PB81-178410

Highway Accident Report
Central Texas Bus Lines, Inc. Charter Bus, State Route 7 Near Jasper, Arkansas, June 5, 1980

(U.S.) National Transportation Safety Board
Washington, DC

21 Jan 81

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NTSB-HAR-81-1	2. Government Accession No. PB81-178410	3. Recipient's Catalog No.
4. Title and Subtitle Highway Accident Report--Central Texas Bus Lines, Inc., Charter Bus, State Route 7, near Jasper, Arkansas, June 5, 1980		5. Report Date January 21, 1981 6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Accident Investigation Washington, D.C. 20594		10. Work Unit No. 3008A 11. Contract or Grant No.
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20594		13. Type of Report and Period Covered Highway Accident Report June 5, 1980 14. Sponsoring Agency Code

15. Supplementary Notes

The subject report was distributed to NTSB mailing lists: 8A, 8C and 16.

16. