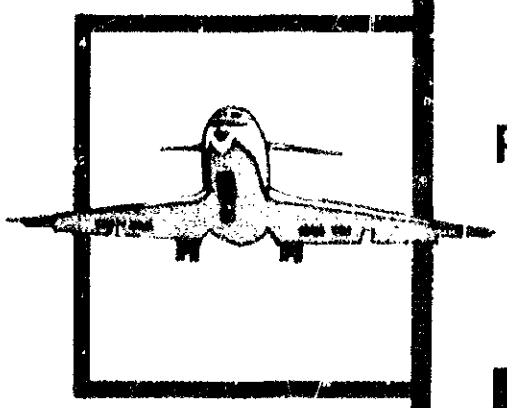
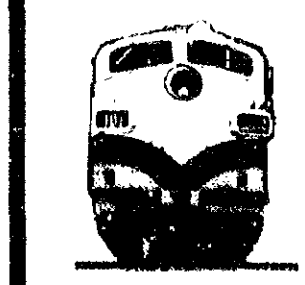
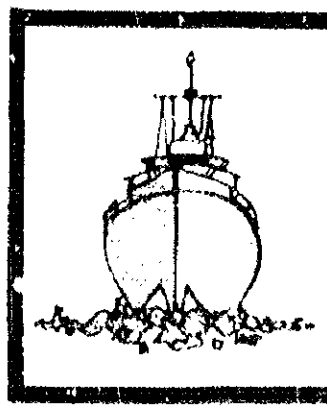
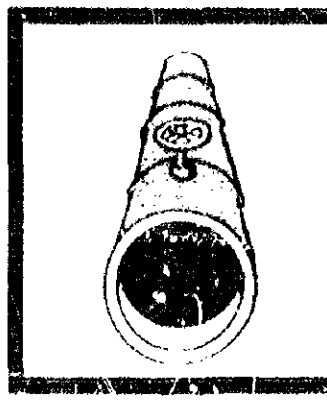








PB87-916304

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

COLLISION AND DERAILMENT OF SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTHORITY SINGLE CAR TRAIN 167 69TH STREET TERMINAL UPPER DARBY, PENNSYLVANIA AUGUST 23, 1986

NTSB/RAR-87/04

UNITED STATES GOVERNMENT

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB/RAR-87/04	2.Government Accession No. PB87-916304	3.Recipient's Catalog No.
4. Title and Subtitle Railroad Accident Report--Collision and Derailment of Southeastern Pennsylvania Transportation Authority Single Car Train 167, 69th Street Terminal, Upper Darby, Pennsylvania, August 23, 1986		5.Report Date September 1, 1987 6.Performing Organization Code
7. Author(s)		8.Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Accident Investigation Washington, D.C. 20594		10.Work Unit No. 4486A 11.Contract or Grant No.
12.Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20594		13.Type of Report and Period Covered Railroad Accident Report August 23, 1986 14.Sponsoring Agency Code
15.Supplementary Notes		

16.Abstract On August 23, 1986, Southeastern Pennsylvania Transportation Authority (SEPTA) single-car train 167 was en route to Upper Darby, Pennsylvania, on the Norristown High Speed Line when a passenger requested to be let off at the Beechwood/Brookline Station. The operator was unable to stop the car using normal braking. Subsequently, he applied the airbrakes in emergency, released the deadman pedal, and applied the mechanical handbrake on each end of the car. The car continued forward and began to accelerate as it descended the grade into the 69th Street Terminal at Upper Darby. The car overrode the bumping block at the end of the track, derailed, penetrated a terminal wall, and came to rest about 6 feet inside the terminal building. Of the 55 passengers on board, 44 were injured; 11 of the 44 injured passengers were hospitalized. In addition, one person inside the terminal building was injured. The operator received minor injuries. Damage to the equipment and building was estimated to be $225,000.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator to remove propulsion power from the car and his failure to use all available means to stop the car. Contributing to the accident was the failure of SEPTA to adequately train the operator to use all means available to stop the car.

17.Key Words Collision; toxicological test; brake system; equipment maintenance; regulatory oversight; supervisory oversight; training; "Hours of Service"; emergency procedures.	18.Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19.Security Classification (of this report) UNCLASSIFIED	20.Security Classification (of this page) UNCLASSIFIED	21.No. of Pages 35	22.Price

NTSB Form 1765.2 (Rev. 9/74)

CONTENTS

EXECUTIVE SUMMARY

On August 23, 1986, Southeastern Pennsylvania Transportation Authority (SEPTA) single-car train 167 was en route to Upper Darby, Pennsylvania, on the Norristown High Speed Line when a passenger requested to be let off at the Beechwood/Brookline Station. The operator was unable to stop the car using normal braking. Subsequently, he applied the airbrakes in emergency, released the deadman pedal, and applied the mechanical handbrake on each end of the car. The car continued forward and began to accelerate as it descended the grade into the 69th Street Terminal at Upper Darby. The car overrode the bumping block at the end of the track, derailed, penetrated a terminal wall, and came to rest about 6 feet inside the terminal building. Of the 55 passengers on board, 44 were injured; 11 of the 44 injured passengers were hospitalized. In addition, one person inside the terminal building was injured. The operator received minor injuries. Damage to the equipment and building was estimated to be $225,000.

This accident report discusses the following safety issues:

1. SEPTA's mechanical requirements for its rail transit equipment;
2. methods of inspection and certification of rail transit equipment in Pennsylvania;
3. SEPTA's managerial oversight and enforcement of its operational rules;
4. performance of the window glazing;
5. toxicological testing of employees in safety-sensitive positions; and
6. SEPTA's operator training program.

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator to remove propulsion power from the car and his failure to use all available means to stop the car. Contributing to the accident was the failure of SEPTA to adequately train the operator to use all means available to stop the car.

As a result of its investigation, the Safety Board issued recommendations to the Governor of Pennsylvania and the Southeastern Pennsylvania Transportation Authority.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

RAILROAD ACCIDENT REPORT

Adopted: September 1, 1987

COLLISION AND DERAILMENT OF SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTHORITY SINGLE CAR TRAIN 167 69TH STREET TERMINAL UPPER DARBY, PENNSYLVANIA, AUGUST 23, 1986

INVESTIGATION

The Accident

At 2:30 p.m., August 23, 1986, Southeastern Pennsylvania Transportation Authority (SEPTA) electrically powered single-car train 167 (car 167) departed the 69th Street Terminal in Upper Darby, Pennsylvania, northbound to Norristown, Pennsylvania, on the outbound segment of a planned round trip on the Norristown High Speed Line (NHSL). (See figure 1.) Car 167 was manned by a single operator, who stated that he took no exception to the manner in which the car handled in either power or braking modes during the outbound trip. Car 167 arrived at Norristown at 3:01 p.m. At Norristown, the operator changed from the operating position at the outbound end of the car to the operating position at the inbound end of the car. At 3:05 p.m., car 167 departed Norristown southbound to the 69th Street Terminal.

En route from Norristown to Upper Darby, car 167 made several station stops. Several passengers stated that the train overshot a number of station platforms and consequently had to back up in order to discharge and/or pick up passengers. In response to a question as to why he overshot these stations (asked at a public hearing held by the National Transportation Safety Board) the operator stated that car 167 braked more slowly than the other cars. The operator said that when he departed the Bryn Mawr Station, he advanced the controller handle (see figure 2) to enable the car to move up and over the crest of a slight upgrade, and then he manually returned the controller handle to the "power off" position as the car began to coast and gain speed.

After the train passed Wynnewood Road Station, a passenger signaled to get off at the next station, Beechwood/Brookline. The operator said he had not used the car airbrake since leaving Bryn Mawr Station, and that at the time the car was coasting. He stated that he applied the train brakes in a normal service application, but that as he moved the brake handle, it did not have the normal resistance to movement that was customary when the brakes were applied. The operator further stated that he did not feel any retarding effect in the car movement. (The operator later testified at the Safety Board's public hearing that prior to this he had not experienced any problems with the brakes on this trip.) He also did not hear any air venting (a normal indication of an application of the brakes). He said he then checked the air pressure gauge and noted that it did not register any brakepipe pressure but that it did indicate about 90 to 100 psi main reservoir pressure.

