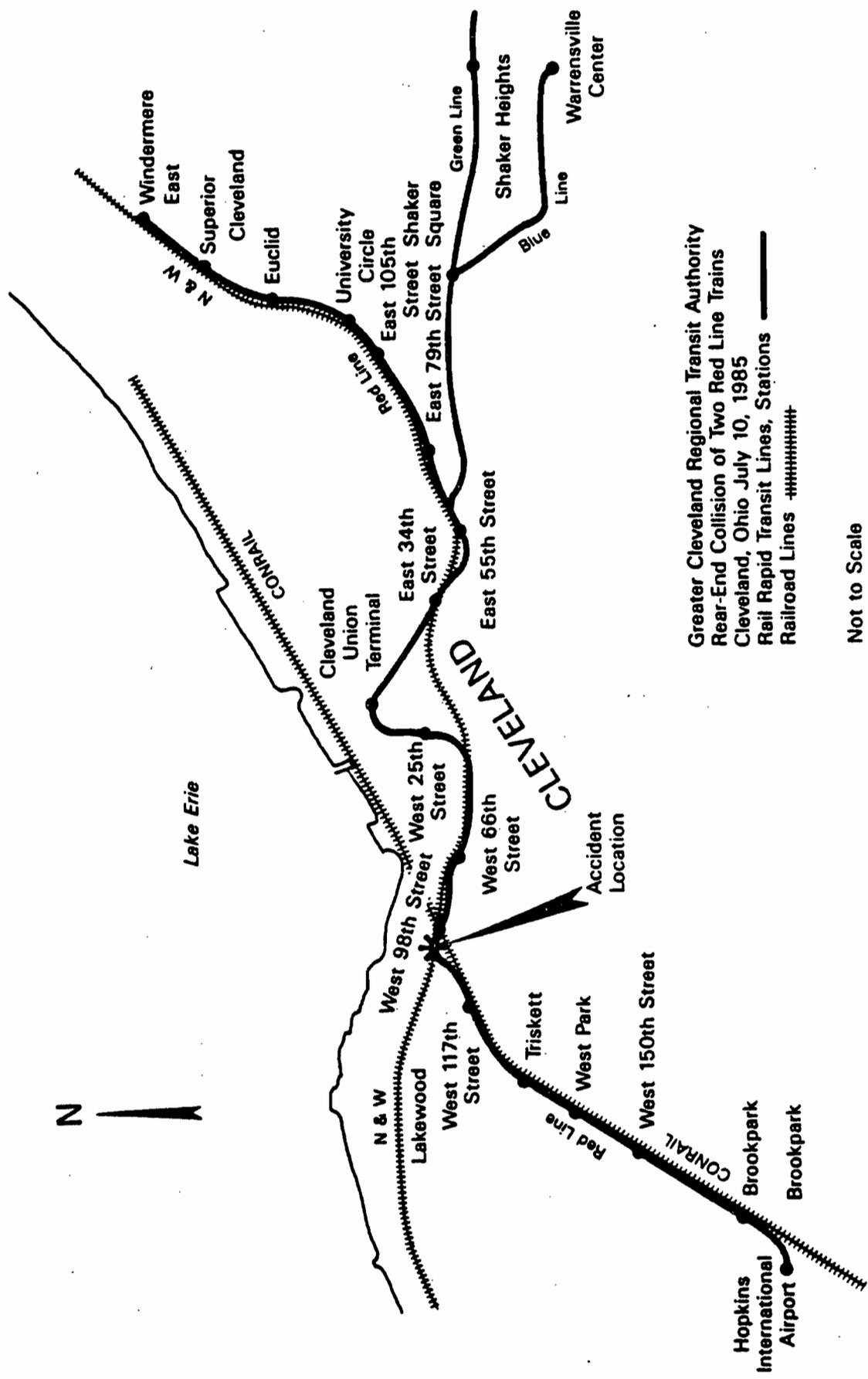
The Accident

Greater Cleveland Regional Transit Authority (GCRTA) Red Line train No. 6614, consisting of three 150-class "Airporter" cars, 1/ was operating as a rush-hour shuttle between the Brookpark Station and the Cleveland Union Terminal. (See figure 1.) According to the published schedule, train No. 6614 departed Brookpark Station at 7:55 a.m. The operator of train No. 6614 testified at a deposition proceeding held by the Safety Board that he believed he left Brookpark Station between 7:45 a.m. and 8:00 a.m. Train No. 6614 was followed by through train No. 6601, consisting of two new 300-class cars 2/, enroute from the Red Line's western terminal at Hopkins International Airport to the eastern terminal at Windermere Station. The two trains were operating on a Red Line schedule, which provided a 5-minute rush-hour headway, or separation.

Train No. 6614 left West 117th Street, the first station west of West 98th Street, at about 8:05 a.m. The operator of train No. 6614 stated that before reaching West 98th Street Station, he noticed that the train's braking system air pressure had dropped from the normal 110 psig to 70 psig and he stopped the train to permit the air pressure to restore to the proper level. (When the supply air pressure reduces to the train brake pipe pressure, the train's brakes will automatically apply.) After this occurred, the operator was able to get the train to resume briefly its movement eastward. The air pressure then again reduced, causing the train's brakes to apply and stop the train. When the train stopped, it was standing in a right-hand curve, eastbound, with the rear end at a point about 3,824 feet east of the West 117th Street Station and 1,413 feet east of eastbound intermediate block signal EW 252. (See figure 2.) The

1/ These cars are described in the section on Train Information.

2/ Ibid.



Greater Cleveland Regional Transit Authority
 Rear-End Collision of Two Red Line Trains
 Cleveland, Ohio July 10, 1985
 Rail Rapid Transit Lines, Stations —
 Railroad Lines - - - - -

Not to Scale

Figure 1.--Sketch of the Greater Cleveland Regional Authority rapid transit system.

April 6, 1987

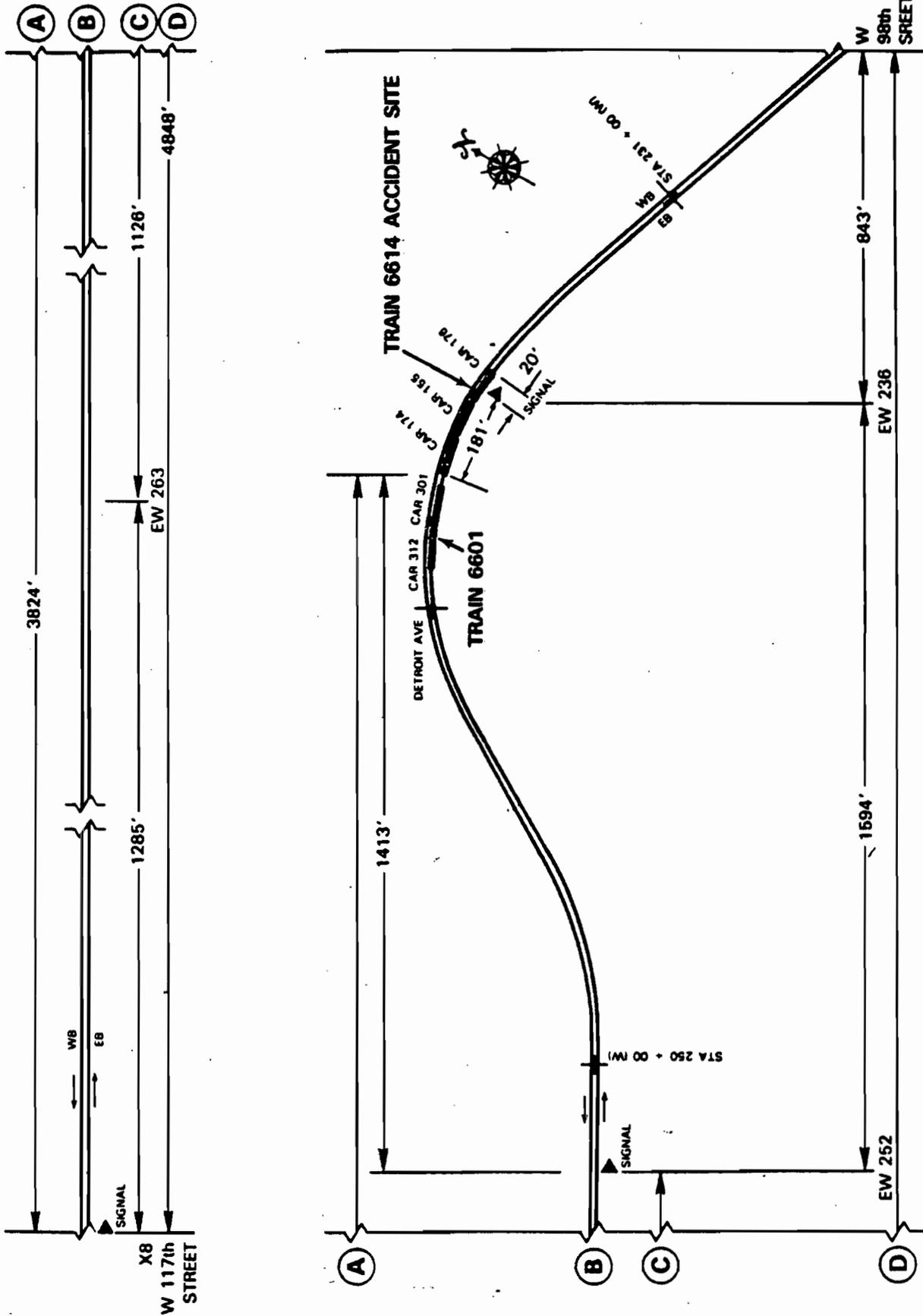


Figure 2.--Track and signal locations from the West 117th Street Station to the West 98th Street Station.

front end of the train was about 20 feet east of intermediate block signal EW 236. According to the operator, he did not manually operate the train's rail sanders 3/ before or during the stopping sequences.

The operator of train No. 6614 contacted the supervisor on duty in the tower control center at the Cleveland Union Terminal by radio and informed him of the braking problem. The tower control supervisor and the train operator discussed the actions the train operator had decided to take to resolve the problem. However, the operator of train No. 6614 was unable to get his train moving again.

The crewmembers of other trains would have been unaware of the conversations between the operator of train No. 6614 and the tower control supervisor unless they had, coincidentally, picked up their phone-type radios at that time. The Safety Board has no evidence that any other train crewmembers overheard these conversations.

According to the operator of train No. 6601, the train departed the Hopkins International Airport terminal and stopped at the berthing marks at West 117th Street Station with signal X-8 opposite the right front of the train. The operator said that, before leaving the station, he observed a green over green "proceed" aspect displayed by signal X-8, an interlocking 4/ signal located immediately east of West 117th Street Station. The operator also stated that a green "proceed" aspect was displayed by signal EW 252 located 2,411 feet east of signal X-8. A short distance east of signal EW 252, the track enters a 1,765-foot reverse curve. While train No. 6601 was moving through the exiting 90° right-hand curve, the operator observed the rear of train No. 6614 ahead. He stated that because of foliage on the inside of the curve, he did not immediately realize that the train was on the eastbound track.

In his sworn testimony, the operator stated that he did not know the distance between his train and train No. 6614 when he first saw it. He stated that his train was moving at about 22 to 23 mph and that he initiated emergency braking when he perceived that train No. 6614 was on the eastbound track. The operator further testified that he saw the red paint around the left rear window of train No. 6614 before the collision occurred. The operator also stated that the braking action did not seem to slow

3/ Sanders are devices that put sand onto the rails to overcome the adverse effects of water, grease, or other contaminants while accelerating the train from start or on braking.

