NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT

STUDENT TRANSPORTATION LINES, INC., CHARTER BUS CLIMBING OF BRIDGE RAIL AND OVERTURN

NEAR MARTINEZ, CALIFORNIA

MAY 21, 1976

REPORT NUMBER: NTSB-HAR-77-2

UNITED STATES GOVERNMENT

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16. Abstract

At 10:55 a.m. on May 21, 1976, a charter bus, carrying 52 persons struck and mounted a section of the bridge rail system on the Marina Vista offramp of I-680 near Martinez, California. The bus rolled off the top of the curved bridge rail and landed on its roof. Twenty-nine of the occupants died and the rest sustained injuries ranging from minor to serious.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the driver, who was unfamiliar with the bus, to correctly monitor the service brake air pressure gauge, recognize the loss of air, and take appropriate action including application of the emergency airbrake.

Contributing to the accident were: (1) the failure of the air compressor drivebelt, (2) the failure of the maintenance program and pretrip inspection to detect and replace the deteriorated air compressor drivebelt, (3) the failure of the signing system to adequately alert the driver to the critical geometrics of the ramp, (4) the severe radius of the curvature of the ramp, (5) the design of the curb as part of the ramp railing, and (6) a bridge rail system that did not redirect the bus.

The Board made recommendations to the California Department of Transportation, the California Highway Patrol, and the Federal Highway Administration.

17. Key Words Accident investigation; air-compressor drivebelt; bridge barrier systems; bus airbrake systems; bus maintenance; charter bus classification; charter bus safety; drives/vehicle unfamiliarity; instrument panel design; ramp signing; service brake air system failure; vehicle steering geometry; and wall-climbing phenomenon.		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151	
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SYNOPSIS

At 10:55 a.m. on May 21, 1976, a charter bus carrying 52 persons struck and mounted a section of the bridge rail system on the Marina Vista offramp of I-680 near Martinez, California. The bus rolled off the top of the curved bridge rail and landed on its roof. Twenty-nine of the occupants died and the rest sustained minor to serious injuries.

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INVESTIGATION

The Accident

On the morning of May 21, 1976, the person in charge of the Marysville, California, terminal of Student Transportation Lines, Inc., (STL) inspected bus No. 16, a 1950 Crown Coach schoolbus-type vehicle. The bus had been chartered to transport the Yuba City High School Choir from Yuba City, California, to a concert in Orinda, California -- 125 miles away. His inspection, which included a visual examination of the exposed surface of the air compressor drivebelt, revealed no mechanical defects in the bus; the air compressor drivebelt appeared to be in good condition, he said. The official also said that he familiarized the busdriver with the operation of the bus, including the dashboard guages and switches, lights, control system, and brake system, including the emergency handbrake. He watched the driver maneuver the bus around the parking lot and was satisfied with his driving ability.

The busdriver testified that he had never driven bus No. 16 before the day of the accident. The driver had driven two bus trips, each in a different bus before the accident trip; both buses were Ford buses with the conventional engines. Bus No. 16 is a "pusher type," the engine is located underneath the center of the bus. The buses are similar except that the emergency airbrake control was a switch on the dash of the Ford buses and a lever on the right side of the steering column of bus 16. The busdriver stated that he received little instruction from the carrier official on the operation of the bus before he left the terminal. He said that he was shown the light switches and was advised that the bus "had been serviced and gassed and was ready to go." He testified that he was instructed to check the oil when the bus reached San Francisco because "the bus burned a little bit of oil." He was not specifically instructed on the identity of the gauges located in the instrument panel, the emergency airbrake control lever, or any other operational aspects.

The busdriver testified that, before leaving the terminal, the airbrake pressure on the bus built up from zero to 120 psi without actuating the low-air warning buzzer or illuminating the low-air warning light. He stated that when the bus left the terminal, he did not know if it was equipped with a low-air warning buzzer nor did he ask anyone; he considered the air gauges his source of low air pressure warning.

The bus arrived at Yuba City High School between 8:15 and 8:30 a.m. without incident. While awaiting passengers, the engine was turned off and the busdriver disembarked. The driver told the choir director that he might have to stop to add engine oil during the trip.

About 9:00 a.m., 51 passengers boarded bus No. 16, and the engine was started. The busdriver stated that he monitored the air gauges as pressure built up and, again, the buzzer did not actuate and the warning light did not illuminate. Shortly after 9:00 a.m., the bus left Yuba City on Interstate 680. The choir director followed in his personal car. The trip proceeded without incident to Woodland (38 miles south of Yuba City) where the choir director stopped for gas. The bus continued without stopping.

About 46 miles south of Woodland and about 14 miles north of the accident site, the choir director caught up with the bus. He saw what he thought was a piece of rubber hanging from the central undercarriage of the bus. He also noticed "white vapors" or "steam" from the area where the piece of rubber was hanging. A few miles later, the choir director passed the bus and directed it into the Vista Point offramp to arrange for a rest stop for the occupants.

A student seated immediately behind and to the right of the busdriver stated that during the above portion of the trip he heard a "popping noise" 1/ from the dashboard area. He discussed it with the driver who was not concerned about it and who said that the owner of the bus had explained it to him as normal. The busdriver testified that when he stopped at Vista Point the air pressure gauges "were up" and the brakes "worked perfectly."

When the choir director boarded the bus at Vista Point, the driver informed him that the oil pressure was 5 pounds below normal and pointed toward the right side of the instrument panel. The busdriver testified that he left the bus and that although he had mentioned oil for the bus to the choir director, they did not discuss a loss of oil pressure. The choir director did not mention the "piece of rubber" he saw hanging beneath the bus because he assumed it was a static electricity groundstrap. They agreed to stop at the earliest opportunity to service the bus and to provide a rest stop for the students.

The bus followed the automobile from the Vista Point interchange southward on I-680. The student seated behind the driver did not see the air gauges nor did he hear either air escaping or a warning buzzer. He was not in a position where he could see the low air or low oil pressure warning lights. The driver stated that he had no difficulty with the bus and that the service brakes were operating normally, the air pressure gauge showed 120 psi, and neither the low-air warning buzzer nor light activated. During this portion of the trip, the speed of the buse was between 45 and 50 mph. Traffic conditions were moderate.

As the vehicles approached the Marina Vista offramp, they entered the deceleration lane. The bus followed about four car lengths behind the automobile. A 20-mph speed limit and exit sign was posted at the ramp approach. (See figure 1.) After the accident, the busdriver remembered the advisory speed sign but could not recall the actual numbers on it. As a motorist approaches the deceleration lane, the sign is partially obscured by luminaire poles.

Initially, the ramp is level. About 200 feet before the overhead exit sign the grade begins to descend 1.7 percent. The descent increases to 3.86 percent about 64 feet past the overhead exit sign. A right curve with a 177-foot radius (measured at the left curb) and with a maximum 12.5 percent superelevation begins 168 feet beyond the overhead exit sign. (See figure 2.)

1/ Investigators later determined that the sound was caused by a bleed line from the air compressor governor, which was located under the dashboard.

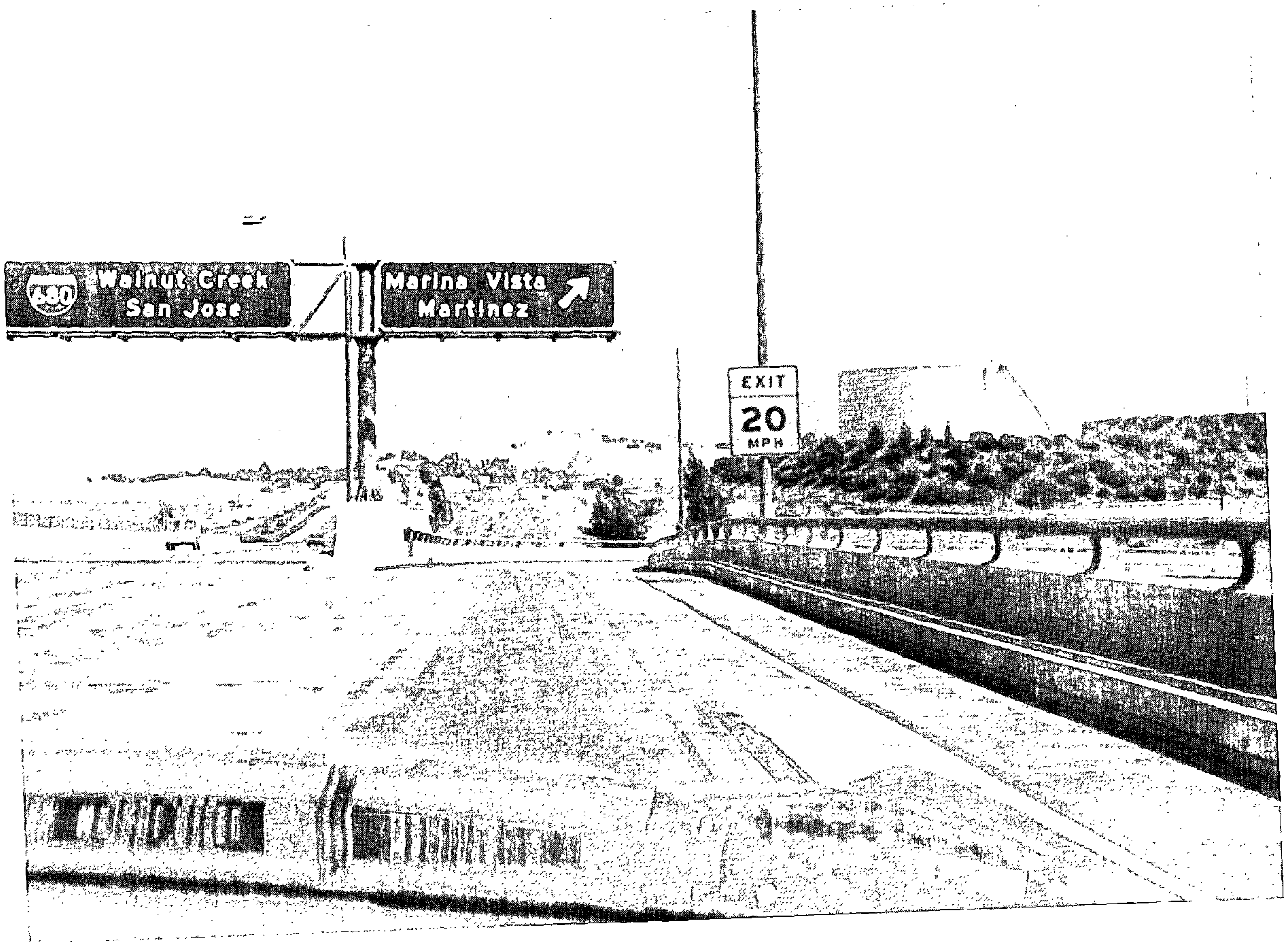

Figure 1. Approach to Marina Vista offramp showing the exit and 20-mph speed advisory signs and entrance to ramp.