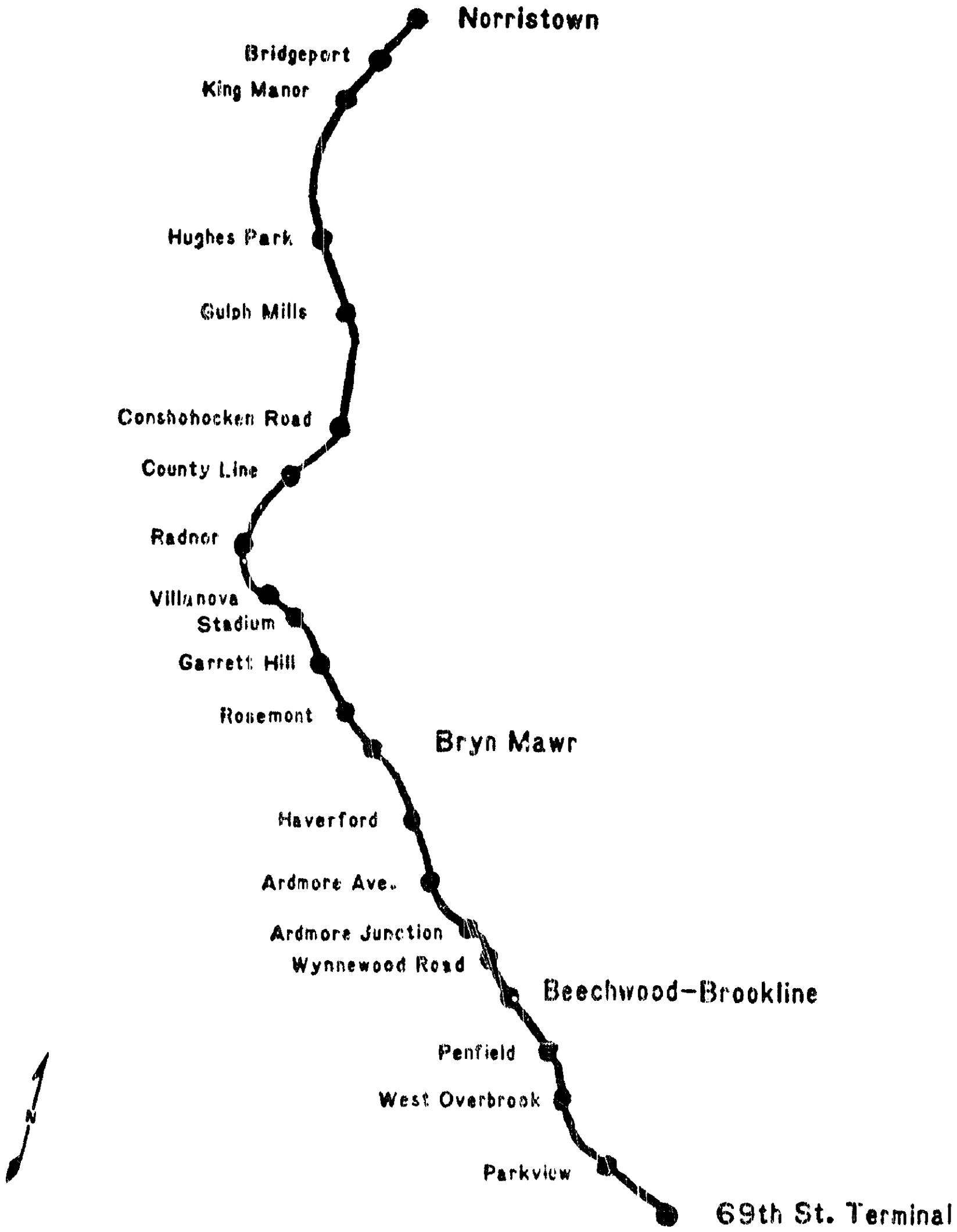
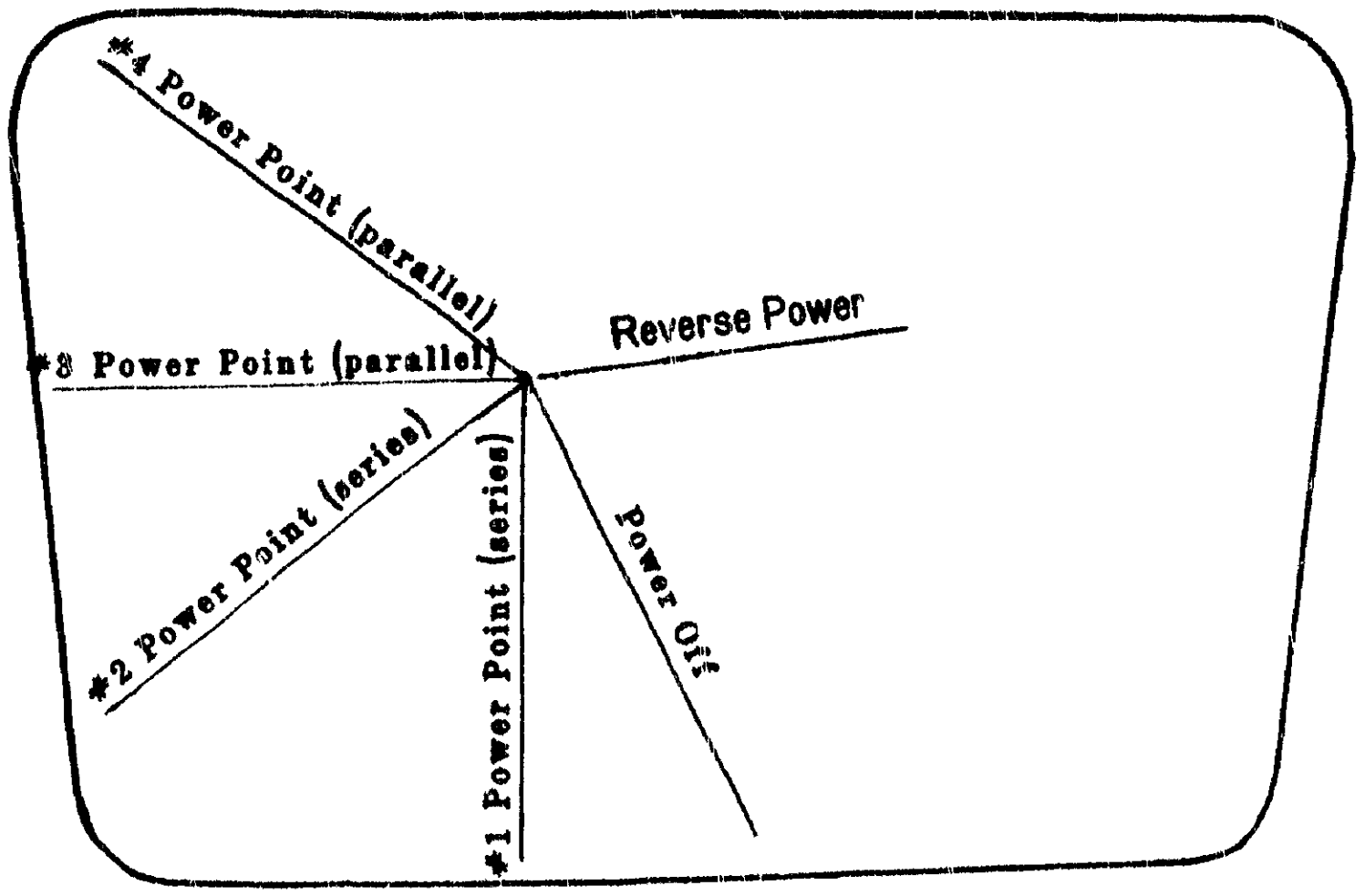


Figure 1.--Norristown high speed line.



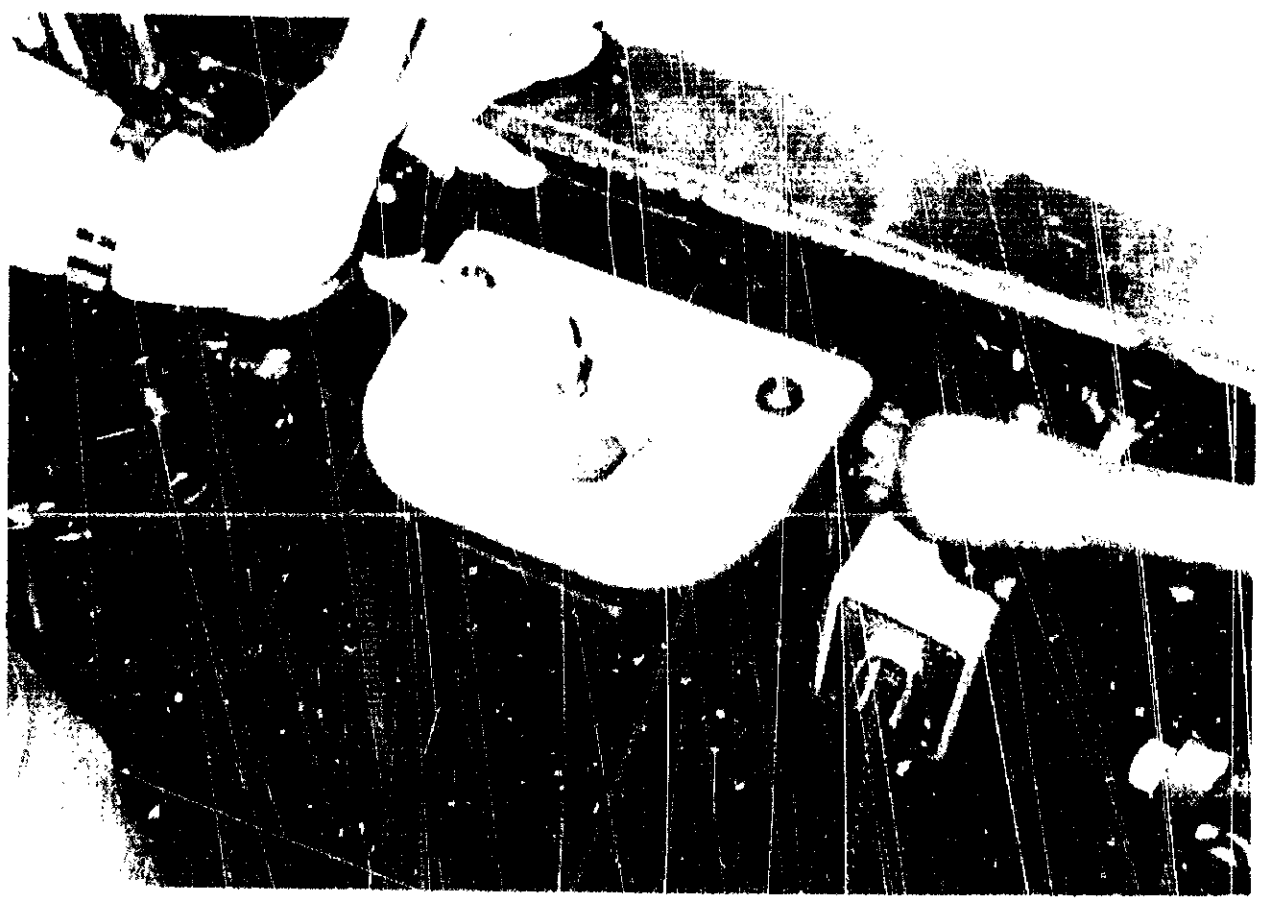


Figure 2.--Controller handle positions.

According to the operator, he then placed the brake handle in the emergency position. (See figure 3.) The operator stated that he still did not get any retarding effect and that he did not hear any air venting from the brakepipe or equalizing reservoir, as would be expected with an emergency brake application. He stated that he then placed the brake handle back in the release position so the air compressor could restore brakepipe pressure (nominally 70 psi operating pressure). This normally takes 8 to 12 seconds. The operator stated that when he did not see any brakepipe pressure increase on the gauge after about 3 seconds, he returned the brake handle to the emergency position. The operator stated that he repeatedly attempted to contact SEPTA central control by radio to request assistance, but that he was unsuccessful.

The operator stated that after failing to get any retardation from the airbrakes and failing to get a response from central control, he intentionally released the deadman pedal. He further stated that he did not hear air venting from the brakepipe or the equalizing reservoir and that he still did not perceive car 167 to be slowing. The operator did not inform the passengers of the brake problem. The passenger who had signaled her desire to detrain at Beechwood/Brookline Station had come forward in the car and was standing in the doorway separating the operating platform and the passenger compartment. The operator informed the passenger that he would be unable to let her off at the Beechwood/Brookline Station and that he would stop at the next stop, Penfield Station. She testified that two other passengers were with the operator on the operating platform. One passenger appeared to be an artist and was seated on the operator's portable stool, sketching the operator; the second passenger was standing near the side entrance/exit door. Two other passengers stated that a young man was seated on the operator's stool sketching a portrait of the operator, and that the "artist" and the operator were talking and laughing together. The operator confirmed that passengers were in the operating area, but he denied any knowledge as to what the seated passenger was doing and denied talking and laughing with any passenger.

Meanwhile, the operator had moved over to the manual handbrake control located to his far right and cranked the brake wheel as tight as he could to set the handbrake. He said that he did not notice any braking response after setting the handbrake. The operator stated that he again tried to radio central control to advise the controller of his problem and to ask for instructions, but that he was unable to reach the controller. He then ran to the rear of the car and applied the handbrake located there. When the car did not slow, the operator returned to the forward end of the vehicle and notified the passengers to move to the rear of the car, that the car's brakes were not holding, and that there was going to be a collision. Shortly afterward, at 3:42 p.m., car 167 overrode the bumping block at the 69th Street Terminal and struck the terminal building.

The bumping block was constructed of welded sections of steel angle bar and was bolted to the track through the web of the rail. The height of the terminal building floor was such that when the car hit the terminal building, the floor of the car moved under the building floor. Before the car stopped, the force of the collision with the building pushed the car nose back over the car operating platform about 5 feet, lodging it against the bulkhead separating the passenger compartment and the operating platform. After the crash, the operator was temporarily pinned in the operating platform because of the car nose deformation. However, he extricated himself from the crushed operating platform, went to a station platform telephone, and called central control to notify the controller of the accident and to request emergency assistance for the passengers. Of the 55 passengers on board, 44 were injured; 11 of the 44 injured passengers were hospitalized. In addition, one person inside the terminal building was injured.

