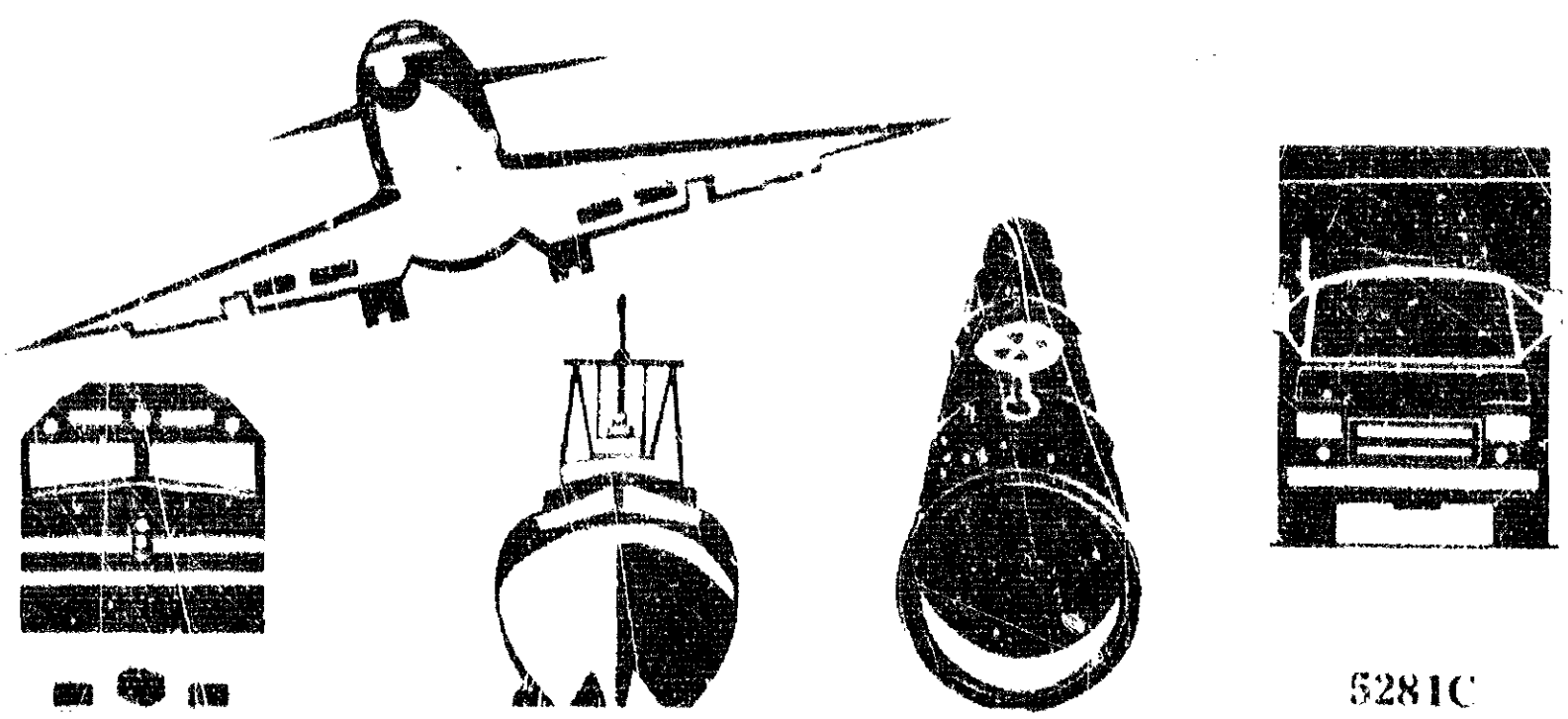
PB91-916301
NTSB/RAR-91/01

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

RAILROAD ACCIDENT REPORT

DERAILMENT OF
SOUTHEASTERN PENNSYLVANIA
TRANSPORTATION AUTHORITY (SEPTA)
COMMUTER TRAIN 61
PHILADELPHIA, PENNSYLVANIA
MARCH 7, 1990



5281C

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MARCH 7, 1990

ADOPTED: APRIL 23, 1991
NOTATION: 5281C

Abstract: This report explains the derailment of Southeastern Pennsylvania Transportation Authority (SEPTA) commuter train 61 in Philadelphia, Pennsylvania, on March 7, 1990. The safety issues discussed in the report are mechanical inspection procedures and maintenance practice oversight, supervision and training of SEPTA employees responsible for transit equipment, failure of the motor support bolt assembly, Federal and State regulatory requirements for mass transit operating practices and mechanical equipment inspectors, effectiveness of SEPTA's drug and alcohol testing program, and emergency communication between operating crews, tower personnel, and emergency response personnel. Recommendations concerning these issues were made to SEPTA, the Governor of Pennsylvania, the Transport Workers Union, and the City of Philadelphia Fire Department.

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EXECUTIVE SUMMARY

At 0821 on March 7, 1990, westbound Southeastern Pennsylvania Transportation Authority (SEPTA) Market-Frankford Subway Elevated (MFSE) train 61 derailed in a tunnel 238 feet west of the 30th Street station platform in Philadelphia, Pennsylvania.

Train 61 had 2 crewmembers and about 180 passengers aboard when the derailment occurred. Extensive car damage, together with darkness, cramped wreckage conditions, and debris in the tunnel complicated rescue efforts that took about 5 hours to complete. Four passengers were killed, and 158 were injured. One crewmember and a firefighter sustained minor injuries. Damage to the equipment and track was estimated by SEPTA to have been about $2 million.

The National Transportation Safety Board determines that the probable cause of the derailment of train 61 was the failure of SEPTA's inspection and maintenance program to detect the defective motor support system. Contributing to the accident was the failure of the State of Pennsylvania to have effective safety oversight programs for mass transit systems.

This accident report discusses the following safety issues:

- mechanical inspection procedures and maintenance practice oversight,
- supervision and training of SEPTA employees responsible for transit equipment,
- failure of the motor support bolt assembly,
- Federal and State regulatory requirements for mass transit operating practices and mechanical equipment inspectors,
- effectiveness of SEPTA's drug and alcohol testing program, and
- emergency communication between operating crews, tower personnel, and emergency response personnel.

As a result of its investigation the Safety Board issued recommendations to the Governor of Pennsylvania, the Transport Workers Union, the Southeastern Pennsylvania Transportation Authority, and the City of Philadelphia Fire Department.

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DERAILMENT OF SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTHORITY (SEPTA) COMMUTER TRAIN 61 PHILADELPHIA, PENNSYLVANIA MARCH 7, 1990

INVESTIGATION

Accident

At 0710 eastern standard time on March 7, 1990, Southeastern Pennsylvania Transportation Authority (SEPTA) Market-Frankford Subway Elevated (MFSE) train 61 departed from the 69th Street terminal. It headed east toward the Bridge-Pratt Frankford terminal, which was 13.26 miles away. (See figure 1.) Its six cars consisted of three semipermanently coupled two-car sets: cars 725-726, 818-817, and 770-769.

The crew consisted of a motorman, who operated from the control compartment of car 725, and a conductor. The motorman had reported to the 69th Street station about 0655, and the conductor had reported about 0700. A platform supervisor who had observed them stated that they had appeared fit for duty. Neither the motorman nor the conductor did a walk-around inspection of the cars, and they were not required to do so. However, as part of their normal duties, yard crewmembers had inspected the train before its arrival at the platform. The yard crewmembers are not mechanical inspectors.

Communication on SEPTA trains was by radios, commonly known as train phones. The motorman and the conductor were assigned a handset to plug into the train phone. The motorman stated that he had tested his handset when he came on duty and that it had functioned as designed. Neither crewman had a portable radio.

On the morning of the accident, the assistant general manager of the MFSE had ridden train 61 eastbound, from 30th to 15th Streets. At the 15th Street station he talked to the motorman and complimented him on the smooth ride. He later told Safety Board investigators that the motorman had appeared alert and fit for duty.

While the train was going east it passed the Bridge-Pratt dragging equipment detector without tripping it. The detector is 9.2 miles from the accident site; it is a mechanical device that is pushed over if objects are being dragged along beneath the cars. If triggered, it activates an alarm in the tower, causing the tower personnel to notify the train operator. The towerman on duty at the Bridge-Pratt station at the time of the accident verified that the detector had not sounded as the train passed over it. The train completed the crossover from the eastbound to the westbound track behind the station tower. The motorman "changed ends" by moving the controls from what was now the last car to what was now the first car (from car 725 to car 769). He returned the train to the platform for the return trip to the 69th Street terminal. The train departed about 0754. According to the crewmembers, the trip to the 30th Street station was uneventful. The line supervisor

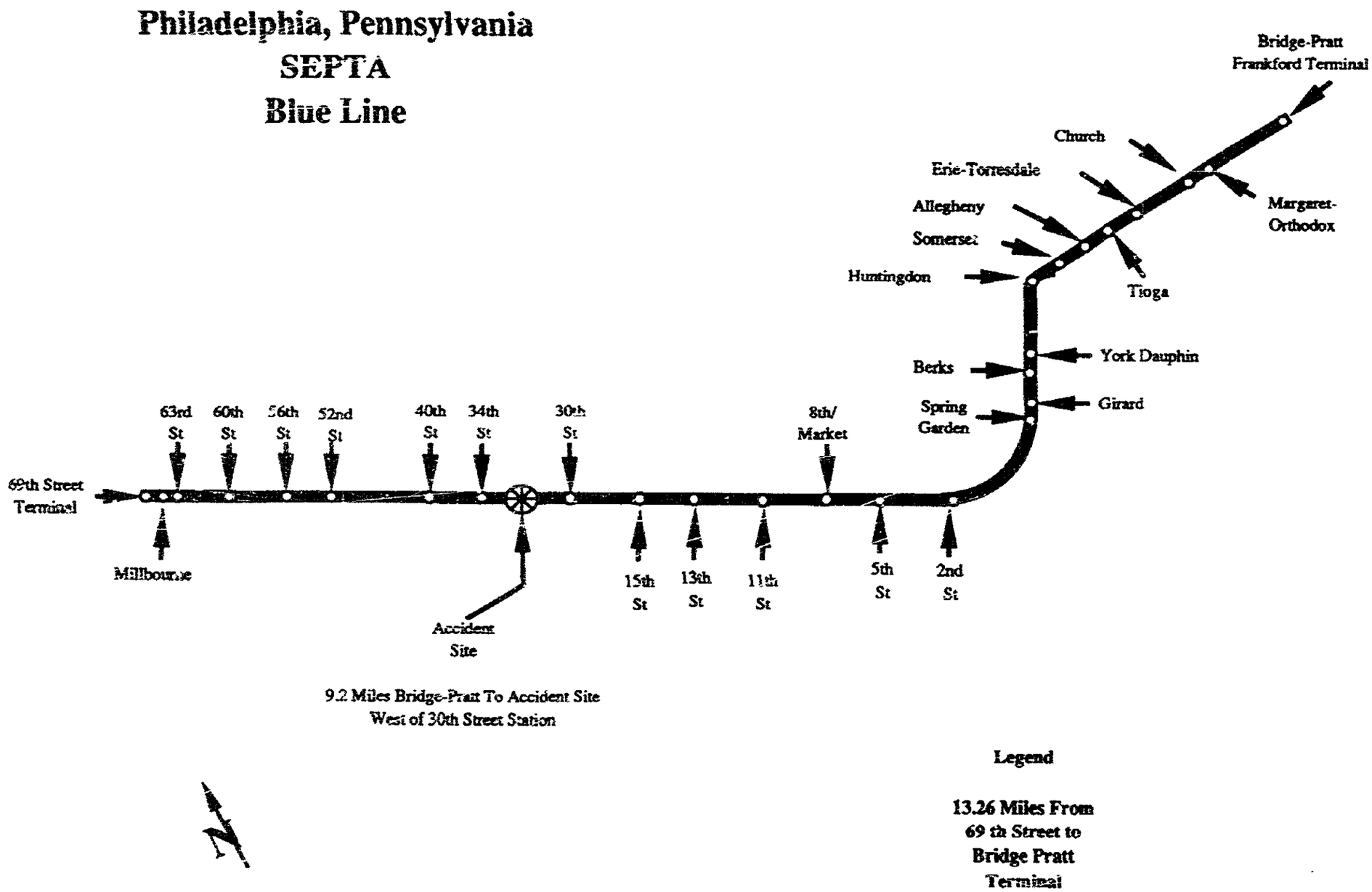


Figure 1.--Philadelphia, Pennsylvania, SEPTA Blue Line traveled by train 61.

at Spring Garden observed the train as it passed his station and noted nothing unusual.

According to the passengers and the crew, the train appeared to be operating normally when it left the 30th Street station about 0820. The motorman stated that on departing the station, he had accelerated slowly by applying the series (low) range of power and had approached the No. 7E interlocking crossover switch with caution. After having observed the switch points, which were 238 feet west of the 30th Street platform, he had increased the power by switching to the parallel (high power) range.

The motorman stated that while passing over switch No. 7E at a speed he estimated at 25 to 30 mph, the train had jolted, flashed its lights, jolted again, and suddenly stopped. When the train jolted, the first three cars remained on the track, as did the lead truck of the fourth car; but the second truck of the fourth car began following the turnout, veering to the left. The last two cars then followed the turnout track to the left, through the crossover to the eastbound track. The fourth car, No. 918, struck the steel columns that support the tunnel structure between the westbound and eastbound track. The impact sheared the car open. At this location in the tunnel, the MFSE tracks parallel the subway surface line (SSL) trolley tracks. (See figure 2.)

Immediately after the accident, the motorman and the conductor tried to contact the dispatcher on their train phone; neither was able to because the train phone was inoperative. The motorman was at the controls in the lead car, and the conductor was in the control compartment of the fourth car.

Once outside the train, the conductor saw the motorman walking toward him and shouted to him to stop a passing SSL trolley on the adjacent tracks for assistance. The motorman then stopped the eastbound trolley 200, while the conductor helped the injured passengers.

Control center tapes revealed that the trolley operator had stopped at the accident site at 0824 and had radioed the SEPTA dispatcher about the derailment. The trolley remained at the site to help move injured passengers to the 30th Street station during the evacuation.

Because the motorman worked occasionally as a towerman, he had a key to the 30th Street station tower. He walked to the tower and at 0825 used its telephone to confirm that the dispatcher had been notified of the accident.

Emergency Response

Recovery Operations.--At 0822, according to the SEPTA control center audio tapes, the operator of trolley 165 told the Juniper Street trolley supervisor as he passed the site, "You have a derailment on the el. I don't know if there's any injuries or not." About 0824, the trolley 200 operator told the same supervisor, "There's a real bad accident out there. A lot of people are hurt. Yeah, they're all over here on this rail, too."

At 0825 the SEPTA chief controller notified the SEPTA police dispatcher that a train had derailed at 30th Street. According to SEPTA police communications tapes, at 0828 the SEPTA police dispatcher contacted the Philadelphia police dispatcher and notified him of the incident. The SEPTA police dispatcher stated, "At 30th and

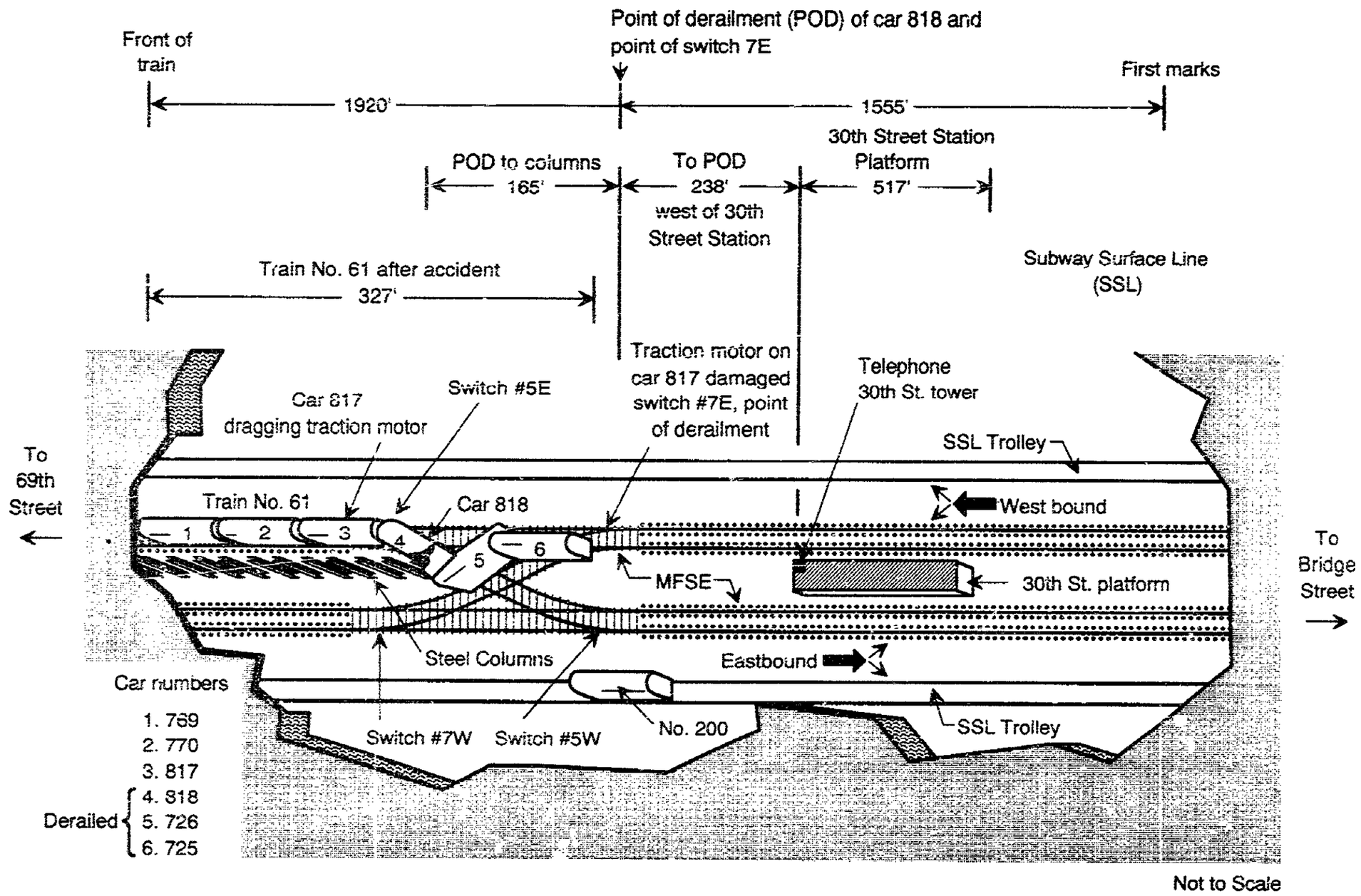


Figure 2.--View of the accident scene at the SEPTA MFSE 30th Street station.