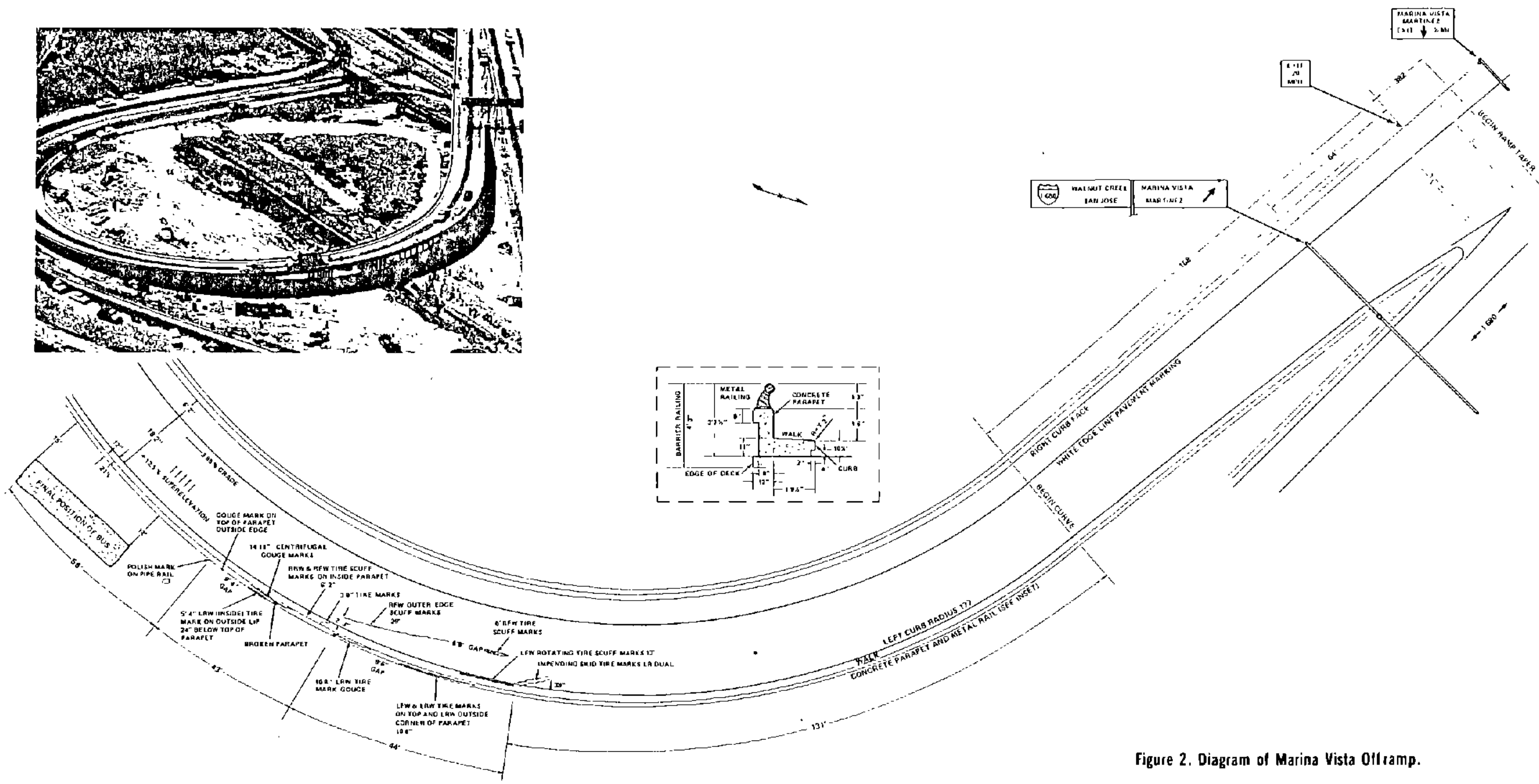

Figure 2. Diagram of Marina Vista Offramp.

As the bus entered the curved portion of the ramp at a speed between 30 and 37 mph, the driver observed that the automobile, now some 50 feet ahead, braked and "slid a little bit." The busdriver said he then steered the bus "just a little" to the right to avoid hitting the car and then straightened the bus. The busdriver stated that he applied the service brake three times but the bus did not decelerate. He then pulled the mechanical parking brake handle, "changed gears, hunted for emergency things to pull," and tried to steer the bus into the curve. He did not apply the emergency brake because he said he was not aware of the emergency brake lever on the right side of the steering column. The left front wheel of the bus contacted the left curb and the steering wheel was jerked out of the driver's hands and spun counterclockwise.

The student testified that as the bus entered the curve the speedometer indicated "around 40 to 43 mph" and the tachometer was "around 25." He did not see the driver actuate the emergency air lever or the hand-operated mechanical parking brake, or shift the transmission from high gear.

After mounting the curb and traveling 13 feet, the left front and then left rear wheels of the bus struck and climbed onto the bridge parapet. The bus rode along the top of the parapet wall for 74 feet, dislodging the wall's horizontal aluminum rail, before it leaned to the left and rolled off the wall. The bus rotated 180° counterclockwise about its longitudinal axis while traveling 56 feet horizontally through the air, and struck the ground 21.6 feet below. The left front roof area struck the ground first and the bus skidded on its roof about 4 feet before stopping. The roof collapsed rearward and downward, crushing the tops of the seatbacks down to the windowsill level and rearward 19 inches. Because the roof was so severely deformed, all possible exit points from the bus were blocked. This prevented immediate escape by ambulatory survivors and access by rescuers. Although gasoline spilled from the inverted fuel tank, no fire ensued.

Injuries to Persons

Injuries	Driver	Passenger	Other
Fatal	0	29	0
Nonfatal	1	22	0
None	0	0	

Vehicle Damage

The bus was totally destroyed. (See figure 2.) The following is a description of only that vehicle damage pertinent to the reconstruction of the crash dynamics:

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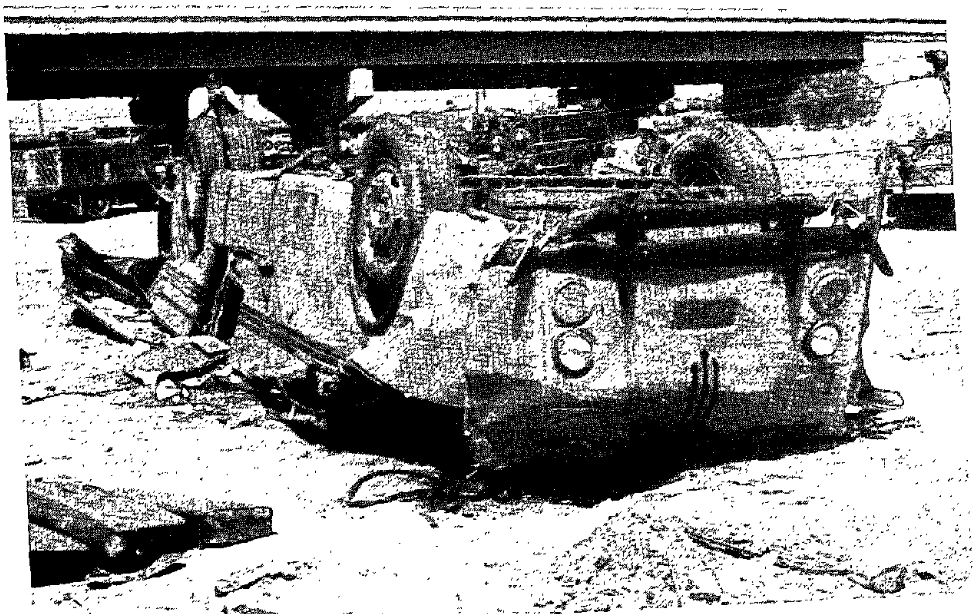

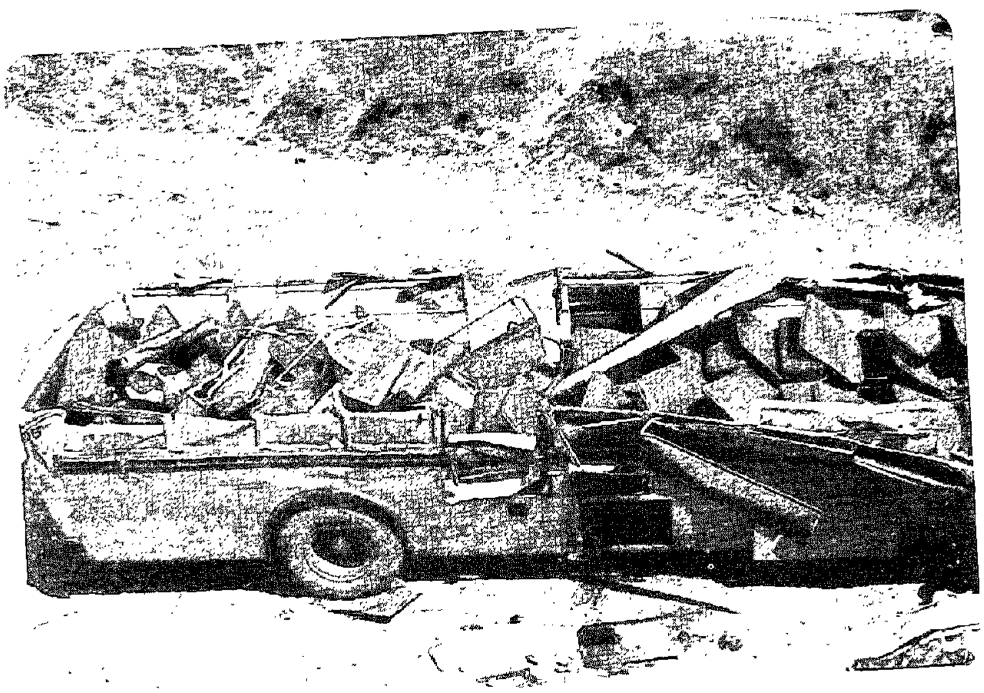

Figure 3. Damaged bus at the accident site. The roof was cut from bus during rescue efforts.