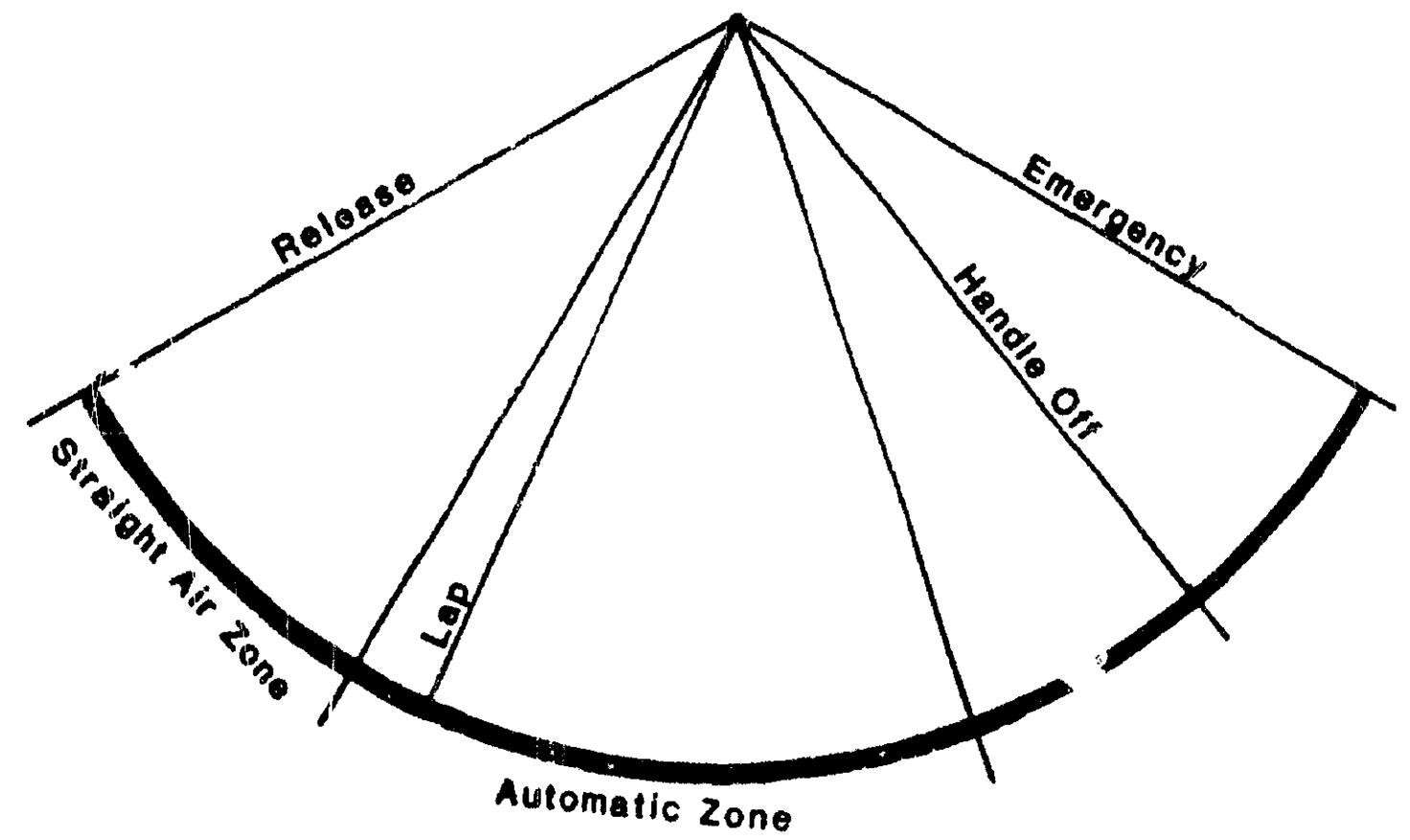


Figure 3.--Brake handle positions.

A SEPTA employee who witnessed the accident was walking northward beside the track as car 167 approached the 69th Street Terminal. When interviewed immediately after the accident he said that the car sounded like it was under power. He estimated the car speed to be 20 to 25 mph at the time. (Later, at the National Transportation Safety Board's public hearing, he testified that he did not remember whether or not the car was under power.) He testified that after the car passed him, he turned and saw it hit the bumping block and the terminal building. He immediately went to a third-rail power switch located near the passenger loading platform and opened the switch to deenergize the third-rail power in the accident area. When he contacted the controller, the operator of car 167 had already informed the controller of the accident. The controller already knew at that time that the power to the third rail had been deenergized.

Injuries to Persons

Injuries	Crew	Passengers	Others	Total
Fatal	0	0	0	0 1/
Serious	0	11	0	11
Minor	1	33	1	35
None	0	11	0	11
Total	1	55	1	57

Train Damage

The forward end wall of the car was displaced rearward from about 1 foot at the top to about 5 feet at the floor level where it was in contact with the end bulkhead. (See figure 4.) The bottom of the end bulkhead was displaced rearward about 2 feet and was resting against the first seat on each side of the aisle.

Both the left and right windshields were broken; the center windshield was intact. Three side-facing windows were broken. The glass in both sections of the end bulkhead was broken. All the broken glass was nonshatterproof.

Seven of the 28 bench seatbacks were bent forward at various angles; 1 seatback was torn loose. Two seatmounts were torn loose, and one seatmount was twisted but remained secure. Three seats were displaced upward; the displacement ranged from about 8 inches to about 1 foot. (See figure 5.)

Personnel Information

The operator of car 167 was hired by SEPTA in 1982 as a bus operator, a position he held for about 2 years. During a "sign up" period in 1984 which allows employees to interchange between bus and rail service, he signed up for a rail car operator's position, which he held for about 1 year. During that year, he operated rail vehicles on both the Media-Sharon Hill line and the NHSL. In 1985, the operator rotated out of rail service for about a year and then back into rail service on the NHSL in June 1986.

1/ One passenger died 4 months later without ever having been discharged from the hospital.

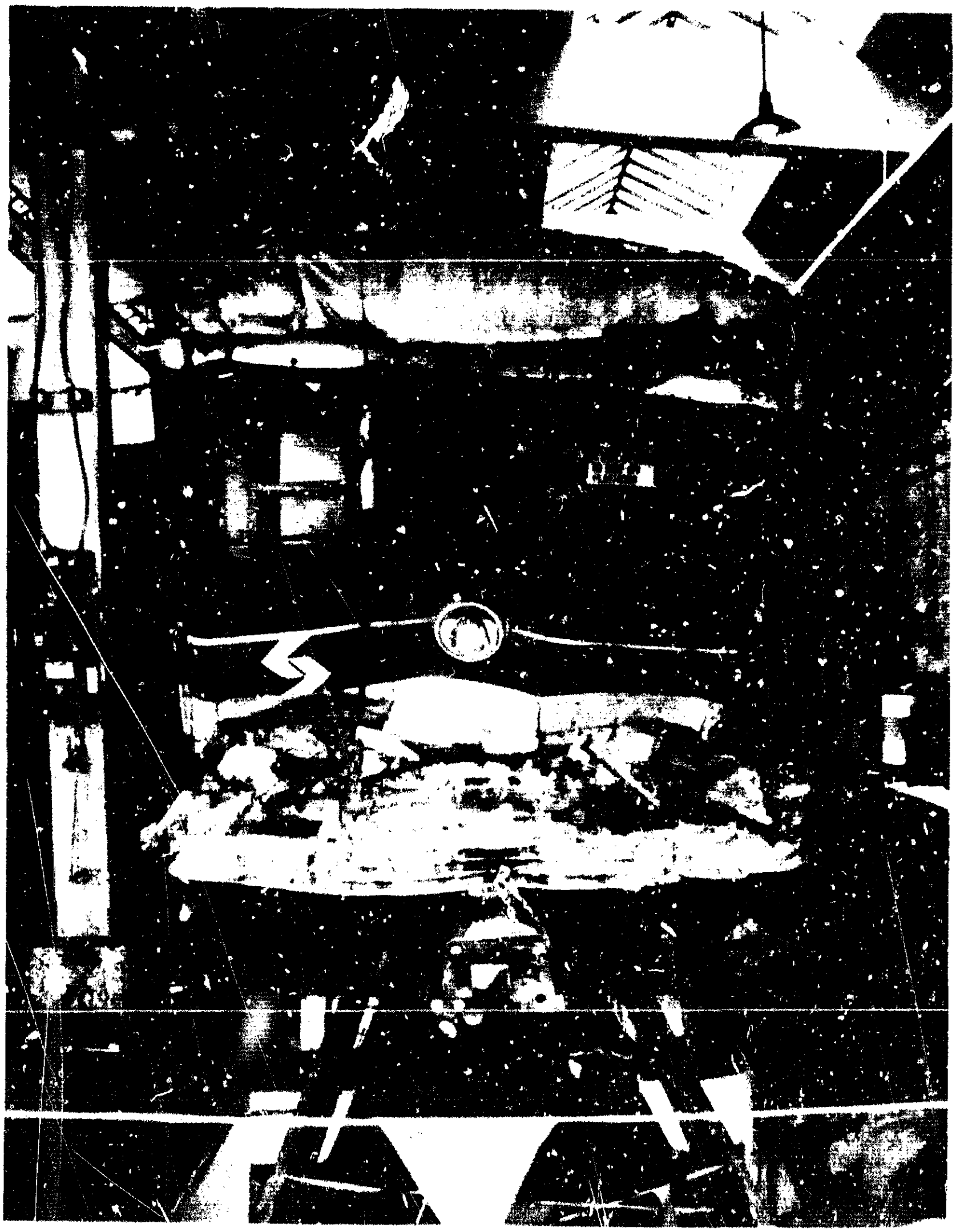


Figure 4.--Car 167.

Figure 5.--Postimpact interior of car 167.

The operator's name was on a list of qualified available relief operators, and thus he was subject to call for any shift assignment. He normally was off duty 12 to 14 hours between assignments. There are no applicable Federal or State of Pennsylvania requirements for hours of rest between tours of duty. The operator had worked an "early shift" from 7:15 a.m. until 4 p.m. during the week before the accident. He had rested from about 10 p.m., August 22, until about 6 a.m., August 23; he stated that he was well rested at the time of the accident. He stated that he did not have any known chronic medical problems and that he was not required to wear corrective lenses. SEPTA requires annual medical examinations for all NHSL operators.

A review of the operator's service record revealed that he had been verbally warned on July 9, 1986, for operating a car at 50 mph and on July 11, 1986, for operating at 47 mph; both violations were in 25 mph zones. On July 15, 1986, the operator failed to report for duty at the proper time. These reprimands were not entered on his service record in chronological order. The July 15 incident appeared on the record before the July 9 or July 11 incidents.

Train Information

General.---At the time of the accident, SEPTA operated 12 cars on the NHSL, 6 of which were 60-series cars. The 60-series cars were built by the Brill Company of Philadelphia, Pennsylvania, in the 1920's and they were equipped with cast-iron brakeshoes.

Car 167 (a 60-series car) was built in 1927 and rebuilt in 1931. The car was 50 feet 6 inches long, 9 feet wide, and 12 feet 8 inches high. There were 28 bench seats in the car. Propulsion power was provided by four axle-mounted traction motors (one per axle) which developed 100 horsepower each. Electric power was picked up from a 600-volt d.c. third rail that paralleled the running rails. Primary power for on-board communications, fare collection, and emergency lighting equipment was obtained from a 12-volt battery auxiliary system.