4/ Interlocking is an arrangement of signals and signal appliances operated from an interlocking machine; the signals are interconnected by means of mechanical and/or electric locking so that their movements must succeed each other in proper sequence, train movements over all routes being governed by signal indication.

his train appreciably before it struck the rear of the standing train. At the time, the lead end of train No. 6614 was about 20 feet east of eastbound intermediate block signal EW 236. According to the operator of train No. 6614, about 4 or 5 minutes transpired between the time his train stopped and the time the accident occurred.

Injuries to Persons

<u>Injuries</u>	<u>Employees</u>	<u>Passengers</u>	<u>Total</u>
Fatal	0	0	0
Serious	0	1	1
Minor	4	45	49
None	0	354	354
Total	4	400	404

Damage

The rear car of train No. 6614 had its rear truck derailed. While the car was not overridden by the impact, there was considerable deformation of the molded fiberglass end assembly as well as damage to the underframe, draft gear, and control equipment of the car. It was necessary to retire the rear car of train No. 6614 because the damaged end assembly could not be replaced. The other cars of train No. 6614 sustained minor coupler damage. The lead car of train No. 6601 had minor damage to the exterior of the front end assembly and cab interior. GCRTA estimated the cost of repairing the four cars to be \$42,000. The car that was retired was relatively old and had little or no book value.

There was no damage to track, the overhead system, or signals.

System and Track Information

The Red Line is a double-track rapid transit line 19 miles long. It extends from Windermere Station in the city of East Cleveland westward to the Cleveland Union Terminal in downtown Cleveland, and southwesterly to Hopkins International Airport. The entire line is on a dedicated right-of-way, mostly adjacent to other railroad lines. It is a surface operation except at bridges, grade separations, and short underground sections at Cleveland Union Terminal and the airport. It was built by the municipally owned Cleveland Transit System (CTS) and operated by that agency until being taken over by GCRTA in 1975. The original section from Windermere to West 117th Street Station was opened in 1955; westerly extensions to West Park and the airport were opened in 1958 and 1968, respectively.

Red Line trains are operated by electric current collected from an overhead catenary system by pantographs mounted on the roofs of the cars. The line was built to railroad standards with 100-pound section jointed rail 5/ laid on double-shouldered tieplates atop treated crossties laid in crushed stone ballast. Every second tie is box anchored. In sharp curves, a guard rail is laid close to the gauge side of the inside rail to prevent derailments. The running rails are wire-bonded at the joints to maintain electrical continuity for the signal system.

From the airport to the West 117th Street Station, the Red Line is located immediately north of the main line tracks of the Consolidated Rail Corporation (ConRail). The tracks run in a generally southwest-northeast direction. From West 98th Street Station east, the Red Line changes route to run immediately adjacent to the east-west main line of the Norfolk & Western Railway (N&W), which passes under the ConRail tracks just west of West 98th Street Station. Because of this change of alignment and the need to pass under the ConRail tracks, it was necessary to construct the Red Line through a long reverse, or "S" curve. The distance between the West 117th Street and West 98th Street stations is 4,848 feet, of which 1,765 feet is contained in the "S" curve and its spirals. 6/

The track between the West 117th Street and West 98th Street stations has the following configuration. For about 1,520 feet northeast from West 117th Street Station, the Red Line is straight and continues immediately adjacent to the ConRail tracks on a 63° heading. The Red Line then enters an 8° 54' left-hand curve that is 577 feet long, including spirals. There is an 81-foot section of straight track before entering a 9° 5' right-hand curve. Including the 240-foot spirals at each end, the right-hand curve is 1,107 feet long.

About 65 feet after passing from the entering spiral to the 9° 5' curve, the eastbound main track begins passing diagonally under the Detroit Avenue overpass. The 85-foot-long east abutment wall of the underpass extends about 228 feet west of the

5/ At the time of the accident, GCRTA was replacing the original jointed rail with new 100-pound section continuous welded rail (CWR), but the eastbound main track between West 117th Street and West 98th Street Stations still had the original rail. Two joints did not have bond wires. The absence of bond wires could have caused the signals to display an aspect more restrictive than what would be displayed with the bond wires intact.

6/ Spirals are the sections of track connecting curved portions of track to tangent (straight) track.

accident location. At this point, the abutment wall is about 6 feet to the field side of the south rail of the eastbound track. For about 50 feet beyond the abutment wall, foliage was growing to within 2 to 3 feet of the south rail and about 10 to 12 feet above the rail level. (See figure 3.)

At the time of the accident, five rail joints in the eastbound track between West 117th Street Station and the accident location were missing both bolts from one of the connected rails.

A flange lubricator, or greaser, was located on the gauge side of the south rail of the eastbound track 1,283 feet west of the accident location. The purpose of this device was to reduce wheel and rail wear in the "S" curve. The operator of train No. 6601 said he had encountered in the past grease on top of the south rail beyond the lubricator. This, he said, made stopping difficult at West 98th Street Station. In his sworn testimony, he stated that he had seen a gob of grease on the rail as his train approached the accident site. However, the operator of train No. 6614 did not indicate that there was a problem with grease on the morning of the accident. No reports of grease or wet rail at or near the accident site were made by other operators prior to the accident.

Signal Information

The 4-mile section of GCRTA's Red Line between West Park Station and Hopkins International Airport is operated under an automatic train control (ATC) system. Cab signals and track circuitry enforce speed restrictions by automatically applying the trains' braking systems.

The remainder of the Red Line, between West Park and Windermere Stations, is operated under a General Railway Signal Company (GRS) three-aspect, color-light, automatic block signal system equipped with automatic train stop (ATS). 7/ The wayside block signals of this system are located to the right of the track they govern. This signal system was patterned after one used on the New York City subway system. It was installed on the Red Line in the early 1950s, and at that time was the most advanced type of signal system in use in the rail rapid transit industry.

7/ According to GCRTA, the ATC operation is programmed for extension from West Park Station to Cleveland Union Terminal by the end of 1987. However, at this time the original signal system remains in operation on this part of the Red line.



Figure 3.--Train appears at a distance of 266 feet.

The ATS feature is designed to stop a train if the operator fails to comply with a "stop" signal aspect. This is accomplished by means of a trip arm located at each interlocking and intermediate block signal. Because the Red Line signal system was designed to provide double block "stop" protection at the second signal displaying a "stop" aspect behind a stopped train, the trip arm should be in a raised (tripping) position. When the trip arm is raised, it will trip a paddle on a passing car, causing a loss of traction power and an emergency application of the train brakes.

However, slowing the train short of an intermediate block signal and operating the train slowly up to the signal will cause the trip arm to drop from the tripping position within 3 seconds of the train crossing the proximity circuit, even though the

aspect of the signal remains "stop". This enables a train to proceed through the "stop" signal. In his testimony, the operator of train No. 6614 referred to this procedure as "knock[ing] down" the signal. The operator of train No. 6601 was also aware that the "stop" feature of the intermediate signals could be defeated in this manner. However, despite the "knocking down procedures," the signal rules require that the operator should not proceed without calling the tower control supervisor for instructions when the aspect of an intermediate block signal is "stop".

There is a second way in which a train operator can get by an intermediate block signal which is displaying a "stop" aspect and has a functioning trip arm. The train operator would have to stop his train, disembark, push down the trip arm, and tie it down with a clamp. The tower control supervisor on duty at Cleveland Union Terminal at the time of the accident testified at great length at the Safety Board's deposition proceedings of how this is done. He further testified in response to questions as to whether the operator stops after passing the signal and unties the switch: "It depends on my instructions. If I tell him to do that or not. Sometimes I tell him to tie it down and just leave it tied down and sometimes I tell him to tie it down and go through it and untie it."

Unlike the intermediate block signal, the interlocking block signal cannot be "knocked down". However, to drop the trip arm of an interlocking block signal, the operator needs only to depress a pushbutton on the side of the signal mast. The operator may reach the pushbutton through a window at the right front of the train.

Because of the extremely short sight distances in the "S" curve, the signal system, with interlocking signal X-8 at West 117th Street and three intermediate block signals between it and West 98th Street Station, was designed to provide more protection than the double block "stop" protection in operation elsewhere on the Red Line system. These signals were arranged to display "stop" aspects with the trip arm of the second signal behind the accident in tripping position if there was a train between the two stations or if some other condition shunted the circuitry in this section.

These signals were configured as follows: intermediate block signal EW 263 was located 1,285 feet east of signal X-8; intermediate block signal EW 252 was located 1,126 feet east of signal EW 263; and intermediate block signal EW 236 was located 1,594 feet east of signal EW 252. Signal EW 263, which had been struck down by a ConRail freight train derailment during the the summer of 1984, was out of service. Signal EW 252 was mounted on the retaining wall south of the track about 900 feet east of where a 2.40 percent descending grade began, but it was west of the "S" curve and could be seen from the operator's compartment

of a train standing at signal X-8. The trip arms on signals X-8, EW 263, EW 252, and EW 236 were broken. One of the two westbound intermediate signals between West 117th Street and West 98th Street Stations was also broken. Broken trip arms or other defects in the ATS apparatus do not affect the aspects displayed by the signals.

The operator of train No. 6601 stated that he was not aware that the trip arms of signals X-8 and EW 252 were broken. However, he also stated that he did know that the trip arms on other signals were broken and he had reported some of these to the tower control supervisors in the past. He also stated that the signals in this area often did not operate properly.

The operator of train No. 6614 stated that he too was aware that the trip arms at signal X-8 and at signal EW 252 were broken. He also stated that he reported the broken trip arm at signal X-8 but not at signal EW 252. In addition, the conductor of train No. 6601 and the conductor of train No. 6614 stated that they knew that trip arms were often broken and had reported the broken arms to Cleveland Union Terminal. However, neither stated that they knew of the broken signal trip arms between West 117th Street and West 98th Street. The tower control supervisor stated that he thought the trip arm at signal X-8 was not operating on the day of the accident.

The Safety Board's investigation determined that the signal X-8 trip arm had been broken about 5 months before the accident. GCRTA's rail safety committee had reported to the Director of Rail Transportation in October 1984, that many signal trip arms were broken. In October 1984, GCRTA ordered 10 replacement trip arms from a manufacturer. The safety committee again reported the broken trip arm problem about 2 months before the accident. This report, as with the earlier report, was a general observation; specific locations were not given. GCRTA records indicate that there were no spare trip arms in GCRTA stock at the time of the accident.

According to GCRTA, the ATS trip arms had proven vulnerable to damage by track machines and during snow-clearing operations. Heavy snows are relatively common during the winter months in Cleveland. According to the GCRTA, a program of track upgrading was in progress for some time before the accident. Outside contractors were performing this work.

GCRTA replaced the trip arm, restoring the signal X-8 ATS function a few days after the accident. A postaccident survey by the GCRTA signal department revealed that at least 29 of the 63 interlocking block signals and 63 of the 121 intermediate block signals on the Red Line had broken trip arms or otherwise inoperative ATS apparatus. GCRTA began repairing the defective signals on July 17, 1985, and completed the work on October 17, 1985. The trip arms on signals EW 236 and EW 252 were replaced on August 8, 1985. Signal EW 263 was never restored to service.