The forward spring shackle of the right front suspension was partially fractured. The left front shackle at its forward connection to the frame was severed; marks on the rear shackle indicated rearward movement. Tire treadmarks were found on the sheet metal of the wheel wells above and behind the position of the left front and right front wheels. The left section of the front bumper and the sheet metal between the bumper and wheel were deformed inward and rearward. There were minor abrasions on the undercarriage and lower edge of the rear bumper; the engine oil pan was broken. The outside of the left front wheel rim was indented. Abrasions on the wheel measured about 23 inches counterclockwise from the indentation. Two indentions were found about 170° apart in the left rear outside wheel rim. The sidewalls of several of the tires had been scuffed. Rubber was missing in two places from the left front tire tread. The outer panels of the body below the windowsill level were slightly damaged. The frame was not deformed.

Other Damage

The horizontal aluminum pipe rail was displaced. The displaced rail sections showed evidence of yellow paint transfers, tiremarks, petroleum liquid, and abrasions that were generally longitudinal. The vertical face of the left curb was scraped. Yellow paint transfers were found at two places on the parapet.

Driver Information

The 50-year-old busdriver held a valid Class 1 [2/] California driver's license without restrictions. The driver was not subject to Federal Motor Carrier Safety Regulations (FMCSR) because STL did not operate in interstate commerce.. The driver did have a current medical certificate as required by California regulations. There was no evidence on his physical examination record of any medical condition that would disqualify him as a Class 1 driver.

In 1971, the driver was awarded a permanent disability rating of 5 percent for a partial loss of grip in his left hand. However, the doctor of record in that case certified that the driver was able to continue his regular employment as a lumber truckdriver. In 1974 the driver was awarded a Workmen's Compensation Comprise and Release for a back injury which he received in 1972.

Although he had driven airbrake-equipped heavy-duty trucks and tractor-trailers for about 20 years, his experience with buses was limited to two previous trips. Each was made in a different model bus within 1 week prior to the day of the accident. The driver testified that he had not received formal truckdriving or busdriving training in

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2/ Permits the driving of vehicles and combination vehicles except for school system buses used for pupil transportation and two-wheel motorcycles.

either a classroom or behind the wheel. He had been employed by the STL as a part-time driver about a week before the accident and was not familiar with either the bus or the route the bus was traveling at the time of the accident. The driver's first bus-driving experience was driving an STL busload of children on a 2 1/2 hour tour of the City of Sacramento while being followed by a bus driven by an experienced driver.

The driver had gone to bed early the previous night and made no complaints when he reported for work in the morning. He had not consumed any alcoholic beverages and was not taking any medication that would impair his driving ability. The busdriver had no history of emotional or mental instability. During the trip, he appeared to be in good spirits. None of the survivors commented adversely about his driving.

His known traffic driving record included two traffic violations (one driving while under the influence of alcohol and one for speeding) and an accident in the preceding 3 years.

Vehicle Information

The bus was a 2-axle, 1950 Crown Coach Model A-504-11, 79-passenger vehicle with dual tires on the rear wheels, service and emergency airbrake systems, mechanical parking brake, manual steering, and a 5-speed manual transmission. Maximum road speed in 5th gear at engine governed speed of 2,500 was 58.8 mph. The bus had an amidship, underfloor 6-cyclinder Hall-Scott 504-CID gasoline engine, a wheel base of 235 inches, a tare weight of 16,900 pounds, and an odometer reading of 120,571 miles. The bus was painted schoolbus yellow and with lettering and devices affixed that identified it as a schoolbus. For this trip, however, the lettering and overhead stop lights were taped out. 3/ A lap restraint was available to the driver, but he did not use it.

The compressed air system consisted of a Bendix-Westinghouse 7 1/4 cubic foot per minute compressor and two service and one emergency air reservoirs. An air compressor governor was located behind the instrument panel. Power was transmitted from the engine to run the air compressor through a pulley drivebelt arrangement.

The bus was equipped with three air-related gauges (see figure 4).

Air Application Gauge -- The air application gauge was located in the upper left corner of the instrument panel to the left of the tachometer. This gauge registered the air pressure, on a graduated scale from 0 to 150 psi, that was applied to the service brake system when a footbrake application was made. This gauge had the word "air" at the bottom of the dial.

3/ Required by the California regulations when the bus is used in other than scheduled pupil transportation service.

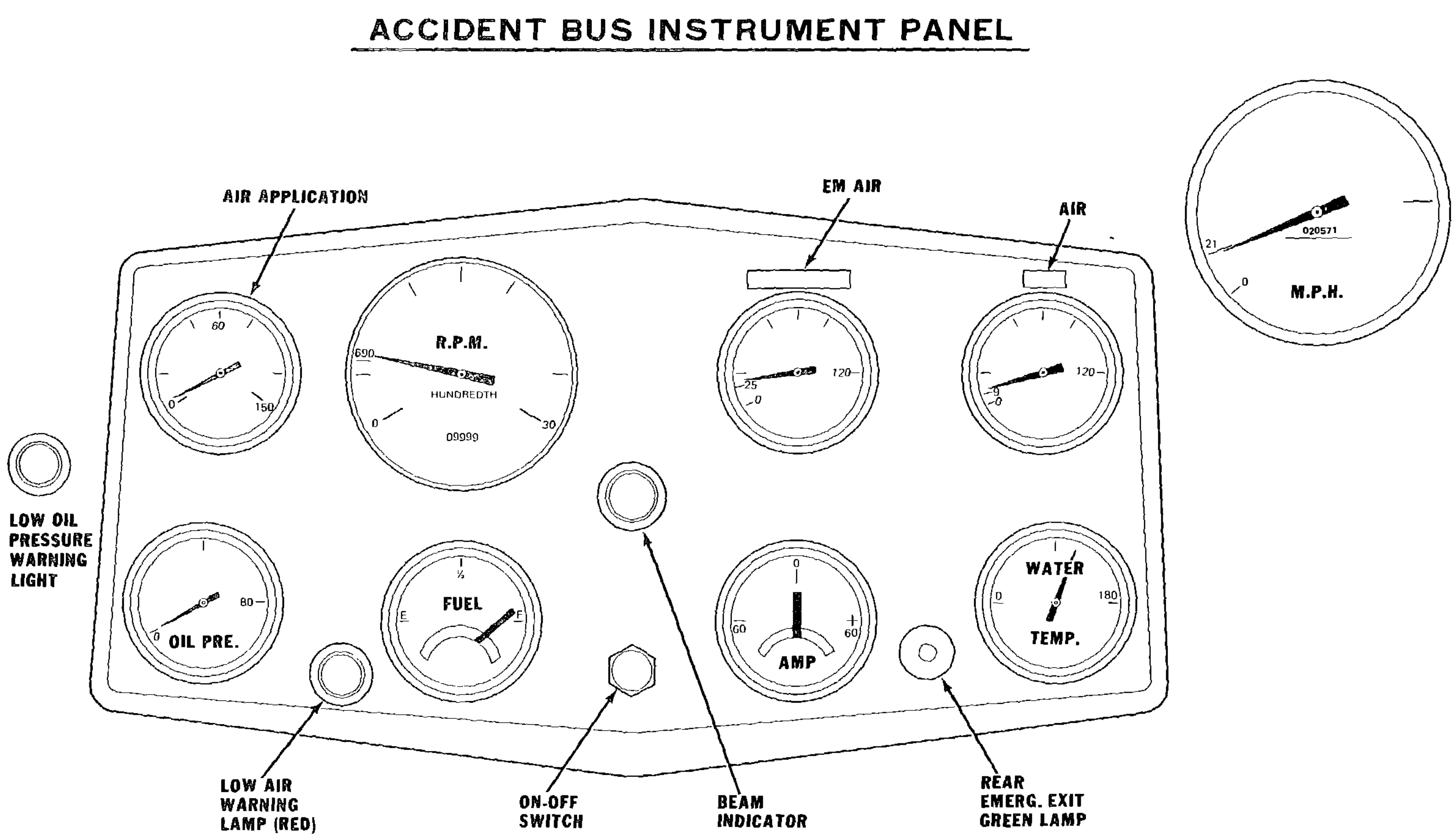


Figure 4. Diagram of instrument panel of accident bus.

Emergency Brake Air Gauge -- The emergency brake air gauge was located in the upper right center of the instrument panel to the right of the tachometer. This gauge registered the air pressure from 0 to 150 psi in the emergency airbrake reservoir and was independent of the service brake system. The gauge was not installed by the original manufacturer. The emergency airbrake system was activated by a lever on the right side of the steering column just below the steering wheel. The gauge was labeled with a plastic label with "EM Air" printed thereon and the word "air" was printed at the bottom of the dial.

Service Brake Air Gauge -- The service brake air gauge was located in the upper right corner of the instrument panel. This gauge registered the amount of air from 0 to 150 psi in the service airbrake reservoirs. These reservoirs contain the air for the service brakes and the door-operating system. This gauge was identified by a plastic label with the word "air" printed thereon and the word "air" at the bottom of the dial.

A low-air warning light was located in the lower left of the instrument panel and directly adjacent to the oil pressure gauge. It was set to illuminate whenever the air pressure in the service brake reservoirs dropped to 60 psi or below. This warning light was not labeled. A low-air warning buzzer was set to actuate whenever the air pressure in the service brake reservoirs dropped to 60 psi or below.

The oil pressure gauge is located in the lower left corner of the instrument panel. Unlike the air gauges, it is designed to register from 0 to 80 psi. The gauge is labeled "oil pre."

The mechanical parking brake lever protruded from the floor to the left of the driver.

The two tires on the front axle and the four on the rear were size 11.00/20, 12-ply. They measured 42 inches in diameter.

The bus had a 4-way, manually adjustable, pedestal driver's seat with a seatbelt, 24 passenger seats, and 1 bench seat across the rear. Two luggage compartments were located under the floor with access from the outside of the bus.

STL acquired the bus in 1972 after it had been used by a southern California school district for 22 years. It had been used as a schoolbus and a charter bus by STL. It had been inspected by the California Highway Patrol (CHP) in 1975, but not in 1976. The 1975 certificate was still valid even though it was over 12 months old.

During the trip occupants of the bus saw nothing unusual except that the front door blew open and had to be propped shut with a suitcase. The busdriver attributed this to the heavy winds.

Roadway Information

Interstate 680 is a north-south freeway in the San Francisco Bay area. The posted speed limit for all vehicles is 55 mph. The Marina Vista offramp provides access to the industrial area near Martinez, California. The California design drawings for this ramp were dated August 8, 1960. The ramp construction was started shortly thereafter.