Car 167 had operating controls at each end, on the left side of the car relative to the direction of travel. The car could be operated either by the operator sitting on a portable stool or from a standing position.

Car 167 had been involved in an on-board fire on July 18, 1986. Detailed records of the damage resulting from the fire were not available; however, the car was removed from service for 10 days while repairs were made.

The Controller.--Propulsion power is regulated by a controller handle mounted on a controller contact box immediately in front of the operating position on each end of the car. (See figure 6.) The controller handle can be rotated clockwise from the off position to the full power position. When the spring-loaded controller handle is released, it is designed to return to the power off position. The controller handle has a spring-loaded detent protruding from the bottom which, when in travel, moves over two raised projections on the top plate of the controller box.

During the investigation, it was discovered that the controller handle from car 167 would sometimes stick on the raised projection of the controller plate and not return to the power off position. SEPTA mechanical supervisors stated that before the accident they were not aware that a controller handle could stick. Maintenance records indicate that before the accident, on July 2, 1986, car 164, and after the accident, on April 29, 1987, car 161 were reported defective due to a sticking controller. Both cars were 60-series cars. SEPTA records indicate that in the first incident 15 minutes were devoted to an inspection of the problem; no defects were found, and no repairs were made. Since the accident, SEPTA has modified the propulsion system to open the line switches during an emergency or deadman brake application and thus remove power. This precludes simultaneous brake and power applications.

In its clockwise rotation, the controller handle is moved through four notches. Contactor switches are electro-pneumatically positioned to provide the power appropriate for the position of the controller handle. When the controller handle is advanced through the first two of four notches, the contactor relays electrically configure the traction

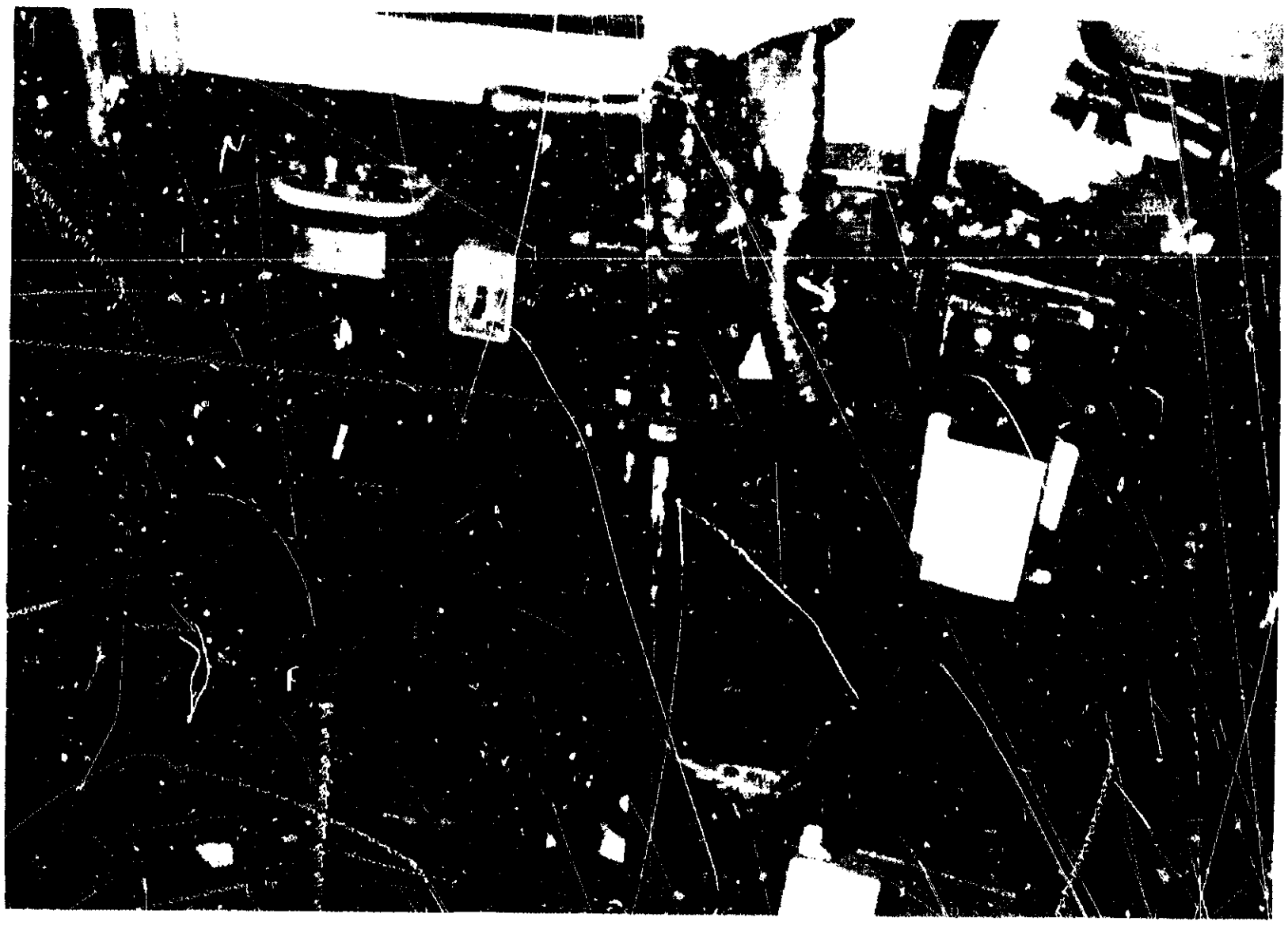


Figure 6.--60-series control location.

motors in a series arrangement. 2/ When the controller handle is moved through notches three and four, the contactor relays configure the traction motors in a parallel arrangement. The propulsion system is designed so that the controller handle can be advanced immediately to the full power position and the increasing steps of power will follow through the appropriate voltage and current combinations.

If the controller handle is set for full power and the car speed must be reduced, the controller handle must be returned to the power off or zero power position and then repositioned for the new speed desired. The traction motor electrical configuration would not allow a power reduction by moving the controller handle counterclockwise from full power to a midpoint position.

2/ Series and parallel refer to the electrical arrangement of the armature of the traction motors. In series, the armatures are connected in a manner to provide the greater power needed for acceleration; in parallel the armatures are connected in a manner to provide higher speeds after initial acceleration.

Power Switch.--Car 167 had an electrical power disconnect breaker accessible to the operator located over the operating position at one end of the car. When this breaker control is opened, propulsion power is removed from the car.

Forward/Reverser Switch.--Car 167 was equipped with a forward/reverser switch, also located over the operating position at each end of the car. The direction of travel of the car could be reversed from either operating position of the car by positioning the forward/reverser switch to reverse and operating the controller handle counterclockwise.

According to SEPTA, operators are instructed that the reverser switch also can serve as a last resort emergency stopping procedure. When the reverser switch is placed in the reverse position while the car is moving forward, the controller handle can be operated counterclockwise, as for a reverse move, and power will be applied to the traction motors to reverse their rotation. Thus, the traction motors will be attempting to propel the car in the reverse direction, resulting in a retarding force. SEPTA refers to the action as "jacking the motors." When the motors are to be used to stop the car, the reverse power must be applied in short applications, i.e., apply reverse power for a matter of seconds and return the controller handle to off. The cycle can be repeated. Applying reverse power in a prolonged application should cause an electrical circuit protection fuse to blow and no power would be available on the car. When reverse power is applied for a prolonged period, the traction motors overheat and are ruined.

Deadman Control.--The deadman control on car 167 was designed to work when the car was standing or when the traction motor is in the series transition. The deadman pedal was designed in the 1920's to work in conjunction with the spring-loaded controller handle. If the deadman pedal was not depressed when the controller handle was in the power off position, or in the first two points of power, a penalty application of the airbrakes would occur. Advancing the controller handle to any power point within the series range would activate the deadman feature.

The deadman feature was not dependent on the speed of the vehicle but solely on the controller position. If the controller handle was quickly and continuously advanced to a parallel power position from the off position, the deadman feature would be nullified. However, the deadman feature would function at any speed when the power control handle was in the off position.

After the accident, SEPTA modified the deadman control to function in all controller positions.

Handbrake.--Each end of the car was equipped with a wheel-operated handbrake located to the operator's right. The handbrake was designed to provide a means of applying the car brakes mechanically without air pressure. The brakeshoes were brought against the wheel treads through a gear-driven system of rods and levers. To apply the handbrake, the operator had to step on a pedal-activated pawl at the base of the handbrake stand and turn the wheel clockwise. After the handbrake was applied, the operator could release the pedal-activated pawl and the handbrake would lock in the applied position. If the train brakes had already been applied by air in an emergency application, the handbrakes would not provide any additional braking effort.

Glazing.--Glazing material on the 60-series cars was glass. Maintenance records indicate repeated instances of broken windows. SEPTA supervisors stated that vandals throwing rocks and other projectiles was the most common cause of broken windows.

Other portions of SEPTA's fleet that operate under the auspices of the Federal Railroad Administration (FRA) are equipped with approved safety glazing. The operational environment of the NHSL is similar to other SEPTA rail divisions.

Track Information

The track on the NHSL is laid to railroad standard gage, 56 1/2 inches, on treated timber crossties. Both welded and jointed rail is used. The maximum grade is 2 1/2 percent, and the minimum curve radius on the main track is 716 feet. Southward from Wynnewood Road Station to Parkview Station, there are descending gradients varying from 0.5 to 2.5 percent. At Parkview Station, a 1.6-percent ascending gradient extends southward for about 2,000 feet, after which the gradient descends at 2.5 percent until just before entering the 69th Street Terminal where the track becomes level.

The third rail, which provides electrical propulsion power for the NHSL, is covered by a protective wood board; in some areas, a plastic cover had been installed to replace the wood board.

By dialing through the telephone network to a specific number, the controller (dispatcher at 69th Street) can remotely deenergize the power on the third rail, on a system basis, for either track. Individual sections cannot be remotely deenergized. The third-rail system has automatic circuit breakers which have to be reset manually when they are tripped.

Equipment Maintenance and Inspection Procedures

Cars on the NHSL are given an A-inspection twice weekly, even though the cars may be used every day. The A-inspection is divided into nine major divisions; d.c. pickup, interior electric, interior carbody, exterior carbody, exterior electric, trucks, air, electric and air valves, and emergency equipment. Multiple items are detailed under each major division. Results of the inspection are recorded on SEPTA's "Preventive Maintenance Work Sheet (R.A.D. Norristown Line)." After each item is a column which can be coded in one of four ways: ( ) O.K., (A) Adjustments Made, (O) Repairs Needed, or (#) Repairs Made. Adjacent to this column is another column for the mechanic who inspected individual item to enter his initials.

A maintenance log, "P&W--Defects," was used to record road failures and inspection defects on NHSL equipment. A review of the logs revealed that car 167 experienced 16 road failures and 21 inspection defects in the 43 calendar days it was operational before the accident. Eight road failures were for "weak brakes," and 12 inspection defects were for brake adjustments. Also, during the same period, car 167 received additional brakeshoe attention 13 times; brake adjustments would be made routinely at the same time.