Method of Operation

Trains operating over the Red Line between Windermere and West Park Stations are under the supervision of a tower control supervisor at the Cleveland Union Terminal. The supervisor has a modelboard, but it does not display the locations of trains west of West 38th Street (which is well east of the accident site). Radio (two-way VHF transceiver) is used for communications between the tower control supervisor and trains enroute. The tower control supervisor can transmit simultaneously to all trains or he can key in a specific train and communicate with that train alone. In either case, the train operator receives an audible indication that he is being called. Unless a train operator coincidentally picks up the phone-type radio, he will be unaware of any radio communication between the tower control supervisor and another train. According to the tower control supervisor, he did not attempt to and was not required by the rules to contact train No. 6601 by radio to warn him that train No. 6614 was stopped by a brake malfunction at signal EW 236.

In testimony provided at deposition proceedings, in conversations with GCRTA operating employees, and in observations made while riding trains, Safety Board investigators learned that radio communications between tower control supervisors and operators were generally limited to requesting and receiving permission to proceed through "stop" aspects of signals and for emergency situations. Normally, tower control supervisors were not aware of the precise location of their trains when they were not in areas covered by the modelboard.

During rush hours, trains are manned by an operator and a conductor who is a qualified operator; during off-peak hours, trains are manned only by an operator. When a train has a conductor, he rides in the operator compartment of the rear car of the train. The conductor opens and closes the doors of the rear car and determines that passengers put the proper fare in the on-board farebox. The train operator operates the doors and is responsible for collecting fares on the lead car. When a train has no conductor, the doors are opened only on the lead car and passengers use the end doors to pass to and from trailing cars.

In accordance with GCRTA operating rules, the conductor is not in charge of the train, although he may take the place of the operator in an emergency and operate the train with the permission of the tower control supervisor. The conductor has access to the radio in the rear car's operator compartment, but the radios have no intra-train transmission capability. The train operator and conductor communicate instead by means of a train intercom system.

Because the operator's compartment of the rear car is on the right side in the direction of forward movement, the conductor can observe the wayside signals by opening the side

window of the compartment. GCRTA rules do not require the conductor to do this, and the conductor has no responsibility or authority under the rules to take action if he notices that the operator has failed to comply with a signal aspect. The conductor of train No. 6601 stated that he did not observe the aspects displayed by signals X-8 and EW 252. He said that he was working a crossword puzzle at the time of the accident.

The maximum authorized speed for Red Line trains is 40 mph, but there is a permanent 25-mph speed restriction through the "S" curve between West 117th Street and West 98th Street Stations. Beginning on June 11, 1984, GCRTA issued a one-page bulletin order imposing eight temporary speed restrictions on the Red Line including a 5 mph restriction on the eastbound track between signal EW 236 and West 98th Street Station. This order was still in effect on the day of the accident. This 5 mph speed restriction was imposed because of a minor track irregularity in the affected section. The bulletin order was not issued individually to the train operators, but it had been posted on a bulletin board where the operators report for duty and was still posted on the day of the accident. The operators were required by the operating rule to check the bulletin board daily and to familiarize themselves with all posted bulletins. According to GCRTA, the operators were not required to acknowledge in writing that they had read the bulletins.

However, in response to Safety Recommendation R-77-22, issued by the Safety Board on August 19, 1977, asking GCRTA to ensure that general orders and bulletins were read and understood, GCRTA replied on November 18, 1977, that it now "required operators to sign the bulletins". Based on this response, Safety Recommendation R-77-22 was closed, acceptable action, on September 14, 1978.

According to GCRTA, a speed restriction sign with the numeral "5" was placed to the field side of the eastbound track at a point about 390 feet west of the rear of the train at the accident location, or about 571 feet west of signal EW 236. However, GCRTA informed the Safety Board that the sign was removed by vandals 2 days before the accident and it had not been replaced. At the time of the accident, a similar sign was in place at signal EW 236, the beginning of the speed restriction.

The operator of train No. 6601 acknowledged that he knew about the 5 mph speed restriction, but he thought that it no longer applied because the advance speed restriction sign was no longer posted. The operator also stated that had he known that the speed restriction was still in force, he would have started braking to reduce speed "before the train reached the right hand curve," or about where he would first be able to see the advance "5" sign that was missing on the morning of the accident. It was not clear from the operator's testimony at the deposition proceedings whether he had looked at the bulletin board on the morning of the accident.

GCRTA's operating rules govern the actions of the operators, tower control personnel, and other employees. The GCRTA book of operating rules was first issued on February 28, 1978, and was revised January 18, 1980. According to GCRTA, the rulebook was issued to all employees whose duties were prescribed by the rules, and all employees issued the rulebook were required to "...know, understand, and comply with every one of these rules." The operator of train No. 6601 stated that although he had received a copy of the rules, he had never been examined on the operating rules. GCRTA employee service records provided no evidence to refute this statement. The operator of train No. 6614 stated that he had attended a 1-day training session on the book of rules when he received the rules and again when they were revised in 1980. However, GCRTA service records provided no evidence of this training.

Rule 5.1.40 defines line of sight as "The speed which is consistent within the range of vision." Rule 8.1.1, under the heading "OPERATION ON SIGHT," states that "Operators must keep a minimum distance of 1,000 feet or more between trains and operate on line of sight and be prepared to stop should the train ahead make a sudden stop." Rule 8.1.2 states, "Operators must operate their trains on sight at all times, including while under signal protection." The term "on sight" means within the range of vision. Changes in the range of vision must be anticipated." (See Appendix C.)

GCRTA rule 8.20.2 requires,

Where speed limit signs are provided, the Operator must reduce the speed of the train accordingly before the train passes the sign and must not exceed the posted speed until the last car has cleared the speed zone governed by that speed limit sign.

The rulebook did not contain a rule providing for the posting of signs in advance of speed restrictions, nor did it describe or illustrate the speed limit signs provided for in Rule 8.20.2.

When the intermediate signals display a green aspect, the GCRTA signal rules permit the operator to "proceed within the permitted speed"; when the aspect is yellow, the rules require that the operator "proceed on line of sight prepared to stop at next signal"; and when the aspect is red, the rules require that the operator "stop, remain standing for 30 seconds and call the tower control supervisor for instructions."

The signal rules require that when an interlocking signal, such as X-8, displays a green over green, then the train operator may "proceed on main route within the permitted speed"; when a yellow over green aspect is displayed, the operator may "proceed on main route on line of sight prepared to stop at next signal"; when a red over red aspect is displayed, the operator must "stop,

remain standing for 30 seconds and call the tower control supervisor for instruction"; and finally, when a red over red over yellow aspect is displayed, the operator must "stop, operate the trip arm-release." 8/ However, a footnote to the rule specifically addressed to signal X-8 requires the operator to notify the "Tower" before proceeding past signal X-8 when the aspect is red over red over yellow. These rules, along with the other signal rules, were formalized in the 1978 book of operating rules.

In testimony given to the Safety Board at a deposition proceeding, the operators of trains No. 6601 and No. 6614 both stated that the tower control supervisor will sometimes permit or even tell the operators to proceed through a "stop" aspect of a signal after being called and told that the signal is red. However, the operator of train No. 6614 stated that "...it's very seldom he'll give you a call-on in the S-curve".

During the investigation of this accident, Safety Board investigators rode the entire GCRTA system. Several times during the trips, operators were observed to call the tower control supervisor at Cleveland Union Terminal after getting a "stop" aspect at a signal. They received instructions to go through the red signal and proceed in the "line of sight." This included both interlocking and intermediate block signals. As previously described, in testimony to the Safety Board, the tower control supervisor who was on duty at Cleveland Union Terminal at the time of the accident described, in detail, the procedure to tie down the trip arm at an intermediate block signal so that the train can proceed into a "stop" signal block.

During testimony in deposition proceedings, the operator of train No. 6601 stated that he had been instructed by a control tower supervisor to pass red indications and to "stop and the arm will go down and you proceed slow." He further stated that he had been told to close up behind a train in front of him and he described how this was done: "You come up to the signal and knock the arm down and go up to the other train." Further, when asked whether he was always told to close up on trains in front of him, he replied "yes."

Train Information

Train No. 6614 consisted of three GCRTA 150-class rapid transit cars built by Pullman-Standard for the Red Line airport extension in 1968. Called "Airporters" by GCRTA, these cars are constructed of stainless steel with low-alloy, high-tensile steel underframe ends and molded fiberglass end assemblies. They seat

8/ The rule covering this aspect permitted the operator to proceed "on line-of-sight expecting to find the block occupied."

80 passengers in 40 double transverse seats and have a normal maximum capacity of 130 passengers, including standees. Thus loaded, the cars weigh about 99,000 pounds. The "Airporter" cars are 70 feet long when measured from the anti-climbers, which are mounted on the angled end bumpers at the front and rear of each car. They have two sliding doors on each side and doors in both ends. The passenger seats have hard, molded grabrails and the floor level luggage racks are constructed of bare metal tubing.

Train No. 6601 consisted of two of the 60 new 300-class cars recently built for GCRTA by the Tokyu Car Corporation. Although 75 feet long, these cars are similar to the "Airporters" in that they are constructed of stainless steel with high-tensile steel underframe ends, are of the same platform height, and are equipped with anti-climbers. The Tokyu cars also have 40 fixed double transverse seats, half facing forward and half facing rearward. Standing room capacity is similar to that of the "Airporters." As with the 150-class cars, maximum design speed of the 300-class cars is 60 mph.

The 300-class cars are equipped with a blended air braking and dynamic braking system. The cars' master controller for propulsion and braking control can be placed in the emergency position, or it can simply be released by the operator and the controller's "deadman" feature will apply the brakes in emergency. Sand can automatically be applied on the rails ahead of the wheels when emergency braking is initiated. Sanding is not automatic with service braking, but must be done manually. The "Airporter" cars do not have the automatic sanding feature; all sanding with these cars must be done manually.

Both the 150-class and the 300-class cars are equipped with speed indicators in the operators' cabs, but neither type has a speed recorder nor does either type have any type of overspeed control.

The 150-class cars are equipped with two amber lights, one on each side of the headlights above the bumper on each end. Although it could not be established that the amber lights on the rear of train No. 6614 were lighted at the time of the accident, they normally would have been as long as the cars were under power. The pantographs of train 6601 had not been lowered from the catenary after the train stopped at signal EW 236, and the train was still under power.

The original cars bought by the Cleveland Transit System for the Red Line in 1955, all now retired, had operator compartments in the right-hand corners of the ends, which was an appropriate location with the signals located to the right of the tracks. Following the accident, the berthing limits at West 117th Street Station were set back to give train operators a better angle from which to view the signals from the compartment on the left side of the train.

Inspection of train No. 6601 after the accident revealed no defect in the braking systems of the cars. The rear car of train No. 6614 was found to have a blown compressor fuse. This would have prevented the compressor from restoring and maintaining the required air brake pressure, thus causing the train to come to an undesired stop.

Crewmember Information

GCRTA considered the operators and conductors of the trains involved in this accident to be qualified under their requirements. Both operators had been employed by the transit agency for more than 20 years and both had been train operators for more than 10 years. (See appendix B.)

The operator of train No. 6601 had reported for duty at his regular time of 3:18 a.m., and was making his second trip between the airport and Windermere Station. He had been on duty 4 hours 54 minutes when the accident occurred. Before going on duty, he had been off for about 15 hours. The previous day he had gotten off work at his regular time, shortly after noon. After eating lunch, he napped for several hours, ate supper at about 6:00 p.m., and went to bed by 9:00 p.m. He arose at about 2:00 a.m. to get ready for work. The operator said that this was his regular working day pattern.