The ramp is 24 feet 4 inches wide, from curb to curb, and has a concrete surface. The travel lane is 18 feet 2 inches wide and is bounded on the right by a 4-inch, solid white stripe to delineate the 6-foot-wide shoulder. The ramp surface was in good condition and was bordered on both sides by a 10.5-inch-high concrete curb, a 21.5-inch-wide sidewalk, a 17.5-inch-high concrete parapet above the walk, and a 6-inch-diameter horizontal aluminum rail mounted on and extending 15 inches above the parapet. (See figure 5.)

The curvature of the left curb has a 177-foot radius. The road surface in the curve had a 12.5 percent superelevation and a 3.86 percent downgrade. The length of the deceleration lane from the beginning of the taper at the freeway to the start of the curvature of the ramp was about 550 feet. The length of the deceleration lane from a point where it widens to 12 feet to the beginning of the 177-foot-radius curve was about 400 feet. A 20-mph advisory speed and exit sign was located on the right shoulder 64 feet before the overhead exit sign. (See figure 1.)

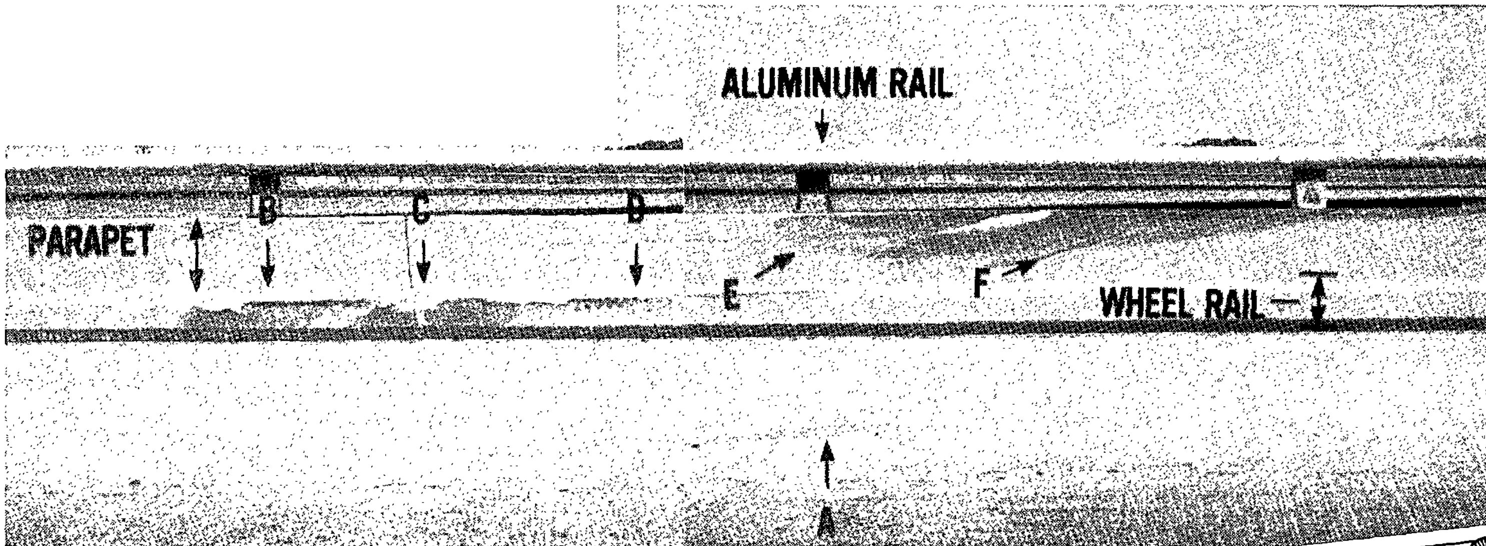
The bridge railing on the Marina Vista ramp was a California Type-2, which was adopted in 1958 for general use in the State highway system. The barrier system was subjected to dynamic crash testing by the California Department of Transportation (CALTRAN), which established that the Type 2 was capable of retaining and redirecting automobiles in severe high-speed and high-angle collisions. The Type 2 rail conformed with Federal standards that were current at the time of installation. The barrier has been used on about 140 miles of roadway in California.

From 1970 to May 20, 1976, seven accidents were reported on the ramp. Three of the seven involved contact with the bridge rail. No vehicles had climbed the parapet and no fatalities had been recorded.

The average daily traffic count for the ramp was 1,760 vehicles; the average daily traffic count for I-680 was 36,000 vehicles.

Meteorological Information

The weather was clear and sunny, and the road surface was dry. The ambient temperature was 70° F. The winds were variable from the west at 5 to 17 mph.



Legend

A - Six-foot tire scuffmark made by right front tire of bus.
B - Scuff tiremark on curb face made by left front tire.
C - Rotating tiremarks on curb face made by left rear tire.
D - Scuff tiremark on rail parapet made by left front tire.
E-F - Rotating tiremark on rail parapet made by left rear tire.

Figure 5. Accident bus tiremarks on curb and parapet of Marina Vista offramp.

Medical and Pathological Information

The 51 passengers aboard the bus were from 14 to 25 years of age. The predominant injuries sustained were to the head and chest regions. Most injuries were of the crushing, blunt-force, trauma type. Asphyxiation as a result of these injuries was a major factor in the fatalities.

Toxicology revealed that none of the fatally injured had a carbon monoxide level higher than 2 percent saturation. Any saturation less than 10 percent is considered insignificant and no immediate threat to health.

Survival Aspects

Major rescue efforts were required to extricate the bus occupants. Two cranes were used to raise the vehicle slightly as roof support pillars were cut. In order to remove the occupants, the roof remained on the ground, as the cranes held the bus above it.

Twenty-nine of the occupants died, and the 23 others experienced minor to severe injuries. Passengers in the right front quadrant of the vehicle received the most severe injuries. (See figure 6.)

Tests and Research

The CHP thoroughly inspected the bus mechanically immediately after the accident. Some of their findings were as follows:

No precrash defects were found in the steering or suspension systems. Drive train components were in operating condition. The transmission was in the 4th gear. The exhaust system showed no precrash defects. The low oil pressure buzzer was operative. There did not appear to be any precrash defects in any of the brake systems.

The air compressor drivebelt was broken. A large section was found on the inverted floorboard at the front of the engine. (See figure 7.) A small section was lodged in the crankcase, and the bottom of the crankcase was broken.

The air compressor was tested with a new belt by driving it with a 2-HP electric motor at compressor crankshaft speed of 1,050 rpm. At the end of 1 minute, it raised the system pressure to 40 psi; after 2 minutes, to 65 psi; after 3 minutes, to 85 psi; and after 4 minutes, to 100 psi. After 4 minutes the air governor began to leak because of accident-related damage.

Both of the service airbrake reservoirs were empty. The emergency airbrake lever was in an activated position and the rear wheels were locked.

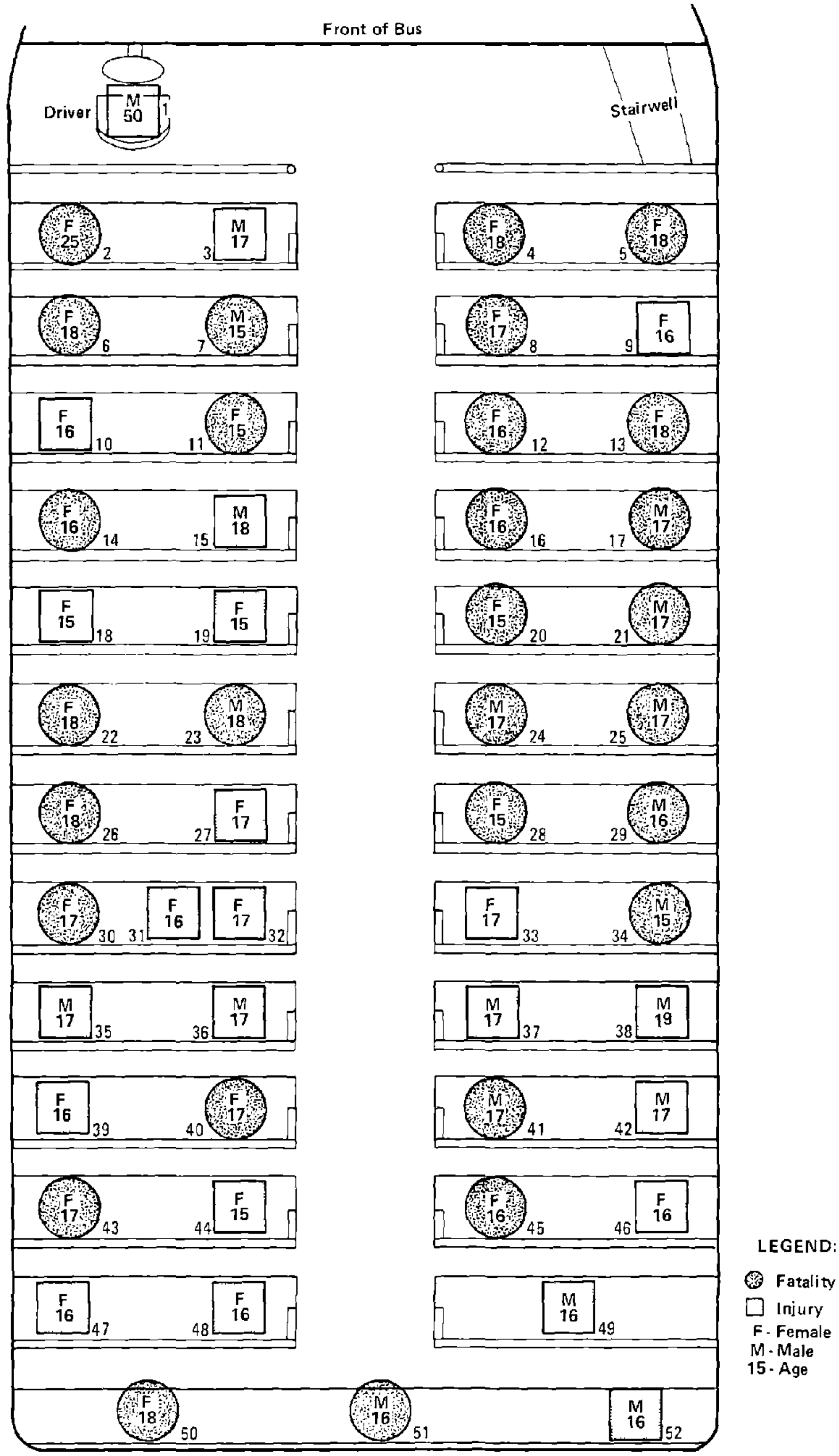


Figure 6. Seating chart of accident bus.