Market we have a possible derailment or a possible fatality." The Philadelphia police dispatcher responded, "Is it a person under the train?" The SEPTA police dispatcher answered, "I don't know yet." After verification from the chief controller, the SEPTA police dispatcher stated, "It's a derailment and possible fatality." The phone call then was transferred to the Philadelphia fire department communications center.

According to fire department communications tapes, at 0830 the department received a call on the SEPTA hot line from the SEPTA train dispatcher. The fire department dispatcher told a second unit to respond to the accident.

At 0831, the Market Street Station dispatched fire department units, which arrived 3 minutes later. The firefighters determined that the third rail electricity, eastbound and westbound, had been turned off, evaluated the need for additional units and special equipment, began using hydraulic tools to open the side doors of car 818, and evacuated passengers. They assisted with transporting rescue equipment, medical supplies, and lighting equipment and with stringing communication lines. They treated injured passengers and carried stretchers to the ground level.

The fire department established a field command post on the eastbound tracks near the 30th Street platform. The fire department used multiband portable radios and hard-wire telephone lines to communicate between the underground and the surface.

At 0842, the fire department dispatched its communications van, which had arrived at the 30th Street subway entrance by 0914. Direct communication with the fire department communications center was continued through cellular telephones, mobile radios, and multiband portable radios.

Twenty fire department rescue units responded to transport patients and assist at triage. The majority of the injured passengers were removed from the accident site and were on the way to or at a medical facility within an hour of the accident. Four passengers trapped in car 818 were extricated by 1316.

Eight hospitals were involved in treating injured passengers. The hospitals that received a substantial number of patients activated their disaster plans.

Emergency Preparedness.--According to SEPTA emergency operating procedures, the fire department was to take the lead role once it had arrived, giving it the primary responsibility for extricating trapped persons and for evacuating passengers. The department could employ the expertise of other agencies' forces as needed.

Injuries

Injuries	Operating Crew	Passengers	Others	Total
Fatal	0	4	0	4
Serious	0	6	0	6
Minor	1	152	1*	154
None	1	18	--	19
Total	2	180**	1	183

*firefighter
**SEPTA estimate

Damage

SEPTA estimated the train and track damage at $2 million. The tunnel structure was not damaged.

Personnel Information

Motorman.--SEPTA hired the motorman on November 1, 1974, as a rail operator on the Germantown trolley line. He was assigned to the MFSE line on February 2, 1980. At the time of the accident, he was working as a motorman and, once a month, as a tower operator. His regular motorman shift was during the morning and evening rush hours, Monday through Friday.

He was on sick leave on Friday, March 2 (5 days before the accident.) He was off-duty on the weekend and took personal leave on Monday, March 5. On Tuesday he worked his morning schedule as a motorman between 0710 and 0830 and was scheduled to work a night shift as a tower operator beginning at 2200. After arriving for work at 2130, he learned that the tower assignment had been canceled. He stated that he returned home, went directly to bed, and slept until 0530 on Wednesday.

The motorman described his health, vision, and hearing as "good." He stated that he did not drink alcohol, use drugs, or take prescription medication. He held a valid Pennsylvania driver's license and had no history of motor vehicle accidents or violations. (See "Toxicological Information.")

Before March 14, 1989, a SEPTA employee could be dismissed if he had more than 12 unexpected absences. Pursuant to the labor agreement with SEPTA dated March 14, 1989, employee attendance records are monitored by means of a point system. An employee acquires points if he has an unexcused absence. For example, if he is absent without leave (AWOL), he acquires 10 points; if he is late for a shift, he acquires 3 points. When he has 25 points, he is subject to dismissal for substandard attendance. For any month in which he has no attendance violations, his total points are reduced by 2.

According to the motorman's employment record, he was disciplined by SEPTA on six occasions, of which four had to do with substandard attendance patterns and/or being AWOL.

On September 18, 1984, the motorman received an "involuntary termination of employment" due to a "substandard attendance record." He was reinstated on October 14, 1984, as a result of a grievance procedure. A report submitted by a Transport Workers Union representative, as part of the grievance procedure, explained that the motorman was "presently in a rehabilitation center for treatment of the disease alcoholism." (The absence occurred before the adoption of the point system.)

On January 20, 1986, as a result of an incident in which a train was moved despite several open doors, the motorman received a 1-day suspension which was reduced to a written warning for "failure to contact [the] train dispatcher in an emergency situation."

On May 2, 1988, he received a 1-day suspension for "substandard attendance (pattern)."

On April 12, 1989, he received a "discharge, reduced to 3-day suspension with caution" for being AWOL.

On May 8, 1989, he received a "discharge modified to 5-day suspension and final caution" for being AWOL.

He was AWOL from June 2, 1989, to June 27, 1989, at which time he received an "involuntary termination" for having "failed to report to medical as directed." He was reinstated on August 7, 1989, after reporting to the superintendent of operations (his direct supervisor, who was charged with monitoring attendance) that his absence was the result of marital difficulty. The superintendent made the motorman's reinstatement contingent on his attending family counseling through the Employee Assistance Program (EAP). He saw an EAP counselor, who sent a letter to SEPTA confirming that he had visited; and he was allowed to return to work on August 31, 1989, after being released from the Medical Department. His extended absence did not constitute a reason for testing him for drugs or alcohol because he returned after January 19, the date on which the court had struck down the requirement that any employee who had been absent for a long period be tested for drugs before being allowed to return to work.

Conductor.--SEPTA hired the conductor on June 14, 1974, as a rail operator on the Woodland line; on January 20, 1975, he was transferred to bus operations; and on April 12, 1979, he was re-assigned to the Woodland line. On May 13, 1979, he was assigned to rail operations on the MFSE line.

According to his SEPTA employment record, the conductor was disciplined on three occasions. On June 27, 1985, he received a "discharge reduced to 1-day suspension" for having moved a train while its doors were open. On July 14, 1986, he received a 5-day suspension for a "signal violation." He was working as a motorman in both incidents. On January 31, 1989, the conductor received a written warning for having a "substandard attendance (pattern)."

Train Information

General Description.--The MFSE cars involved in the accident were constructed in 1960 by the Budd Car Company (now Transit America) in Philadelphia, Pennsylvania. Each car was 55 feet long, 9 feet wide, and 13 feet high. Each car was equipped with two two-axle trucks; each axle was connected to a nominal 100-horsepower traction motor through an axle-hung gear drive unit. Each car weighed approximately 46,760 pounds. The cars were designed to travel at a speed no greater than 55 mph on power supplied by a nominal 600-volt direct-current third-rail system. A car could be slowed to 5 mph by the dynamic brakes, and it could be stopped by the air brakes, which had tread brake shoes.

The train consisted of six cars in three semipermanently-coupled car sets. The train had an operating cab at each end.

A car set is composed of two cars, that are coupled together by a draw bar. Each car has an A and B end; the A end contains the cab with the motorman's controls. The draw bar couples each car set together, B end to B end. A car cannot

be operated unless it is joined to another one; the two cars in set share braking and propulsion equipment.

Each car had an unpainted stainless steel exterior and three biparting automatic sliding doors on each side. The right side had six windows and the left had seven; all of the windows were made of tinted safety glass and were permanently set in stainless steel frames.

Each car interior was lined with plastic material. Each car had 29 passenger seats, of which 2 were side-facing single-unit seats, 7 were side-facing double-unit seats, and 20 were transverse double-unit seats. Of the transverse seats, half faced the rear. (See figure 3.) The seats had upholstered cushions with coil springs and padded backs that were covered with vinyl-coated plastic fabric. Grab bars extended across the top of the transverse seat backs. Vertical grab bars extended from the aisle-side tops of the seats to the ceiling. (See figure 4.)

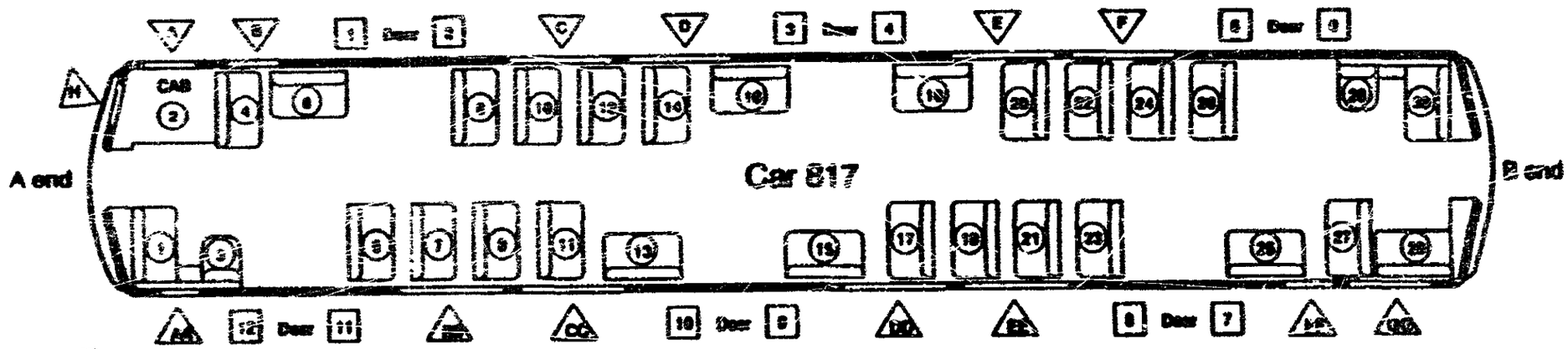
Each car interior was lighted by two rows of fluorescent lights that extended the length of the car. A pressure ventilation system was contained in four separate roof housings along the length of each car. The plywood floors had a rubber covering.

Each MFSE car set had one cab-mounted train phone, as well as two remote control units, in the control cabs. The train phones were a low frequency system. The power to operate them was produced by a 37 1/2-volt battery system that was charged by electrical power from the third rail.

The propulsion systems were provided by the General Electric Company (GE) and Westinghouse Electric (WE). The odd numbered cars had GE traction motors, and the even numbered had WE traction motors. The GE motors were 1 11/16 inches longer than the WE motors. The bolster support plate bolted to the truck bolster frame could accommodate the different length by rotating it a half turn, resulting in the same slope of the vertical support bolt attached to the motor housing. Consequently, as originally designed, either motor/gear drive combination could be installed properly by rotating the support plate 180 degrees. The traction motor and gear drive assembly were supported at the bolster end by a vibration isolator assembly that included the motor support bolt. They were supported at the other end by the gear unit that was mounted on the axle. (See figure 5.)

The No. 2 traction motor of car 817, a GE propulsion equipped car, was a WE motor; its bolster support plate was turned properly. The MFSE cars were designed to allow for mixing GE and WE traction motors. The WE motor was placed in car 817 on October 4, 1989; after that date, SEPTA made not mixing types of motors a policy.

In the late 1960s, SEPTA's predecessor, the Philadelphia Transportation Company (PTC), modified the traction motor gear drive. SEPTA records indicate that in 1967 gear drive units were changed from a 7-6 to a 7-7 gear ratio. The change apparently included a modification to the bolster support plate that forms the upper anchor for the vertical support bolt for both GE and WE traction motor configurations. In addition, the GE traction motor support bolt assembly was modified. Apparently these changes were made because the physical dimensions of the gear drive units changed when the gear ratio went from 7-6 to 7-7. None of the parties have been able to locate historical dates or documentation regarding this change. The SEPTA engineering department had no record of analyses that may have contributed to this modification and asserted that SEPTA had merely



← West Bound Direction of Travel for Married Pair Cars

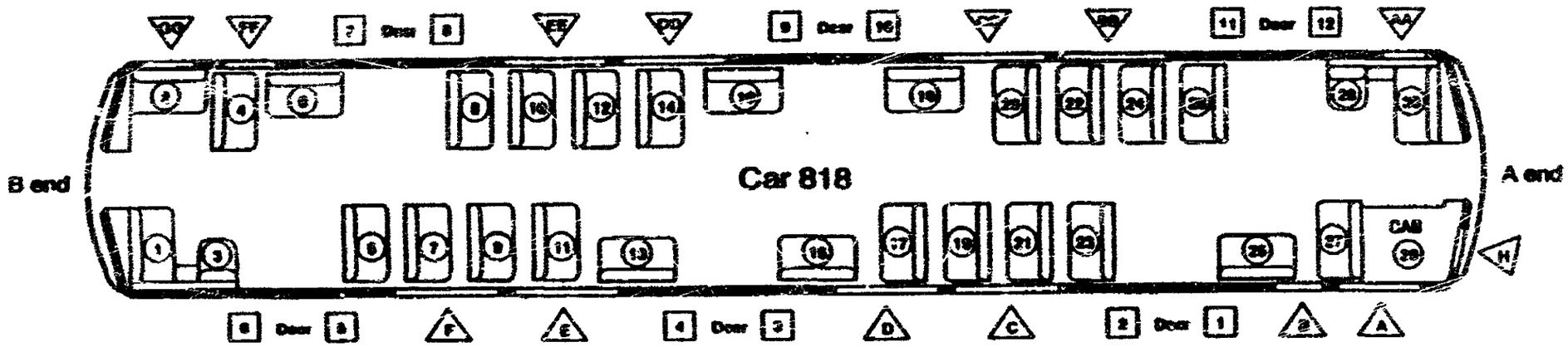


Figure 3.--Postaccident number and lettering system for seats, windows, and doors of SEPTA cars 817 and 818.

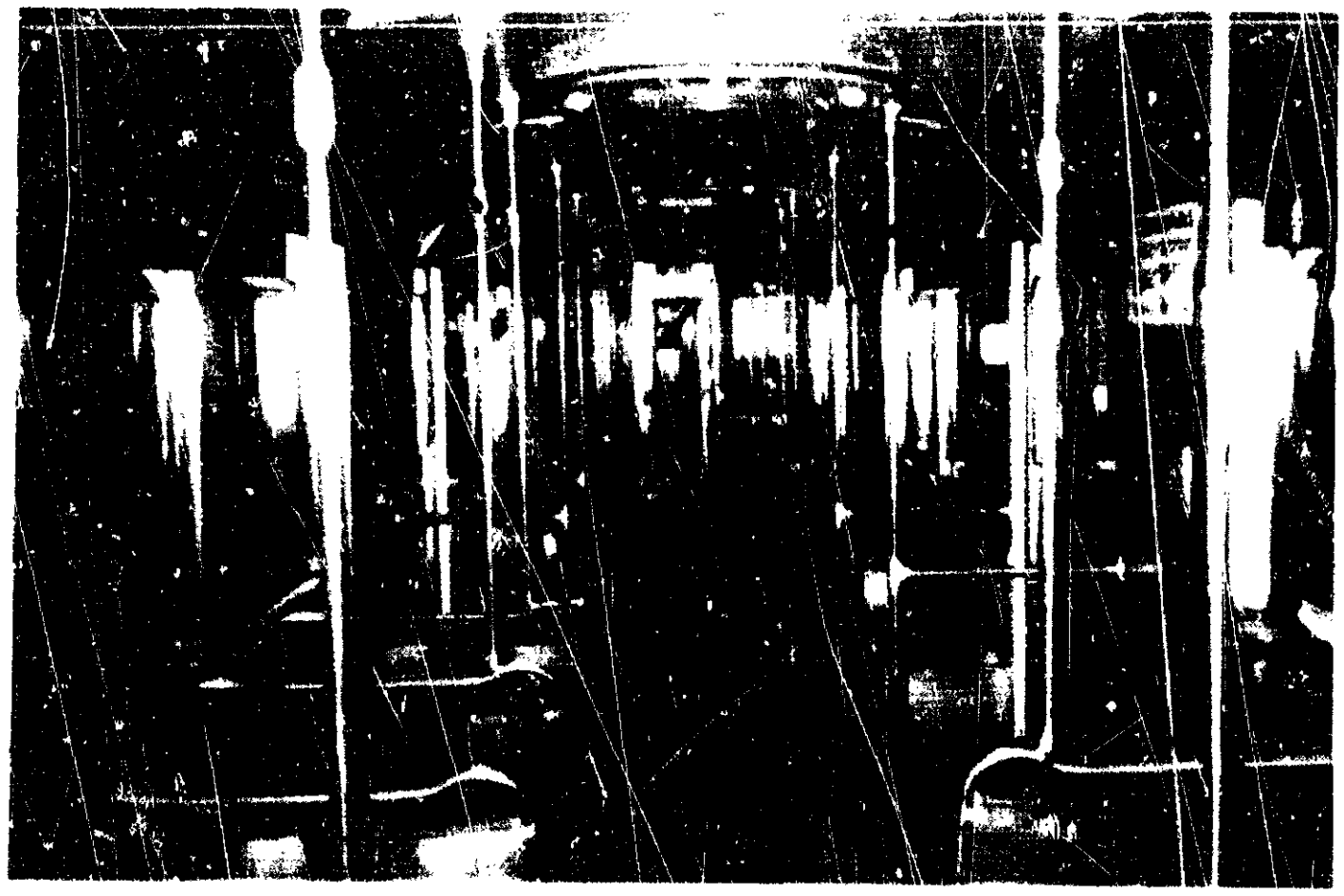
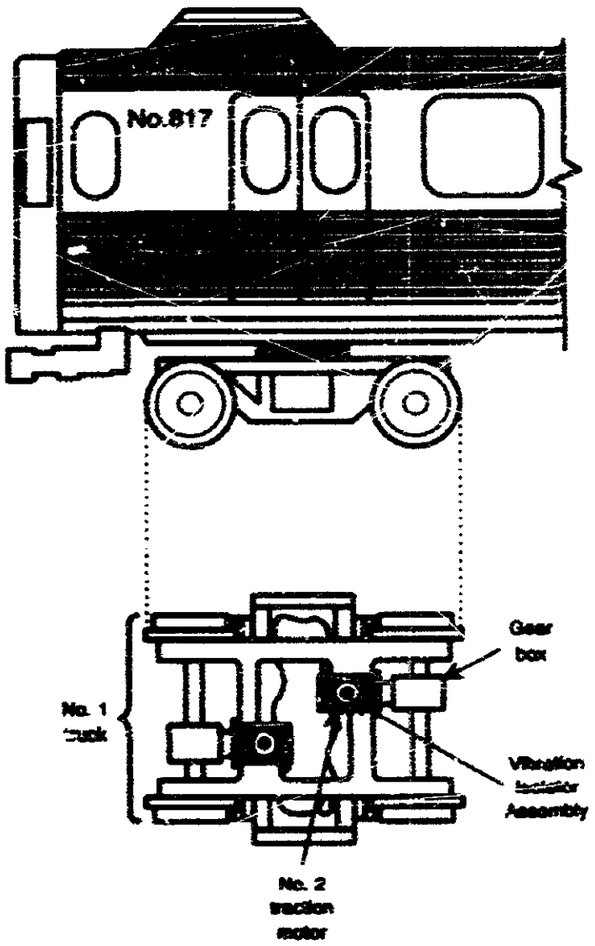


Figure 4.--Interior of MFSE car.

maintained the fleet with this configuration. On July 1, 1990, SEPTA contracted Battelle Institute to perform an engineering study to determine the forces affecting the total drive train (axle, gear unit, and traction motor) during various load cycles; SEPTA is expected to receive the Batelle report in May 1991.