According to the operator, he worked 5 days a week, Monday through Friday. He said he liked the shift he worked and found it to be "easy." The operator also said that he was in pretty good health, did not use alcohol or drugs, was not taking any kind of medication, and had not been ill for some time before the accident. He stated he had no part-time job or employment other than with GCRTA. He used eyeglasses for reading, but did not require them otherwise. He stated he did not wear sunglasses on the job.

All of the crewmembers in the accident submitted to toxicological testing after the accident. The test results of all were negative for alcohol and for the drugs for which tests were made.

Training and Supervision

GCRTA had two training supervisors who were responsible for the development and implementation of the rail training program. In addition to training the operators and conductors, they also trained new tower control supervisors. The training officer had about 15 years of service with GCRTA and its predecessor, Cleveland Transit System (CTS). He had worked as a rail operator, conductor, platform supervisor, and tower control supervisor before being assigned to the training program. He had received a 2-day course on training techniques and had attended a number of seminars and brief courses since becoming a training supervisor.

According to the training supervisor, GCRTA provides a 17-day rail training course for bus drivers transferring into the Red Line rail operation. He described the course as 3 days of formal instruction (1 day on the operating rules, 1 day in the yard with a yard instructor, and 1 day of instruction out on the line and examination). This, he said, was followed by 9 days of on-the-job training with a regular operator qualified as a road instructor, and 3 days of additional unspecified instruction. According to the training supervisor, operator-trainees were required to score a grade of 95 percent or better on a test composed of 25 essay-type questions.

The senior training supervisor stated that he and his assistant tried to follow up with newly-qualified employees once a month, but their workload was such that followup checks were sometimes made only once every 3 months. He also said that newly-qualified operators were re-examined after 90 days on the job, and again 90 days later. Tower control supervisors, he said, received 5 days of formal instruction from him or his assistant, and then received on-the-job training in the control towers.

According to the senior training supervisor, all Red Line operators and conductors were trained and examined on the new operating rulebook after it was issued in 1978. He said that all operators and conductors were given an annual 8-hour refresher course and were tested on safety, operations, and trouble-shooting. However, GCRTA service records provided to the Safety Board did not indicate this training had been given and the GCRTA was unable to produce additional records to verify the training supervisor's statement. The only annual training that was documented was training in winter trouble-shooting procedures.

Both the training supervisor and GCRTA's director of rail transportation stated that the old CTS training program for rail operators consisted of a 5-day course, including 2 days of formal instruction, 2 days of on-the-job training with a qualified operator, and 1 day of "finalization," which included a written test.

The senior training supervisor described the operator of train No. 6601 as "the best one we had." He also stated that the tower control supervisor who was in radio contact with the operator of train No. 6614 on the day of the accident should have informed the operator of train No. 6601 that a train was standing ahead, disabled in the curve.

While giving his sworn testimony, the senior training supervisor incorrectly stated part of the definition for "operation on sight" as the definition for "line of sight." Although given an opportunity to reflect and reconsider, he did not change his definition. The director of rail transportation defined "line of sight" correctly, but he indicated that there

may have been some confusion between that phrase and "operation on sight" in the initial book of rules issued in 1978, but he believed that the ambiguity had been clarified in the revised book of rules, issued in 1980. He also stated that he was uncertain how an operator could comply with the 1,000-foot line of sight requirement in curves with limited visibility.

When questioned on their training, the operators of trains No. 6601 and No. 6614 recalled that they had completed the 5-day CTS program when they went to work on the Red Line in the early 1970's. As stated earlier in this report, the operator of train No. 6601 maintained that he had not been trained or tested on the 1978 book of operating rules. The operator of train No. 6614 stated that he had attended a 1-day training session on the book of rules when it was issued to him and again when the rules were revised. The only refresher training he recalled was a day's instruction on the new 300-class cars. GCRTA produced no records to refute this testimony. Both operators stated they were regularly used to train new operators on the job.

Operators' service records contained numerous reports by platform supervisors of checks on how train crews opened and closed the car doors, how they supervised fare collection, and whether they avoided leaving stations ahead of schedule. There were no reports about how operators performed in relation to speed restrictions, restrictive signals, and bulletin instructions. The operators of the trains involved in the accident could not recall having had supervisors ride with them in their cabs, or of having been cited for operational failures.

Previous GCRTA Train Accidents

Safety Board investigators determined that no serious train accidents involving operator non-compliance with restrictive signal aspects had occurred during the 20 years in which the Cleveland Transit System operated the Red Line and during the 33 years in which the City of Shaker Heights operated what are now GCRTA's Blue and Green Lines. However, since GCRTA took over these rail lines in 1975, the Safety Board has investigated six collisions and one derailment involving passenger-carrying trains on these lines. In addition to the accident of July 10, 1985, and the 1976 rear-end collision and 1977 head-on collision previously referred to, the Safety Board investigated the following four accidents:

- 1) A collision on December 6, 1977, between a standing Red Line train and a following Red Line train moving at 20 mph. Forward visibility was restricted and the following train operator failed to comply with a stop signal. 2/

2/ NTSB Brief of Railroad Accident: CHI-78-F-R013.

2) A collision on May 5, 1982, between a standing Red Line train and a following Red Line train moving at 14 mph. The following train operator failed to comply with a stop signal. Further, forward visibility was restricted by track alignment and uncut vegetation. 10/

3) A side collision on September 10, 1984, in the Cleveland Union Terminal between a standing Shaker Heights train and a second Shaker Heights train moving at 20 mph in a 5 mph restriction where visibility was critically limited. 11/

4) A derailment on November 4, 1985, of a Red Line train that overran a stop aspect at a red interlocking signal, passed through a crossover, derailed, and traveled several hundred feet down the opposing main track. 12/

Passengers were injured and there was substantial damage in each of these accidents.

GCRTA Safety Department

The Safety Department was composed of three permanent and two part-time persons (one of whom was a secretary), including the head of the department (the safety supervisor). This department is responsible for the safety of the bus service and the rail service. The bus service of the GCRTA is a much larger operation than rail service. Of the three individuals in the safety department, one is assigned to bus operations and one to the rail operations, with the head of the department trying to cover both services. The head of the safety department stated, "unfortunately, many times the individual for the rail side is pulled over to the bus side because of the size and magnitude of the bus side."

The head of the safety department has worked for the GCRTA for 6 years. Before coming to the GCRTA, he had worked for the Euclid Municipal Bus Company as a busdriver, supervisor, and assistant superintendent. He has a B.A. in communications and has attended several courses with the Transportation Safety Institute in Oklahoma dealing with rail accident investigation and rail system safety. He attended safety classes with the Ohio Industrial Commission, but was not eligible to graduate because he lacked sufficient experience in the safety field. He did, however, obtain a Certified Safety Professional standing. One of the other individuals in the safety department came from the equipment maintenance department; his safety background is in police work and he works as a part-time police officer. He was also involved with the safety committee at the facility. The third individual came to the safety department from the facilities maintenance department and had also been involved with the safety committee.

10/ NTSB Brief of Railroad Accident: NYC-82-F-R035.

11/ NTSB Brief of Railroad Accident: CHI-84-F-R011.

12/ NTSB Brief of Railroad Accident: ATL-86-F-R033.

The safety department reports to the Assistant General Manager of Marketing and Management. Asked about the responsibility of the individuals in the safety department, the head of the department responded,

the other two permanent assigned employees are my assistants and they are responsible for attending local safety meetings at the various facilities. They're also responsible for following up on safety problems that might arise depending upon the severity. They're responsible for putting those reports together... dealing basically with statistical information relating to accidents and employee injuries.

When asked if supervisors are given special safety training, he replied, "not normally...at this point." Asked how the supervisor would convey safety matters, the head of the safety department replied, "well, if it pertained to matters of operations, supervisors have a sense of safe operation."

The safety department does get involved in the development of operating practices, but, according to the safety supervisor, even since this accident occurred, it does not get involved in all of the decisions on the development of operating rules. The safety department is given only 30 minutes on graduation day to train employees in safety. The safety department head advised,

it's not sufficient time to talk specific safety rules and regulations. ...we're just trying...to impress upon them the importance of safety, just overall safety, in the performance of their duties.

The train operators are not given regular safety training, nor do they normally attend safety meetings. During the investigation of this accident, the head of the safety department said he had never seen and was not aware that Urban Mass Transportation Administration (UMTA) published guidelines for use by the transit industry. Asked if he was satisfied with the comments and actions of the employees involved in this accident, he answered that their understanding was not complete and that they needed additional training to reinforce the operating rules and safety concepts. He added that

there's a need for supervision to monitor the activities...and followup when we find infractions or violations of rules and things of that sort. I had some misgivings about our training and our methods of doing followups...

Oversight of the GCRTA

No administration within the U. S. Department of Transportation (DOT) oversees or regulates the safety of rail rapid transit operations. As a result of the two prior GCRTA accidents that it had investigated and of concerns raised by the investigations, the Safety Board on March 6, 1978, issued Safety Recommendation R-78-10 to the DOT asking it to ensure that "the safety of rail rapid transit systems will be regulated by a responsible State or Federal agency." The Safety Board further recommended that Federal oversight of the safety of rail rapid transportation should be vested in the administration that provides Federal grants to aid the development of the industry.

In 1981, Safety Recommendations R-81-1 and -2 were addressed to the Secretary of Transportation, asking that the DOT propose legislation authorizing DOT to regulate the safety of federally assisted rapid transit systems and, pending such legislation, require UMTA to establish Federal guidelines for equipment and operations. The recommendation also suggested that DOT conduct substantially increased safety oversight of these systems. These were rejected by the Secretary of Transportation on April 22, 1981. The Secretary stated that the DOT was seeking repeal of Section 107 of the National Mass Transportation Act of 1974 ^{13/}, to remove the Federal Government from an intrusive role in rail transit safety because such a role is a local responsibility, best handled at the State and local level. Section 107 was subsequently repealed. However, Section 22 was amended to give the DOT the authority to investigate potentially unsafe conditions, to require corrective action, and to withhold financial assistance if a corrective plan were not implemented.

The Safety Board subsequently reconsidered Safety Recommendations R-81-1 and -2 and closed them because it had concluded that detailed regulation of rail rapid transit safety should not be the responsibility of the Federal government. However, the Safety Board also informed the DOT that it did not believe that a total abdication of responsibility, at the Federal level, for safety on transit systems was desirable. The Board also stated that it believed that UMTA has safety oversight responsibilities and should act to exercise those responsibilities.

The DOT has stated that it believes that its existing oversight capability of rail transit safety is adequate and that it is exercising that capability. However, the Safety Board has

^{13/} Section 107 contained authority for UMTA to conduct investigations of unsafe conditions and to attach safety conditions to Federal funding for rail rapid transit systems.

not seen evidence that DOT is inclined to use the authority prescribed in section 22, given that the DOT appears to have used it only on one occasion. In January 1987, the Safety Board wrote to the Secretary of DOT, stating that it was concerned about the passive Federal safety oversight of rail rapid transit systems, particularly UMTA's failure to conduct safety investigations, even of equipment that has been funded by UMTA capital grants. Because the Safety Board believed that further dialogue on the matter was futile, Safety Recommendation R-78-10 was closed--unacceptable action.