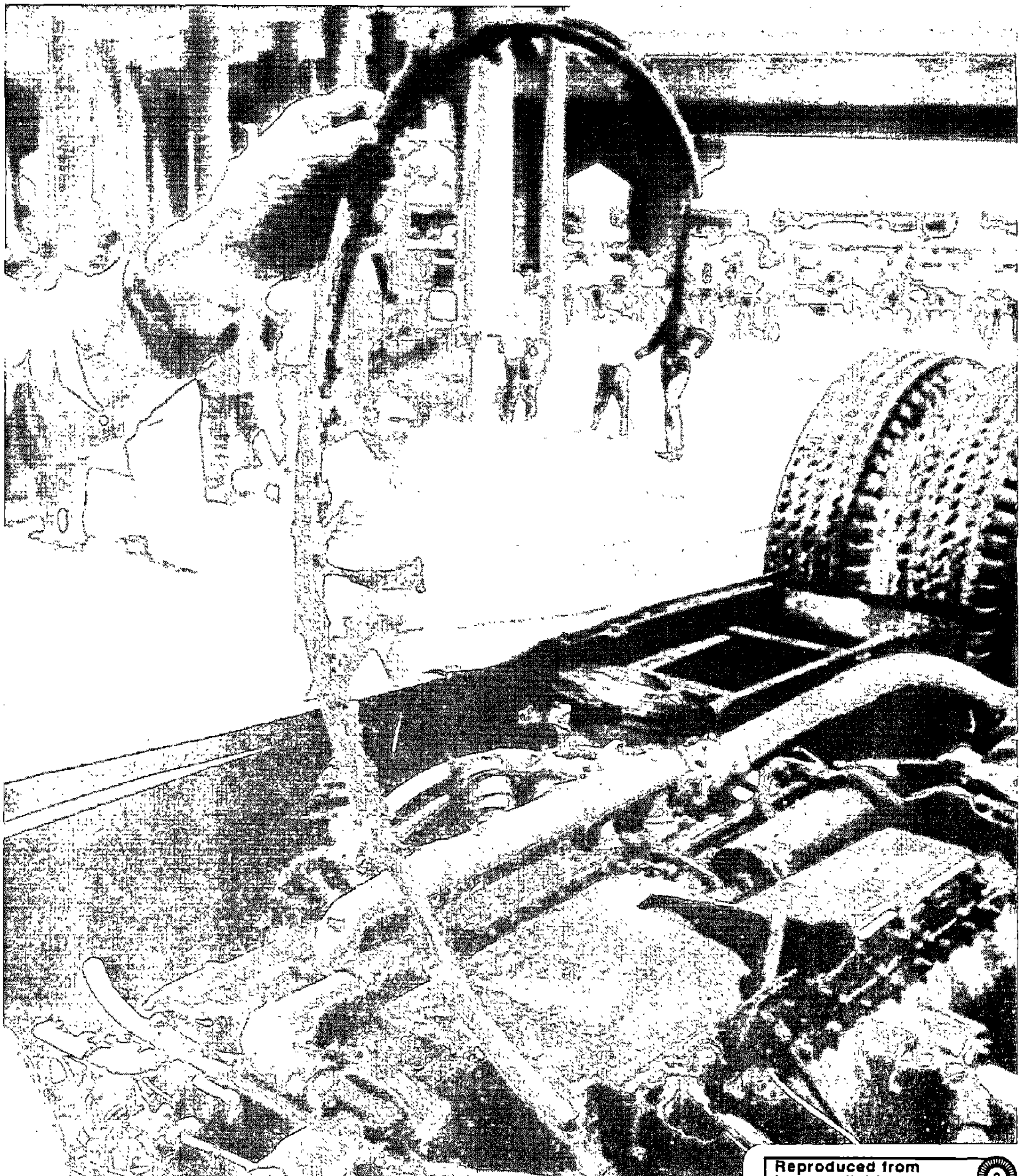


Figure 7. Air compressor drivebelt as found in the engine compartment of the bus.

About 2 1/2 hours after the accident, the emergency airbrake system had 43 psi pressure with the rear brakes applied.

Service airbrake reservoir capacity was tested by charging the system with 106 to 110 psi and footpedal applications were made. Six full footbrake applications caused the pressure to drop to 59 psi; 21 applications were required to reduce the pressure to 14 psi.

All three air pressure gauges -- application, emergency, and service -- were operational. The low air pressure warning buzzer and light were examined. The buzzer was not operable because of a loose wire connection, but functioned normally when the loose connection was corrected. The electric circuitry for the low air pressure warning light was in good condition; the bulb in the warning light had been destroyed during the accident.

All brake linings were 1/2 inch to 5/8 inch thick, which is acceptable. The right rear type-30 chamber slack adjuster was set at 2 1/2 inches, which represents the maximum stroke capability for the type-30 chamber. Type-30 chamber slack adjusters should be readjusted when the stroke reaches 2 inches. The left rear, type-30 chamber slack adjuster was set at 1 5/8 inches. Both type-16 rotochanger slack adjusters on the front axles were set at 1 3/4 inches.

The mechanical driveshaft parking brake and emergency airbrake lever were in the applied position. With some minor discrepancies, the remainder of the brake system was in good condition.

The air delivery system for the entrance door operating system had been damaged extensively in the accident.

An engineering firm was retained to perform the necessary laboratory tests to determine if the air compressor drivebelt had failed before the crash, and, if so, why it failed and how long before the accident it failed. In summary, the report on the test concluded:

The belt failed as a result of fatigue before the accident, and not as a result of crash damage. Microscopic examination of the belt, studies using a scanning electron microscope, physical rupture tests, and mechanical abrasion simulation tests confirmed the fact that the belt failed before the accident. The belt failed as a result of extraordinarily long service under detrimental operating conditions. It experienced poor pulley flange surface conditions, pulley misalignment, and oil soaking. This was confirmed by examination of the belt and the engine crankshaft drive pulley. The belt had been used beyond its normal, useful life and beyond the point at which the wear surfaces displayed visual signs of fatigue and degradation. Belt fatigue was accelerated by a 3/16-inch misalignment of the compressor (driver) and crankshaft (drive) pulleys and by distortion (because of wear) of the inner sheave of the crankshaft pulley. After it ruptured, the belt became wedged between the rotating drive pulley and an adjacent copper tube. It rubbed against the copper tube for about 1/2 to 1 1/2 hours. In addition, the belt had traces of zinc on its surface from rubbing against a galvanized fitting, for about 1/2 to 1 1/2 hours. The belt had major abrasion and gouge areas which matched the drive pulley flanges and which were made by the drive pulley during the 1/2 to 1 1/2 hours that the belt was wedged between the drive pulley and the adjacent copper tube.

On May 30, 1976 the CHP conducted a test run between Yuba City and the Marina Vista offramp with a schoolbus identical to the accident vehicle. The run was made to approximate the number of service brake applications made by the accident bus on the day of the accident. Each of the 25 brake applications made during this run drained between 3 and 5 pounds of air from the system. In addition, it was assumed that a normal air loss of 3/4 pounds per minute occurred and 2 or 3 pounds were used to operate the bus door at the Vista Point stop.

Other Information

CHP's Motor Carrier Ratings -- The CHP administers and conducts an annual Motor Carrier Safety Operations Program as a part of its Commercial Enforcement Program to improve safety for persons and cargo in highway transportation. To accomplish this, the program emphasizes compliance with California laws and regulations in the areas of (1) driver records, (2) adequacy of carrier's vehicle maintenance programs, and (3) safety practices of transportation and charter-party carriers. Depending on the degree of compliance, carriers are rated A, B, or C in descending order. Vehicles are not rated; they either pass or fail inspections. The CHP manual, "Motor Carrier Safety Operations" (HPM 84.1), states: "A C-rated carrier is one showing evidence of widespread non-compliance with or showing disregard for regulatory requirements." Although any single serious factor may warrant assignment of this rating, a carrier shall normally be rated a "C carrier" for two or more violations. The inspection program reveals to the carrier and the State regulatory agency those unsafe operations that should either be corrected or prevented from operating in commerce.

The objective of the program is the prevention of accidents in vehicles used to transport persons and property. Obtaining compliance with legal requirements is achieved by: voluntary compliance by carriers, warning flagrant violators in writing of the department's intent to press criminal charges, or seeking a criminal complaint in the appropriate court when persistent refusal to comply is encountered.

The Marysville, California, terminal of STL had been inspected by the CHP in 1974, 1975, and 1976. The 1974 inspection resulted in a Class "C" rating. The 1975 and 1976 terminal inspection reports recorded non-compliance conditions similar to those contained in the 1974 report. However, no rating classification had been entered. The CHP could not explain this omission. They did testify that the conditions reflected in the 1975 and 1976 reports would rate the Marysville terminal as a Class "C" carrier. Testimony also revealed that the Class "C" rating had been in effect when the charter service was contracted and on the day of the accident. The "C" rating was awarded as a result of inadequate maintenance records. The program provides for enforcement procedures to be initiated when "a carrier fails to upgrade compliance as evidence by three consecutive 'C' ratings." There is no evidence that the CHP either sent a warning letter to the STL or that it sought a criminal complaint in an appropriate court to force an upgrading of the deficiencies for which the "C" rating was assigned.

Users of passenger motor carriers were not advised of such ratings nor were there any provisions to make such information accessible to them. Because these ratings were not publicized, the users are not generally aware of their existence or significance. Neither the choir director nor those school representative who arranged to charter the bus were aware of the rating system.

ANALYSIS

Monitoring of Guages

The laboratory report estimated that the compressor drivebelt had failed anywhere from 1/2 to 1 1/2 hours before the crash. Each application of the service brake and each opening and closing of the door depleted the amount of air in the service brake reservoir that remained for further brake applications and door operations. The air used was not being replaced into the reservoir after the belt failed.

After the accident, investigators determined that all brake air gauges were working, and the Safety Board concludes that they were working before the accident. It is difficult to understand why a driver with 20 years experience in airbraked vehicles did not respond to the many clues associated with the degenerating service brake system during the last hour before the accident. Based on the CHP finding that the service brake air system was free of leaks after the accident, it is possible that the air pressure was 60 psi or greater when he first started the engine at the terminal, although he stated that he monitored the air buildup from zero to 120 psi. It is doubtful that the system dropped to 60 psi during the 1/2-hour shutdown while boarding the passengers. And, it is possible that the low air warning light and buzzer would not have activated during the pretrip bus operation nor during the engine startup at the school.