In July 1986, brake deficiencies accounted for 46 percent of the reported defects on the 60-series cars. From August 1-23, 1986, brake deficiencies accounted for 62 percent of the reported defects on the 60-series cars. Between August 1 and the day of the accident, 61 percent of the defects reported on car 167 were for brake problems. Car 167 had not received any adjustment on the day of the accident. SEPTA's records detail several instances where 60-series cars were reported as having defective brakes or needing brake attention twice in the same day. There was one instance where car 168 was reported three times in the same day. Safety Board staff conducted a review of NHSL mechanical records in May 1987. Brake deficiencies were reported only 5 times during April 1987.

Brake piston travel was measured on five cars in the 60-series fleet after the collision. Car 167 had the longest travel of any car measured. Median travel on the other 60-series cars was 2 7/8 inches; car 167 measured 3 7/6 inches.

With the exception of car 207, the cars were not equipped with any type of speed indicator before the accident. Since the accident, the cars have been retrofitted with speed indicators; however, a review of the April 1987 maintenance records revealed that the digital speedometers are routinely reported for "erratic display."

The cars receive a B-inspection semi-annually. The B-inspection is more comprehensive than the A-inspection, but neither inspection involves the scheduled replacement of parts or components by any established standards of time or wear. Periodic inspection and maintenance is not required by SEPTA for the airbrake system.

Pennsylvania requires an inspection of electric mass transit (EMT) vehicles at least twice a year; however, EMTs may be inspected more frequently if a transit authority so desires. The Pennsylvania Department of Transportation delegates regulatory authority over SEPTA to its Bureau of Public Transit (BPT). To perform EMT inspections, inspectors must be certified by the BPT. SEPTA recommends supervisory personnel from SEPTA to the BPT as qualified to perform such inspections. The BPT subsequently certifies these individuals. The Pennsylvania Public Utilities Commission (PPUC) has very limited authority over SEPTA, basically in those locations where SEPTA crosses a highway.

The Pennsylvania State Police conducts routine records audits to determine that the required inspections are completed. The actual inspections are not made in the presence of the State Police nor does the inspecting trooper have a background in mechanical inspection of rail rapid transit equipment. The trooper who conducts the audits of the State inspections on the NHSL testified that "we allow them [SEPTA] to self-certify themselves." Since neither the BPT nor the State police had in-house rail rapid transit experience in 1980, when BPT regulatory efforts began, SEPTA was allowed to write its own inspection manual. There are no wear tolerances on any components delineated in the manual. Due to the age of the equipment, few drawings are available representing the original equipment or many of the modifications that have been completed over the years.

SEPTA's corporate structure does not give equipment maintenance jurisdiction of the NHSL to SEPTA's chief mechanical officer (CMO). Rather, mechanical maintenance authority for the NHSL is vested in a general superintendent. The general superintendent is dependent on the CMO for much of his major maintenance material, such as wheels and airbrake equipment.

Training

Initial training for a car operator is scheduled to last 20 workdays. The first 5 days are comprised of classroom instruction which covers operational rules, safety rules, radio communication, and emergency procedures. The next 5 days consist of on-the-job-training (OJT) in which the student actually operates a train in revenue service under the supervision of a SEPTA supervisor. This segment of the training is conducted exclusively during daylight hours. The next 9 days are also OJT in revenue service; however, the instructor is a qualified instructor/operator (but not a SEPTA supervisor), and the training may occur during any shift. On the 20th day, the student is given a written examination. The student must correctly answer 85 percent of the questions to qualify.

Although the cars now have speed indicators, among the skills that the students were required to become proficient at, and to which they were exposed during OJT, was estimating train speed. One technique that operating supervisors used to help operators estimate their speed was the use of a radar gun. One supervisor operated the radar gun to determine the speed of an approaching car, then an assistant held up a flash card with the recorded speed printed on it for the operator to see. The radar gun was used sporadically after the initial training was completed.

A SEPTA road supervisor testified that operators should be able to judge speed based on experience gained while driving an automobile. SEPTA does require its railcar operators to hold a valid automobile driver's license. At the time of the accident, SEPTA reviewed annually the status of the driver's license of its operating employees. The road supervisor further testified that he gave check rides "Maybe once or twice a month, if I get the time."

Railcar operators also were instructed in the methods for stopping a car under normal conditions using service braking and in emergency stopping procedures. Emergency stopping instructions include the use of the emergency airbrake, the function and use of the deadman pedal, operation and use of the manually operated handbrake, and the technique of reversing the traction motors while under power. On several occasions, the operator of car 167 told Safety Board investigators that he was not aware of the procedure to reverse the motors as a method to stop a car in an emergency situation.

SEPTA training instructors stated that students are instructed in the procedure to remove electrical power (by the overhead switch) from the car in the event of an emergency. They stated however that students are not encouraged to remove the electrical power, because such action would eliminate the protection afforded by the deadman control. The operator of car 167 testified that he had not attempted to remove the on-board electrical power during his efforts to stop the car because he believed it was necessary for the electrical power to be on in order for the car to function. The operator further testified that he was unsure if the airbrakes or handbrakes would work if the power was off.

Training records indicate that the operator had received 20 days of training in 1984 and 20 days in 1985. The operator had requested additional training in 1984; he stated at the time that his height (6 feet 3 inches) made it difficult for him to smoothly brake the trains. (When standing the operator's eyes were above the top of the windshield causing him to bend over or stoop to see forward properly). SEPTA provided an additional 2 days training. Examinations were administered both in 1984 and 1985; however, they did not indicate a score, only that the tested employee had read and understood the corrections made to the test. SEPTA's records indicated that in 1984 the operator had been instructed in the procedure to reverse the motors for an emergency stop.

A recertification test consisting of a written examination containing 121 questions (valued at 1 point each) and a performance evaluation (total attainable points 96) was given to the operator on his return to the NHSL in 1986. Three requirements had to be met in order to be certified: (1) 85 percent on the road test during the performance evaluation; (2) 85 percent on the fire and evacuation test during the performance evaluation; and (3) 85 percent (184 points out of a possible 217 points) on a combined written test score and the performance evaluation scores. The operator scored 100 percent on the road test, 100 percent on the fire and evacuation test, and 80.16 percent on the written test. The higher scores on the performance evaluation brought his total overall score to 88.94 percent. The SEPTA supervisor responsible for administering the operator's recertification examination testified at the Safety Board's public hearing that he had never disqualified or failed to recertify an operator on the NHSL.

Five of the incorrect answers on the written test were on emergency procedures. One question on the examination that the operator could not answer, and left blank, concerned reversing the traction motors in the event of a brake failure. SEPTA said that after an examination is corrected, a training supervisor reviews the missed questions with an operator, giving the proper answers. The empty blank had been filled in by the operator's service supervisor with the phrase "jacking the motor." However, there was no indication that there was any followup explanation or training provided to the operator to assure that he understood this or the other answers that he missed.

Method of Operation

SEPTA serves the greater Philadelphia area, providing rail commuter service on the NHSL and the Regional Rail Division (RRD). The RRD is larger in terms of track miles, personnel, and equipment. SEPTA's method of operation on the NHSL is not covered by Federal or State of Pennsylvania regulations; however, its larger RRD operation comes under the jurisdiction of the FRA.

Trains are operated on the NHSL 13.2-mile double main track by the indications of a three-aspect, automatic block, color light signal system; bulletin orders; verbal or written train orders; and schedules. The easterly track is designated for the movement of northbound trains, and the westerly track is designated for the movement of southbound trains. Traffic density is about 82 trains in a 24-hour period.

A controller, located in a central control facility at 69th Street, directs the train operation on the Norristown and the Media-Sharon Hill rail lines. In addition, the controller directs the bus operation; the bus terminal is also located at the 69th Street facility. The controller does not record any departure, passing, or arrival time for the trains on either line. The primary means of contact between central control and a train on either line or a bus is via radio. A backup telephone system extends along the roadway of the NHSL by which train operators can contact central control.

Operating employees on the NHSL are governed by a portion of the Red Arrow Division Rule Book which became effective in 1976. There is no maximum authorized speed. The rulebook contains no reference to the use of radios on the NHSL. SEPTA Notice Order No. N-86-45, issued July 29, 1986, relates to the radio notification of all vehicles in the event of an emergency,

Trains are scheduled to depart either the 69th Street Terminal or Norristown on headways varying from 30 to 2 minutes. Trains depart the terminals on schedule authority. A one-way trip in either direction takes about 31 minutes. Passengers signal the operator that they want to board the train by operating a switch located on the station platform, causing a white light to illuminate in approach to the station. If an operator runs past a station, he can reverse the car to the platform if he has not passed an automatic block signal.

At the time of the accident, a number of slow orders were in effect because of track conditions. Slow order notices listing the speed restriction and their locations were posted at the operators' on-duty point.

SEPTA operating rule 22, governing train operations on the NHSL, states, in part, that "Unnecessary conversation with passengers or employees riding on trains will not be permitted." SEPTA supervisors interpret this rule to mean no passengers will be allowed to ride on the operating platform from which the car is being operated. Signs restricting passengers on the operating platform are posted inside the cars. (See figure 4.)

Train operators and SEPTA supervisors testified that it was a common occurrence for passengers to stand in the restricted area. One SEPTA supervisor testified ". . . at times, we have to have people up there due to the fact that we're in the business of hauling people, and we get heavy loads sometimes during rush hour. And that is permitted as long as there's no conversations carried on."

SEPTA mechanics who inspect and repair equipment under the jurisdiction of the FRA are required to protect the track they are working on by lining the track switch away from the track they are working, securing the switch with a lock, and placing a blue signal (flag). SEPTA has opted not to require mechanics who work on the NHSL to so protect themselves. NHSL mechanics are not required to line switches away from the track they are working on or to secure the switch. Mechanics work daily on what are generally termed "live" tracks.

Rail and bus routes operating out of the 69th Street facilities are served by the same radio system. The base station is powered by a General Electric 300-watt transmitter and is monitored by the controller who can contact either buses or a railcar on either the Media-Sharon Hill or the Norristown rail lines. The communications systems in the central control facility are monitored by a tape recorder.

When the controller wants to contact a car on the NHSL, he transmits a tone signal to that car, causing an annunciator to sound in the car. The car operator then verbally answers the controller. If an operator wants to contact the controller, he depresses the push-to-talk button on the handset and calls the controller. The on-board equipment, also General Electric, are 50-watt transmitters. The system is not designed for car-to-car communication.

During the time the operator of car 167 was attempting to notify the controller on the day of the accident, a transmitter button on another car, 164, had been intermittently sticking. The sticking button on car 164 permitted conversation on car 164 to mask the voice of the operator of car 167 when he tried to report the emergency. SEPTA personnel stated that they did know of any previous occurrences of stuck transmitter buttons. The tape recorder on the communication system verified the stuck transmit button as well as an attempt by another caller trying to reach central control. SEPTA supervisors identified the caller as the operator of car 167.

The NHSL mechanics use a unique "flag" system for cars in the repair facility. An orange-colored flag is placed in a holder on the end of the car being worked on; a white-colored flag signifies that a car has been repaired but needs a test before it can be returned to service. The absence of a flag indicates that either the car is inbound defective (before the orange flag has been put on by a mechanic) or that the car has been repaired and is available for service; there is no way to distinguish which is the case. There are no "Bad Order" cards affixed to the side of the car nor is there always on-board documentation that a car is defective.

Meteorological Information

The temperature at the time of the accident was 74° F. It was daylight and clear. There was no atmospheric restriction to visibility.