During the early 1980's, the Safety Board became increasingly concerned about recurrent operational and maintenance problems on the rail rapid transit lines of the New York City Transit Authority (NYCTA). The Safety Board did not believe that its periodic accident investigations, public hearings, and occasional studies of rail rapid transit safety issues were a satisfactory substitute for a program of structured oversight of the NYCTA's rail rapid transit plan by a regulatory agency. Because of the DOT's support for and the policy of UMTA not to monitor and regulate safety on rapid transit lines, the Safety Board addressed these concerns to the State of New York. On September 22, 1981, the Safety Board recommended that the State of New York take legislative and/or executive action to authorize a new or existing independent agency to oversee and regulate the safety of the NYCTA system 14/. Subsequent to this recommendation, the State established the New York State Public Transportation Safety Board, empowered to oversee and regulate rail rapid transit lines in the State. The State of California also has an agency that actively regulates its rail rapid transit systems.

GCRTA is administered by a board of directors chosen from the various Metropolitan Cleveland communities. For the most part, the directors do not have transportation backgrounds. A general manager and his staff operate the GCRTA bus and rail systems day-to-day. The board of directors maintain control over personnel selection, expenditures, service, and so forth.

Insofar as the Safety Board has been able to determine, the State of Ohio Public Utilities Commission (PUCO) presently has no oversight or regulatory authority over GCRTA. However, PUCO has a long history of oversight and regulation of rail passenger service in Ohio. In 1906, it began to implement a number

14/ Special Investigation Report -- "Eight Subway Train Fires on New York City Transit Authority with Evacuation of Passengers" (NTSB-SIR-81-5).

of legislative acts relating to the safety of the State's electric interurban railway system, a system not covered by Federal regulation. This system, which connected every major city in Ohio, was almost exclusively used to carry passengers over intercity and suburban lines. It had a remarkable history of relatively safe operation while under PUCO oversight. Although never directed to oversee Ohio's street railway systems, PUCO did regulate the Cleveland Interurban Railroad, which built and operated GCRTA's present Shaker Heights rapid transit lines until 1942.

Meteorological Information

According to the National Weather Service, at the time of the accident, the weather at Hopkins International Airport was partly cloudy with visibility of 20 miles and temperature of 65° F. The sun had an approximate altitude of 22° and an azimuth of 079°. Rain showers, mostly light to moderate, began at 1:40 a.m. and ended at 7:09 a.m. According to the operator of train No. 6601, the sun was shining at the time of the accident.

Survival Aspects

Damage to the cars involved in this collision was confined to the colliding end sections. There was no structural deformation of the cars' passenger compartments, and none of the seats was dislodged. According to passenger statements and hospital records, most injuries were fractured noses, muscle strains, and contusions.

The platforms of the opposing cars did not override, and much of the impact energy was absorbed by the end assemblies and end underframes. Shear bolts in the couplers of all the cars in the trains were broken. The rear truck of the rear car of train No. 6614 was derailed, but it did not diverge substantially from the track and the car remained completely upright.

Response to the Emergency

The Cleveland Emergency Medical Service (CEMS) dispatched the first ambulances to the accident site at 8:15 a.m. following notification of the accident by the GCRTA Tower Control Supervisor. CEMS and GCRTA personnel jointly concluded, at the time, that there were no seriously injured passengers or crewmembers. GCRTA then decided to transport all those aboard the two trains to the West 98th Street Station, rather than carrying them or having them walk the 900 feet to the station

over the ballast and in proximity to the ConRail tracks. An empty train was brought abreast of the accident trains on the westbound track and used to transport them. CEMS ambulances and a GCRTA bus then transported the 46 injured passengers and the four injured crewmembers from the station to nearby hospitals. Within an hour and a half, all injured persons had been transported to the hospitals.

Tests and Research

Shortly after the accident and before the two trains were removed from the eastbound track at the accident location, GCRTA supervisors and signal personnel observed that signals EW 252 and X-8 displayed stop aspects. Subsequent testing of the signal circuitry and relays revealed no defects and the signal system functioned as intended throughout.

Postaccident testing established that with a 300-class train standing at the berthing marker for the eastbound track at West 117th Street Station, the aspect being displayed by signal X-8 could not be seen from the operator's seat because, from that location, the operator can only see the side of, and not the face of, the signal. However, the aspect could be seen by leaving the operator's compartment and going to the right-front corner of the car.

Following the accident, a train of "Airporter" cars was placed on the eastbound track where train No. 6614 had been standing at the time of the accident. Sight-distance tests supervised by Safety Board investigators established that the extreme left hand corner of the rear car was visible from the operator's seat of a 300-class car at a point 266 feet west of the point of impact. (See figure 3.) Had the rear of the car not been masked by foliage on the inside of the curve, much of the car would have been visible from at least the 266-foot point. (After the accident, the Safety Board learned that the GCRTA had cut back some of the foliage and had contracted for vegetation control on its right of way.) At a distance of 140 feet, the entire end and a small part of the rear right side of the "Airporter" car was visible. (See figure 4.) At the 140-foot distance, enough of the train and its location on the track was visible to recognize readily that the train was standing on the same track.

Stopping distance tests established that, at a point 266 feet from the impact point, a two-car test train of 300-class cars required 126 feet to stop from 22 mph; at a point 140 feet from the impact point, the two-car test train required 131 feet to stop from 22 mph. Two tests made in the rain indicated that stopping distances were similar to those made when it was not raining.



Figure 4.--Train appears at a distance of 140 feet.

ANALYSIS

The Accident

As long as train No. 6614 was stopped on the eastbound track adjacent to signal EW 236, all the signals between the West 117th Street and West 98th Street stations (i.e., signals X-8, EW 252 and EW 236) would, by design, simultaneously and continuously display stop aspects. (Signal EW 263 was not functioning because it had been struck and pushed down during a derailment of a ConRail freight train.) Because of the short sight distance in the reverse "S" curve, this special feature was incorporated into the signal system at this location by the Cleveland Transit System, which had built the Red Line and operated it for 20 years prior to the take over by GCRTA in 1975. Postaccident testing established that the signal system functioned properly.

Further, the Safety Board's investigation established that when an eastbound train was berthed at the station, the operator could not see the aspect of signal X-8 without leaving the operator's compartment and going to the right-hand side of the car. This situation resulted because GCRTA failed to relocate signal X-8 or to change the train berthing marks at the station when the Red Line began using cars with the operator's compartment on the left side instead of the right. Thus, it is unlikely that the operator of train No. 6601 could have seen signals X-8 and EW 252 displaying green proceed aspects as he stated. Therefore, the Safety Board believes that the operator of train No. 6601 either failed to observe or disregarded stop aspects displayed by interlocking signal X-8 at West 117th Street Station and intermediate signal EW 252 at the entrance to the reverse curve.

When an air compressor fuse failure caused train No. 6614 to be inoperative, it was standing with its rear end at a very critical location in terms of sight distance. The "S" curve and the uncut vegetation reduced the distance at which a part of the rear of the train could be seen to 266 feet and the distance at which the entire rear of the train could be seen to somewhat more than 140 feet. Therefore, it was very important for the operator of train No. 6601 to observe and respond properly to the stop aspects of signals X-8 and EW 252.

However, even though the operator of train No. 6601 failed to comply with the "stop" aspects of these signals, this accident did not have to occur for a number of reasons. The Red Line's signal system was equipped with an automatic train stop (ATS) feature consisting of trip arms located at the signals. The trip arms were designed to prevent a train from being operated improperly past a stop signal. However, at the time of the accident, at least half the Red Line's 184 trip-arm-equipped wayside signals had broken trip arms. In the hazardous section between the West 117th Street and West 98th Street stations, signal X-8 and all the eastbound intermediate signals had broken trip arms. Thus, the entire section was without the ATS backup protection intended to prevent a collision in the event a train operator failed to obey the signal system. If the ATS trip arm of signal EW 252 had been operative, train No. 6601 could not have proceeded into the reverse curve unless the operator had "knocked down" the signal and proceeded through the "stop" aspect without calling the tower control supervisor. (Calling the tower control supervisor was required by the GCRTA operating rules.) Thus, had the trip arm been operative and the operator obeyed the rules, the accident probably would not have occurred, because the operator would have contacted the tower control supervisor at Cleveland Union Terminal and learned that train No. 6614 had stalled on the track ahead about 2 to 3 minutes earlier.

Nevertheless, even the absence of an operative trip arm at signal EW 252 would not necessarily have occasioned an accident. Even if signal X-8 had an operative trip arm, the operator of train No. 6601 should not have moved his train from the West 117th Street Station without permission of the tower control supervisor because the aspect of signal X-8 would have been "stop" as long as train No. 6614 was stopped in the "S" curve section ahead. Although all Red Line interlocking signals, including X-8, had a button on the mast that a train operator could push to release the trip arm from the tripping position, the signal rules required that operators contact the tower control supervisor for instructions when the signal aspect was "stop". The special arrangement of the signals between West 117th Street and West 98th Street, which caused them all to display a "stop" aspect in this case, was yet another safety backup feature prompted by the short sight distance in the reverse curve. With the trip arm broken, however, there was no physical impediment to keep the operator of train No. 6601 from proceeding through the signal without contacting the tower control supervisor.

It is not unreasonable to assume that, had they been in radio contact, the tower control supervisor would have informed the operator of train No. 6601 of the problems experienced by train No. 6614. It was highly unlikely that the supervisor would permit train No. 6601 to proceed on the eastbound track, since it may have become necessary to cross eastbound trains over to the westbound track at West 117th Street to run around the disabled train should its problems be too serious to be solved quickly. At that time of the day, keeping the inbound rush hour traffic moving would have been a high priority for the tower control supervisor.

The tower control supervisor was not required by GCRTA operating rules to notify the operator of train No. 6601 of the problems being experienced by train No. 6614. However, because of the location of train No. 6614 and the fact that train No. 6601 was running only 5 minutes behind it, the tower control supervisor should have contacted the operator of train No. 6601 by radio, informed him of the situation, and held him at the West 117th Street Station. The supervisor was aware of the deficiencies in the ATS equipment, and he believed that the signal X-8 trip arm was probably defective. Nevertheless, the supervisor made no effort to contact train No. 6601 by radio before or after it left West 117th Street Station. Had he done so, however, the accident could have been prevented. GCRTA rules should require the tower control supervisor to broadcast a warning of hazards to operators of trains in the vicinity of the hazard.

Another factor in the accident may have been GCRTA's failure to restore to service inoperative signal EW 263, the first intermediate signal east of West 117th Street Station.

Given the double block stop protection provided elsewhere on the Red Line system, and assuming that the train No. 6601 operator did not know or did not remember the special arrangement that all the signals behind an eastbound train back to West 117th Street would display "stop" aspects until the train reached the West 98th Street Station, the operator may have assumed that the train ahead had passed signal EW 236. This hypothesis requires that the operator of train No. 6601 would assume that the aspect of signal X-8 was not "stop" and that the aspect of signal EW 236 far ahead up the track was "stop". The operator of train No. 6601 would not have been able to learn that the aspect of signal X-8 was "stop" from his position in the operator's compartment because he could not see the signal aspect from there. He also could not determine if the aspect was "stop" from the position of the trip arm, because it was broken. Thus, he may have assumed that the aspect of signal X-8 was clear, that he was in double block "stop" protection territory, that signal EW 252 with its "stop" aspect was the second signal behind signal EW 236 (also with a "stop" aspect), and that train No. 6601 was ahead of signal EW 236. If so, this could have suggested to him that the track was clear through the reverse curve and past the accident location. Had signal EW 263 been operational and had the operator seen both it and signal EW 252 displaying "stop" aspects, and had he believed he was in double block stop protection territory, he might have approached the accident location at a lower speed, alert to the possibility that he might encounter a train or a track problem beyond signal EW 252.