Evidence indicates that all brake systems operated normally until the air-compressor drivebelt failed 1/2 to 1 1/2 hours before the accident. The CHP post-accident tests on the air system, the compressor belt tests by the laboratory, the visual observation that the belt was dragging under the bus, and the student's report of a "popping noise" sometime before the bus stopped at the Vista Point, all support the probability that a considerable time elapsed between belt failure and crash.

Following the belt failure, the service air system was depleted at a rate based on the amount of air used to reduce speed, to stop, and to operate the door. The CHP estimated that 35 psi or less was available when the bus stopped at the Vista Point. Possibly, the low-air warning light illuminated before the stop at the Vista Point and the driver falsely assumed that the low-air light was the low oil pressure light, because of its location alongside the oil pressure gauge. This may have prompted the driver's concern with low oil pressure as expressed to the choir director.

Possibly, the driver did not react to the low service air pressure gauge reading because he thought that the center gauge (emergency air) was service air pressure. After air pressure had reduced to 35 psi, there would have been a gradual decrease in brake performance, and an experienced driver should have recognized it and responded to it. He had several opportunities to stop the bus safely after leaving the Vista Point and before entering the ramp. The air emergency system was available for use and could have stopped the bus. Sometime between belt failure and the post-crash inspection, the emergency airbrake system had been applied at least three times. The CHP test results with 100 psi original pressure indicated that the first application left 75 psi, the second left 56, and the third left 43 psi -- the exact amount found during the post-crash inspection. The driver testified that he was not aware of the location of the emergency air control. All of the vehicles he had driven previously had this control in the form of a switch on the dash and not a lever on the steering column. However, the same lever is used for trailer brakes in truck combinations and is found in many truck tractors. Since the driver had been driving the bus for more than 2 hours and since he had 20 years of experience driving airbraked vehicles, the Safety Board concludes that he should have been aware of the location of the lever and its use.

Climbing of Curb and Bridge Rail

Analysis of the mechanism by which the schoolbus initially climbed the curb and parapet shows an unfavorable relationship between the profile of the wall and the steering geometry of the schoolbus with implications for change. Figure 5 shows that the axis of the bus contacted the curb at an angle of 15 1/2°. The first contact was with the left front wheel. The Safety Board could not determine how far the steered wheels were directed away from the straight-ahead position, but the driver was attempting to steer to the right. The driver stated, however, that the steering wheel was jerked counterclockwise out of his hands. That steering of the wheel directed the bus up and over the curb.

The Board examined the possibility that the angle of approach to the bridge rail would permit the curb to redirect the front wheels of the schoolbus. The side wall of the left front tire heavily smudged the curb at contact and the rim of the wheel heavily gouged the curb just below the top of the curb, and left a light-colored mark which traces upward movement (see figure 4). The rotation of the wheel and tire was downward relative to the curb in the lower forward half of the circular face formed by the outside surfaces of the tire and wheel. This downward rotation produced downward friction on the curb which lifted the tire and rim; the path of the rim gouge and the rubber smudge support this sequence.

The frictional force on the outside surface of the rim and tire also acted rearward. This force was not balanced from left to the right but acted at a distance considerably to the left of the steering pivot represented by the king pin axis. In this type of vehicle, which lacks centerpoint steering, the king pin axis is displaced inward from the center of the tread so that forces acting even at the center of the tire tread produced unbalanced steering. Contact with the outside surface thus acted with a torque leverage of not less than 6 inches in relation to the king pin axis, This action tended to rotate the left front wheel to the left. Such a force did not act on the right front wheel, which explains the driver's report that the wheel was jerked out of his hands counterclockwise.

The left front wheel was thus steered to the left into the parapet just as the wheel mounted the curb. Further, the right front wheel was also steering the bus into the wall. This unfavorable action would have been much reduced if the curb or parapet had been higher. The left front wheel was free to turn leftward because there was nothing for the higher front portion of the tire to contact above the curb. The Board believes that the rim and tire could not have climbed a higher curb.

The next marks of the left front wheel begin at E in figure 6 and move to the right and upward. They appear as raking marks with striations generally horizontal but inclined upward, and are covered over by more vertical marks placed later by another wheel. At E this sharp leftward turning of the left front wheel has moved the front edge of the tire beyond the fender line so that forwardmost part of the tire contacts the surface of the wall. This part of the tire was near the height of the axle, and the shoulder of the tread, which was serrated, made the horizontal striations. The force on the steering system now had an even larger leverage in relation to the king pin, so that still greater leftward steering forces were produced. The steering linkage was now against the left stops -- an action which would have been completed by this contact, if not by the curb contact.

Several forces were acting to raise the front of the bus. The left front springs of the bus were probably in rebound at this time, which would raise the left front wheel. The center of the left front wheel was higher than the 17-inch-high parapet; so consequently, the shoulder of the leftward cramped tire would have presented a sloping surface at the top of the parapet, which would tend to cam the wheel upward under lateral loads. This camming tendency reached its maximum when the wheel went against the stops. There was an added tendency of the steering force produced at the right wheel to lift the left side because the axle was inclined upward. There was a tendency of the sliding action to induce a slight rotation of the left wheel, but this was a small factor.

The contributing technical factors can be listed:

(a) The relatively low curb could be mounted easily and permitted the curb and wall to be mounted in two stages.

(b) Nonpower steered wheels were more easily jerked to the left than power-steered wheels or those equipped with shock absorber stabilizers.

(c) The concrete curb and wall helped to create greater friction than metal-surfaced barriers, which increased the tendency to steer vehicle front wheels to the left.

(d) Use of noncenterpoint steering increased the tendency of the curb contact to direct wheels strongly against curb and wall.

(e) Vehicle speed and angle of impact affected the importance of all the above factors.

The relative importance of these contributing factors in permitting the wall to be mounted is difficult to analyze and it is not known by what margin the bus climbed the rail. The curb was overcome in a short distance, but the length of the horizontal striations on the side of the parapet suggests that a relatively small reduction in one of the climbing tendencies might have prevented the final action from occurring.

The Safety Board concludes that bridge rail designs should be tested for their interaction with vehicles of this type and vehicles should be tested to determine what features they have to make them compatible with various barriers.

Since the features of this bus which permitted it to climb the barrier were almost identical to those of most trucks of similar front wheel weight, tests of the curb and barrier design probably would have revealed the drastic steered-wheel behavior. Barriers currently approved in California have been tested, but there is still no national requirement to prevent untested barriers from being employed by highway departments.

The sensitivity of heavy vehicles having noncenterpoint steering or nonpower-steered vehicles to lateral contact with curbs or barriers has never been tested so far as can be determined. Theoretically, it should be possible to design vehicles and barriers to cooperate for maximum effectivness and least cost.

The tiremarks made by the rotating left rear wheel on the curb and parapet indicate that the rear wheels were turning at the time of impact and were not locked. This suggests that the emergency braking system was not applied during this phase of the crash sequence and confirms the testimony of the driver that he did not activate the emergency airbrake lever. The emergency brake control lever, which was found in an activated position, could have been moved to that position anytime during the crash or the rescue and salvage efforts. When the driver was removed from the bus, a chain was attached to the steering column to pull it away from the pinned driver. A number of persons were in and out of this area during rescue work.

Speed of Vehicle in Curve

The bus entered the curve at a calculated speed of about 45 mph. From the bus tiremarks on the road leading to impact with the curb and parapet, it is evident that the bus had some braking capability but not enough to slow it significantly. (See figure 5.) This reduced braking could have resulted from a combination of limited service braking as the last of the air was used and the effect of the parking brake application. The parking brake would have had only a slight effect on decelerating a vehicle on a level surface at 45 mph and probably no effect on a 3.86 percent downgrade.

Faced with a combination of excessive speed, preoccupation with avoiding the vehicle ahead, unfamiliarity with the vehicle controls, and the braking effort, the driver steered the bus into a calculated radius of between 238 and 395 feet which was insufficient to safely negotiate the 177-foot outside radius of the ramp. The left front wheel of the bus struck the curb at a calculated speed of 45 mph and at a 15 1/2° angle.

While the offramp is posted with a speed advisory sign of 20 mph, it can be negotiated safely at higher speeds depending on driver skills, vehicle size and condition, and other variables. However, the calculated speed of 45 mph at impact with the curb was probably too great to enable the bus to negotiate the curve under any circumstances.

Design of Ramp and Curve

The 1960 California design drawings for the ramp were compared to the standards of the American Association of State Highway Officials (AASHO) 4/ which are found in AASHO's "A Policy on Arterial Highways in Urban Areas," dated 1957, and "A Policy on Design of Urban Highways and Arterial Streets," dated 1973. These standards have been adopted as Federal standards by the Federal Highway Administration of the U. S. Department of Transportation. The 1957 specifications are applicable to the ramp design. The deceleration lane length and the percent of downgrade and superelevation were in compliance with the 1957 standards.

According to the 1957 and 1973 specifications, the design of the freeway indicates that the minimum curve on the ramp should have provided for an inside radius of the right curb of 230 feet and a speed of 30 mph. A corresponding outside radius of the left curb on the ramp would have been 254 feet. The ramp as constructed with an outside radius of 177 feet did not comply with the 1957 specifications which were in force when it was built.

The engineering practice of CALTRAN has been to construct loop ramps with radii of 150 to 200 feet. This guideline is based upon their operational experience that the slight increase in comfortable speed permitted by a larger radius does not offset the substantial increase in travel time and distance, right-of-way requirements, and construction costs. This guideline is applied to all Interstate road system designs in California.

The Federal Bureau of Public Roads 5/ approved the plans for the interchange design even though Federal funds were not used in its construction. CALTRAN asked for Federal approval because the roadway would be incorporated eventually into the Interstate road system.

The absence of left side tiremarks to indicate that the bus was in an impending side skid clearly suggests the driver was not steering the vehicle into the sharpest curvature (shortest radius) possible. Since there is no information on the exact path of the bus as it entered the curve, and because of other related design factors, the Safety Board could not determine if longer outside radius of 254 feet would have permitted the busdriver to safely negotiate the ramp. It would, however, have increased his chances of doing so.

4/ AASHO is now titled American Association of State Highway and Transportation Officials (AASHTO).