Medical and Pathological Information

The majority of the injuries sustained by the passengers included lacerations, abrasions, contusions, sprains, and strains. One passenger, a 30-year-old male was admitted to Mercy Catholic Medical Center with a fractured spine; he also had received a

blow to the head and was transported unconscious to the hospital; this passenger died December 10, 1986. Another passenger who was pregnant was treated as a priority patient at the triage center. One person in a telephone booth inside the terminal building was injured when a floor-mounted air conditioning unit was dislodged during the collision and fell on the telephone booth.

The operator of car 167 was taken to Laukenau Hospital in Philadelphia, primarily for treatment of a foot injury which was caused when the car nose moved backward and pinned his leg in the wreckage. He also sustained a neck injury, bruises, and abrasions. A SEPTA supervisor asked the operator to give blood and urine samples at the hospital for toxicological testing. The operator complied with that request. Body fluid samples, suitable for toxicological testing, were collected from the operator about 5 p.m. in the emergency room of Lankenau Hospital where he was being treated. Tests results were negative for the presence of amphetamines, barbiturates, benzodiazepines, glutethimide, narcotics and other bases, phenothiazines, phenytoin, and tricyclics. Initial screening for blood alcohol content (BAC) proved negative but a trace amount, 4 MG/DL (0.004 percent), of blood alcohol was detected in subsequent gas chromatography-mass spectrametry analysis. Tests for cannabinoids (marijuana) were not conducted because when the order for tests was written at Laukenhau Hospital, a requirement to test for cannabinoids was inadvertently not transmitted to the testing facility.

According to a toxicologist at Laukenau Hospital, a reading of 0.004 percent BAC is typically the result of electronic noise in the testing process or of endogenous alcohol, which can be present regardless of drinking, in the human body. The State of Pennsylvania accreditation standard for reporting positive BAC levels is anything greater than 20 MG/DL. Levels below 20 MG/DL are reported as zero BAC. The BAC techniques used generally have a precision (reproducibility) level of plus or minus 4 MG/DL.

Emergency Response

SEPTA central control notified the Upper Darby emergency services dispatcher in Upper Darby Township of the accident and requested assistance. The Upper Darby emergency services dispatcher in turn notified the Delaware County emergency services dispatcher. The Upper Darby dispatcher directs heavy rescue and fire equipment, while the Delaware County dispatcher directs ambulances and other rescue equipment. Basic life support (BLS) units are attached to area volunteer fire departments. Advanced life support (ALS) units are attached to area hospitals and to the Lime, Media, and Collingdale Fire Departments.

The first unit on the scene was an ALS unit from the Delaware County Memorial Hospital. Personnel on board this unit observed some passengers exiting the terminal building on foot and observed about 25 persons on the adjacent platform, none of whom appeared to be seriously injured. Passengers reported that they exited the car through windows and doors on the undamaged end of the car. They noted that only the operator and one passenger (who had previously left the car to make an emergency call and then reboarded the car) remained aboard, both at the front of the car. Neither person was trapped and no extrication was required.

A paramedic who was aboard the first arriving ALS unit took charge and became the incident commander. A triage area was established on the platform. All persons who were transported to area hospitals were examined to determine the seriousness of their injuries, and then transported according to their priority. Two passengers were initially

determined to be in serious condition; both of these passengers were transported within 9 minutes of the arrival of the first responding unit. All other persons were transported within about 1 hour of the accident.

The incident commander initiated the County Disaster Plan whereby the county dispatcher notifies the area hospitals who then activate their individual disaster plans. Patients were transported to five local hospitals and to two local medical facilities. The incident commander testified that no problems were experienced either on scene or with the activation and implementation of the disaster plan. However, initially there was difficulty ascertaining if the electrical third rail was deenergized. Immediately after the collision, smoke and heat were emitting from under car 167. The fire department considered using water to cool the area but was unsure if the third rail had been deenergized.

Tests and Research

Between August 25-27, 1986, a series of running tests using the same type of equipment as car 167 were conducted on the NHSL. The tests were conducted to determine stopping capability under various power and braking conditions. Speeds were determined by a handheld radar gun. Representatives from the Safety Board, SEPTA, and the United Transportation Union were present during the tests.

Run 1.--The car departed Wynnewood Road Station with the controller handle in the power off position. Beechwood/Brookline Station was passed at a speed of 10 mph. The car drifted to a stop short of the crest of the grade just south of Penfield Station.

Run 2.--The car departed Wynnewood Road Station using full power. Beechwood/Brookline Station was passed at 24 mph at which time the controller handle was placed in the power off position. The car passed Penfield Station at 16 mph but drifted to a stop short of the crest of the grade just south of Penfield Station. The car held the grade without the brakes applied.

Run 3.--The car departed Wynnewood Road Station using full power and a speed of 27 mph was attained. The controller handle was returned to the power off position just before passing Penfield Station. The car slowed to about 4 mph but did pass the crest of the grade just south of Penfield Station. As the speed of the vehicle increased, the handbrake was applied, taking 22 seconds to apply and the car was stopped in 430 feet.

Run 4.--Penfield Station was passed at 24 mph using full power but also with application of the emergency brake using the brake valve. The car traveled over the crest of the hill and proceeded toward the 69th Street Terminal. The car was stopped by returning the controller handle to the power off position.

Run 5.--Car 164 was used for this test after the controller unit from car 167 was installed on the leading end. An examination of the controller from car 167 indicated that the controller could stick in the third point of power when returned manually. During the test, the controller did stick in the third point of power after having been returned from the full power position. While proceeding inbound from Wynnewood Road Station at a speed of 49 mph, with the controller stuck in the third point of power, an emergency brake application was initiated at the brake valve. The vehicle passed by Penfield Station, crested the hill, and proceeded toward the 69th Street Terminal. The car was stopped by returning the controller handle to the power off position.

Run 6.--Run 5 was repeated with the same results.

Tests and inspections were conducted at a SEPTA maintenance facility on car 167. All airbrake tests were performed with "house air" 3/ at 70 psi. Representatives from the Safety Board and SEPTA were present during the testing. The test results were:

Test No.	Description	Results
1	Handbrake test, A-end	Brakeshoes applied, 4 1/8-inch piston travel
2	Handbrake test, B-end	Brakeshoes applied, 4 1/8-inch piston travel
3	Straight air, 4/ brake application	Brakeshoes applied, 3 7/8-inch piston travel
4	Tightened B-end handbrake, dragged car	Wheels slid, brakes locked
5	Put brake handle in emergency and moved car	Wheels slid, brakes locked
6	Tested outside magnet valves 5/	Valves opened and closed as designed
7	Measured piston travel on cars 161, 162, 163, and 164 for comparison	Piston travel varied from 2 to 3 3/4 inches
8	Drained main reservoirs of condensate and inspected airbrake system filters	Approximately 1/2 gallon of water was drained, filters were dirty, but functional
9	Blew out pneumatic piping in the relay contactor cabinet	No debris or plugged piping was found, all pipes were clear and functioning
10	Operated A-end and B-end brake valves, M24C, on the B-end (undamaged) mounting and tested functions	Both brake valves functioned well
11	Made leakage test in airbrake application for 20 minutes	No brake cylinder leakage was detected and brakes remained applied

3/ Compressed air supplied from a permanent installation within a mechanical repair facility.
4/ Brake pressure is applied by air admitted directly through the brake control valve -not by means of a reduction in brake pipe pressure.
5/ A valve that is opened and closed by an electromagnet.

Test No.	Description	Results
12	Tested functioning and sequencing of relay contactors manually	All relays manually functioned and in sequence
13	Tesied minimum voltage cut in and drop out of relays and contactors	All contactors and relays appeared to pick up and drop out normally
14	Measured the pressure of the brake heads to the wheels in straight air application	Brakeshoe pressure approximately 3,500 psi and consistent among all cars tested
15	Brakeshoe surface comparison between shoes from car 167 and a "control" group of random scrap shoes	Shoes from car 167 showed more heat exposure and metal flow than the control group
16	Tested efficiency and functioning of compressor with governor bypassed	Compressor continued to pump past 130 psi main reservoir pressure and worked well
17	Inspected wheels, traction motors, and undercarriage for unusual wear or damage	No exceptions were found or noted
18	Tested master controller for position and contact	No exceptions were found or noted

Brakeshoe pressure tests were performed on cars 167, 164, and 161. Pressure readings from car 167 ranged between 3,200 psi in emergency application to 3,600 psi in straight air application. Car 164 ranged between 3,000 psi in both straight air and emergency applications to 4,100 psi in both straight air and emergency applications. Car 161 was only partially tested; however, uniform measurements of 4,200 psi were noted.

Other Information

Toxicological Testing.--In December 1985, SEPTA began toxicological testing of employees in cases where there was a reasonable suspicion that the employee was under the influence of alcohol or drugs. SEPTA records revealed that alcohol and a number of illicit drugs, including heroin, have been discovered as a result of the tests. On April 1, 1986, in an effort to upgrade supervisor proficiency in recognizing the symptoms displayed by a person "under the influence" of drugs or alcohol, SEPTA sent 320 supervisors to a 2-day training session, entitled "Program for Drug and Alcohol Detection," at the Pennsylvania Institute. The last of SEPTA's supervisors completed the training on August 12, 1986.

In January 1987, SEPTA instituted random toxicological testing of its employees. On the first day of this program, samples were collected from 11 railcar operators before labor unions representing SEPTA employees brought legal action to halt the program.

SEPTA Accidents.--Since 1982, the Safety Board has investigated 17 accidents involving the SEPTA system. These accidents are categorized as: collisions--8, derailment--1, derailment with subsequent collision--2, passenger fatality--2, employee fatality--2, and highway grade crossing--2.

ANALYSIS

The Accident

The operator of car 167 said that when he departed the Bryn Mawr Station en route to Upper Darby he advanced the controller handle to enable the car to move up and over the crest of a slight upgrade and then he manually returned the controller handle to the power off position. The operator did not attempt to stop the car at the Wynnewood Road Station because there were no passengers who wanted to get on or off. When he attempted to stop the car at the Beechwood/Brookline Station by making a normal service application of the train brakes, the operator said he did not experience a retarding effect and thus made an emergency application of the brakes. When this failed, he attempted to recharge the airbrakes (although he did not allow the system sufficient time to recharge) and made another emergency application. He then released the deadman pedal and applied the handbrakes on both car ends. None of these efforts retarded the forward movement of the car as it passed the Penfield and Parkview Stations and then struck the 69th Street Terminal building. There is no evidence that he manipulated the controller handle at any time while trying to stop the car.

Running test 1-3, conducted with similar equipment, were unsuccessful in recreating the sequence of events leading to the collision by having the controller handle in the power off position and by using the braking techniques the operator of car 167 said he used. However, examination of the controller from car 167 indicated that the controller handle could stick in the third point of power when returned manually. Had the controller handle never returned to the power off position from a full power position, as the operator said it had, the car would have remained under full power, even though the handle was partially returned. In subsequent running tests, 5 and 6, with the controller from car 167 installed on the test car, the controller did stick in the third point of power after having been returned from the full power position. The tests showed that a similar 60-series car with the controller in the third point of power and with the brakes applied in emergency could negotiate the grade past the Penfield Station and continue forward to the point of collision. The Safety Board was unable to determine any way in which the test car could negotiate the grade with its brakes applied unless the car was under full power. The brake tests conducted after the accident, the comparison of the brakeshoes on car 167 with the shoes from the test car on which the brakes were applied while the car was under power, and the statements by the operator of car 167 that he had no problems with the brakes on car 167 until the time of the accident indicate that the brakes on car 167 were working well enough to stop the car if it had not been under power. Therefore, the Safety Board concludes that the controller handle on car 167 was not in the power off position during the accident sequence, as the operator believed, and that the car was operating under power up to the collision.