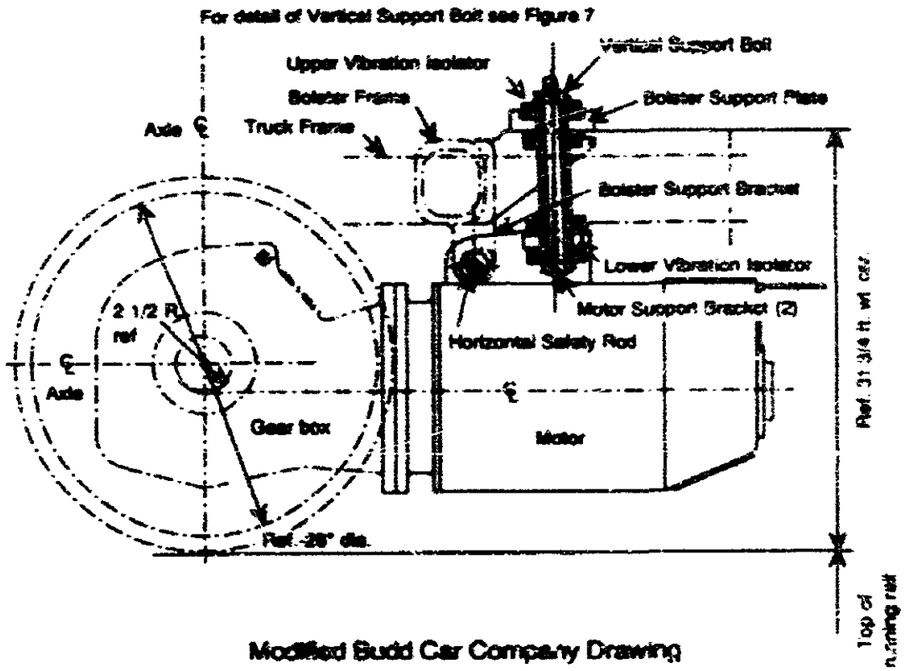
When the Safety Board reviewed SEPTA mechanical drawing No. C-1004 (see figure 6), it found that the upper part of No. 46F was a shorter metal sleeve than was the sleeve in the lower part of No. 46F. However, the drawing showed no washer between the lower half of the upper vibration isolator assembly (46D) and the metal sleeve between the upper and lower isolator assemblies (46G). This is in conflict with the Budd Car Company's original drawing in which a washer was shown at this location. (See figure 7.) Safety Board investigators found that both the upper and lower metal sleeves on the vertical support bolt from car 817 were 2 inches long, and SEPTA officials testified that 2-inch sleeves had been used for both the upper and lower vibration isolator assemblies for as long as they could remember.

Truck Assembly



(Suspended from Bolster)

Traction Motor Attachment to Truck Assembly



Modified Budd Car Company Drawing
(side view)

(Source Budd Car Company)

Not to Scale

Figure 5.--Truck assembly and traction motor support attachment to truck assembly.

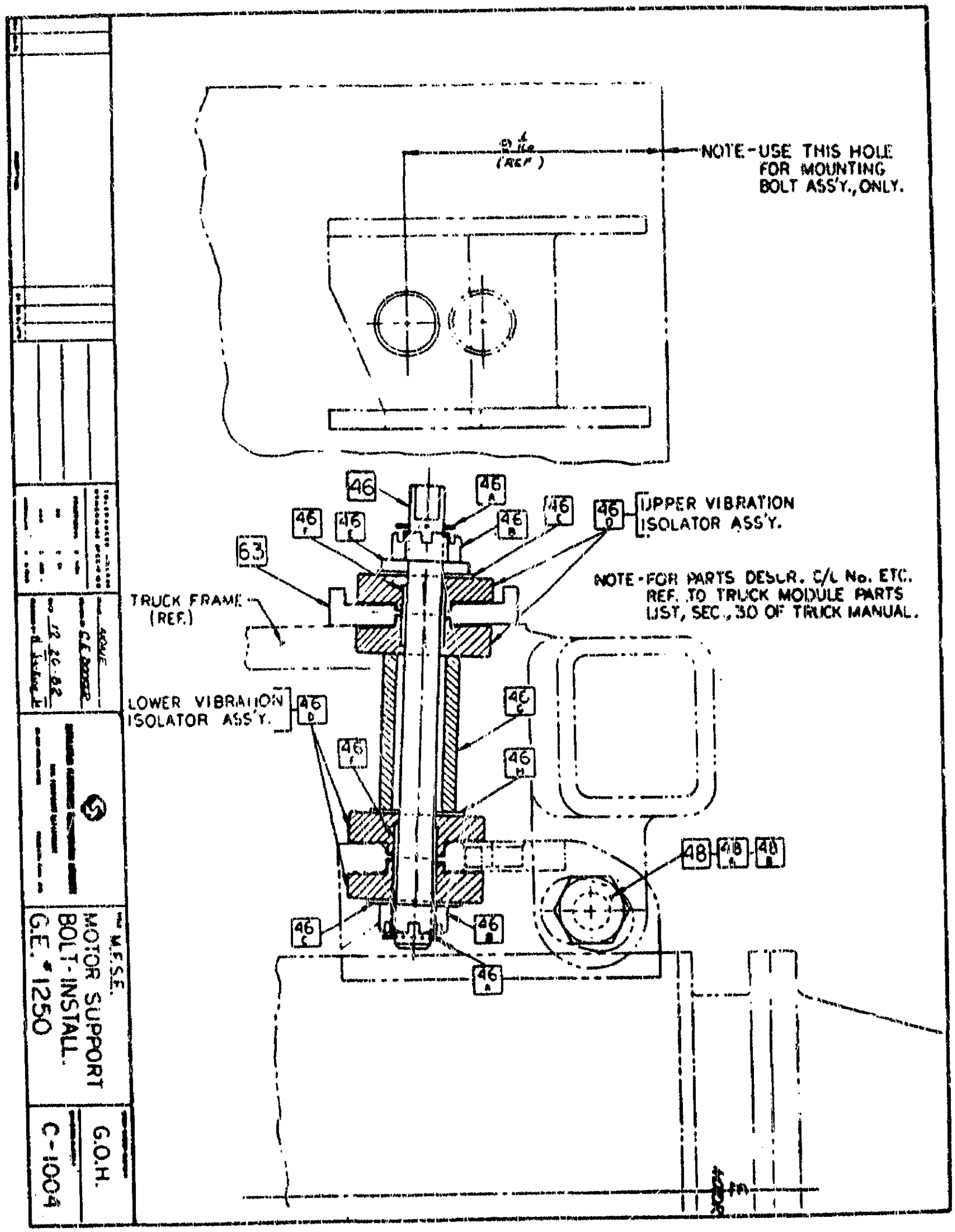
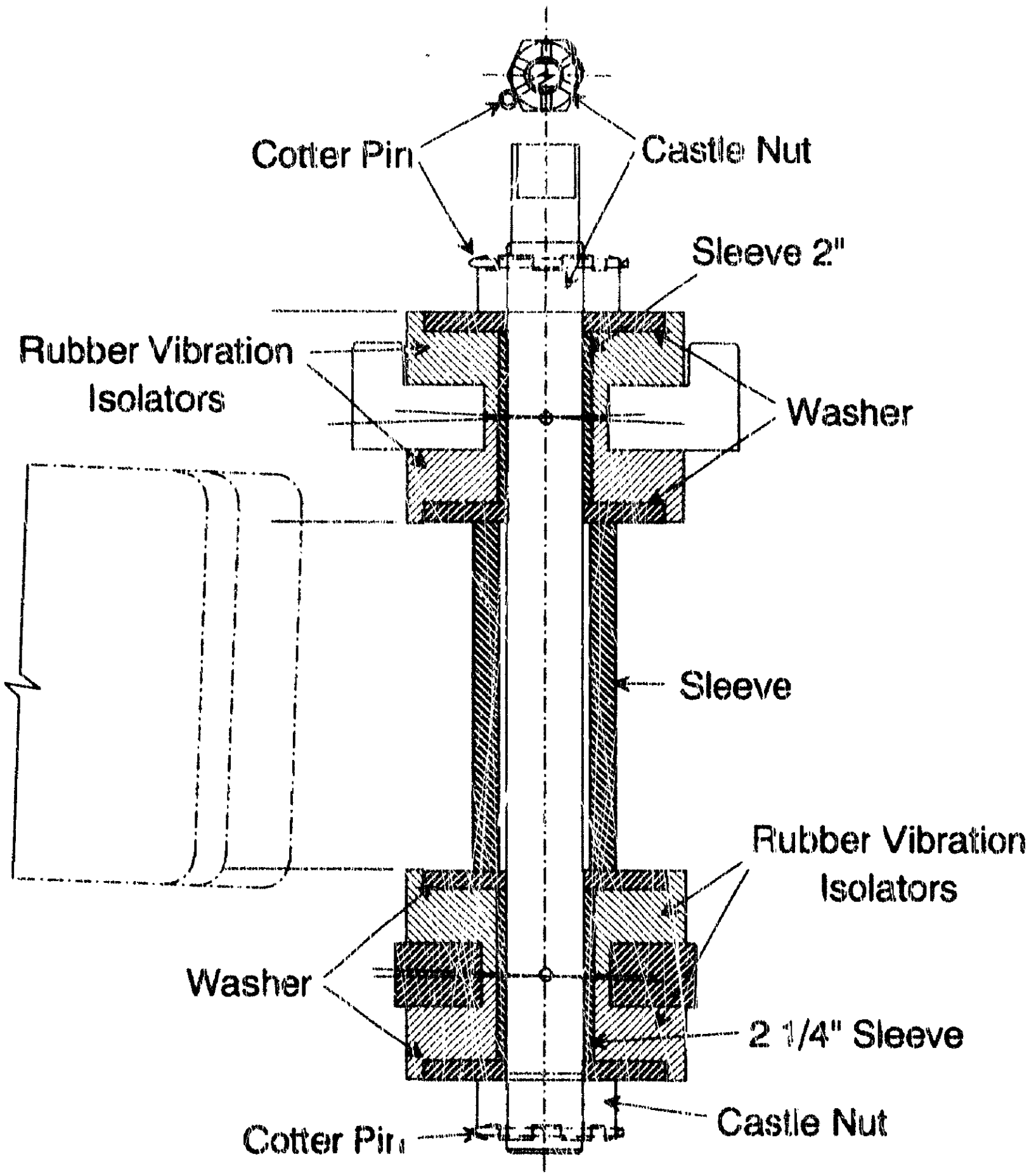


Figure 6.--SEPTA vertical support bolt drawing No. C-1004.



Not to Scale

Figure 7.--Budd Car Company vertical support bolt drawing.

Motor Support Bolt Installation.--According to SEPTA management testimony at the hearing, the original design of the vibration isolator stacking arrangement in the traction motors on Budd Cars had been changed. In the original design the spacer sleeves in the vibration isolators were two different lengths. The top sleeve was 2 inches long, and the bottom sleeve was 2 1/4 inches long. The difference occurred because the mounting plate was 1/4 inch thicker on the bottom than on the top. When the bolt assembly was put on a car, in a proper assembly containing washers on both ends of the isolators, the compression in the isolators was limited to the length of spacer sleeves under the isolators.

The MFSE *General Overhaul Manual* (GOH) instructions on truck assembly state that the horizontal safety rod should not rest on the brackets of the traction motor mounting housing. The horizontal safety rod connection is a safety arrangement to prevent the motor from dropping to the track, and is part of the traction motor support brackets welded to the traction motor housing. The horizontal safety rod, connected to the truck bolster frame, passes through the two 2 1/4-inch-wide by 3 1/4-inch-long oval holes in the motor support brackets. With the vertical support bolt properly assembled and secured, the brackets would not be in contact with the horizontal safety rod. If the vertical support bolt failed to properly support the traction motor, the upper surface of the oval holes in the motor support brackets would rest on the horizontal safety rod, supporting the traction motor and preventing it from dropping to the track.

Postaccident Inspection.--Train 61 was examined at the accident site on March 7 and 8, 1990. There was no evidence of smoke or fire damage. The major impact damage was sustained by car 818. Safety Board investigators observed that the car's No. 2 traction motor had dropped and that the horizontal safety rod had worn through the traction motor support brackets. Upon impact the traction motor and gearbox rotated vertically around the truck axle about 180 degrees from their installed position. The vertical support bolt was attached to the motor; however, the top castle nut and cotter pin were missing, and there was grease in the cotter pin hole. The upper vibration isolator assembly and washers, as well as the spacer between the isolators, were missing. Half of the bottom castle nut was missing, but the other half and the cotter pin were in their proper positions. Only one washer was found corresponding to the lower isolator assembly.

At the 15th Street station a 9 3/4-inch scrape mark on the closure rail on switch 7E's left side was the first indication that equipment had been dragged along the track. No other marks were found until approximately 800 feet east of the 30th Street station. Further evidence of impact marks were found on the center portion of the ties approaching the turnout, as well as at switch 7E.

The first three cars (769, 770, and 817) were not derailed. The fourth car (818) derailed in the crossover between the eastbound and the westbound tracks. The lead truck wheels of the sixth car (725) were derailed in the crossover on the westbound track. This car's rear truck wheels were on the closure rails of the turnout. The fifth car (726) was derailed in the crossover. The left side of car 818 (the fourth car) collided with steel 12-inch by 12-inch H beam uprights that were 165 feet west of switch 7E. The car's body was sheared open for 30 feet and was almost severed near the midpoint. (See figures 8 and 9.)

The ceiling panels of car 818 had several cracks between the B end and the first vent fan. The ceiling between the first and second fan had cracks on the right panel. The left panel was missing. Insulation and roof structure were hanging into the

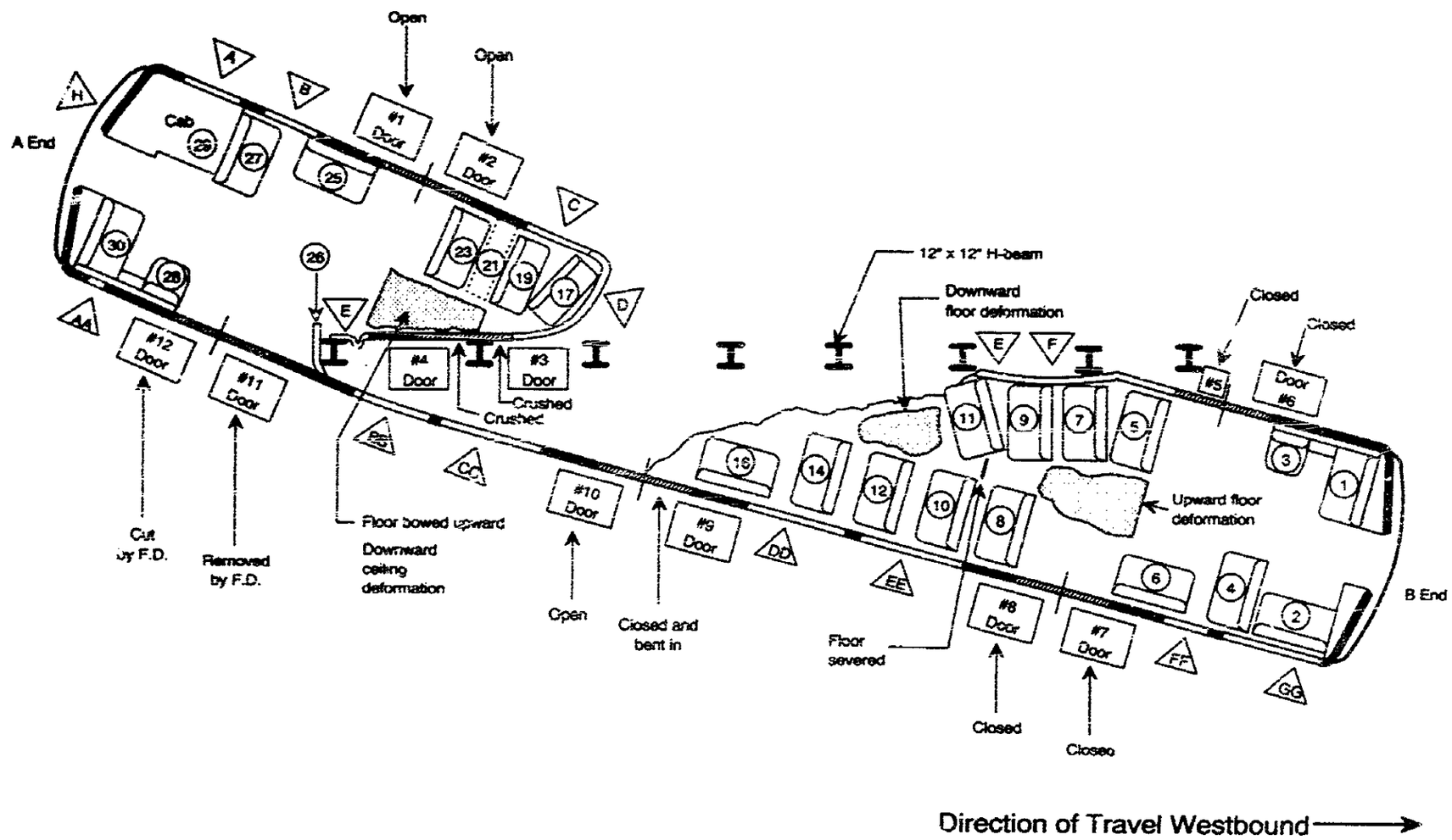


Figure 8.--Damage profile of car 818.