5/ The Bureau of Public Roads is now known as the Federal Highway Administration (FHWA) of the Department of Transportation.

Design of Ramp Bridge Railing System

The bus struck the curb at a 15 1/2° angle. The angle of 16° has been used as the maximum angle at which heavy vehicles have been tested with traffic barrier systems. The calculated speed of about 45 mph is also within the maximum test speeds at 16°. Tests are conducted with straight barriers on level surfaces with vehicles traveling in a straight path and without braking before impact. Traffic barriers have not been tested using either light or heavy vehicles to determine how curves or surfaces with cross-slopes affect their performance.

As the left front tire mounted the curb and contacted the concrete parapet, the combination of road geometry and bus dynamics placed the front bumper above the top of the concrete parapet and increased the opportunity for the bus to climb the barrier system. Curbs on high-speed roadways are hazardous and were banned from use on Federal-aid roads in 1967. From 1953 to 1955 California conducted dynamic crash tests on curbs to determine their effect on passenger automobiles and to determine an optimum design. The tests indicated that the best curb design tested would not redirect an automobile moving faster than 40 mph. They also found that the curbs can have a substantial destructive effect on the wheels, suspension, and steering system of vehicles which strike them.

In this accident, the significant damage to the bus suspension system was probably caused by the curb rather than the parapet. If the curb had been removed from the bridge railing system and the top of the parapet and pipe rail had remained fixed to the parapet, the bus may possibly have been redirected. Curb removal would have raised the effective bridge rail height by 10 1/2 inches, which would have eliminated the ramping effect of the left front of the bus. Also, the bottom of the bumper of the bus would have been substantially below the top of the parapet. However, it is not likely that the top of the railing would have been as high if the original design of the bridge rail had eliminated the curb.

Barrier designs used on new California roadways in recent years are curbless and have a 15-inch-high concrete parapet with a metal box beam rail on top. The total bridge rail height is 27 inches. Such a railing design would probably not have had a significant effect on redirecting this bus. In fact, it might have permitted the climbing of the parapet sooner and from a higher elevation. It is unlikely that the metal rail would have resisted the force of the bus, and the parapet is too low to prevent climbing by a 42-inch-high tire.

Based on an FHWA study on fatal accidents on the Interstate road system from 1968 through 1971, about 18 percent of fatal, single-vehicle accidents involved striking a bridge or overpass as a first event. When the bridge and overpass was the second object hit, the involvement increased to about 28 percent. In 1976, bridges accounted for about 1,921 miles--about 5 percent--of the total Interstate system.

Many of these accidents involved railings that were too weak to prevent penetration of passenger vehicles, railing surfaces that snagged vehicles, railings so low that they were vaulted, and inadequate or nonexistent connections between the approach guardrail and the bridge rail that left a pocket for vehicles to enter.

The Safety Board has revealed many of these bridge barrier rail inadequacies in previous accident investigation reports. The Board has recommended that the FHWA establish mandatory performance standards for bridge barrier rails for various classes of vehicles. The Board believes that those standards should be supported by vehicle crashtesting.

The FHWA has recently conducted research to develop both standards and barrier systems to accommodate heavier commercial vehicles. One barrier system that has been in use on the nation's highways--the concrete "safety shape" or "New Jersey type" --has been tested with tractor-semitrailers and intercity buses with substantial success. The FHWA has not yet established requirements to determine where bridge railings that will accommodate heavy vehicles should be located.

The FHWA has not fully accepted the concern of the Safety Board that the AASHTO bridge specifications, which have been adopted by the FHWA for the design of bridge railings, do not provide the necessary safeguards that insure a bridge rail with predictable performance. The current AASHTO specifications allow designers latitude in designing bridge barrier railings that may contain inadequacies that can permit catastrophic results to an impacting vehicle and its occupants. Researchers in crash dynamics of vehicle/barrier systems agree that controlled crashtesting of each new barrier design is essential. Minor changes in a design may eliminate serious dynamic deficiencies. The FHWA recently began to test several barriers designed in accordance with AASHTO specifications to determine how they perform under performance criteria accepted by FHWA for barrier research projects.

California is one of the few States that has established performance standards for bridge and guardrail systems and has crashtested them dynamically. The performance criteria have been for passenger cars and not for commercial vehicles such as buses.

The "safety shape" parapet design, adopted by California in 1972 for use on bridges, has not been tested under conditions such as those on the Marina Vista ramp. Through crashtesting, the safety shape has been proven adequate to redirect 40,000-pound buses moving at high speed and hitting the barrier at 16° angles. The test barrier was straight and on a level surface, however. How the safety shape parapet would have performed in this accident cannot be determined based on current knowledge. The Safety Board believes that the safety shape barrier should be tested with both automobiles and heavy vehicles under various geometric conditions to determine its range of use. Current information suggests that the barrier may perform well when impacted by buses under roadway environments similar to that on the Marina Vista offramp.

Some CALTRAN officials have stated that only two bridge rail designs would be necessary to serve the diverse requirements of geographic and climatic conditions in California. The Safety Board concludes that the wide variety of 100 or more barrier designs currently used nationwide is unnecessary and, because they are untested, result in injuries, increased injury severity, and property damage to both the vehicle and bridge railing that is not warranted.

The development and dynamic testing of bridge barrier railings from which six designs could be selected for mandatory application would provide a higher level of safety on the Nation's bridges and perhaps lower installation cost through standardization. In those instances where a State or other Government institution wishes to design a special rail, that rail should be tested to insure compliance with the performance criteria that apply to the mandatory designs.

Retrofit of Existing Bridge Railings

The Safety Board has recommended to FHWA that programs to retrofit bridge railings, including the removal of curbs, be developed. The FHWA has developed several designs for retrofits that will accommodate passenger automobiles. The Board believes that the research, testing, and evaluation of retrofit designs should include heavier vehicles, such as school and intercity buses.

In April 1976, the Department of Transportation published the "National Highway Safety Needs Report," which ranks the cost benefit of various countermeasures for improving safety. The improvement of bridge rails and parapets was ranked as No. 11. The Safety Board believes that the FHWA and the States should identify immediately locations where bridge rails have contributed or might contribute to catastrophic accidents and set priorities for necessary improvements.

Signing

The 20-mph exit and speed advisory sign at the ramp was partially obscured by a luminaire pole in the immediate approach to the offramp deceleration lane. The yellow sign with black letters also tended to blend with its background, which consisted in part of hills covered with golden brown grass.

The sign does not come into full view until after the tapered lane begins and at a point where a vehicle normally starts a maneuver into the ramp at about 350 feet before the start of the ramp curve. The overhead exit sign at the gore point does not provide any indication of the severe ramp geometry.

The Federal standards for signing contained in the Manual on Uniform Traffic Control Devices (MUTCD) indicate that exit speed signs can be placed in or near the gore and where "engineering investigations of roadway, geometric or operation conditions show the necessity of advising drivers of the maximum recommended speed on a ramp." The MUTCD also advises that "Where additional advisory speed indication is needed on the ramp well beyond the gore, a standard warning sign with an Advisory Speed plate (13-1) is to be used."

While the MUTCD does not specifically require the use of a curve warning arrow on ramps, it also does not prohibit their use. The engineering investigations of a roadway for which geometry and operating conditions dictate that the recommended speed on a turn be 30 mph or less, and that this recommended speed be equal to or less than the speed limit for that section of highway, a turn sign may be used to emphasize the severity of the curve ahead. 6/

However, a better solution might be the installation of the large arrow sign developed by CALTRAN that includes a diagram to illustrate the general severity of a curve on a ramp and includes the advisory speed CALTRAN does not, however, erect the sign unless a ramp has had an accident history to demonstrate the need for such information. The sign normally is not erected at a site before an accident has occurred because CALTRAN maintains that such use would cause drivers to lose confidence in the sign. CALTRAN also does not have provisions in its standards for a conventional arrow sign on ramps with sharp and obscure curves.

The effects on this accident of the design and placement of traffic control devices for exiting traffic cannot be determined based on available evidence. However, the Safety Board believes that had the driver known earlier of the severity of the ramp geometrics, he might have applied the brakes earlier, which should have provided to the driver an indication of deteriorated braking capability. Had he known of the deteriorated braking capability before or in the vicinity of the ramp entrance, he may have chosen not to exit into the ramp and may have continued on the through lanes and coasted to a stop.

6/ Manual on Uniform Traffic Control Devices For Streets and Highway, U.S. Department of Transportation, Federal Highway Administration, 1971, section 2C-4 Turn Sign.

The FHWA and CALTRAN are cooperating in a survey to determine the adequacy of the visibility of exit signs on California offramps. However, CALTRAN has indicated that it does not believe that there is any need to improve the traffic control device at the Marina Vista offramp.

The Safety Board concludes that the geometry of the Marina Vista offramp is sufficiently severe and sufficiently obscured from approaching drivers to justify a highly visible curve warning sign as well as an advance warning of the ramp exit. The Safety Board does not accept loss of credibility for the sign as appropriate argument against its use.

The Board believes that the criteria contained in MUTCD with regard to traffic control devices for exit ramps can be improved. The MUTCD does not provide adequate guidance in the treatment of the more difficult ramp configurations, including the approach geometrics and environment. There are no criteria contained in the MUTCD that can be used to aid the evaluation of existing or proposed designs with regard to driver performance.

The FHWA has been working for several years on the concept of "positive guidance" and has published several documents relating to the subject. Positive guidance, as described by FHWA, "...joins the highway engineering and human factor technologies to produce an information system matched to the facility characteristics and driver attributes. It is based on the premise that drivers can be given sufficient information where they need it and in the form that they can best use to avoid hazards."

The Board has supported, through recommendations, the FHWA's past work on positive guidance. Much is yet to be learned about driver needs as related to the driving task. The efforts to further develop the positive guidance concept should continue and new results, as they occur, should be used to improve national standards and aid in the evaluation of existing facilities.

Maintenance Practices

The laboratory report indicated that the compressor drivebelt had been used beyond its normal, useful life and after it exhibited visible deteriorated conditions. This was contrary to testimony that the belt had been inspected and was in "good" condition as recent as the morning of the accident. However, a reason for the conflict may simply be a misunderstanding about the proper technique used in the inspection of V-belts. The belt manufacturer recommends that V-belts be inspected by turning the belt over, examining the bottom, both sides, and the top. The inspection of the drivebelt that failed involved looking only at the top surface of the belt through the engine oil access point.