The testimony provided by the operator of train No. 6601 at the Safety Board's deposition proceedings indicated that he did understand the special arrangement of the signals between West 117th Street and West 98th Street. Therefore, if the operator did believe he was in double block stop territory, he must have temporarily forgotten about the special signal arrangement beginning at signal X-8. It is possible that the GCRTA over-emphasized the double block stop protection aspect of its system or that the operator simply had a temporary lapse of memory. However, for whatever reason, the operator failed to comply with the "stop" aspects displayed by signals X-8 and EW 252.

Still another action that might have prevented the accident was for GCRTA to have reposted the 5 mph speed restriction sign that had been removed by vandals 2 days before the accident. Although the 5 mph speed restriction was related only to minor irregularities in the track, and the track speed in that area was normally 25 mph, had the speed restriction sign been reposted and had it been observed, train No. 6601 could have stopped and the accident been averted. Traveling at 5 mph, the train could have been stopped in less than 2 seconds or in about 15 feet. The sign had been posted about 390 feet west of the rear of train No. 6614. The operator of train No. 6601 originally indicated to Safety Board investigators that he first saw train No. 6614

standing and applied the train brakes when about 25 feet from train No. 6614. At 5 mph, he would have been able to stop train No. 6601 before a collision, even if he had not observed train No. 6614 when it was first observable, 266 feet from the collision, or when the rear and part of the side was visible, 140 feet from the collision. Because the track speed in this area was normally 25 mph, the Safety Board does not believe that GCRTA's failure to repost the 5 mph speed restriction was a contributing factor in the accident. However, the failure to report the sign does indicate a lack of adequate attention to the maintenance of its wayside system.

Finally, however, despite the failure of GCRTA to repair the trip arms and signal EW 263, the failure of the operator of train No. 6601 to observe the rules about not proceeding through stop aspects without contacting the tower control supervisor, the failure of the tower control supervisor to warn the operator of train No. 6601 of the hazard ahead, and the failure of the GCRTA to repost the 5 mph speed restriction sign, the accident was still not inevitable.

Sight distance tests revealed that the left rear end of the standing train could be seen from a distance of 266 feet. Uncut vegetation, foliage, and other obstructions obscured the remainder of the train. The entire rear of the standing train and part of its right rear side could be seen from a distance of 140 feet. (In fact, it could be seen from somewhat farther back on the track.) Also, from that distance it was readily observable that the standing train was on the same track as the test train. Based on a deceleration rate for the 300-class Tokyu cars, while traveling at 22 mph, of 3.5 mph/sec with emergency brakes applied, train No. 6601 would have required 109 feet to stop. Assuming 2 seconds were needed for the operator to observe the train, perceive that it was standing on the same track, and apply the emergency brakes, the train would have traveled 65 feet during this time. Thus, the train could have been stopped in about 174 feet, including reaction time. It is reasonable to assume that although the operator of train No. 6601 could see part of train No. 6614 at the 266-foot distance, he may not have been able to perceive readily that the train was on the same track at that distance. Had the GCRTA cut back the foliage and vegetation at the accident site, the rear of train No. 6601 would have been fully visible from more than 140 feet away. However, because the operator could see a part of the train at 266 feet, he should have been able to perceive that it was on his track before he reached the 140-foot point so that, when he could fully see the rear of the train, he should have decided to apply the brakes and begun to do so. Thus, it is reasonable to conclude that had the operator been alert and attentive to his tasks while operating in the "S" curve with its known sight distance limitations, he should have been able to stop his train and not collide with train No. 6614.

As far as could be determined during the Safety Board's investigation, the operator of train No. 6601 was neither impaired nor distracted after his train left West 117th Street Station. There was no evidence that sand, grease, or other foreign matter on the rails may have prevented train No. 6614 from shunting the signal EW 252 circuit. The train's operator stated that he did not apply sand manually when stopping, and his train did not have the automatic sanding feature. There was no evidence to support the contention of the operator of train No. 6601 that grease on the south rail may have retarded braking performance. Further, the train operator's occasional encounters with grease at this location should have caused him to adjust the way he operated his train in this area.

It is difficult to identify the specific reason the train operator failed to stop the train when he had the opportunity to do so, had he been alert, vigilant, and not physically or mentally slow to react. The operator's primary duty while the train was between stations was to monitor the train speed and the track ahead. Little else required his attention.

Therefore, the train operator either did not see the train, saw it but did not perceive it was stopped, perceived it was stopped but not necessarily on his tracks, or perceived that the train was stopped on his tracks but was not able to apply the brakes in time to stop the train before the collision. The Safety Board cannot be certain which of these scenarios actually took place. If the train operator did see the train in time to stop it safely but failed to perceive that the train ahead was stopped, or if he failed to react after realizing that it was stopped, it is possible that he failed to stop because he simply failed to pay attention to his tasks.

It is clear that the train operator did not properly perform his duties of vigilantly monitoring the track ahead of the train or, if he was monitoring the track, he was unable to react in time.

GCRTA Maintenance of the Red Line System

An important causal factor in a 1977 head-on collision on the GCRTA Shaker Heights rapid transit line, in which 60 persons were injured, was GCRTA's failure to keep vegetation from obscuring vision in a 6° curve. In its report of the investigation of that accident 15/, the Safety Board found that the vegetation on the inside of the curve prevented the motormen

15/ Railroad Accident Report--"Head-on Collision of Two Greater Cleveland Regional Transit Authority Trains, Cleveland, Ohio, July 8, 1977" (NTSB/RAR-78-2).

of the trains from seeing the opposing train in time to stop. The Board's finding that the vegetation was a contributing factor in the probable cause of that accident apparently has not motivated GCRTA sufficiently to produce an ongoing program of vegetation control at critical sight distance locations along its rail lines.

In this Red Line accident, the operator of train No. 6601 could have stopped his train short of the stalled train despite GCRTA's poor maintenance of the vegetation had he been alert and attentive to his job. However, the Safety Board believes that had the view around the curve not been masked by foliage, the operator of train No. 6601 would have had a clear view of train No. 6614 in time to stop his train clear of it, even if his recognition of the danger and his response to it were slower than normal.

The Safety Board's investigation also determined that the Red Line's many signal shortcomings had been reported repeatedly to tower control supervisors, and to GCRTA's safety supervisor, and thus to GCRTA management. Further, the rail safety committee reported such problems to GCRTA twice in the 9 months preceding the accident. GCRTA did not have a stock of spare trip arms at the time of the accident, and had placed an order for only 10 trip arm replacements. Moreover, GCRTA apparently did not attempt to take undamaged trip arms from intermediate signals at non-critical locations to replace the broken trip arms at signal X-8 and at EW 263, 252, and 236 interlocking signals. Nevertheless, GCRTA managed to repair and restore the ATS function in 92 defective signals in scarcely more than 3 months after the accident.

In the report of its investigation of the head-on collision at Shaker Heights, the Safety Board also cited the inadequate maintenance of the Shaker Heights line by the GCRTA. The Safety Board found that more than 150 rail bond wires were broken in the Shaker Heights signal system. Several block signals were either malfunctioning or not functioning at all. On September 6, 1977, during the investigation of the Shaker Heights accident, the Safety Board issued Safety Recommendation R-77-26, requesting that GCRTA:

Immediately inspect and repair the block signal system and implement procedures for its maintenance to insure that it continues to function as intended.

On January 4, 1979, the GCRTA responded, telling the Safety Board that "the signal system had been repaired and was functional as of December 1977 and that signal personnel ride all routes on a daily basis, inspecting and maintaining the system". The Safety Board closed R-77-26, acceptable action.

The overgrown vegetation in the "S" curve with its limited sight distance, the broken signals and trip arms, and the missing track bolts and bonding wires suggest, strongly, that GCRTA did not learn all of the important lessons from the Shaker Heights accident. The GCRTA must improve its maintenance of the Red Line system since it could well experience additional accidents as a result of this poor maintenance.

GCRTA Operational Procedures

As stated in the previous section, 3 months after the accident, GCRTA repaired and restored the ATS function to many of the defective signals. However, its long-term failure to restore and maintain the capability of the ATS portion of the Red Line system before the accident suggests that GCRTA was satisfied to operate its system with a degraded ATS. Testimony obtained and evidence developed during the course of this investigation tends to support this position.

The operators of both trains indicated that the trip arms of the intermediate signals can be "knock[ed] down"; that is, the trip arm is lowered when a train approached the signal slowly. This enables trains to be operated through signals displaying "stop" aspects. Further, the trip arm at the interlocking signals can be lowered by pushing a button on the signal mast, which can be reached through a window at the right front of the train. The clear implication of the testimony was that the procedure of defeating the trip arm to proceed through "stop" aspects of signals was being practiced on the Red Line. This practice can condition operators to believe that the strict adherence to or compliance with the aspects displayed by the signals is not absolutely necessary to the safe operation of the system. This "mind set" would be reinforced if the operating employees believed that GCRTA management condoned the practice.

Further, the operating rules for compliance with the signals require the operators to call the control tower supervisor whenever they reach a signal (either an interlocking or an intermediate block signal) with a "stop" aspect displayed. In testimony provided to the Safety Board by the operators of trains No. 6601 and No. 6614 and in direct observation while riding trains of the Red Line, Safety Board investigators learned that when operators contact the tower control supervisors in such situations, the supervisors will often tell the operators to pass the signals and proceed on line of sight.

This permission to proceed through a signal displaying a "stop" aspect and to operate on line of sight has been given at signals with trip arms functioning and at signals with trip arms not functioning. Further, the operator of train No. 6601 stated in testimony to the Safety Board that he had been instructed by the tower control supervisors to proceed through stop "aspects," describing the process of "knocking-down" the signal and then

closing "up to the other train". In fact, in response to a question of whether he was always told to close up on trains in front of him, he replied "yes". Additionally, the tower control supervisor on duty at Cleveland Union Terminal at the time of this accident testified, in great detail, on how to tie down the trip arm of an intermediate block signal in order to proceed through red signals into "stop" blocks. Operating personnel could interpret this action by GCRTA supervisory personnel as tacit approval of a policy that strict compliance with signal aspects and with operating rules is not necessary for safe operations.

In addition to the disregard for operating rules, the GCRTA failed to repair the many broken signal trip arms and to replace signal EW 263. These devices were designed as a part of the Red Line system to provide positive assurance of compliance with GCRTA's written operating rules for the ATS territory. GCRTA's failure to maintain this system could well have reinforced the employee "mind set" that strict compliance with the rules was not an absolute necessity. It appears that GCRTA had created a situation in which, at the least, the ATS portion of the Red Line system was not being operated under its signal rules, but rather, under a hybrid operation that was neither a signaled nor a manual block operation. The method of operation had, de facto, become a "permissive block operation".

Unfortunately, however, GCRTA was not adequately structured to provide the safeguards necessary to operate the ATS portion of its Red Line system safely under a permissive block operation. Train operators, conductors, and tower control supervisors were not provided adequate procedures and equipment. GCRTA operating rules addressing this type of operation were confusing, ambiguous, and lacking in specific guidance. GCRTA's "Operation on Sight" specifically permits following an operation within blocks (that is, operation of two trains within the same block under certain conditions), or permissive block operation. However, under the provisions of these rules, an operator must keep a minimum distance of 1,000 feet between his or her own train and a preceding train.