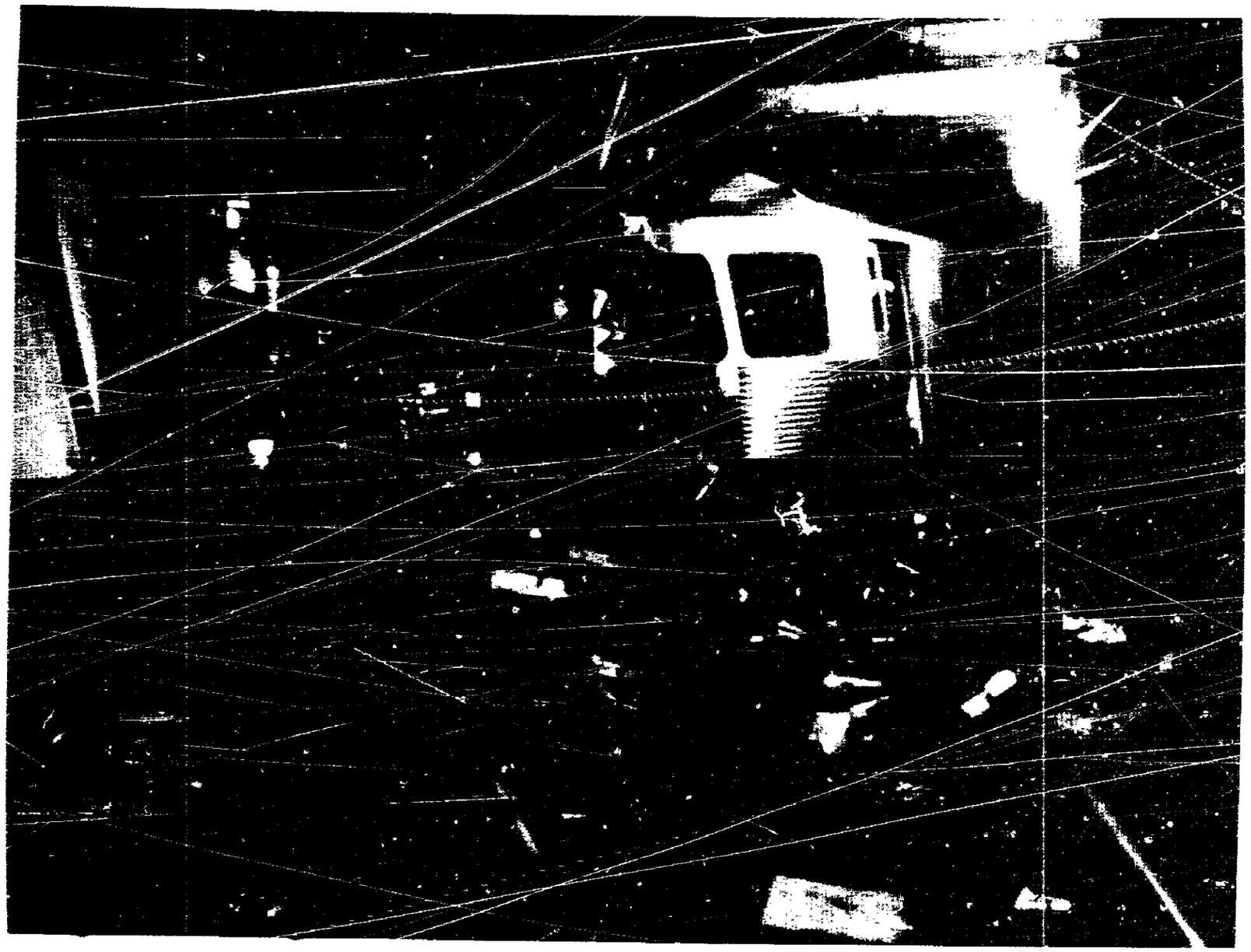


Figure 9.--View of accident site.

passenger compartment. The ceiling panels between the third and fourth fans were destroyed, and the roof structure was hanging into the passenger compartment. The roof had been pushed down until it was only 55 inches (a little more than 4 1/2 feet) above the floor. The panel between the fourth fan and the A end showed minor cracking. Ninety percent of the interior lights were shattered or missing. The only vertical grab rails that remained secured to the ceiling were between the fourth ceiling fan and the A end.

The seats in all the cars were numbered 1 through 30 from the A end. The six biparting automatic sliding doors were numbered 1 through 12 clockwise, starting with the right A end door. The windows were lettered A through F on the cab side and AA through GG on the opposite side. Windows A and H were the cab windows. (See figure 3.)

In car 818, windows C, D, E, and F were missing. Window DD's glass had a vertical slash 6 inches by 1 1/2 inches, and window CC had stress fractures. Rescue personnel had removed window BB.

Car 818's doors 1 and 2 were open; 3 and 4 were crushed; 5, 6, 7, and 8 were closed; 9 was closed, but the inside lower panel was bent inward; and 10 was open, but skewed. Rescue personnel had removed door 11 and cut into the closed door 12.

The floor of car 818 had been deformed, displaced, and crushed in several areas. Injured passengers, including the fatalities, were seated in the area of seat 26.

Car Inspection and Maintenance.--Each car received three kinds of inspections: A, B, and C. SEPTA required an A inspection, which was done every time a car had traveled 3,000 miles or had been used for 30 days, whichever came first. The Pennsylvania Department of Transportation (PADOT) required two B inspections per year; at least one had to be done within 9 months of the original preceding B inspection, and the second had to be done within 12 months. The B inspections were part of the electric mass transit vehicle (EMTV) inspection program. The C inspection was required by PADOT and included all aspects of the B inspection plus additional items. SEPTA performed all of the inspections, and PADOT certified the B and C inspections. In each inspection, the foreman was required to make certain the work was done. All inspections required a complete inspection of both the motor support and safety rod connections. In addition, SEPTA required a monthly motor support-bolt inspection. Information about the inspections is summarized below:

Inspection	Time Interval	Mileage Interval	Required by
A	30 days	3,000 miles	SEPTA
B	4 months	12,000 miles	PADOT
C	24 months	72,000 miles	PADOT
Motor support bolt	30 days	3,000 miles	SEPTA

The PADOT capital grants and safety manager stated that he did not normally investigate SEPTA accidents and that he had not taken any action to initiate corrective measures after this accident.

SEPTA cars traveled an average of 3,000 miles per month when they were in regular service. Since they were not equipped with odometers, mileage was determined by the number of trips made. The A inspection was a 12-part general safety inspection and testing of all areas of the car. The mechanic who, on February 10, performed the last A inspection before the accident said that he had never seen a copy of the A inspection manual and that he had received his procedure instructions from the foreman. The foreman testified at the Safety Board public hearing that he had distributed the manual to the employees. The A manual was a 14-page document that gave no instructions on performing the inspection and only outlined the areas that required inspection. The following subjects were covered in the manual: car component specifications, lubricants, interior electric, interior carbody, couplers, exterior carbody, exterior electric, trucks (including all motor support bolt and safety rod connections), controls, air, lubrication, and doors. After an A inspection, the foreman who inspected the work was required to complete a SEPTA form F-114.

The B and C inspections were more detailed than the A one. SEPTA required a five-part B inspection every 4 months or 12,000 miles that included testing of the heat and ventilation system, in addition to the 12 areas in the A inspection. The C inspection was performed during the 4-month period at the end of 24 months or 72,000 miles when the five-part series of B inspections were completed. The mechanics and foreman were supposed to sign and date B and C inspection forms, which were then to have been reviewed by the car house superintendent.

A review of inspection and repair records for car 817 showed the work performed on the No. 2 traction motor as:

10/04/89	Traction motor removed and replaced
1/04/90	Regular B inspection
2/10/90	Regular A inspection
3/02/90	Traction motor safety rod inspection
3/07/90	Accident

Car 817 received its last PADOT-certified B inspection on January 4, 1990, at the 69th Street car shop. This car was scheduled for an A inspection on February 10, 1990. Car shop records showed that car set 817 and 818 was in the shop on that date. Work orders indicated that the A inspection was completed; however, the form was not signed by the foreman, and the identification number of the only mechanic on duty was not entered. The foreman told Safety Board investigators that his handwriting was on the form and that he could not remember any details. The mechanic could not recall whether he had inspected car 817. The mechanic was not required to sign the work order as proof that the inspection was completed.

The general foreman at the Bridge Street car shop was interviewed during the Safety Board public hearing and testified that SEPTA's monthly motor support bolt inspection was in addition to the A, B, and C inspections. The general foreman stated that although the inspection form for the monthly motor support bolt inspection was undated, inspection of cars 817 and 818 would have occurred at Bridge Street on March 2, 1990. (See appendix F.) He further stated that his method of inspection was to check the condition of the support bolts from the underside.

His method did not include inspecting the top castle nuts or cotter pins of the support bolts because it was too difficult to reach those components from the mechanics' pit. SEPTA had no motor mount inspection instructions.

The last time the traction motor had been replaced was 154 days before the accident.

SEPTA's MFSE Car Maintenance Practices.--During a postaccident interview, the foreman on duty on February 10, 1990, at the 69th Street shop stated that used cotter pins had been used to secure the motor support bolt castle nut. The cotter pins are removed and reused after the motor support castle nuts are tightened in order to lift the traction motor brackets so that they do not rest on the horizontal safety rod.

SEPTA Training and Procedures for Mechanics.--The A inspection mechanic stated that he had worked for SEPTA since 1982 and had worked previously as an aircraft mechanic. He had had to pass written exams and undergo a 60-day probation period to qualify as a SEPTA mechanic. He had received no classroom training, but had been assigned to another mechanic during the probation period, learning through on-the-job experience. He had received no formal training in performing an A inspection. He was unaware of any written manual, checklists,or engineering diagrams from which to work. He was also unaware that the mechanic or supervisor was required to sign for the completed work. The mechanic determined what was done in the A inspection, based on his experience, although sometimes a supervisor provided general directions about areas of emphasis. The mechanic had never installed a motor during his time with SEPTA; however, he had replaced two broken motor-support bolts. The motor-mount inspection emphasized a check to ensure space between the horizontal safety rod and the support brackets. The mechanic said that before the accident some supervisors had rechecked his work, while others had not. He stated the A inspection would be improved by having the mechanic climb a ladder to view the motor mount and by having the mechanic and the supervisor certify by signing a form that the work was completed satisfactorily.

This mechanic's supervisor began working for SEPTA in 1983 and had served as a supervisor for 4 years. Before working for SEPTA, he had completed 3 years of technical training involving engines, transmissions, and electronics. The supervisor stated he was enrolled in science classes at Drexel University because SEPTA had a paid, personal improvement program for management and hourly employees. The supervisor characterized his mechanic's ability as a "6 or 7" on a scale "from 1 to 10." He said that the A inspections began about 3 years before the accident and did not involve any checkoff sheets or forms. Mechanics determined what to inspect from their past experience, understanding that "the A inspection includes everything." Supervisors were responsible for assigning the work and emphasizing certain areas as necessary.

At the public hearing, the mechanic who was responsible for the A inspection on February 10, 1990, testified that he had received no classroom training in inspection procedures. He said that the in-shop training depended mainly on the instructions of senior personnel. He was often left on his own. He stated, "The senior men ... had a feeling that they didn't want to instruct the new coming-in men. 'I wasn't hired as an instructor. You're on your own.'... Once I asked the question to a senior man, senior man's reply is, 'You go ask the guy in the white shirt.'" However, the SEPTA spokesman at the hearing stated that before the accident, the

mechanic had received some programmed training to improve his maintenance skills (although there was no documentation of his training in his personnel file).

The mechanic who performed the B inspection stated that he was employed by SEPTA in 1980. Before that, he had completed a course in air conditioning maintenance. To qualify for the mechanic's position, he had passed tests and had undergone a 60- to 90-day probation period while being paired with a senior worker. He had not received special training for working on the cars when he joined the Market Street division in 1986. He said that SEPTA provided occasional recurrent training, such as a 2- to 3-day classroom training period about propulsion box systems that he had attended 1 or 2 years before.

He stated that he was responsible for traction-motor inspections as part of a larger team that carried out B and C inspections. He said that he received "no specific training" for inspecting the motor mountings and had learned the procedure "from an old timer." He inspected for any play in the sleeve that wraps around the motor mount bolt. He noted that some mechanics needed a ladder for this, as the sleeve was about 6 feet 6 inches above the floor of the inspection pit. Since he had suffered a work-related back injury several years before, he was assigned to traction-motor inspection because it involved less climbing. He said that about 2 years before the accident, the schedule for completing B and C inspections had been accelerated and the A inspections has been introduced, resulting in the need to do more work in the same amount of time.

The mechanic's supervisor stated that he had worked for SEPTA since 1983. He had previously worked as a mechanic on rail cars with GE, and he had come directly to SEPTA as a supervisor. He said that a major change in inspection procedures took place at the time the A inspection was introduced. Before that, motor-support bolts were inspected on a weekly basis by foremen. Then the inspection of the motor-support bolts became part of the A inspection, the B and C inspection schedules were accelerated, and additional mechanics were added to the inspection teams. He stated that written B and C inspection procedures were available on computer disk and in hard copy in the department files. In practice, however, mechanics learned the inspection procedures through hands-on experience. SEPTA periodically provided the mechanics with training classes that focused on specific aspects of the cars. He estimated that only about 20 percent of his time was spent on the shop floor because so much of his time was taken up by paperwork.

The mechanic who last mounted the accident motor stated that he was employed by SEPTA in 1986 after he had worked as an aircraft mechanic. When he began at 69th Street, he worked for 5 months in the car house to prepare for performance tests. After he passed the tests, he was put in the overhaul shop and given additional training before being transferred to the overhead hoist. All training consisted of hands-on experience working with senior mechanics. He said that for recurrent training, formal motor, electric, or truck courses were listed on the bulletin board "every now and then." He had received no recurrent training in the 3 years he had worked on the overhead hoist, and his partner had attended one course about 1 1/2 years ago.

The mechanic stated that general shop procedure prescribed that he should not bend the cotter pin too far when he installed a motor. "When somebody has to get up there and adjust it, if things work loose, it's a lot harder to get that cotter pin out if they're bent all the way around." He said that it could be difficult to adjust the level of the castle nut relative to the cotter pin because mechanics had been

instructed verbally, for reasons not clear to him, to use only one washer in the mounting assembly. He noted that since the accident these instructions had changed and mechanics could now use as many washers as necessary to achieve the proper adjustment.

He had never had occasion to consult engineering diagrams in his work. He stated that it was "very, very rare" for a supervisor to check the work. He also stated that it was difficult to obtain new parts. As an example, he cited the WE motor studs used to mount motors to the pinion gear box assembly. New studs had not been available for 8 months, old studs were reinstalled, and aluminum substitutes used. He suggested pressure existed "to get the car on the line, that's the most important thing."

The general manager of SEPTA, who had been hired by SEPTA in August 1988, stated at the public hearing that SEPTA was in the process of instituting management and organizational reforms.

Track and Signal Information

The SEPTA MFSE blue line was equipped with two self-restoring spring loaded type model SRD-5 dragging equipment detectors. These detectors were designed to sound a bell and to light an indicator on the towerman's control panel. Both detectors were installed on inbound tracks, one at the eastbound entrance to the Bridge-Pratt station and the other at the westbound entrance to the 69th Street station.

After the accident, the dragging equipment and defect detectors at 69th Street and Bridge Street were inspected. No defects were found, and the detectors functioned as designed when tested.

SEPTA had 17 track inspectors on the subway system. One was assigned to the light rail line, six to the Market-Frankford line, and eight to the Broad Street line. Two inspectors worked the three lines when the regular track inspectors were off.

The accident track between 8th Street and 45th Street was inspected by the assigned track walker on March 4, 5, and 6. He did not report any defects or unsafe conditions on crossover switch 7E. The track walker did note defective ties on the eastbound track opposite the accident site on crossover switch 5W.

After the derailment, inspection of the track revealed that the traction motor on the No. 1 truck of car 817 had been dragging on the crossties between the rail 800 feet east of 30th Street station. Scrape marks on the left side of the closure rail at the 15th Street station crossover were the first indication that equipment had been dragged along the track. The distance between the point where the traction motor started dragging to the point of derailment at the 7E switch was 1,555 feet.

The 7E switch in the crossover 238 feet west of the 30th Street station was lined for straight track and looked proper to the motorman as he approached it. The motorman did not see any damage in the 7E switch before the accident.

Operations Information

SEPTA was responsible for public transportation throughout the Philadelphia metropolitan area, which encompassed Philadelphia, Montgomery, Bucks, Chester,

and Delaware counties. The transit system had approximately 110 bus, 5 trackless trolley, 10 trolley/light rail, 3 high-speed/subway elevated, and 13 commuter rail routes. SEPTA provided about 80 million vehicle miles of service a year on 2,750 miles of routes, carrying about 1.5 million riders per workday.

At the time of the accident, the SEPTA City Transit Division Control Center in Philadelphia was responsible for the management of all bus, trolley, trackless trolley, and subway-elevated routes within the city of Philadelphia. It also coordinated all service problems and activities between city transit, commuter rail, and suburban transit divisions. All vehicles were equipped with either portable radios, vehicle mounted radios, or train phones. The control center was fully integrated with all operations control, including the transit police force, located in a single facility. All service decisions were made and implemented through the control center.

A train dispatcher in the control center directed train operation on the MFSE. At the time of the accident, the dispatcher was seated at a two-position dispatching console that contained transmit-receive modules for control of the radio, train phone, and telephone systems. The Broad Street line train dispatcher occupied the second position. The two dispatchers shared duties as demands required.

The MFSE line normally operated 182 daily trips eastbound and westbound on weekdays, using a maximum of 180 cars. On weekends, the line operated only 116 trips. At the time of the accident, the time between trains was 3 minutes.

Employees of the MFSE/Blue Line were governed and qualified by *SEPTA's Transportation Department Subway-Elevated Rules for Employees, 1978 Edition*. Crewmembers were trained in the operating rules and were supervised for compliance with these rules.