Norristown Line Equipment Maintenance

A controller handle was reported stuck on another 60-series car on July 2, 1986, 52 days before this accident. Since the accident, SEPTA has retrofitted the 60-series cars

with a "power knock-out" feature that prevents simultaneous application of power and braking. Given the potential consequences of a controller handle sticking in the power mode, the Safety Board believes that SEPTA should have conducted a thorough investigation into the July 2 report, instead of expending only 15 minutes to inspect the vehicle and determine that no repair was necessary. Further, the Safety Board believes that the power/brake interlock should have been installed on the 60-series cars long before the accident.

Due to the relatively small pool of equipment being operated on the NHSL at the time of the accident, the operators would become very familiar with the operational characteristics of that equipment. The Safety Board's investigation established that the 60-series cars were being routinely reported by the operators for weak brakes, as well as broken and maladjusted brakeshoes. Often the defect reports were on days subsequent to brake attention and adjustments made by SEPTA mechanical forces, resulting in brake attention about 3 out of every 4 days in the month before the accident.

SEPTA terms much of the repair work it does on the NHSL equipment as "preventive maintenance." If a component is broken or if it malfunctions during an inspection it is generally immediately repaired or replaced. In the rapid transit industry, this manner of inspection and repair is generally termed "running repair" rather than preventive maintenance where components are replaced at predetermined limits of time or wear. At the time of the accident, there were no rudimentary scheduled maintenance requirements, nor periodic attention to the airbrake system. There also were no condemning wear limits for wheels or other components. The Safety Board does not consider the repair methods on the NHSL to have been a preventive maintenance program.

Brake attention appeared to be extensive during the 2-month period preceding the accident. However, brake attention appeared to be appreciably less following the accident. The significantly higher maintenance levels and failure rate suggests that there may have been a deterioration of the braking effectiveness of the 60-series fleet preceding this accident. Further, it appears that this deterioration may have been brought under control following this accident.

Piston travel was measured on nearly all the cars in the 60-series fleet after the accident. The piston travel on car 167 was longer than that of any of the other cars. Without established standards, it is not possible to calculate travel limits for the development of maximum braking retardation; however, as piston travel extends outward toward the limit of its stroke, actual braking effectiveness decreases. SEPTA does have established standards of piston travel for pneumatic brakes on its other rail equipment. The Safety Board believes that SEPTA should establish specific limits for piston travel on the NHSL equipment.

The deadman feature on the 60-series cars was not a fail-safe device. Most deadman features in the rail and transit industry apply the brakes when the pedal is released regardless of other factors, unless the brakes are already being applied. The deadman feature on the 60-series cars only applied when the car was stopped or the controller handle was in the lower half of the power range (series). The deadman pedal was designed in the 1920's to work in conjunction with the spring-loaded controller handle. If the controller handle was in the parallel range or stuck before returning to the power off position, the deadman feature was nullified. After the accident, SEPTA modified the deadman control to operate in all power control handle positions. The Safety Board believes that SEPTA should have corrected this deficiency long before the accident.

Car 167 traveled about 3 miles under power with full braking applied while carrying a full passenger load. Part of the 3 miles was up a steep grade. Cars in the 60-series fleet are equipped with an overload relay for electrical circuit protection. During the first few days of the on-scene investigation, SEPTA representatives dismissed the "power on/brake applied" theory because it was held that under such stress, the traction motors would have been creating so much electrical resistance that the overload relay would have operated and cut power. It became apparent from repeated tests that this was not occurring. Not once did an overload relay open from an excess of current while overcoming the brakes. Had an overload relay opened, power to the traction motors would have been interrupted, car 167 would have stopped, and the accident would not have occurred. The Safety Board believes that SEPTA should establish realistic standards for the sensitivity of the electrical circuit protection on the 60-series cars.

In a letter dated March 6, 1987, the SEPTA general manager notified the Safety Board that SEPTA had arranged to "Modify controller plates on the 60 series cars so as not to allow any controller handles to mechanically 'hang up' in series or parallel circuit. This was complete as of August, 1986." In reviewing the maintenance records of the NHSL equipment for April 29, 1987, the Safety Board noted that car 161 was reported defective for "A-end controller sticks." The defect was diagnosed as a "stuck finger"; repairs made were reported as "filed finger." Apparently, SEPTA's modification of the controller plates to eliminate controller handle sticking was not successful in all cases, and the Safety Board urges SEPTA to review its modification program to ensure that the problem will be eliminated.

SEPTA Operational Procedures

The investigation of this accident revealed deficiencies in SEPTA operational procedures in several areas. Several passengers stated that a person was sitting on the operator's stool in the operating compartment sketching the operator before the accident. The operator and the person sketching him reportedly were talking and laughing while the train was en route. The activity on the operating platform may have distracted the operator in performing his duties. This distraction in the moments preceding the operator's initial recognition that the train was not slowing after he applied the brakes, may have contributed to his failure to recognize that the controller handle was not in the power off position. SEPTA's operational rules prohibit passengers from being in the operating compartment while a train is en route and a sign is posted to that effect in the operating compartment. However, SEPTA supervisors and train operators repeatedly stated that passengers do ride in the operating compartments daily, generally during rush hours. The Safety Board believes that for a system of operational rules to be effective, they must be uniformly and consistently enforced. Supervisors ignoring or condoning violations of rules cast doubt in the minds of the employees as to the credibility and/or applicability of the entire rules system.

SEPTA's operating rules required its train operators to operate their trains in accordance with speed restrictions on portions of the NHSL. However, at the time of this accident, none of the 60-series cars were equipped with speed indicators or speedometers, and only one of the 200-series cars was so equipped. As early as 1976, the Board had recommended that SEPTA equip its trains with reasonably accurate speed indicators. While SEPTA subsequently equipped some of its cars with speedometers, it did not so equip cars operating on the NHSL. SEPTA's method of using radar guns and flash cards could only provide an operator information about his train speed at a given instant. Further, SEPTA's belief that a train operator can judge train speed based on experience gained driving an automobile (SEPTA required its train operators to be licensed automobile drivers), is not supported by any empirical data of which the Safety Board is

aware. Consequently, although SEPTA required its train operators to operate trains in accordance with speed restrictions, there was no consistent and accurate means provided to the operators which would enable them to determine their speeds at any given time. Rather, operators were required to estimate the speed of their trains to comply with the various speed restrictions.

Two earlier speeding violations by the train operator involved in this accident were not listed on his disciplinary record in the proper chronological sequence. This suggests to the Safety Board that speed restrictions may not have been consistently enforced on the NHSL and that SEPTA's actual practice was inconsistent with its written policy.

The Safety Board is aware that subsequent to this accident, SEPTA installed speed indicators on the NHSL equipment; however, the Safety Board has also been informed that the digital speed indicators have such a proclivity toward erratic display that they are repeatedly reported as being defective by the operators. This unreliable information is of little use to a train operator in attempting to maintain the appropriate speed of his train. The Safety Board believes that SEPTA should take immediate action to correct the erratic display of the in-cab speed indicators.

The Safety Board's investigation of this accident also revealed shortcomings in other aspects of SEPTA's operating methods which, although not factors in this accident, could compromise safety if the practice were to continue. SEPTA's failure to require switch lock track protection for workers on the NHSL who are regularly on, under, or between rolling equipment is inexcusable. The Safety Board finds no valid reason why each manually operated switch providing access to the track on which work is being performed should not be lined against movement and locked with an effective locking device, as is done on SEPTA's other rail operations. The Safety Board does not believe it should be necessary for an accident to occur before SEPTA institutes corrective procedures.

Also, SEPTA's "flag" system for identifying defective equipment on the NHSL does not differentiate between equipment that has been repaired and equipment that is being routed to the NHSL repair facility for repairs. In both cases, there is an absence of a flag. In some instances, there may be an on-board defect report from the operator; however, if the controller routes a car to the repair facility, it probably will not have on-board documentation. The Safety Board believes that SEPTA should establish a positive method with on-board documentation of identifying defective equipment.

SEPTA has failed to establish guidelines concerning the amount of time an NHSL operator must be off duty between shifts. SEPTA does have "hours of service" standards on other portions of its rail operations. The Safety Board does not understand why SEPTA fails to operate the NHSL in the same manner as its Regional Rail Division (RRD). There are more areas where the RRD and the NHSL are similar than there are areas where the NHSL is unique. The RRD's detailed instructions concerning operational, mechanical, and maintenance-of-way systems could certainly aid the NHSL to function more safely.

SEPTA supervisors knowingly allowed operational rules violations to continue on the NHSL. Over-the-road performance evaluation of NHSL operators by SEPTA supervisors was sporadic. Operating rules violations on the NHSL were subjectively assessed. Safety procedures established and proven effective on other portions of SEPTA were not implemented on the NHSL by SEPTA supervisors. This leads the Safety Board to believe that supervision of the NHSL was not aggressively pursued and that SEPTA's managerial oversight of NHSL supervision was lacking.

Training

Initial training of railcar operators consisted of classroom instruction coupled with extensive over-the-road evaluations by both SEPTA supervisors and qualified train operators. However, previously qualified railcar operators who had rotated between bus and rail service were only required to pass a written and field examination in a recertification program that generally lasted a single day.

The operator of car 167 was qualified by SEPTA on the characteristics of the equipment and territory of the NHSL. He had passed his recertification examination when he returned to rail service from bus service about 2 months before the accident. However, he was not given any refresher training about railcar operations at that time, and this may partially account for his failure to exercise all of the options available to stop the car before the accident. Had the operator turned off the overhead power or reversed the traction motors, the latter of which was taught during his initial railcar training in 1984, car 167 would have stopped before colliding with the terminal building.

The operator had missed test questions on the recertification examination about emergency procedures, including that of reversing the traction motors as an emergency means of stopping a railcar, and although his service supervisor had filled in the words "jack the motors" in the blank spot on the examination, there is no evidence that the operator was ever provided with an explanation of, or training on, this procedure. There is little doubt that the operator was making considerable effort to stop the train. It also is apparent that sufficient time was available to the operator to attempt different methods of stopping. Since the operator made these efforts and had the necessary time to stop the train, the fact that he was unable to do so indicates that he was not adequately trained to deal with emergency situations.

Based on SEPTA's system of requalification, an operator could qualify with a score as low as 73 percent on the written portion of the examination. The Safety Board is concerned that SEPTA's recertification program would permit operators to return to rail service even if they did not correctly understand 27 percent of the questions on a written examination.