Red Line signal blocks are typically longer than 1,000 feet; the block in which the accident occurred was nearly 1,600 feet long, and with signal EW 263 out of service, the first block east of West 117th Street Station was 2,400 feet long. However, many Red Line locations, like that at which the accident occurred, have available sight distances of less than 1,000 feet. The GCRTA's rules are silent on what operators should do in this situation. The "line of sight" rule leaves the issue of speed under these conditions entirely to the operator's judgment. None of the train crewmembers, tower supervisors, and training supervisors, nor the safety supervisor or the rail superintendent, who were questioned by Safety Board investigators

in deposition proceedings, was able to explain adequately the rules regarding "operation on sight" and operating on "line of sight", nor could they explain how an operator could comply with the 1,000-foot requirement where forward vision was less than 1,000 feet.

In addition to the ambiguous rules, GCRTA did not have available for the tower control supervisor at Cleveland Union Terminal a modelboard that covered the system west of West 38th Street. A modelboard that located trains at all times would be essential to the safe operation of any system operated in less than strict adherence to its signal rules.

The communication procedures of the Red Line system were also inadequate for this type of block operation. Statements by tower control supervisors and observations by Safety Board investigators of communications between operators and supervisors revealed that these communications are generally limited to requesting and receiving permission to proceed into "stop" blocks or for emergency purposes. In general, the tower control supervisors do not know the locations of trains at any given time precisely enough to operate a permissive block operation safely.

However, the practice of operating its systems with less than strict adherence to rules adequate for the safe operation of its system is not new to the GCRTA. In its investigation of a 1976 rear-end collision on the Red Line 16/, in which 20 persons were injured, the Safety Board found that GCRTA had no method to ensure that an operator would stop his train before moving past the second stop signal protecting the rear of a preceding train. The investigation also found that the ATS system was compromised by the practice of allowing a train to approach and pass a stop signal slowly enough to drop the trip arm from the tripping position. The Safety Board also determined that contributing to the probable cause of the accident was "...the ineffectiveness of the protective devices and procedures to prevent a following train from entering an occupied block."

As a result of its investigation, the Safety Board issued, on August 19, 1977, Safety Recommendation R-77-21, in which it recommended that GCRTA "Operate trains on an absolute block. If it becomes necessary to enter an occupied block in an emergency, provide procedures that will insure safe operations." On November 18, 1977, GCRTA responded that,

Trains now operate on an absolute block. When it is necessary to enter an occupied block, in an emergency, permission must be received from the tower control supervisor.

16/ Railroad Accident Report--"Rear End Collision of Two Greater Cleveland Regional Transit Authority Trains, Cleveland, Ohio, August 18, 1976" (NTSB/RAR-77-5).

Subsequently, GCRTA informed the Safety Board that it had issued a bulletin rule applying to all red stop blocks that required trains to

stop short of red block, remain standing for 30 seconds, and then call the tower control supervisor for permission to enter the block. If permission is received, speed within the block shall be no more than 10 mph.

Because of GCRTA's response, the Safety Board closed out the Safety Recommendation on a "Closed--Acceptable Alternate Action" basis. However, when the bulletin rule was incorporated into GCRTA's new book of operating rules issued February 28, 1978, the 10-mph speed restriction was not included. It is possible that GCRTA did not include in its 1978 operating rules the 10 mph speed restriction for trains permitted to operate into a red stop block because it believed the 10 mph limit would not be needed in some portions of its system where sight distance would allow adequate distance to stop. GCRTA may have believed that this limit was too restrictive, which may be true where sight distance is 1,000 feet. Certainly with the deceleration capabilities of the cars being operated in this accident, an alert operator can safely stop a train in far less than 1,000 feet.

The Safety Board's investigation revealed that instead of being restricted to a relatively slow specified speed, GCRTA train operators have been permitted to proceed past red signals entirely on the basis of their own judgment and in line with GCRTA's unique "line of sight" speed rule with its attendant uncertainties. GCRTA continued to rely on the use of a permissive block operation with trains routinely allowed to pass stop signals. The result is total dependence on human management of its trains, even when tower control supervisors have no modelboard indications of train locations. These facts indicate that GCRTA was operating the Red Line on a basis of "close-up" or expedited train movement.

It is also clear that it is unsafe for train operators to have no guidance regarding the maximum speed at which they should operate their trains in areas where the sight distance is limited, such as in the "S" curve where this accident occurred. This accident may have been avoided had an adequate speed limit been posted at a distance from the curve appropriate for the sight distance, train braking capabilities, and human reaction and response time.

The manner in which the GCRTA operated its Red Line system --- its failure to enforce strict compliance of its operating rules, its failure to maintain the signal system, its adoption of confusing and ambiguous operating rules -- produced an

environment in which a permissive block operation existed. This may have been the unintentional result of GCRTA management's failure to direct attention or resources to these problems. However, it may also have been the result of a conscious management decision to operate the system on an "expedited" or "keep-the-trains-running-up-close" basis. Whichever is the case, the inevitable result of such a method of operation is degraded safety and accidents like this one.

Previous GCRTA Train Accidents

The results of this method of operation appear, indeed, to increase the number of accidents. Safety Board investigators determined that there had been no serious train accidents involving operator non-compliance with restrictive signal aspects during the 20 years in which the Cleveland Transit System operated the Red Line and during the 33 years in which the city of Shaker Heights operated what are now GCRTA's Blue and Green Lines. However, since GCRTA took over these rail lines in 1975, the Safety Board has investigated six collisions and one derailment involving passenger-carrying trains on these lines. Passengers were injured and there was substantial damage in each of these accidents.

The Safety Board believes that GCRTA will continue to experience accidents involving non-compliance with restrictive signal aspects with consequent peril to the public until it addresses its permissive block procedures. GCRTA must place safety before operational expediency and establish and enforce safe operating procedures that leave no doubt as to precisely what is required on the part of its train operators. Automatic train control may lessen the human management factor as long as it is functional, but a responsible approach to operation when the ATC is non-functional will still be needed. Moreover, as far as the Safety Board has been able to learn, no program is presently underway to replace the existing ATS system with ATC on the east side portion of the Red Line.

Training and Supervision

Despite GCRTA assurances of improvements in training, retraining, and supervision, the Safety Board is concerned that serious deficiencies remain in these important functions. As a result of its investigation of the 1976 Red Line head-on collision, on September 6, 1977, the Safety Board issued Safety Recommendation R-77-20, in which it recommended that GCRTA:

Develop a system assurance and safety program that will provide and insure the following:

- 1) A set of operating rules and procedures that will provide objective requirements for a safe and efficient operation.

2) A training program that will originally acquaint operating personnel with the rules and a system of reexamination to keep them current with the rule requirements.

3) A system of supervision which will enforce the rules and will provide an efficient operation.

GCRTA responded to the Safety Board that it drafted and issued to its employees a book of operating rules in February 1978. GCRTA also informed the Safety Board on November 18, 1977, that it had "developed an outline of the basic operator training procedures along with a schedule of the succeeding reviews and an annual examination to keep them current with the rule requirements," and had "implemented a system of supervision which will enforce the rules through proficiency testing". As a result, the Safety Board closed Safety Recommendation R-77-20 as "Acceptable Action" on March 22, 1979.

Although GCRTA may be providing more thorough initial training of its new operators than it had in the past, the results of the Safety Board's investigation of this latest accident suggest that GCRTA did not accomplish all it said it was going to do, especially in regard to the training of its operators who had been with the company prior to the establishment of the improved training procedures. Both train operators involved in this accident had been operating trains since the early 1970's and had received the Cleveland Transit System 5-day course and on-the-job training at the time they were qualified. Nevertheless, the operator of train No. 6601 stated that he had never been trained or examined by GCRTA on the 1978 book of operating rules and could not recall having received any GCRTA annual "refresher" training and examination. The operator of train No. 6614 stated that he had attended a 1-day training session when he received the rules and again when the rules were revised in 1980. GCRTA service records did not contain any information on the rules training that the operators may or may not have received.

GCRTA may believe that its older, more experienced operators (those who have been with the system since the training was improved) are sufficiently competent and that its training resources should be concentrated on new rail operators. However, testimony given to the Safety Board clearly demonstrated that both operators, despite their experience, were unsure as to the meaning of a number of important operating rules.

Further, the Safety Board is concerned that GCRTA's leading training supervisor incorrectly defined the "line of sight" rule, which is relied on almost entirely when trains enter occupied blocks. Certainly if the teacher does not understand the subject matter, there is little reason to believe that he will be able to explain it adequately to his students.

GCRTA's Internal Safety Oversight

The Safety Board is also concerned with the adequacy of GCRTA's supervisory oversight. Although the training officer related that he, his assistant, and other supervisors often rode with train operators to assess their proficiency, this testimony was corroborated neither by written records nor by the testimony of the operators and conductors who were interviewed. Although it appears that GCRTA platform supervisors, who were primarily promoted train operators, did routinely check train crew performance, the checks appear to have been confined to largely non-safety concerns, such as leaving stations ahead of schedule and ensuring that passengers pay fares. If operators were checked for compliance with lineside signals and other operating procedures, no records of such checks were provided to Safety Board investigators.

It also appears that GCRTA's safety department was not effective in overseeing rail training and operational performance. The safety department was unable to provide sufficient resources to the rail rapid transit operations, had limited authority to make changes, had limited time with trainees, was improperly staffed, and was not oriented toward the prevention of operational safety problems.

Oversight of the GCRTA

As previously noted, the GCRTA did not, as it told the Safety Board it would in its response to Safety Recommendation R-77-21, incorporate in its new book of operating rules a protective speed restriction imposed on trains permitted to pass stop signals. GCRTA's action in this case is not an isolated incident. On September 14, 1978, the Safety Board closed another Safety Recommendation, R-77-22, as acceptable action when the GCRTA indicated that operators were required to sign the bulletins. However, contrary to that response, testimony presented at deposition proceedings indicates that the operator of train No. 6601 did not and was not required to sign the safety bulletin regarding the 5 mph speed restriction. Thus, GCRTA was not operating as it told the Safety Board it would operate.

Accidents involving the Greater Cleveland Regional Transit Authority first alerted the Safety Board to the need for continual oversight and regulation of the rail rapid transit operations of regional transit authorities. Although the actions that GCRTA indicated it had or was taking appeared to be responsive to most of the Safety Board's recommendations of 1977 and 1978, they did not actually resolve the problems at Cleveland before the investigation of this accident. GCRTA has continued to experience passenger-injury-producing collisions and derailments caused by improper operating practices since passage of the National Mass Transportation Assistance Act of 1974.

These accidents, and GCRTA's failure to carry through with the Safety Board's recommendations, indicate that GCRTA needs oversight by an independent agency. In 1978, and later in 1981, the Safety Board recommended that the Department of Transportation get involved in the regulation of the safety of rail rapid transit systems that receive Federal funds. The DOT rejected these recommendations and the Safety Board subsequently reconsidered the 1981 recommendations and closed them. However, the Safety Board also told the DOT that it should not totally abdicate its role in the safety of rail rapid transit systems.