Medical and Pathological Information

Fatal Injuries.--Four passengers in car 818 near seat 26 sustained fatal injuries when they were trapped between the steel H-column and the interior side wall near door 11. (See figures 8 and 9.) The medical examiner's report stated that they sustained multiple trauma and compression injuries.

Other Injuries.--Among the other passengers on the train, 158 injuries were recorded. These included contusions, abrasions, lacerations, muscle strains, and broken bones.

Toxicological Information.--As a matter of company policy and in compliance with the operating rules, after assisting the injured passengers at the site, the crew of train 61 was accompanied by a SEPTA supervisor to be tested for drug and alcohol use.

> Rule 1-6 of the subway elevated's rules for employees stated:
>
> Employees must not indulge in, nor be under the influence of, intoxicating liquor, malt beverages, harmful drugs or patent medicines containing harmful drugs:
>
> a. While on duty.

b. When reporting for duty, including the second half of a swing run.

c. While off duty but on any authority property or equipment, or in uniform immediately adjacent to authority property.

Possession of, or carrying of, intoxicating liquors, malt beverage, harmful drugs or patent medicines containing harmful drugs is prohibited. "Under the influence" shall include odor on the breath of any of the above which would be apparent to the average person and make such person suspect their use.

The motorman was tested under the SEPTA requirements, as outlined in the labor contract. The test was a breathalizer one and was negative. A urine sample obtained at 1145, March 7, 1990, was tested by SmithKline Bio-Science Laboratories in Norristown, Pennsylvania, for evidence of amphetamines, barbiturates, benzodiazepines, cocaine, marijuana, methadone, methaqualones, opiates, phencyclidine, and propoxyphene. The sample was positive for cocaine at a concentration of 1885 ng/ml and for cocaine metabolite at a concentration of 65,380 ng/ml. The Safety Board requested a second test of the sample by the Drugscan Laboratory in Willow Grove, Pennsylvania, and it tested positive for cocaine at 840 ng/ml and for cocaine metabolite at 73,000 ng/ml. The SEPTA medical records indicated no previous drug tests on the motorman.

Also under the same SEPTA requirements, the conductor was tested for alcohol by a breathalizer test, and it was negative. A urine sample was tested by the SmithKline lab and found negative on the same drug screen used for the motorman. The SEPTA medical records indicated that the conductor had undergone previous drug testing in January 1988 after returning to work from an extended illness. The tests were negative for alcohol and drugs.

According to the SEPTA chief industrial relations officer, the SEPTA drug testing program had been in effect since September 1985. Covered employees included those in safety-sensitive positions, those who operated revenue vehicles, dispatchers, those involved with signals, and their supervisors. The program included preemployment, reasonable suspicion, and postaccident testing, as well as testing for any employee returning after an absence of more than 30 days. This last testing requirement was dropped on January 19, 1988, when it was struck down in Federal court. SEPTA supervisors received in-house training in recognizing the signs of drug and alcohol abuse.

Added to the existing program in 1989, SEPTA's random testing program was among the first in the transit industry. From its inception to February 28, 1990, 1,215 random drug tests were performed in an employee population of about 6,000. Thirty-four employees (3 percent) tested positive for drug use. Following the accident, SEPTA initiated a study to document the program's effectiveness and concurrent deterrent effects.

Since the SEPTA program was relatively new, no drug tests had been performed on the accident motorman before the accident date. According to testimony at the public hearing, SEPTA began drug testing in September 1985 and added random testing in September 1989. By the time this was added, the return-to-work requirement for testing was eliminated by a court decision. The motorman was hired before SEPTA had preemployment screening and had had no

other accidents that required postaccident testing. His lengthy absences occurred after the removal of the return-to-work requirement, and therefore he was not tested in these instances.

Survival Aspects

Safety Board investigators interviewed six injured passengers who were admitted to hospitals. The six stated that they had had no warning of the derailment and subsequent collision. Their first indication of instability was a feeling that the train had passed over a large object and a loss of power. Four said that they were pinned in their seats and could not move until they were extricated by firefighters. The others stated that they sustained disabling injuries from striking interior components and were unable to evacuate the train without assistance.

The Safety Board sent questionnaires to 150 passengers about their location and observations before the collision, the difficulties encountered in evacuation, and the circumstances that caused or contributed to injuries. Thirty-eight questionnaires were returned; however, not all respondents answered all questions. Nine stated they heard the train dragging an unknown object; however, none saw the object. Eleven responded that they were aware the accident was about to happen because they either had felt the train's unusual movement or had heard an unusual sound.

The majority of the passengers who were injured stated that on impact they were thrown against seat backs, metal stanchions, grab bars, the floor, and other passengers. Most stated that no emergency instructions were posted inside the cars. They evacuated the train and walked, or were helped by other passengers and firefighters, to ground level. From there, rescue units or buses transferred them to hospitals. A large number of seat cushions separated from their frames.

Test and Research

General.--During a Safety Board investigation on March 9, 1990, at the 69th Street car shop, investigators observed about 30 used traction motors with motor support brackets that were worn where the horizontal safety rods passed through the brackets. The wear was as much as 1/4 inch on some of the brackets in the same area where the failure occurred on the traction motor brackets on car 817.

Safety Board investigators conducted an inspection of traction motor support bolts. They inspected 19 cars, including the 3 head cars of the accident train. They looked at 75 motor support bolt assemblies and found that 27 bolts had the top castle nut torqued down to the point that its top was below the cotter pin. As a result, on March 9, 1990, the Safety Board issued Emergency Safety Recommendation R-90-001 for SEPTA to "immediately inspect the traction motor support systems of all applicable passenger cars to verify that the traction motors are properly installed including the vertical support bolt and its locking nut and cotter pin assembly for the systems and correct any discrepancies before returning those passenger cars to service."

In response to the recommendation, SEPTA began to inspect on March 12, 1990. Of 147 cars inspected, SEPTA found 15 cars on which 1 or more of the traction motor support brackets was in contact with the horizontal safety rod. Twelve cars were placed in the shop for repair before they were returned to service.

Testing the radios after the accident disclosed that the extensive damage to car 817 caused a short that blew the fuses. The batteries lost their charge within minutes of the accident, resulting in no power to the radios.

Wear of Traction Motor Support Bracket.--SEPTA conducted a postaccident bracket test on an in-service MFSE car by placing the traction-motor support bracket in contact with the horizontal safety rod. This was done to determine how much time it would take for the horizontal safety rod to wear through the support brackets. For the purposes of this testing, the traction motor vertical support bolt was removed entirely, allowing the full weight of the traction motor to be suspended from the horizontal safety rod. As a back-up safety support in case the motor support bracket failed, a cable was installed around the motor.

The test began April 18, 1990, and is still in progress. As of January 31, 1991, the test vehicle had accumulated the equivalent of 88 normal service days of operation by running at night when the system was closed to revenue service. The maximum wear for the safety brackets was 45 percent of usable metal. In a different location on the same car, the nuts on two motor support bolts were also reconfigured to eliminate cotter key restraint. In both instances, the 3/4-inch long spacer beneath the nut and upper isolation mount washer was removed permanently, and the nut castellations were positioned totally clear of the cotter key, which was left in place as a secondary stop. In one case, the nut was hand tightened, and adhesive applied; in the other, the nut was backed off two turns from its normal location on the bolt without adhesive. During the test only movement of the total vertical bolt assembly occurred. Neither nut moved with respect to its bolt. The parameters on this test were the same as those noted for testing the motor support brackets.

Speed.--On March 13, 1990, the speed of seven trains was measured at a point 238 feet west of the 30th Street station, using a hand-held radar gun. The purpose was to determine the average speed of the trains as they passed switch 7E during normal morning rush hour operation. The radar gun was calibrated at 35 mph with a 35-mph tuning fork. Representatives of SEPTA and the Safety Board conducted the tests. The results are shown below:

Time	Speed Switch 7E	Speed 4th Car-Column
0812	29 mph	33 mph
0814	29 mph	35 mph
0817	31 mph	35 mph
0821	19 mph	25 mph
0824	29 mph	34 mph
0829	26 mph	28 mph
0831	25 mph	32 mph

The trains went over switch 7E at an average speed of 28 mph. At the point where the fourth car struck the steel column, 165 feet west of the switch, the train's average speed was 33 mph. Because the motorman on the 0821 train did not operate at normal speeds, his speeds were not included in the averages.

In addition, the maximum speed of two trains was determined by radar to have been 48 mph. According to the Budd Car Company design-information furnished when the car was manufactured, its maximum designed speed was 55 mph.

Metallurgical.--The Safety Board materials laboratory examined components from car 817's motor support system and several comparison pieces. The components included the car's traction motor case, horizontal safety bolt, bent vertical support bolt, and broken nut piece from the bottom of the support bolt.

Safety Rod and Traction Motor Support Brackets.--The shank of the horizontal safety rod was extensively worn in two spots. On assembly, the two spots corresponded to the positions of the two vertical members of the motor support brackets. (See figure 5.)

The engineering drawing specifies that the horizontal safety rod be manufactured from 4340 steel heat-treated to a hardness range of 39 to 43 Hardness Rockwell C (HRC), the equivalent in tensile strength of 180 to 200 thousand pounds per square inch (ksi).

The motor support brackets had gaps in both of the vertical members that surround the horizontal safety rod. The texture of the surfaces around the gaps were indicative of heavy side-to-side abrasion with another object, such as the horizontal safety rod. Fracturing was not evident. The distance from the top of the oval-shaped hole in each vertical member of the bracket to its upper surface was approximately 1 1/4 inches. The maximum hole dimension measured approximately 3 5/16 inches. These measurements complied with the engineering drawing cut out dimension requirements for these holes. Hardness measurements of the motor support bracket gave values averaging HRC 1 (RB 83), which was much softer than the specified hardness for the horizontal safety rod.

Vertical Support Bolt Assembly.--The upper threads on the top portion of the support bolt where it passes through the truck bolster mounting plate were damaged. Fractures indicative of fatigue were noted through numerous thread crowns near and below the cotter pin hole in the bolt. The thread cracking appeared to begin on the downside of the thread with the cracks spreading upward and inward toward the next thread root above. Some cracks clearly began at the thread flank, with cracking almost through to the thread root above. However, in other areas the fatigue fractures were partially obliterated by postfracture mechanical damage. The separated thread crowns in localized areas were moved and deformed into the next higher thread root.

Longitudinal cross sections through the damaged threads in the upper area of the vertical support bolt showed some evidence of thread deformation directions. For the threads above the cotter pin at the top of the vertical support bolt, thread deformation was in both directions. The first appeared in the upward direction, followed by deformation in the downward direction. For those threads below the cotter pin hole at the top of the bolt, the deformation was in the upward direction against the thread flank.

Hardness measurements of the thread sections had values ranging from 395 to 425 Diamond Pyramid Hardness (DPH) (40 to 43 HRC equivalent). Grain flow around the thread roots indicated the threads were roll formed as required.

Fractured Castle Nut Examination.--The fractured castle nut was removed from the lower thread area of the motor support bolt. The fracture surface had discolored zones representative of preexisting quench cracks produced during the rapid cooling process on heat treatment during manufacture. Within the discoloration a thin light band was noted along the outside surface, and outside the light band was a dark-colored area.

A scanning electron microscope examination of the castle nut fracture surface showed that the discolored zone was intergranular. In the light band area near the surface, the intergranular features appeared coated with a deposit. X-ray energy dispersive spectra (EDS) of this surface produced peaks of cadmium and sulfur.

The dark discolored area was intergranular without notable deposits. The EDS of this area contained only the peaks associated with 4340 steel without cadmium or sulfur. Fracture features outside the discolored zone were representative of a tensile overstress break.

The side surfaces had three visible cracks extending below the castellation cutouts. The cracks also extended from the outside flat into the sharp corner of the castellated groove, progressing halfway inward toward the thread. All surface flats had a finish typical of cadmium plate. The cracks were identical in shape and extent to the preexisting cracks found on the castle nut fracture surface.

Other Information

Previous SEPTA Motor Separation Incidents.--Although SEPTA has no record of the incident, a SEPTA towerman told Safety Board investigators that he had experienced a motor separation in 1975 while he was working as a subway motorman. He stated he was approaching the Spring Garden station in revenue service when he felt "a little surge, like you may have lost a little power." Inspection revealed that a motor had separated completely from the fourth car and that the motor was wedged in the tracks about 200 feet behind the train. The towerman said he learned from another motorman, who had been riding in the fourth car as a passenger, that "the train had just jumped up in the air and come down again as it ran over the motor."

A SEPTA transportation system engineer (TSE) told Safety Board investigators of a motor separation in 1988 or 1989 that SEPTA did have a record of and that occurred on a subway train that was entering the yard after completing revenue service. According to the TSE, the "case which binds the motor to the gear housing split; the motor had a bearing failure which dropped the armature on the field poles and stalled the motor, and the case split." He said the safety brackets performed properly and held the motor in place.

Inspection reports from July and August 1990 outlined failures of the vertical support bolt. These failures were found during routine inspections of the bolt. On March 7, 1990, SEPTA instituted the practice of having all motor support bolts inspected visually every 48 hours.

SEPTA Accident History.--In the 4 years from February 5, 1986, through February 26, 1990, SEPTA had 13 serious accidents that were investigated by the Safety Board. A synopsis of these 13 accidents follows.

On February 5, 1986, at Thornbury Township, train 3355 struck a vehicle stalled on the track, killing one person and injuring four others in the vehicle. The hearing-impaired driver of the vehicle was inattentive to the approaching train. The conductor had negative toxicology testing; the engineer was positive for alcohol and marijuana. (NYC86FX010)

On February 7, 1986, at Philadelphia, train 817 ran into the rear of train 345 and shoved it into train 0117, resulting in 20 injuries. The motorman failed to comply with a restricting signal. All crewmembers had negative toxicology test results. (NYC86FR011A,B,C)

On August 23, 1986, at Upper Darby, train 167 failed to stop short of the bumping post at the 69th Street terminal and penetrated 6 feet into the terminal building, resulting in 45 injuries. The inattentive motorman failed to comply with proper operating procedures. (DCA86MR005)

On December 10, 1986, at Philadelphia, train 0151 struck the rear of train 9843 at Suburban station, resulting in 28 injuries. The engineer on the train did not comply with a restricting signal. He tested positive for cocaine. Two car attendants on train 9843 tested positive for marijuana, and one was positive for cocaine. (NYC87FR006A,B)

On January 26, 1987, at Ardmore, transit car 202 struck the rear of transit car 207 and shoved it into a disabled work car, 401, that was stopped on the main track, resulting in 18 injuries. The operator of car 202 failed to comply with a stop signal. The operator of car 207 tested positive for marijuana. (NYC87FR009A,B)

On January 12, 1988, at Norristown, train 626 stopped at a signal on the main track and was struck head-on by a runaway Consolidated Rail Corporation (Conrail) hopper car, resulting in nine injuries. The Conrail carman released the hopper handbrakes because of a defective derailing device on the track. No toxicology tests were required or performed. (NYC88FR007B)

On April 10, 1988, at Philadelphia, trolley 9061 derailed on a curve, resulting in 26 injuries. The engineer was operating at excessive speed. Toxicology tests on the crew were negative. (ATL88FR012)

On April 27, 1988, at Philadelphia, train 598 struck an abandoned vehicle on the main track operated jointly by SEPTA and the National Railroad Passenger Corporation (AMTRAK), resulting in 11 injuries. Before the collision, the AMTRAK tower operator and police had been notified of the abandoned vehicle and failed to provide proper protection for train 598 to prevent the collision. The train was operating at night during rain on clear signals. Crew toxicology tests were negative. (FTW88FR014)

On June 18, 1988, at Philadelphia, disabled train 1845 stopped on the main track and was struck from the rear by Conrail yard train REL-2, resulting in 34 injuries. The Conrail crew failed to comply with signal rules and was inattentive. Crew toxicology tests were negative. (ATL88FR0188)

On November 12, 1989, at Drexel Hill, light rail vehicle (LRV) 105 was operating on the main track and entered a side track and struck the rear of LRV 120, resulting in four injuries. The switch operator failed to realign the spur track switch after LRV 120 entered the siding. Toxicological tests were negative. (NYC90FR003A,B)

On January 29, 1990, at Upper Darby, LRV 117 struck the rear of LRV 114, which was stopped on the main track, resulting in three injuries. The operator of LRV 117 failed to control movement after using the emergency brakes. Toxicological tests were negative. (ATL90FR005A,B)

On February 16, 1990, at Philadelphia, work train CW-3 struck the rear end of rail crane CW-1 in Fern Rock Yard on the lead track, resulting in eight injuries. The tower operator failed to realign the lead track switch, and the CW-3 operator failed to comply with signal indications. Toxicology tests were negative. (NYC90FR009A,B)

On February 26, 1990, at Philadelphia, train 26 struck a signal maintainer who was repairing signals on the main track near Hunting Park station, resulting in his fatal injury. Company rules and procedures were inadequate to protect the signal maintainer. No toxicology tests were performed. (CHI90FR010)

After the August 23, 1986, Upper Darby accident, the Safety Board recommended that SEPTA:

> R-87-040
>
> 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.

SEPTA responded to the Safety Board on April 5, 1988:

> New preventative maintenance and inspection forms and standards have been developed and are currently in use. They address the following operating areas: brake rigging, electrical, truck, wheel reports, car interior, air system and lubrication. Review and refinements to these forms and standards are continuous with revisions being incorporated as required.

As SEPTA continues to update preventive maintenance and inspection forms and standards, the recommendation remains "Open--Acceptable Action."

As a result of the Upper Darby accident, SEPTA closed the Norristown High Speed Line. Because Safety Recommendation R-87-040 was issued and the Urban Mass Transportation Authority (UMTA) invoked its section 22 authority to investigate hazard causing conditions on transit property, the car fleet was examined, improvements were made, and maintenance procedures were tightened. The line was then reopened.

In addition, SEPTA stated that it had placed a manager who came from the railroad industry in charge of the Norristown High Speed Line. He implemented

repair and inspection standards similar to the Federal Railroad Administration (FRA) standards, and these standards were satisfactory to SEPTA.

During the Philadelphia accident public hearing, the Safety Board asked SEPTA officials if Safety Recommendation R-87-040 had been adopted at any other maintenance locations. SEPTA responded in the negative.

Oversight of SEPTA Operations.--An UMTA spokesman testified at the Safety Board public hearing that UMTA has no authority to require a transit system to report accidents, to investigate accidents, or to monitor mass transit operations or transit authority mechanical departments. Nor does UMTA plan to seek regulatory authority for mass transit safety.