Research in education and training 6/ has established basic principles which can be applied to the training of rail operators. One principle addresses the most effective way to learn a complex task. Essentially, related subtasks or components of a larger and complex task should be practiced in a spaced manner (i.e., distributed practice) rather than all at once (i.e., massed practice). This would provide an opportunity for the trainee to absorb new information in an organized way through actual rehearsal. Another learning principle, important for emergency situations, which by their nature occur infrequently, stresses the importance of overlearning, or learning beyond a criterion level to that almost like a reflex. Under emergency or stressful conditions, human tendency is to revert to long-used, engrained patterns of behavior. If new skills have been acquired to perform a particular task, opportunities should be provided to practice those new skills so that they will prevail when the circumstances call for them. A third principle concerns the quality and quantity of feedback given for performance of new skills. The feedback must be specific enough to be informative while reinforcing important aspects of performance. It must also be immediate enough to be corrective, yet not to the point where it becomes a distraction.

6/ Goldstein, I., Training: Program Development and Evaluation, Books/Cole Pub. G., 1974; and Gagne, R.M., The Conditions of Learning, Holt, Rinehart, Winston, 1977.

In this accident, the operator's failure to use all available means to stop the train and his lack of knowledge about jacking the motors underscore the insufficiency of SEPTA's recertification of him for train operation. The evidence shows SEPTA to have a training deficiency that needs prompt attention and correction for safe rail operations. The service supervisor testified at the public hearing that, as a result of the accident, they were "reviewing, re-evaluating, and reformulating aspects of the training program." When asked to provide details, he said they were considering increasing the amount of training and improving the test program as a way to increase operator knowledge of equipment. He also stated that more emphasis would be given to the procedure of jacking the motors as well. The Safety Board believes that SEPTA should evaluate and restructure its recertification program to provide more effective training. This could include, for example, an additional day of "hands-on" training and demonstrations in emergency procedures, and the development and review of an emergency procedures checklist.

Survival Aspects

The emergency response personnel were prompt, efficient, and well organized in their response efforts, despite initial difficulties they encountered in determining if the third rail was deenergized.

The train operator realized before the point of impact that he was not going to be able to stop the train. He warned the passengers about the impending impact and advised them to move as far rearward as possible. The time it took to reach 69th Street afforded them the opportunity to protect themselves as best they could.

When car 167 struck the bumping block, which was constructed of welded sections of angle bar and bolted to the track, the bolts sheared and the bumping block remained relatively undamaged. Virtually no energy was absorbed by the shearing of the bolts, and consequently the speed of the car was unchanged. The car then struck the terminal building pushing the bottom front face of the car back about 5 feet. The composite concrete floor of the car was stripped off the floor plates when the floor frame was bent downward as it underrode the station platform.

All the traumatic injuries were as a result of secondary impacts with interior structures, primarily with the seatbacks in front of each seating position. The seriously injured passenger was located at the forward bulkhead. Since the bulkhead was displaced rearward, the stopping distance was shortened at this position, thereby increasing the G loading for this passenger. The extent and type of his injuries indicated a heavy G-load factor.

Several passengers received cuts. Given the nature of the failure of the ordinary plate glass in the side windows and end bulkheads, and the fact that some of the passengers exited car 167 through the window openings, it is reasonable to assume that the broken glass caused some injuries and further contributed to the severity of other injuries. With the repeated failure of the glass experienced by SEPTA through vandalism and other accidents on the NHSL, it should have been apparent to SEPTA that superior glazing material was desirable. Further, since SEPTA uses modern safety glazing on its RRD, it is apparent that SEPTA knew of the availability of such materials. Since SEPTA's RRD operates through virtually the same type of territory as the NHSL, it seems the only difference regarding glazing standards is that there are no State or Federal glazing requirements on the NHSL equipment. The Safety Board recognizes that SEPTA is currently planning to replace the plate glass side-facing windows on the NHSL equipment with glazing equivalent to that required on its RRD equipment. The Safety Board believes

that all glazing, including the interior bulkheads, should be the same standard as that installed on SEPTA's other rail equipment.

Toxicological Aspects

Toxicological tests conducted on body fluid samples from the train operator involved in the August 23, 1986, accident produced a trace alcohol reading. The tests were done by an independent laboratory located in the Philadelphia area. A BAC of 0.004 is considered negative by the State of Pennsylvania. The Safety Board does not believe alcohol was a factor in this accident.

Oversight of SEPTA

In 1981, the Safety Board issued Safety Recommendations R-81-1 and -2 which recommended that the U.S. Department of Transportation (DOT) propose legislation authorizing the DOT to regulate the safety of federally assisted rail rapid transit systems and, pending such legislation, require UMTA to establish Federal guidelines for equipment and operations. The recommendations also suggested that the DOT conduct substantially increased safety oversight of these systems. These recommendations 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 to remove the Federal government from an intrusive role in rail rapid 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 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. 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.

Although the DOT has retained the authority to investigate potentially unsafe conditions, the Safety Board has seen little evidence that the DOT is inclined to use this authority. After accepting party status and agreeing to participate in the Safety Board's public hearing concerning the August 23, 1986, collision, UMTA failed to send a representative to the prehearing conference held the day before the hearing. After inquiries were made, the Safety Board learned that UMTA had reversed its decision to participate in the public hearing. The Safety Board believes it reflects poorly on the willingness of UMTA to discharge their duties and responsibilities with regard to assuring safe public transportation.

After SEPTA accidents on December 10, 1986, and January 26, 1987, the Secretary of Transportation ordered UMTA to conduct a safety evaluation of SEPTA with initial emphasis on the NHSL. UMTA's safety evaluation addressed the identical issues that were developed in the Safety Board's investigation of the August 23, 1986, accident.

SEPTA apparently chose to control the NHSL in a manner apart from its regional rail operation. Substandard glazing practices, disregard for the safety of mechanics who work under cars without switch lock protection, and lack of fundamental "hours of service" requirements indicate that SEPTA needs oversight by an independent agency.

State regulatory and enforcement authority for the NHSL is fragmented between the Pennsylvania Department of Transportation's Bureau of Public Transit, the Pennsylvania Public Utilities Commission, and the Pennsylvania State Police. There does

not appear to be any clear delineation of authority. The limited authority that exists in the State agencies has been used to set only a few minor equipment standards. Standards for maintenance of way and operations are nonexistent. According to the State police inspector, even the equipment standards are designed such that SEPTA is self-certifying.

After conducting a special investigation of the safety of the New York City Transit Authority (NYCTA) in 1981, 7/ 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. Subsequently, the State established the New York State Public Transportation Safety Board and empowered it to oversee and regulate rail rapid transit lines in the State. The State of California also has established an agency that actively regulates rail rapid transit systems. More recently, after investigating a series of accidents on the Greater Cleveland Regional Transit Authority 8/, the Safety Board recommended that 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 Ohio. The Safety Board believes the State of Pennsylvania should take action to establish an agency with oversight responsibilities for rail rapid transit systems.

CONCLUSIONS

Findings

1. The controller handle probably stuck when the operator of car 167 last moved the handle, and it did not return to the power off position before the accident.

2. Car 167 was being operated with the power and the brakes simultaneously applied before and at the time of the collision; the brakes were adequate to stop the car had it not been under power.

3. The operator did not use all available means to stop car 167, probably due to his lack of effective training in emergency procedures.

4. The operator may have been momentarily distracted before the accident by passengers on the operating platform.

5. The deadman feature on car 167 was not of a fail-safe design.

6. There was no effective means to judge speed on car 167 before the accident.

7. SEPTA inconsistently enforced operational rules on the NHSL.

8. Operations on the NHSL are not regulated by either State or Federal authority.

9. State regulatory and enforcement authority for equipment standards is minimal.

7/ Special Investigation Report--"Eight Subway Train Fires on New York City Transit Authority With Evacuation of Passengers" (NTSB-SIR-81-05).

8/ Railroad Accident Report--"Rear End Collision of Two Greater Cleveland Regional Transit Authority Red Line Rapid Transit Trains Near the West 98th Street Station, Cleveland, Ohio, August 18, 1986" (NTSB/RAR-87/01).

10. SEPTA lacks adequate equipment maintenance standards for NHSL equipment.

11. SEPTA does not require switch lock protection for workers on the NHSL.

12. The plate glass glazing on car 167 caused injuries which would not have occurred had the car been equipped with safety glazing.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the failure of the operator to remove propulsion power from the car and his failure to use all available means to stop the car. Contributing to the accident was the failure of SEPTA to adequately train the operator to use all means available to stop the car.

RECOMMENDATIONS

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

--to the Governor of Pennsylvania:

Initiate legislative action to establish a new independent agency, or authorize an existing agency, to regulate and enforce the safety of rail rapid transit systems in Pennsylvania. (Class II, Priority Action) (R-87-38)

—to the Southeastern Pennsylvania Transportation Authority:

Evaluate and restructure the railcar operator recertification program to include effective retraining of emergency procedures. (Class II, Priority Action) (R-87-39)

Revise the existing maintenance standards program to include comprehensive and specific standards for the inspection, repair, and replacement of all parts and components used on the Norristown High Speed Line. (Class II, Priority Action) (R-87-40)

Retrofit the ordinary plate glass glazing on the Norristown High Speed Line equipment with glazing material that meets the safety standards for the equipment used on the Regional Rail Division. (Class II, Priority Action) (R-87-41)

Establish a positive method, through on-board documentation, to identify defective equipment that is being routed into a repair facility on the Norristown High Speed Line. (Class II, Priority Action) (R-87-42)

Establish detailed procedures for switch lock protection for workers who are on, under, and between equipment on the Norristown High Speed Line. (Class II, Priority Action) (R-87-43)

Establish hours of service requirements for operators on the Norristown High Speed Line. (Class II, Priority Action) (R-87-44)

Take the necessary corrective action so that the in-cab speed indicators display accurate and reliable train speeds. (Class II, Priority Action) (R-87-45)

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

/s/ JAMES L. KOLSTAD
Member

September 1, 1987

APPENDIXES

APPENDIX A

INVESTIGATION

1. Investigation

The National Transportation Safety Board was notified of the accident on August 23, 1986. The Safety Board immediately dispatched an investigator from its Washington, D.C., headquarters and an investigator from its Atlanta, Georgia, field office. A Safety Board Member and four additional investigators departed for Philadelphia the following day.

Groups were formed to investigate operational, survival, human performance, and vehicular aspects of the accident. The groups were composed of personnel from the Southeastern Pennsylvania Transportation Authority and the United Transportation Union, and were directed by Safety Board investigators.

2. Hearing

A public hearing was held in Philadelphia on December 3-4, 1986. Sworn testimony was taken from 17 witnesses. Parties to the investigation were the Southeastern Pennsylvania Transportation Authority and the United Transportation Union.

APPENDIX B

PERSONNEL INFORMATION

Rail Car Operator Albert Cheshire, Jr.

Mr. Albert Cheshire Jr., 31, was employed by SEPTA on January 18, 1982, as a busdriver. He was trained and qualified as a railcar operator in 1984. In 1985, he returned to driving a bus and in 1986, to rail service. He was recertified to operate railcars on June 28, 1986. He was current on the examinations and performance evaluations required by SEPTA at the time of the accident.

Road Supervisor Walter S. Simcox, Jr.

Mr. Walter S. Simcox was hired by SEPTA in 1960 as a railcar operator. He spent about 5 years operating railcar trains on various SEPTA lines, about 5 years as a busdriver, and 8 years as a dispatcher. He had been a road supervisor for about 7 years before the accident. Part of his function as a road supervisor was to administer recertification examinations, including the performance evaluation of over-the-road operation to railcar operators.

* U. S. GOVERNMENT PRINTING OFFICE: 1987-181-101:60036