Since the deterioration of the drivebelt was not discovered before its failure, it is obvious that the maintenance of critical components, as discussed before in a recent Safety Board highway accident report, 7/ requires a more comprehensive program of pretrip inspections and regularly scheduled maintenance. This is also supported by the findings of the Southwest Research Institute (SWRI) following indepth investigations of five schoolbus accidents. In its report 8/ SWRI stated that it "has not been particularly impressed by the quality of maintenance on schoolbuses in accidents inspected by our team," and stressed the need for improved preventive maintenance practices and inspection.

The "C" rating given the STL for 1974 and the poor inspection records for 1975 and 1976 are further indications that preventive maintenance is a significant problem and a contributing factor in this accident. The Safety Board concludes that proper maintenance practices would have discovered the deteriorated drivebelt and would have prevented this accident.

Survival Aspects

The seating positions of the bus occupants did not appear to be significant in the survivability of the accident. The loss of cross-sectional integrity of the bus body because of the failure of the window posts and the deformation of the roof to the windowsill level insured crushing and compression-type injuries commonly noted among the occupants. The dynamic forces imposed on the roof of the inverted bus were outside of the realm of practical design limitations.

The Safety Board considered the possible effect which the wearing of seatbelts might have had on the reduction of severity of the injuries sustained by the bus occupants. Any benefits resulting from the occupants being restrained in their seats would have had to be supplemented by significantly increased vertical roof support and by high-back, padded seats. There is no evidence to indicate that the use of occupant restraints would have reduced the severity of the injuries sustained in this accident.

Motor Carrier Ratings

Drivers must be qualified and equipment must be in safe operating condition in order to assure a high level of safety. The objectives of the CHP Motor Carrier Safety Operations Program follow that principle. The motor carrier terminal inspections and subsequent ratings provide the vehicle

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7/ National Transportation Safety Board, "Siskiyou Union High School District Schoolbus/Automobile Collision and Rollover, I-5, Ashland, Oregon, May 9, 1975, NTSB HAR-76-1.

8/ "Multidisciplinary Accident Investigations," Volume 2, 1976, Southwest Research Insitute for the Department of Transportation, NHTSA, Washington, D.C. (August 1976) with which to accomplish this objective. However, to be effective, programs must be conducted completely. Although the STL had three consecutive "C" ratings no enforcement action was initiated. Since resources for such programs are limited, priorities must be established. The CHP manual provides for setting priorities for the reinspections and followup of borderline cases. Those carriers and terminals which receive "A" ratings need less attention while those with "C" ratings need more frequent attention. While discretion will always be necessary, the more positive enforcement action is, the more effective the program will be toward acquiring compliance.

The current program allows carriers with "C" ratings 2 years from the date of the receipt of the first "C" rating to the date of receipt of the third "C" rating to bring their operations into compliance with safety regulations. Carriers should be required to correct their maintenance, operations, and recordkeeping within 1 year of a "C" rating.

Possibly, had the terminal "C" rating and its significance been made known to the choir director or the school representative, they would not have contracted their services. Such safety information and its significance needs to be made known to all users of passenger carriers.

Carriers should also be held responsible for the skills and vehicle handling capabilities of their drivers -- both new and experienced. In the case of the accident driver, he was not adequately tested in the vehicle, no experienced person rode with him to observe his driving practices or to test his knowledge of the operations and controls on any of the three buses he drove. Had he known that the air emergency control lever was located on the steering column and used it, the severity of the accident would have been reduced.

CONCLUSIONS

Findings

1. The busdriver held a valid California operators license.

2. The bus was being operated as a charter-party motor carrier with a valid California inspection certificate.

3. The busdriver had not been thoroughly or properly instructed concerning the significance of the air gauges and other warning devices on the dashboard before being dispatched on this trip.

4. The busdriver was not sufficiently familiar with the braking features and characteristics of the bus to properly respond in an emergency.

5. Although the configuration and labeling of the instrument panel could confuse an unfamiliar driver, a constant monitoring of the gauges should have alerted the driver to the impending emergency.

6. The loose electrical connection of the low-air audible buzzer and the failed air compressor drivebelt were the only precrash mechanical defects which could be directly related to the cause of the crash.

7. A proper pretrip inspection of the air compressor drivebelt should have detected its badly deteriorated condition and prompted its immediate replacement.

8. An effective preventive maintenance program would have discovered and brought about the replacement of the deteriorated drivebelt before the accident.

9. Possibly, had the emergency airbrake system been applied in the tangent to the curve of the ramp, it would have utilized whatever air remained in the brake system, and the speed of the bus would have been reduced so that the driver could steer it through the curvature of the ramp.

10. The climbing of the parapet wall by the bus was initiated by steering rotation of the left front wheel into the face of the parapet wall because of uncontrollable movement of the steering wheel when the left front wheel struck and rubbed against the curb. It could not be determined whether the use of a more favorable "centerpoint steering" arrangement in the original bus design would have prevented this action.

11. The FHWA Manual on Uniform Traffic Control Devices needs improved criteria for the design and placement of traffic control devices for exit ramps.

12. Had the curvature of the ramp been in compliance with the 1957 AASHO specifications, the opportunity for the driver of the bus to negotiate the ramp would have been greatly improved.

13. The unnecessary curb structure of the bridge rail system substantially aided the bus in climbing onto the top face of the bridge parapet.

14. The same bridge rail height without the curb structure might have redirected the bus.

15. The impact loads on the roof of the bus reduced the interior volume and blocked all possible escape openings, prevented unaided escape of survivors, and delayed rescue efforts.

16. A carrier's operational quality ratings, as assigned by the CHP following a terminal inspection, and their significance should be made available to users of charter-party buses and schoolbuses.

7. Although the 1975 and 1976 Terminal Inspection Reports did not indicate that the STL Marysville Terminal was assigned a rating, the discrepancies noted justified a "C" rating.

18. According to the CHP Motor Carrier Safety Operations Manual, if the proper paperwork on the 1975 and 1976 inspection reports had been completed and "C" ratings assigned, the STL Marysville Terminal would have had three "C" ratings and would have been subject to enforcement action.

19. Had the choir director and school representative who chartered the bus been aware of the "C" ratings over a period of three inspections, and the significance of the ratings, they may not have contracted the charter service.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the driver, who was unfamiliar with the bus, to correctly monitor the service brake airpressure gauge, recognize the loss of air, and take appropriate action including the application of the emergency airbrake.

Contributing to the accident were: (1) the failure of the aircompressor drivebelt, (2) the failure of the maintenance program and pretrip inspection to detect and replace the deteriorated aircompressor drivebelt, (3) the failure of the signing system to adequately alert the driver to the critical geometrics of the ramp, (4) the severe radius of the curvature of the ramp, (5) the design of the curb as part of the ramp railing, and (6) a bridge rail system that did not redirect the bus.

RECOMMENDATIONS

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

-- to the California Department of Transportation:

"Erect at the approach to the Marina Vista offramp an exit sign that incorporates a diagram of the curvature of the ramp to illustrate its severity and relocate or supplement the advisory exit speed sign to improve its warning to approaching drivers. (Class I, Urgent Followup) (H-77-16)"

-- to the California Highway Patrol:

"Initiate a program that will insure the availability of information about carrier terminal ratings and their meanings to all users of charter-party and schoolbus carriers' services. (Class II, Priority Followup) (H-77-17)

"Modify the enforcement policy set forth in its Motor Vehicle Safety Operations Program to provide for letters of warning and/or the initiation of charges against those carriers/terminals upon the receipt of a second consecutive "C" rating. (Class II, Priority Followup) (H-77-18)

"Modify its Motor Carrier Safety Operations Program to require that each carrier is held responsible to insure that all drivers--both new and experienced--are properly tested and examined to assure their driving capability and that such drivers are thoroughly familiar with all of the operational functions and controls of each vehicle they drive. (Class II, Priority Followup) (H-77-19)"

-- to the Federal Highway Administration:

"Prepare and issue an advisory document citing the proper techniques for inspecting air compressor drivebelts. The bulletin should be disseminated widely throughout the commercial motor carrier industries and to all agencies charged with the regulation of intrastate motor carrier safety. (Class II, Priority Followup) (H-77-11)

"Develop bridge railing designs that will meet performance standards to be established by FHWA for various classes of vehicles and that will be sufficient in number to meet the various State requirements with regard to climatic and other physical conditions that affect the operation and maintenance of a roadway system. Such bridge barrier railing designs should be available to States that do not desire to develop their own designs in accordance with mandatory performance standards issued by FHWA. (Class II, Priority Followup) (H-77-12)

"Investigate through dynamic crashtesting and analytical procedures the effects of various geometric configurations and adjacent roadway surfaces on the performance of traffic barrier rail systems. The investigation should also consider how maintenance practices or the lack of maintenance affects the performance of the barrier rail systems. (Class II, Priority Followup) (H-77-13)

"In cooperation with the States, establish priority guidelines for improving, through modification or retrofit, the performance of existing traffic barrier rail systems at bridges. Consideration should be given in the priority guidelines to the potential for multi-fatality accidents involving high occupancy vehicles such as buses. (Class II, Priority Followup) (H-77-14)

"In cooperation with the States, determine if the current design and placement of guide, directional, advisory, and warning signs, and other necessary traffic control devices on highway exit ramps are adequate to provide a driver with understandable and performance-related information necessary for the selection and safe negotiation of the desired ramp. The results of the investigation should be used to improve the criteria contained in the Manual on Uniform Traffic Control Devices. (Class II, Priority Followup) (H-77-15)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ KAY BAILEY
Acting Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ WILLIAM R. HALEY
Members

September 29, 1977

APPENDIX

INVESTIGATION

This report is based upon an investigation by the National Transportation Safety Board in cooperation with the California Highway Patrol, the California Department of Transportation, and the U. S. Department of Transportation under the authority of the Independent Safety Board Act of 1974. The investigation included a public hearing conducted by the Safety Board in Yuba City, California, on August 10-13, 1976. Parties to the hearing were: the Crown Coach Corporation, State of California, the Gates Rubber Company, the Student Transportation Lines, Inc., the U.S. Department of Transportation, and the Yuba City Unified School District. A deposition of the busdriver was conducted in Yuba City on December 7, 1976. All parties were invited to attend and participate.

CHP Investigation -- The Vallejo Area Command of the CHP was responsible for investigating this accident. At the height of the CHP investigation, about 30 investigators were working full-time on the accident. A detailed report of the CHP investigation was released in July 1976. 9/

9/ A copy of the CHP report is included in the public docket of this accident at Safety Board headquarters in Washington, D.C.