The UMTA spokesman stated that UMTA is a financial-assistance agency with programs to help State and local communities implement transit systems based on local needs. It is basically a grant-and-aid agency and does not use safety requirements as a criterion for determining eligibility.

The spokesman said that by statute the agency does not have the authority to develop national approaches, solutions, programs, standards, or regulations for transit systems. The UMTA spokesman referred to the ruling of the Court of Appeals of the District of Columbia that UMTA does not have the authority to issue drug-related regulations.

The Secretary of the DOT has discretionary authority under Section 22 of the Urban Mass Transportation Act, 49 U.S.C., Section 1618 to investigate hazard-causing conditions on transit property.

> The Secretary may investigate conditions in any facility, equipment, or manner of operation financed under this chapter which the Secretary believes creates a serious hazard of death or injury. The investigation should determine the nature and extent of such conditions and the means which might best be employed to correct or eliminate them. If the Secretary determines that such conditions do create such a hazard, he shall require the local public body which has received funds under this chapter to submit a plan for correcting or eliminating such condition. The Secretary may withhold further financial assistance under this chapter from the local public body until he approves such plan and the local public body implements such plan.

During the hearing it was established that the UMTA has conducted only three investigations under section 22 of the Urban Mass Transportation Act of transit properties since its inception and that each was after a Safety Board investigation.

On February 11, 1981, the Safety Board issued Safety Recommendations R-81-1 and -2 urging the DOT to propose legislation that would authorize the DOT to regulate the safety of federally-assisted rail rapid transit systems and, pending such legislation, to require the UMTA to establish Federal guidelines for equipment and operations. The recommendations also suggested that the DOT increase safety oversight of these systems. These recommendations were rejected by the Secretary on April 22, 1981, who stated that the DOT was seeking repeal of section 107 of the National Mass Transportation Act of 1974:

> The Secretary of Transportation shall investigate unsafe conditions in any facility, equipment, or manner of operation financed under this Act which creates a serious hazard of death or injury for the purpose of determining its nature and extent and the means which might best be employed to eliminate or correct it. If the Secretary determines that such facility, equipment, or manner of operation is unsafe, he shall require the State or local public body or agency to submit to the Secretary a plan for correcting the unsafe facility, equipment, or manner of operation, and the Secretary may withhold further financial assistance to the applicant until such plan is approved or implemented.

The purpose was to remove the Federal Government from an intrusive role in rail rapid transit safety as the DOT believed this was a State and local responsibility. Section 107 was subsequently repealed; however, section 22 was amended, giving the DOT authority to investigate potentially unsafe conditions, require corrective action, and withhold financial assistance if no corrective plan is implemented.

The Safety Board subsequently reconsidered and closed Safety Recommendations R-81-1 and -2 on October 1, 1982. However, the Safety Board expressed its view to the DOT that abdication of Federal responsibility for transit system safety was unsatisfactory.

Philadelphia received $173 million in UMTA-administered capital operating assistance and planning grants for SEPTA in 1989, of which $5.2 million were for operating assistance. The UMTA stated that safety is not considered in determining the level of Federal funds.

The UMTA considers the 13 SEPTA accidents in the past 4 years to be "incidents" and has determined that these have not caused a condition that necessitates investigation.

UMTA Attempt at Drug Regulation.--UMTA issued regulations in 1988 to require recipients of Federal mass transit funds to implement a drug testing program for employees who perform safety-sensitive functions. The UMTA associate administrator for technical assistance and safety testified at the Safety Board hearing that the District of Columbia Court of Appeals ruled that UMTA does not have the authority to issue drug related regulations.

Pennsylvania Electric Mass Transit Vehicle Inspection Program.--State Act No. 67 of 1980 amended the State vehicle code (section 102, title 75) to require the inspection of subway cars, buses, trolleys, and trackless trolleys, but not railroad passenger cars. Under the act, PADOT and State police are responsible for the electric mass transit vehicle (EMTV) inspection program.

The State-certified EMTV inspectors for the MFSE are MFSE supervisors. The State requires no safety training program for these supervisory personnel. The mechanics who perform the inspection and repair are not certified by the State, nor are the PADOT representatives and the State police troopers assigned to oversee the inspection activity. The PADOT and the State police representatives have received no formal EMTV training. Their primary role is to verify that the State inspection files are complete and that the vehicle inspection stickers are properly affixed to the cars. No inspector or inspection facility has ever been decertified in the State program.

Emergency Training Procedures and Drills.--SEPTA service operations supervisors, train dispatchers, and train personnel received training in emergency procedures. According to the training agenda, 16 hours of classroom and hands-on emergency training were given to train personnel in the initial training classes. Both crewmembers of train 61 received 20 to 21 days of initial training that included instructions and tests on operating procedures, safety rules, and emergency actions.

The conductor testified about emergency evacuation drills and how they were conducted. He stated that in initial training and recurrent training about 30 minutes were spent in classroom evacuation training. Evacuation drills were held; however, no passengers, emergency services, or communications operations were involved.

Annual recertification training for operating personnel consists of 8 hours of classroom instruction and testing on operating procedures, safety rules, and emergency actions. The motorman and conductor of train 61 completed recertification training on May 13, 1989, and November 18, 1989, respectively.

SEPTA had conducted annual simulated emergency evacuation drills from a train at various locations throughout the system. Public service and volunteer organizations were involved. Passenger participants in the drills were employees and their families. However, SEPTA had no requirement that train personnel participate in annual emergency evacuation drills.

SEPTA conducted annual tours for Philadelphia Fire Department personnel assigned to fire stations that respond to subway emergencies. The tour objectives were to familiarize firefighters with the physical aspects of the subway system and its surface stations, to review hand signals used in SEPTA operations, and to discuss general safety and the communications availabilities.

ANALYSIS

General

Postaccident inspection of the track and switch 7E at the 30th Street station revealed no deficiencies in the track structure that were causal to this accident. The extent of crashworthiness was not, as a practical matter, a factor in the severity of this accident. Also, the train crew complied with SEPTA rules in operating train 61.

Accident

After leaving the 30th Street platform, train 61 continued to travel west to a remote-controlled interlocking switch (7E) that was 238 feet from the platform. The first two cars proceeded through the switch and remained on the rails. At the same time, the No. 2 traction motor on the A end of the third car dropped to the track, striking the ties. It passed over the switch, damaging the switch mechanism. The third car and the lead truck of the fourth car continued over the damaged switch and remained on the track. But the traction-motor had bent the switch points to the open position, allowing the rear truck of the fourth car to be diverted. The body of the fourth car was directed sideways as westbound movement continued until the car derailed and struck the steel H-columns between the eastbound and westbound right-of-ways. The side of the car struck the columns, which penetrated 30 feet into the car, resulting in injuries and fatalities. The lead truck of the fifth car derailed in the crossover switch as it followed the fourth car. The sixth car derailed but remained coupled to the fifth car.

After the accident, the Safety Board found that the 69th Street shop had about 30 used motors that had as much as 1/4-inch of abnormal wear on the edge of the oval holes that accommodate the horizontal safety rods in the motor support brackets. The bracket of the accident motor had a similar wear pattern. The pattern indicates loose or improperly adjusted vertical bolts, because when the bolts are adjusted properly, the horizontal safety rod should not contact the bracket. The bolts had failed before or during the accident, but the failures had had no effect because the horizontal safety rod arrangements continued to support the motors. This secondary system was not designed as a permanent motor support but as a support to prevent the traction motor from falling to the track if the vertical support bolt disconnected.

The Safety Board's metallurgical inspection of the accident motor's support brackets indicated that the horizontal safety rod was sawing through the vertical members of the brackets as the motor swung sideways while supported only by the horizontal safety rod. Hardness measurements showed that the motor support brackets were much softer than the safety rod; thus, the support brackets wore through while the rod showed only moderate wear.

The threads in the upper attachment area for the vertical support bolt showed evidence of progressive fatigue cracking. Such cracking would have severely weakened the load carrying capacity of the threaded section and could account for a sudden break or slip of the fastened connection. Because of thread obliteration, the extent of fatigue cracking could not be determined. However, cracking such as that found probably was throughout the fastened connection. Dynamic forces from a loose fit in the motor support assembly could account for the cracking in the threads as the motor bounced up and down during normal train operation.

The lower nut fractures of the vertical support bolt showed characteristics of quench cracks produced during the rapid cooling process that is part of the heat treatment during manufacture. These fractures are produced by excessive thermal stress caused by sharp edges or other geometric discontinuities, or by solutioning temperatures that are too high prior to cooling. The cadmium deposit on the fracture surface indicates that cadmium was plated into the cracks during manufacture. The cracks found on the lower nut are unlikely to have significantly affected its load carrying ability if the nut was properly fastened. However, if the cracks had extended deep into the upper nut section, infringing on the threads, they could have split the nut during impact loading (as apparently occurred on the lower nut). The Safety Board believes that SEPTA should ensure that the motor support bolts and nuts on all of these cars have been inspected for cracking.

It is not clear how the vertical support bolt lost its connection to the car truck bolster faceplate. The top castle nut and cotter pin were never recovered. The top cotter pin hole was completely plugged with grease, indicating that the cotter pin had been missing for some time. Perhaps, the top nut was not replaced on October 4, 1989. Perhaps either it disengaged as a result of fatigue cracking of the bolt threads, or it failed suddenly from the same defects found in the part of the nut supporting the bottom of the vertical bolt.

Once the vertical support bolt lost its connection with the truck bolster faceplate, the traction motor would have dropped to the horizontal safety rod for complete support, resulting in wear on the traction motor support brackets. Postaccident tests showed that the brackets can hold the motor for more than

88 days. The wear on the top of the oval-shaped part of the brackets indicates that the motor had dropped down a significant amount of time before the accident. Eventually, after prolonged movement of the support bracket against the horizontal safety rod, the brackets wore through and the motor dropped to the tracks.

The Safety Board believes that had SEPTA properly inspected the motor mount and safety connection on the No. 2 traction motor at the inspections it had after it was installed on October 4, 1989, the deteriorated condition of the top connection could have been detected and corrected and the accident could have been avoided.

In the investigation of this accident, the Safety Board considered the poor quality of SEPTA's mechanical inspection procedures and maintenance practices, as well as oversight of SEPTA maintenance practices by State and Federal agencies.

Inadequate Equipment Inspection, Record Keeping, and Maintenance Practices.--The motor support bolt on car 817 (the third car) ostensibly was inspected three or more times--on January 4, February 10, and March 2, 1990--in the 63 days before this accident.

On January 4, 1990, the car received its State-certified B inspection at the 69th Street car shop. The inspection form was submitted as required, but no problems with the bolt assembly were found. (See appendix G.)

On February 10, 1990, the car was scheduled to receive its A inspection at the 69th Street shop, and the inspection form was submitted. (See appendix G.) However, neither the mechanic on duty nor his foreman remembered any specific information about their activities during that shift. The car work order was not signed by the foreman and did not show the I.D. number of the mechanic or the time involved. The foreman stated that the handwriting on the card was his and that the card indicated that the inspection had been completed. The possibility exists that the inspection was never performed. The Safety Board concludes that SEPTA records are not sufficient to ensure that required inspections are in fact being performed.

The general foreman signed the motor support bolt inspection form on March 2, 1990, 5 days before the accident, with no exceptions. (See appendix F.)

Postaccident testing for 88 days has shown that it would take a great deal of time for the horizontal safety rod to completely wear through the motor support brackets. If any of these inspections had been thoroughly and conscientiously performed, the condition of the motor support bolt brackets would have been detected and this accident prevented.

Discussions with the mechanics revealed many problems with the SEPTA inspection procedure. Preventive and quality maintenance apparently received low priority because of the pressure to release cars for rush hour service. In addition, nearly all maintenance training was completed on the job, and classroom training was limited. The inspection standards and formal training were inadequate. Engineering diagrams apparently were not used by mechanics or were unavailable; and in one case concerning motor support bolt installation, the diagram inaccurately depicted the proper motor mount assembly. Many mechanics involved in installing and inspecting the accident motor stated that supervisors did not check their work. Also, one mechanic's statement suggested the existence of a spare parts problem, including difficulty in obtaining needed parts and improper reuse of parts, that

could signify serious safety concerns. The Safety Board believes that SEPTA did not pay proper attention to quality inspection and maintenance.

In addition, SEPTA's drawing No. C-1004 and overhaul manual, which SEPTA used for a guide in the installation of the vertical support bolts for traction motors differ from the Budd Car Company's original 1960 design. The drawing and manual omit a washer under the lower vibration isolator of the upper isolator mount assembly. Either SEPTA or PTC further changed the installation by making the bottom and top isolator spacer sleeves the same length, contrary to requirements shown on the Budd Car Company drawing and on drawing No. C-1004. This change, which was made in the late 1960's when gear drive units were changed, is not documented by an engineering study, and SEPTA has no records of when or why the change was done. Consequently, when assembled according to SEPTA practices, the proper dimensional relationship between the upper and lower vibration isolator assemblies probably was not maintained, which resulted in excessive slack in the stacking arrangement. These conditions could allow the traction motor to move vertically and horizontally, causing abnormal stress on the vertical support bolt and nut connections.

The Safety Board believes that SEPTA should review and take appropriate action concerning the lack of available and accurate shop manuals and assembly diagrams, the limited amount of supervisory oversight of the work, and the shortage of parts in its mechanical department.

In this regard, it is noted that approximately a year and a half before this accident, a new general manager was hired by SEPTA. He had initiated a reorganization and was already in the process of instituting management and organizational reforms when the accident occurred. During the Safety Board investigation, he offered full cooperation and has begun implementing changes, such as increasing availability of manuals and drawings, improving communications of instructions with followup, and improving record keeping. In the year since the accident, there have been no further accidents on the SEPTA system.

Previous SEPTA Accidents.--Human performance failure was a causal factor in all 13 accidents involving SEPTA that were investigated by the Safety Board between February 1986 and February 1990. In each case, employees violated rules pertaining to train movement or personal behavior. The failure of SEPTA employees to comply with operating or safety rules led to 10 accidents, of which 3 involved crewmembers using drugs and/or alcohol. Three occurred because employees of other railroads operating on SEPTA tracks failed to comply with operating rules.

According to SEPTA, crewmembers were required to attend a 1-day operating-rules class each year. Each employee had to take a written rules test and attain a minimum passing grade of 85 percent. However, four serious human performance accidents occurred in the 90 days before train 61's accident, raising concerns about the effectiveness of SEPTA management, supervision, training, and testing.

The factors that led to train 61's accident are consistent with those in the 13 other human performance failure accidents in the past 5 years. In all 14 accidents, human performance factors, such as traincrews and mechanics failing to comply with published rules, management and line supervisors failing to ensure that updated plans and programs were instituted, and employees failing to comply with operational rules, led to and played causal roles.

Federal and State Oversight of SEPTA. Although in the 1970's the Safety Board expressed its concern about the need for safety oversight of rail rapid transit properties and in 1981 recommended to the DOT that it seek legislation to regulate the safety of rail rapid transit systems, in 1982 the Safety Board concluded that "detailed regulation of rail rapid transit safety should not lie with the Federal Government." Rather, the Board, at that time, supported the development of voluntary safety guidelines for maintenance by the UMTA similar to those it had already developed for emergency preparedness and fire safety. However, UMTA has not developed voluntary standards. Further, following several rail rapid transit accidents, the Board issued recommendations (R-78-10, R-81-1, R-87-38) to various States (Ohio, New York, and Pennsylvania) asking them to provide detailed oversight of the rail rapid transit systems within their jurisdictions. New York was the only State to respond fully to the Board's recommendations. The Pennsylvania Secretary of Transportation (on May 10, 1988) stated that "alternatives were being evaluated."

The human resources and the training provided to State inspection forces are inadequate for the type of safety oversight of SEPTA that the Safety Board believes is required. In essence the State inspection program amounts to a self-inspection program administered by SEPTA with virtually no effective oversight by the State. The PADOT inspection program representative stated that checking inspection records consumes only 10 to 15 percent of his time. Neither he nor the State trooper who is assigned to oversee inspection activity had received any formal training about inspecting or overseeing EMTV operation. The PADOT inspection program representative stated that he did not generally investigate SEPTA accidents and that when he did do so, no remedial action was taken.

The Board is concerned that despite the relatively large number of accidents experienced by SEPTA during the mid-to-late 1980's and the findings by the Safety Board as a result of its investigation of these accidents of deficiencies in SEPTA's operational and maintenance practices, the State of Pennsylvania has not provided effective oversight of SEPTA.

The Board is also concerned, based on its investigation of 52 serious rail rapid transit accidents that have occurred during the past several years in other places (see appendix H), that a program of oversight that depends primarily on State and local governments with the Federal Government providing funding and guidance is not providing the level of oversight that public safety demands. Accordingly the Safety Board will be examining, in detail and in the near future, the issue of the adequacy of the safety oversight of rail rapid transit systems.

Drug Issues

Based on the available evidence, the motorman's performance was not a factor in the accident. The passengers and other SEPTA employees did not see the motorman behave in an unusual way either before the accident or during the emergency response and evacuation. Eyewitnesses stated that there was no warning before the accident. A statement from a towerman about a 1975 incident in which a motor separated entirely from a SEPTA subway car also indicated motor separation could occur without any warning to the motorman. However, this incident could not be located in SEPTA records.

Postaccident toxicological testing showed high concentrations of cocaine and the metabolite of cocaine in the motorman's urine specimen. While not causal to this accident, the levels suggest that the motorman was a frequent or heavy user of cocaine, that this level of use was not a new practice, and that this use may be associated with the motorman's absenteeism problem.

Although we do not have conclusive evidence that the motorman was under the influence of cocaine at the time of the accident, it is troubling that this motorman was apparently operating trains for some time while using cocaine. In this case and undoubtedly in most circumstances, the accident sequence developed quickly, leaving little possibility that the motorman could have known of the failure until it occurred. Thus, the motorman had little time to respond. Nevertheless, no matter what scenario develops, the motorman must be alert, possess good judgment, and be prepared to respond quickly to a myriad of situations presented to him in the conduct of his duties. Indeed, in many accident situations, the severity can well depend on the ability of an operator to respond to emergencies.