Although the DOT has retained the authority to investigate potentially unsafe conditions, to require corrective action, and to withhold financial assistance if a corrective plan is not implemented, the Safety Board has seen little evidence that DOT is inclined to use this authority. In January 1987, the Safety Board wrote to the Secretary of DOT stating this concern.

The experience of the New York City Transit Authority (NYCTA) illustrates how such a corrective plan might be carried out. After conducting a special investigation of the safety of the New York City Transit Authority in 1981, the Safety Board on September 22, 1981, recommended that the State of New York take legislative and/or executive action to authorize a new or existing independent agency to oversee and regulate the safety of the NYCTA system. Subsequently, the State established the New York State Public Transportation Safety Board, empowered to oversee and regulate rail rapid transit lines in the State. Before that, the State of California had also established an agency that actively regulated rail rapid transit systems.

Insofar as the Safety Board has been able to determine, the State of Ohio Public Utilities Commission (PUCO) presently has no oversight or regulatory authority over GCRTA. GCRTA's management has shown little inclination to exercise the safety oversight necessary to provide a high degree of confidence that its rail rapid transit system will be operated safely. The limited resources and authority given to its safety department is further support for this conclusion. The Safety Board believes there is adequate precedent for PUCO or another Ohio agency to oversee GCRTA, and the Safety Board further believes the public welfare and interest would be enhanced if the State of Ohio were to take the necessary steps to accomplish this.

Survivability and Crashworthiness

Based on the statement of the operator of train No. 6601 that his train was moving at 22 mph when he first saw train No. 6614, based on the impact damage, and based on the principle of the conservation of momentum, the Safety Board has estimated that the train's speed at impact was about 19 mph. This is consistent

with the estimate of the operator that he saw train No. 6614 [and applied his brakes] about 25 feet prior to the collision. It would have taken about one second to travel 25 feet and in that time train No. 6601 would have decelerated to about 19 mph.

Damage to the cars involved in this collision was confined to the colliding end sections. There was no structural deformation of the cars' passenger compartments, and none of the seats was dislodged. The majority of injuries sustained were a result of secondary impacts with hard molded seat grabrails and bare metal floor level luggage racks.

Given the estimated impact speed, the crashworthiness features of the rail cars performed reasonably well in this accident.

Emergency Response

The initial response to the accident was timely and effective. The decision to wait for the rescue train to arrive at the scene of the accident, rather than to have the passengers walk or to carry them across the ConRail and GCRTA tracks to the road or on the ballast or crossties along the tracks to the West 98th Street Station, was a prudent and proper decision, given the inherent dangers of these alternatives. The transport of the injured passengers to the hospitals was also timely and efficient.

CONCLUSIONS

Findings

1. Because of a special signal arrangement to compensate for the critically short sight distance at the accident location, the aspect of all eastbound signals between West 117th Street and the accident site would have been "stop".

2. The Automatic Train Stop protection afforded by the three intermediate signals was nullified because the trip arms of all the signals were broken. Additionally, the first intermediate signal, EW 263, had been struck and pushed over and was out of service for a year prior to the accident.

3. As long as train No. 6601 was properly berthed, its operator could not see the aspect displayed by the signal from the operator's compartment because GCRTA had not moved the berthing marks or changed the signal location when it changed to cars operated from the left side.

4. The operator of train No. 6601 stated that the aspect of signals X-8 and EW 252 was green (clear).

5. Although he knew that train No. 6601 was running 5 minutes behind train No. 6614, the tower control supervisor failed to radio train No. 6601's operator that a train was standing disabled on the track ahead; had he done so, the accident may not have occurred.

6. Although the operator of train No. 6601 was required by the rules to contact the tower control supervisor by radio before proceeding through any signal between the West 117th Street Station and the accident site, he did not do so; had he done so, the accident may not have occurred.

7. Had signal EW 263 been in service, the operator of train No. 6601 would have seen red aspects displayed both by it and by signal EW 252 beyond; the operator might have approached the accident location more alert to the possibility of a problem in the area, and may thereby have avoided the accident.

8. Although Safety Board findings in a 1977 GCRTA head-on collision indicated that the accident might have been averted had foliage on the inside of a curve been cut down, GCRTA failed thereafter to keep trees and brush cut along its right-of-way. This reduced, considerably, the sight distance approaching the accident location and the time the operator had to see and perceive that a train was stopped on the eastbound track.

9. The operator of train No. 6601 could see the aspect displayed continuously by signal EW 252 for more than 2,400 feet before his train reached it, but he may have assumed, because of the double block "stop" protection arrangement provided on most of the Red Line system, that the block controlled by the signal was unoccupied.

10. The operator of train No. 6601 had sufficient sight distance to stop his train and not strike train No. 6614.

11. The operator of train No. 6601 was experienced and he was considered to be one of the best operators on the Red Line. There was no evidence that he was impaired or distracted; no condition existed that interfered with his view of signal EW 252 or that curtailed his ability to stop the train short of the train ahead.

12. Although the ATS function on half the Red Line's ATS-equipped signals was inoperative, and GCRTA management had been notified of trip arm failures, there were insufficient replacement parts on hand and no repair program had been initiated.

13. The GCRTA "line of sight" and "operation on sight" rules were ambiguous and confusing, and were not properly understood by train operators or the supervisors who were charged with training rail supervisors and employees.

14. GCRTA's failure to enforce strict compliance of its operating rules, its failure to maintain its signal and lineside system, and its adoption of ambiguous rules produced an environment in which a permissive block operation existed with reliance on "operation on sight" but without adequate safeguards to operate safely with such a method.

15. GCRTA had not required and enforced supervisor checks of operators' compliance with speed restrictions and signal rules.

16. Operating employees who had been with GCRTA prior to improvement of the training program were not adequately trained in the operating rules.

17. There is little or no oversight of GCRTA's safety program by Federal or State regulatory agencies.

18. Despite its heavy investment of public monies in GCRTA, the U. S. Department of Transportation has declined to exercise proper safety oversight of rail rapid transit systems.

19. There are adequate precedent and sufficient safety needs for the State of Ohio to assume the responsibility for monitoring and regulating rail rapid transit safety in Ohio.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the operator of train No. 6601 to comply with the signal aspects displayed and to monitor properly the track ahead and react in time to safely stop the train, and the failure of the Greater Cleveland Regional Transit Authority to enforce strict compliance with operating rules, to maintain its signal system, to adopt unambiguous operating rules, and to monitor adequately the performance of its train operators, thereby creating a permissive block operation. Contributing to the accident was the failure of the GCRTA to prevent vegetation from blocking visibility in areas of critical sight distance.

RECOMMENDATIONS

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

--to the Governor of the State of Ohio:

Initiate legislative action to establish a new independent agency or authorize an existing agency to oversee and regulate the safety of rail rapid transit systems in the State of Ohio. (Class II, Priority Action) (R-87-04).

--to the Greater Cleveland Regional Transit Authority:

Require absolute block operation whenever Automatic Train Control or Automatic Train Stop are not functional. (Class II, Priority Action) (R-87-05)

Modify the rail operations rule book to specify, for conditions requiring the operation of a train past a stop signal, a maximum restricted speed that would enable the train to be stopped short of a standing train, a broken rail, or any other hazard. (Class II, Priority Action) (R-87-06)

Modify the radio rules to require, when hazards such as a disabled train exist, tower control supervisors to notify the operators of following trains and trains on adjacent tracks of the hazard and prohibit them from entering that block without specific authority to do so. (Class II, Priority Action) (R-87-07)

Perform and document frequent supervisory checks using a systematic procedure to determine if train operators are complying with the operating rules including speed restrictions and signal rules. (Class II, Priority Action) (R-87-08)

Make periodic inspections as necessary and maintain an adequate parts inventory to keep its wayside signal system, including the Automatic Train Stop apparatus, functional at all times. (Class II, Priority Action) (R-87-09)

Periodically train and examine all rail train service employees and rail supervisors on the operating rules, operating procedures, and bulletin instructions. (Class II, Priority Action) (R-87-10)

Issue and provide to each train operator and tower control supervisor a rail safety bulletin advising of a signal system failure or malfunction, such as a broken trip arm or inoperative signal, each time such occurs if the failure or malfunction cannot be repaired immediately. (Class II, Priority Action) (R-87-11)

Post, in all areas of the system in which sight distance is less than 1,000 feet, signs displaying restricted speeds, based on the sight distance available and distance required to stop the trains to provide adequate distance to stop a train in the event it does enter an occupied block. (Class II, Priority Action) (R-87-12)

Establish a positive means to determine that speed restriction signs posted because of specific lineside problems, such as track irregularities, remain posted. (Class II, Priority Action) (R-87-13)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ JOHN K. LAUBER
Member

/s/ JOSEPH T. NALL
Member

April 14, 1987

APPENDIX A

The Investigation

The National Transportation Safety Board was notified about 10:00 a.m. July 10, 1985, that a collision of two Greater Cleveland Regional Transit Authority trains had occurred. The Safety Board immediately dispatched two investigators from the Washington office. They arrived at the accident site at 4:00 p.m. Two additional Safety Board investigators arrived and the following committees were formed: operations, track and signals, mechanical, human survival factors, and human performance.

A deposition hearing was conducted by the Safety Board in connection with this accident.

The Safety Board was assisted in this investigation by the Greater Cleveland Rapid Transit Authority and the Amalgamated Transit Union.

APPENDIX B

GCRTA Crewmember Information

Train 6601

Mr. Stanley W. Scott (47), operator, was employed by the transit agency in 1965 and had 20 years service with the transit agency. He had no previous experience with any other transit agency but he had been a driver of buses, trucks, and automobiles in the U.S. Air Force. He was hired first by the transit agency as a bus driver and for 5 years he worked on and off trains and buses. In 1970, he became a train operator. His record is clear of any discipline for violation of operating rules.

Mr. Ronald W. Jackson, Sr. (43), conductor, was employed by the transit agency in 1967 and had 18 years service with the transit agency. He had no previous experience with any other transit agency. He was originally employed by the transit agency as a bus driver. However, 6 months after starting with the transit agency, he had an opportunity to go into rail service and has spent most of his years of service in the rail operations. He is a qualified train operator by GCRTA requirements. For the preceding 2 years, train number 6601 was his regular assignment as a conductor. He often works on his rest days as a train operator when needed.

Train 6614

Mr. James E. Hall (53) was employed by the transit agency on October 14, 1960. He was employed as a bus operator and divided his time between bus driving and rail train operations for about 18 years. In 1978, he became a full-time train operator. He had been working the assignment at the time of the accident for 2 months.

Mr. Marshall J. Garrett (48), conductor, was employed by the transit agency for 5 years. He was employed as a bus operator and qualified for the position of train operator. Mr. Garrett did not have a regular assignment but was an extra man filling vacancies as they occurred.

APPENDIX C

Excerpts from the GCRTA
Rail Operations Rule Book, dated February 28, 1978, and
Revised January 18, 1980.

- R5.1.40 -Line of Sight- The speed which is consistent within the range of vision.
- R8.1.1 -Operators must keep a minimum distance of 1,000 feet or more between trains and operate on line of sight and be prepared to stop should the train ahead make a sudden stop.
- R8.1.2 -Operators must operate their trains on sight at all times, including while under signal protection. The term "on-sight" means within the range of vision. Changes in the range of vision must be anticipated.
- R8.20.2 -Where speed limit signs are provided, the Operator must reduce the speed of the train accordingly before the train passes the sign and must not exceed the posted speed until the last car has cleared that speed zone governed by the speed limit sign.