SEPTA had an active drug testing program that included preemployment, random, reasonable suspicion, and postaccident testing. It was one of the first and most comprehensive programs in the transit industry. According to testimony at the public hearing, SEPTA began drug testing in September 1985 and added random testing in September 1989. Its random testing program was among the first in the transit industry. However, the accident motorman had not been tested for drugs before the accident because the SEPTA program was relatively new. The motorman was hired before SEPTA had preemployment screening, and he had experienced no other accidents that would have qualified him for postaccident testing. In addition, his long absences occurred after the return-to-work testing requirement had been struck down in court. At the time of the accident, the random testing program had been in effect for 6 months; and no more than 20 percent of the employees had been tested.

Furthermore, the MFSE assistant general manager was a passenger on train 61 on the accident morning and stated that he spoke briefly to the motorman. Such senior managers are an important part of the drug program, since reasonable suspicion testing is performed when a supervisor trained in the detection of drug and alcohol use recognizes and substantiates specific behavioral, performance, or physical indicators of probable drug or alcohol use. This assistant general manager had received 4 hours of substance-abuse training from the SEPTA office of safety and training. However, cocaine can be very difficult to detect, especially during a brief encounter.

Although the motorman's record showed that his attendance had been so poor that he had been disciplined, he had never been tested for cause based on his performance record. As determined by union agreement, discipline is based on the number of work days an employee misses. In 1984 the motorman had received an "involuntary termination" for substandard attendance. He had been suspended once in 1988 and twice in 1989 for substandard attendance and for being AWOL. Poor attendance can often be an indicator of a drug abuse problem. However, under the current SEPTA drug program, poor attendance is not a basis for reasonable cause drug testing.

The Safety Board recognizes that it may be difficult, due to court challenges and resistance from labor unions, to devise a program in which drug testing is triggered solely because of poor attendance. Although an effective drug program

cannot be based solely on one factor, such as poor attendance, a program based on a combination of factors, such as absenteeism (tardiness, extended weekends, AWOL, and unsubstantiated use of sick leave), driving records, rules violations, and other indicators, should be viable. SEPTA's current drug testing program could be improved by developing a program based on a combination of these factors to corroborate the possibility of a drug or alcohol problem. Such a change might lead to the early detection of drug problems before they become the cause of serious safety violations.

Communications

Despite the difficulty of extricating the passengers who were trapped in the wreckage, the emergency response was timely and involved a sufficient number of employees and amount of equipment. However, communications below surface were poor during the emergency rescue operations and had to be achieved by line of sight or hard wire application. This difficulty was compounded by the fact that SEPTA and the Philadelphia Fire Department do not use the same terms. The Safety Board believes that SEPTA and the Philadelphia Fire Department should develop a common language.

The Philadelphia Fire Department had equipped its units that respond to emergencies on the Broad Street line with radios capable of underground communications. Since the accident, fire department units that respond to emergencies on the MFSE line have been equipped with the same radios. According to the staff of the fire department's communications center, the new radios should eliminate the antiquated methods of communication used during subway emergencies.

Passengers stated that they were confused and did not know what to do. Had train 61 been equipped with a public address system, the traincrew could have given clear, immediate instructions to passengers, such as instructions about staying aboard until rescuers arrived, about the doors to be used, about the direction to be taken during the evacuation, and about how to avoid the 600-volt third rails and other rail traffic. Had the passengers received such directions, they would have been less likely to leave.

The uninjured and slightly injured passengers evacuated train 61 by walking through the tunnel before rescue personnel arrived to coordinate the evacuation. According to the SEPTA dispatcher audio tapes, at least two subway cars were operating on adjacent tracks. The passengers were fortunate that they were not struck by other vehicles. They might have stayed aboard if emergency evacuation instruction placards had been posted in the cars. The Safety board believes that had clear, concise emergency instructions been posted, passengers might have read and retained information instructing them to remain aboard until the coordinated evacuation was instituted. In addition, SEPTA has not provided any information on passenger procedures in the event of fire, loss of power, emergency evacuation, or an accident. The Safety Board believes that this information, as well as the posting of emergency placards, would have proved helpful to passengers.

The Safety Board also believes that crewmembers should be required to participate in emergency evacuation drills that would include passengers and emergency rescue personnel. Such training should be part of the new-employee orientation. The result would be employees who are better able to provide guidance to passengers in emergency situations.

This accident also demonstrates the importance of portable radios. After the accident, train crewmembers, not having portable radios, had no means of communicating with each other on the train. The motorman walked to the tower and fortunately had a key that allowed him to enter and use the telephone. Although he and the trolley operator gave clear information to the SEPTA dispatcher about the derailment and subsequent injuries to passengers, the accident's severity and magnitude were not emphasized in the radio transmission to the fire department. Since the motorman had no portable radio with which to relay the information himself through his dispatcher, the fire department did not realize the severity of the accident until the first units arrived on the scene.

The Safety Board believes that portable radios could have been valuable in three ways: the traincrew could have coordinated the evacuation of the passengers with other crewmembers so that the best possible evacuation route could have been planned; the train crew could have transmitted information about the accident directly to the SEPTA train dispatcher; and the train dispatcher would have had valid information to relay to the fire department emergency services, thus eliminating the confusion and misinterpretation that occurred because the information had had to pass through five persons.

CONCLUSIONS

Findings

1. The condition of the track and signals did not contribute to the accident.

2. The motorman operated train 61 in accordance with SEPTA operating procedures.

3. The traction motor of car 817 fell to the track because of improper installation and inspection procedures, causing the derailment.

4. Various inspection programs in effect at the time of this accident failed to detect a defect that was obvious and in existence for some time.

5. The SEPTA instructions for the general overhaul of rail equipment trucks included faulty information about the traction motor support and the vibration isolator assembly installation.

6. The inspection of the MFSE cars was not adequately monitored by SEPTA management before the accident.

7. SEPTA's motor support bolt inspection and record keeping was inadequate.

8. The State of Pennsylvania does not provide effective safety oversight to SEPTA mechanical departments, and no Federal standards exist.

9. SEPTA had no policy against re-use of metal parts, including motor support bolts and nuts.

10. If SEPTA and the Transport Workers Union had revised drug test requirements to include poor attendance as a reasonable cause for testing, the motorman probably would have been tested.

11. Given the difficulty of extricating passengers who were trapped in the wreckage, the emergency response was timely and effective.

12. SEPTA and the fire department did not have a mechanism in place to communicate effectively with each other during the emergency evacuation.

13. The lack of a public address system in the cars and portable radios for the train crew made it difficult for the crewmembers to communicate with each other and to address the passengers.

14. There were no emergency evacuation instructions posted in the cars to assist passengers in evaluating the situation and in taking appropriate evacuation actions, thus increasing the confusion and risk after the accident.

Probable Cause

The Safety Board determines that the probable cause of the derailment of Southeastern Pennsylvania Transportation Authority train 61 was the failure of the Southeastern Pennsylvania Transportation Authority to have an adequate program of inspection, maintenance, and quality control to detect the defective motor support system. Contributing to the accident was the failure of the State of Pennsylvania to have effective safety oversight programs for mass transit systems.

RECOMMENDATIONS

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

--to the Southeastern Pennsylvania Transportation Authority:

Revise existing maintenance and inspection programs on all rail lines to include comprehensive, current, and specific standards for the inspection, repair, replacement, and quality control of all parts and components used on Southeastern Pennsylvania Transit Authority rail transit equipment. (Class II, Priority Action) (R-91-1)

Develop and conduct comprehensive training programs for supervisors, mechanics, and inspectors, detailing proper inspection and record keeping methods sufficient to ensure that inspections are performed as required. (Class II, Priority Action) (R-91-2)

Develop and conduct emergency evacuation drills in new and recurrent employee training that include passengers and emergency rescue personnel. (Class II, Priority Action) (R-91-3)

Provide a reliable emergency public address system in each subway elevated car that is independent of third-rail car wiring for its power source. (Class II, Priority Action) (R-91-4)

Provide train crews with self-contained radios that will function in the event car power sources are lost. (Class II, Priority Action) (R-91-5)

Post at conspicuous places in all Southeastern Pennsylvania Transportation Authority subway cars emergency evacuation instructions for passengers, including how to escape from disabled or burning cars; how to locate and use emergency telephones, ladders, and fire extinguishers; and how to exit safely from a tunnel. (Class II, Priority Action) (R-91-6)

In cooperation with the city of Philadelphia Fire Department, review and revise the procedures and terminology that train dispatchers and the fire department can utilize for notification of emergency and rescue personnel, in order to eliminate delays and provide information necessary for proper assessment of equipment and manpower requirements. (Class II, Priority Action) (R-91-7)

In conjunction with the Transport Workers Union, modify existing programs for testing employees for drug or alcohol use, focusing on poor attendance in combination with rules violations, changes in work habits, and motor vehicle driving violations. (Class II, Priority Action) (R-91-8)

--to the Transport Workers Union:

In conjunction with the Southeastern Pennsylvania Transportation Authority, modify existing programs for testing employees for drug or alcohol use when the attendance record is poor, in combination with rules violations, changes in work habits, and motor vehicle driving violations. (Class II, Priority Action) (R-91-9)

--to the city of Philadelphia Fire Department:

Cooperate with the Southeastern Pennsylvania Transportation Authority to review and revise the procedures and terminology that train dispatchers and the fire department can utilize for notification of emergency and rescue personnel, in order to eliminate delays and provide information necessary for proper assessment of equipment and manpower requirements. (Class II, Priority Action) (R-91-10)

Also, the Safety Board reiterated the following safety recommendation:

--to the Governor of Pennsylvania:

R-87-38

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.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ James L. Kolstad
Chairman

/s/ Susan M. Coughlin
Vice Chairman

/s/ Jim Burnett
Member

/s/ John K. Lauber
Member

/s/ Christopher A. Hart
Member

April 22, 1991

Jim Burnett, Member, filed the following concurring statement:

Although I concur with the final report, the probable cause, and the safety recommendations, I believe the Board should have taken two additional steps. We should have added a conclusion that the "serious hazard of death or injury" envisioned by Section 22 of the Urban Mass Transportation Act of 1964 as amended (49 USC Sec. 1618) exists at the Southeastern Pennsylvania Transportation Authority (SEPTA).

We should have also made a safety recommendation directed to the Secretary of Transportation that pursuant to his discretionary authority under Section 22 of that Act, he require SEPTA to develop and implement a plan of correction and withhold financial assistance should SEPTA fail to do so.

I would anticipate that an adequate remedial plan would include authoritative internal safety reviews and audits by SEPTA's safety department and external safety inspection, oversight, and enforcement by qualified and trained employees of State or local government.

/s/ Jim Burnett
Member

APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

Investigation

The National Transportation Safety Board was notified at 0900 EST on March 7, 1990, by the Federal Railroad Administration of a derailment with fatalities on the Southeastern Pennsylvania Transportation Authority (SEPTA) train 61. Three Safety Board investigators were in Philadelphia at the time, meeting with SEPTA officials to discuss previous accidents and were notified by SEPTA on site. The investigator-in-charge and other members of the investigative team were dispatched from the Washington, D.C., office and arrived by 1400. Other investigators were dispatched from field offices in Atlanta, Georgia, and Chicago, Illinois. Committees were established for mechanical, track and signal, operations, human performance, and survival factors for conducting the investigation.

The Safety Board was assisted in the investigation by SEPTA, the Philadelphia Police and Fire Departments, and the State of Pennsylvania.

Public Hearing

A public hearing was conducted in Valley Forge, Pennsylvania, on May 14 and 15, 11990, to take sworn testimony on the facts of the accident. Eighteen witnesses testified.

APPENDIX B

PERSONNEL INFORMATION

Motorman

Motorman Melvin Thomas, age 40, was hired by SEPTA on November 1, 1974, as a rail operator on the Germantown trolley line. He was assigned to the Market-Frankford Subway Elevated line on February 2, 1980. At the time of the accident, he worked both as a rail operator and as a part-time tower operator.

According to his employment record, Thomas received discipline from SEPTA on six occasions, four of which had to do with substandard attendance patterns and/or AWOL. On September 18, 1984, he received an 'involuntary termination of employment" due to a "substandard attendance record." Substandard attendance is determined by labor/union agreement. He was reinstated as a result of a grievance procedure on October 14, 1984. A report submitted by a Transport Workers Union representative as part of the grievance procedure at that time indicated that Thomas was "presently in a rehabilitation center for treatment of the disease alcoholism."

On January 20, 1986, the motorman received a 1-day suspension reduced to a written warning for 'failure to contact train dispatcher in an emergency situation" as a result of an accident in which the train was moved with several doors open. On May 2, 1988, he received a 1-day suspension for "substandard attendance (pattern)." On April 12, 1989, he received a "discharge, reduced to 3-day suspension with caution" for "AWOL." On May 8, 1989, he received a "discharge modified to 5-day suspension and final caution" for "AWOL." On June 27, 1989, he received an "involuntary termination" for "failed to report to medical as directed." He was reinstated on August 7, 1989.

The conductor had observed motorman Thomas the morning of the accident and indicated that he 'looked normal." Hal Davidow, the assistant general manager for the SEPTA subway elevated division, stated at the public hearing that he and Thomas had appeared alert and fit for service.

Conductor

Conductor Steven Young, age 40, was hired by SEPTA on June 14, 1974. He started out as a rail operator, transferred to bus operation, and then to the Market-Frankford Subway Elevated line.

According to his employment record, the conductor received discipline from SEPTA on three occasions. On June 27, 1985, he received "discharge reduced to 1-day suspension" for an incident in which the train moved with doors open while he worked as motorman. On July 14, 1986, he received a 5-day suspension for "signal violation" while working as a motorman. On January 31, 1989, the conductor received a written warning for "substandard attendance (pattern)." Attendance is monitored in accordance with the current labor union agreement.

According to his testimony at the hearing, Young had received one drug test upon returning from sick leave of over 30 days in 1988, and this had been negative. He had never received a random drug test. Drug and alcohol tests done after the accident were negative.

Mechanic, A Inspection

Gino Roman, the mechanic who had performed the most recent A inspection on the subject car 817-818, was hired by SEPTA on February 1, 1982, as a first class general repair mechanic. He performed routine repairs and the A inspections. Before employment with SEPTA, he had worked as an aircraft mechanic. He has a high school diploma.

Mechanic, Motor Support Bolt Inspection

Carmen DiGaetano was hired by SEPTA on August 2, 1971, as a substation repairman. He became a foreman in 1978, was promoted to shop general foreman in 1980, and became car house general foreman in January 1990. He is a high school graduate. He was trained as a machinist at the Philadelphia Navy Yard and in basic electricity at the electrician's class A school during his 2-year Navy duty."

APPENDIX C

A INSPECTION EXCERPTS

SOUTHEASTERN PENNSYLVANIA
TRANSPORTATION AUTHORITY

RAIL EQUIPMENT DEPARTMENT

MARKET FRANKFORD SUBWAY ELEVATED

"A"

INSPECTION MANUAL

VIII) TRUCKS

A) Wheels

1. All wheels are to be inspected.

B) Motor Covers

1. All motor lids are to be inspected. Replace and repair where needed.

C) Trip Cocks

1. All trip cocks are to be gauged and tested.

D) Motor Mountings (Support and Safety Belts)

1. All motor support and safety belts are to be inspected

E) Truck

1. All rubber stops, journal bearings, wear plates, pedestal springs, center castings, king pins, side bearings, piping, belts, clamps, stabilizer pads, bellows, bolster stops, leveling valves, snubbers and all other truck components are to be inspected and, where possible tested and adjusted.

F) Bolster

1. The bolster along with the bolster pads are to be inspected.

G) Gear Drive Unit

1. All gear drive units are to be inspected complete.

H) Traction Motors

1. All motors are to be inspected complete. all brushes, commutators, creepage bands, armatures, brush holders, leads, fields are to be inspected. Any flashing, burning pitting is to be reported to the Foreman.

APPENDIX D

B AND C INSPECTIONS EXCERPTS

Complete 'B' + 'C' Manual.

Page 16

3.3.2 Motor and Mountings

A) Inspect motor for security of mounting and condition of fan.

B) Remove inspection plate and inspect motor carbons, replace if less than 1/2" long.

C) Check commutator for evidence of wear, flashing, and general condition.

3.3.3 Wiring

A) Check wiring for chafing, fraying or cracks.

B) Check terminals and terminal connections for tightness, any evidence of overheating or corrosion.

3.4 Thermostats

3.4.1 Covers

A) Remove covers. Inspect opening slots for cleanliness and set aside.

3.4.2 Thermostat Bulbs

A) Remove temperature bulbs from sockets. Inspect pins and sockets for evidence of overheating or corrosion.

B) Reinstall bulbs into sockets checking for good contact.

3.5 Vent Package

3.5.1 Actuator Plate Assembly

A) Inspect motor, cam, and rheostat assembly for security of mounting and general condition.

3.5.2 Relays

A) Inspect relays for security of mounting and condition.

B) With relays having visible indicators, ensure indicators are in proper position.

C) Inspect contact tips for wear and condition. Polish tips with a burnishing tool or fine sand paper.

3.5.3 Pilot Relay Board

A) Inspect pilot relays for security of mounting, solder connections and general condition.

3.5.4 Wiring

A) Inspect wiring for chafing, fraying or cracks.

10.0 TRACTION MOTORS

-REFERENCES-

1. Westinghouse Inspection and Maintenance of Control and Rotating Apparatus I.B.-20184
2. General Electric Rapid Transit Car, Electric Drive Equipment Maintenance Instructions GEI-78416

SPECIAL TOOLS AND EQUIPMENT	CLASS & LOT OR PART #
1. Megohmeter	Simpson 401 or Equiv.
2. Electrical Tape	
3. Tension Gauge 0-20 Lbs.	
4. 1/16" Fiber Block, Gauge	
5. Torque Wrench 0-200 Ft. Lbs.	
6. Machinist Pocket Rule	

10.1 Mounting

10.1.1 Motor Support Bolt

A) Inspect for tightness, damage and condition of the rubber mounting bushing.

10.1.2 Safety Bolt

A) Check for tightness, damage and overall condition of threads and nut.

10.2 Exterior

10.2.1 Frame

A) Check motor frame for any evidence of damage, and loose or missing hardware.

10.3 Interior

10.3.1 Fields and Interpoles

A) Check field and interpole pieces for security and any evidence of rubbing on the armature.

B) Inspect windings for any signs of burning or overheating and the condition of the insulation.

APPENDIX E

GOH EXCERPTS

4.18 Operation: Motor Support Bolt <46> Installation

1. Equipment & Remarks:

   Refer to SEPTA Drawing #C-1004, while following the procedure presented below.

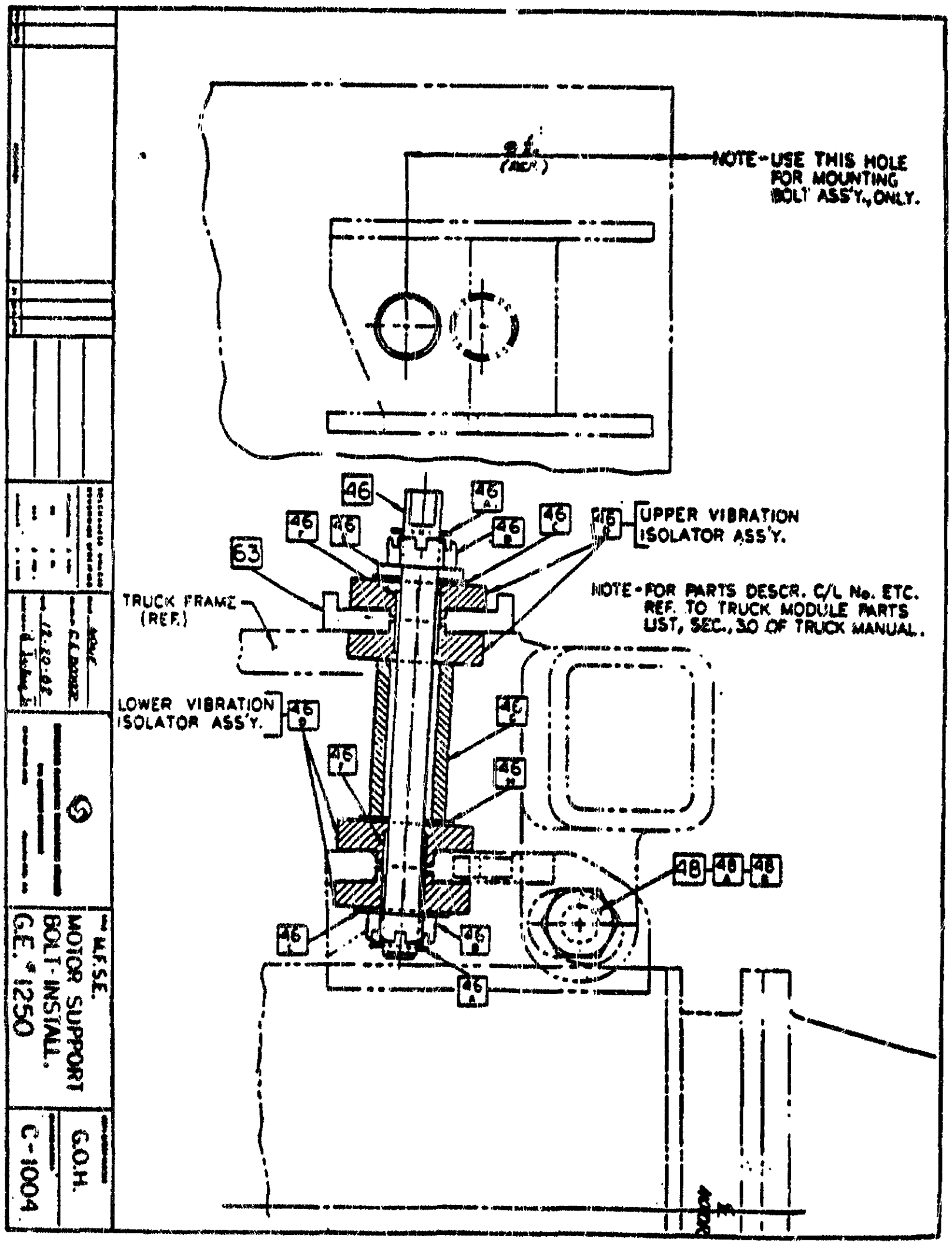
2. Procedure: Level the wheel and axle assembly by installing a piece of wood under the traction motor <45>. Insert one (1) motor support bolt <46> through the top of the traction motor's mounting housing, an integral part of the traction motor <45> shell.

   1. Install the bottom piece of the lower two (2) piece rubber vibration isolator <46D> assembly onto the bottom end of the motor support bolt <46>. The shoulder section of the above-mentioned isolator <46D> should fit flush against the underside of the traction motor <45> mounting housing. Install a flat washer <46C> and a castle nut <46B> on the bottom section of the motor support bolt <45>. Thread the castle nut <46B> down until the cotter pin hole, drilled into the motor support bolt <46>, is visible. Insert the cotter pin <46A> through the castle nut <46B> and the above-mentioned cotter pin hole.

   2. Install spacer <46F> onto the shaft of the motor support bolt <46> from the top of the motor support bolt <46>. Install the top piece of the lower two (2) piece rubber vibration isolator <46D> assembly onto the motor support bolt <46>. The shoulder section of isolator should fit flush against the top of the traction motor's <45> motor housing.

   3. Install a flat washer <46H> on top of the top rubber vibration isolator <46D> part of the lower vibration isolator assembly installed on the motor support bolt <46>. Install a spacer <46G> on top of the above-mentioned flat washer <46H>.

   4. Install the bottom piece of the upper two (2) piece rubber vibration isolator <46D> assembly on top of spacer <46G>. Using the overhead crane and lifting chains with hooks, raise and position the truck frame <1> over both wheel and axle assemblies. Lower the truck frame <1> over both wheel and axle assemblies, making sure to align the journal boxes <47> while lowering the frame <1>.


NOTE-USE THIS HOLE FOR MOUNTING BOLT ASS'Y., ONLY.
UPPER VIBRATION ISOLATOR ASS'Y.
NOTE-FOR PARTS DESCR. C/L No. ETC. REF. TO TRUCK MODULE PARTS LIST, SEC., 30 OF TRUCK MANUAL.
TRUCK FRAME (REF.)
LOWER VIBRATION ISOLATOR ASS'Y.
46
63
48
M.F.S.E.
MOTOR SUPPORT BOLT-INSTALL.
G.E. # 1250
G.O.H.
C-1004

5. Install a spacer <46F> on top of the lower piece <46D> of the upper two (2) piece rubber vibration isolator <46D> assembly. Position the motor support mounting bracket <63> (one (1) per bolt <46>) on the truck frame. Attach and secure the above-mentioned bracket <63> to the truck frame <1> utilizing four (4) bolts <64> and lockwashers <65>.

6. Utilizing the overhead hoist and chains with hooks, install the chain hooks through the ears of the traction motor's <45> mounting housing. Lift and suspend the traction motor <45> in order to install the remaining motor support bolt <46> assembly parts through the opening of the drive unit bell housing.

7. Install the top piece of the upper two (2) piece rubber vibration isolator <46D> assembly on top of the motor support bolt mounting bracket <63>. Install a flat washer <46C> and spacer <46E> on the top piece of the upper rubber vibration isolator <46D> assembly. Install and tighten one (1) castle nut <46B> on top of the above- mentioned spacer <46F>.

NOTE: It might be required that you will have to raise the traction motor <45> in order to align the castle nut <46B> with the cotter pin hole, drilled in the top of the motor support bolt <46>. Once the above-mentioned step is completed, remove the chains and the overhead hoist.

8. Make sure to check that the spacer <46G> does not rotate. If the spacer <46G> rotates, then the top castle nut <46B> that you just installed must be tightened. Once this step is completed and the spacer <46G> does not rotate, insert a cotter pin <46A> into the hole drilled into the top of the motor support bolt <46>. Install safety bolt.

4.19 Operation: Safety Bolt <48> Installation

1. Equipment & Remarks:

Refer to SEPTA Drawing #E-719 for the locations of the above-mentioned bolt <48>.

<48A> 1-1/4"-7UNC-2B Nut
<48B> 3/16" x 2" Cotter Pin
<48C> 1-1/4"-7UNC-2B Elastic Stop Nut
1-7/8" Socket & Ratchet
1-7/8" Box Wrench

APPENDIX F

MOTOR SUPPORT BOLT INSPECTION SHEET

Date is Mar. '90
this is best copy obtainable

BUSWAY ELEVATED DIVISION
RECORD OF CARS

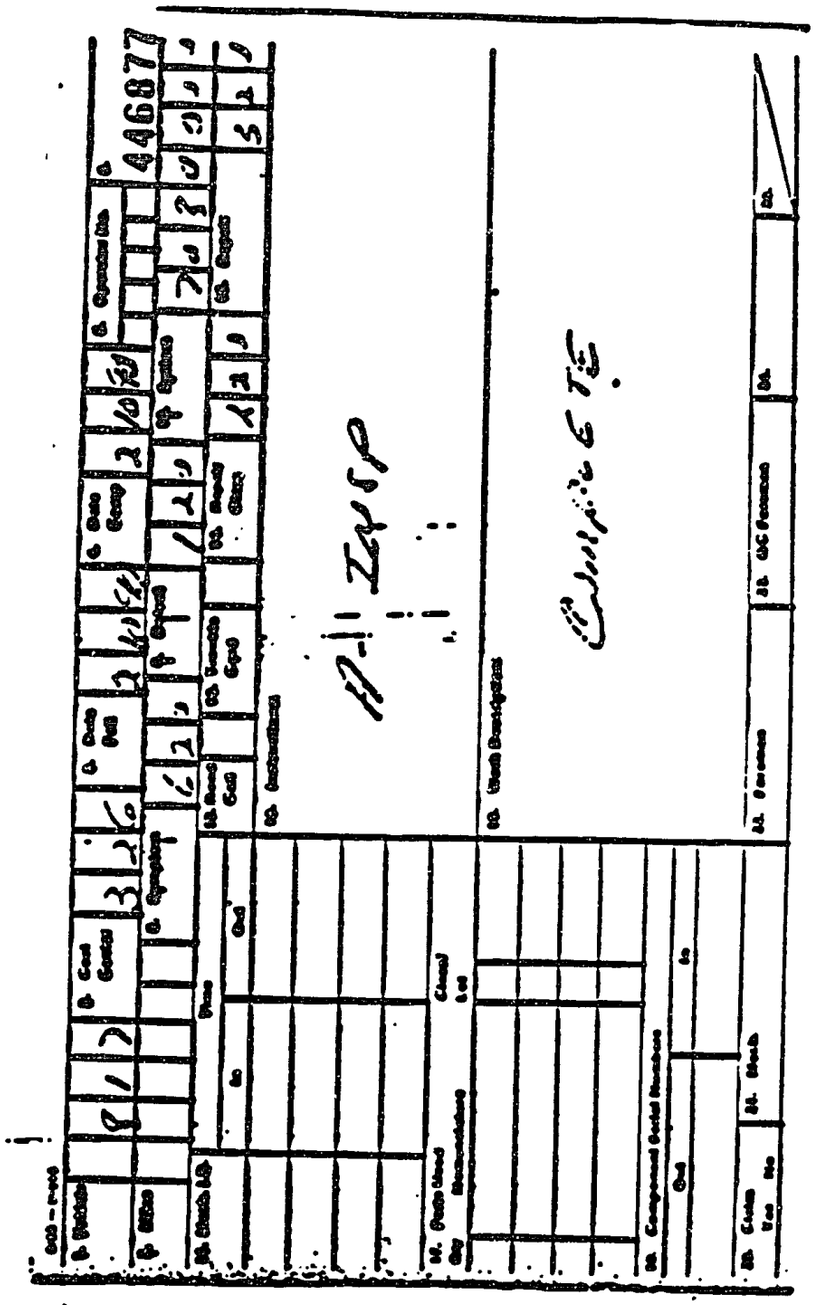
MSB

Date MAR

TOTAL MARKET FRB. ELEVATED CARS

APPENDIX G

A, B, AND C INSPECTION SHEETS



Southeastern Pennsylvania Transportation Authority
Rail Equipment Department

MARKET-FRANKFORD SUBWAY ELEVATED

"B" INSPECTION

PREVENTIVE MAINTENANCE WORKSHEET

Car Number: 817 Miles 867935 Date 1-4-90

This is to certify that each item has been checked in accordance with current Maintenance Instruction

Mechanics Signatures and Dates:

1. [illegible] Date [illegible]
2. [illegible] Date 12-20-89
3. [illegible] Date 1-4-90
4. [illegible] Date 1-4-90
5. [illegible] Date 1-4-90
6. [illegible] Date 1-4-90
7. [illegible] Date 1-24-90
8. [illegible] Date 1-4-90
9. [illegible] 12-20-89
10. [illegible] 1-4-89
11. [illegible] 01-04-90

Inspection Foreman's Signature and Date:

[illegible] Date 1-4-90

Reviewed and Filed:

S. [illegible] Date 1-11-90

Rail Department

17

Southeastern Pennsylvania Transportation Authority
Rail Equipment Department

MARKET-FRANKFORD SUBWAY ELEVATED

INSPECTION

PREVENTIVE MAINTENANCE WORKSHEET

Car Number: 817 Miles 887335 Date 9-20-89

This is to certify that each item has been checked in accordance with current Maintenance Instruction

Mechanics Signatures and Dates:

1. Dennis Mell Date 9-12-89
2. [illegible] Date 9-2-95
3. Bob Burrell Date 9-20-89
4. [illegible] Date 9-20-89
5. [illegible] Date 9-20-89
6. [illegible] Date 9-20-89
7. [illegible] Date 9-20-89
8. Paul Grayll Date 9-20-89
9. Robert [illegible] 9-12-89
10. [illegible] 9-20-89

Inspection Foreman's Signature and Date:

[illegible] Date 9-20-89

Reviewed and Filed:

[illegible] Date 9-22-89

Foreman Supervisor

3:

APPENDIX H

FIFTY TWO TRANSIT ACCIDENTS INVESTIGATED BY THE SAFETY BOARD BETWEEN 1986 AND 1990

Accident Reference Number	Date of Accident	Location of Accident
NYC86FX010	02-05-86	Thornbury Twp, PA
NYC86FR011A, B, C	02-07-86	Philadelphia, PA
CHI86FR012A, B	02-11-86	Boston, MA
NYC86FX012	03-21-86	Norwalk, CT
NYC86FR016	04-25-86	Jamaica, NY
NYC86FX017	05-02-86	Hillsdale, NJ
DCA86MR002A	05-07-86	Brighton, MA
CHI86FR021	06-20-86	Chicago, IL
ATL86MR019A, B	06-24-86	Atlanta, GA
LAX86FR013	08-03-86	San Francisco, CA
DCA86MR005	08-23-86	Upper Darby, PA
NYC86FR029	09-29-86	Manhattan, NY
ATL87FR001	10-04-86	Miami, FL
NYC87FR002	10-28-86	Chicago, IL
NYC87FR004	11-25-86	Boston, MA
NYC87FR006A, B	12-10-86	Philadelphia, PA
NYC87FR010	01-23-87	Washington, D.C.
NYC87FR009A, B	01-26-87	Ardmore, PA
NYC87FR012A, B	02-17-87	Bronx, NY
CHI87FR009	04-01-87	Burnham, IL
NYC87FR017	04-18-87	Manhattan, NY
NYC87FR018	04-18-87	New York, NY
NYC87FR019	04-21-87	Astoria, Queens, NY
NYC87FR020A, B	04-27-87	New York, NY
ATL87FR013A, B	05-04-87	East Point, GA
NYC87FR023	05-20-87	Manhattan, NY
NYC87FR026	07-14-87	Brunswick, MD
LAX87FR012	07-14-87	San Francisco, CA
NYC87FR028	07-23-87	Manhattan, NY
NYC87FR032	08-28-87	New York, NY
NYC87FR034	09-15-87	Brooklyn, NY
CHI87FR022	09-28-87	Pittsburgh, PA
NYC87FR002	10-28-87	Pittsburgh, PA
DCA88MR002A, B	11-12-87	Boston, MA
CHI88FR005A, B	11-20-87	Chicago, IL
NYC88FR005	12-29-87	Queens, NY
NYC88FR006A, B	12-30-87	Boston, MA
NYC88FR007B	01-12-88	Norristown, PA
NYC88FR010A	02-03-88	Manhattan, NY
NYC88FR011	02-03-88	Manhattan, NY
CHI88FR015	03-21-88	New Lenox, IL
NYC88FR014A, B	04-06-88	Mount Vernon, NY
ATL88FR012	04-10-88	Philadelphia, PA
FTW88FR014	04-27-88	Philadelphia, PA

Accident Reference Number	Date of Accident	Location of Accident
NYC88FR015B	05-05-88	South Amboy, NJ
LAX88FR011	05-16-88	San Francisco, CA
CHI88FR023A	06-03-88	Chicago, IL
ATL88FR18B	06-18-88	Philadelphia, PA
LAX88FR016A, B	08-15-88	San Francisco, CA
CHI89FR002	10-21-88	Chicago, IL
LAX89FR006	12-17-88	San Francisco, CA
NYC89FR004	12-18-88	New York, NY
CHI89FR010B	01-11-89	Joliet, IL
NYC89FR005A, B	03-04-89	Boston, MA
NYC89FR006	03-24-89	Jersey City, NJ
NYC89FR007	03-30-89	New York, NY
CHI89FR017	04-06-89	Lemont, IL
NYC89FR009	06-18-89	Manhattan, NY
NYC89FR010A	07-05-89	Brooklyn, NY
NYC89FR011A, B	08-05-89	Boston, MA (Copley Station),
NYC90FR003A, B	11-29-89	Drexel, PA
NYC90FR006	11-14-89	Queens, NY
CHI90FR003	11-17-89	Cleveland, OH
ATL90FR005A, B	01-29-90	Upper Darby, PA
NYC90FR008A, B	02-12-90	Philadelphia, PA
NYC90FR009A, B	02-16-90	Philadelphia, PA
CHI90FR010	02-26-90	Philadelphia, PA
DCA90MR003	03-07-90	Philadelphia, PA
LAX90FR009	04-20-90	Sacramento, CA
NYC90FR015	07-19-90	Arlington, VA
NYC90FR016A, B	07-26-90	Brooklyn, NY
NYC90FR017	08-15-90	Brooklyn, NY
ATL90FR011	08-20-90	Miami, FL
NYC90FR019A, B	09-17-90	Boston, MA
DCA90FR011A	09-21-90	Baltimore, MD
CHI90FR009A, B	12-28-90	Boston, MA
NYV90FR003	12-28-90	Brooklyn, NY

* U.S. G.P.O.:1991-281-626:20043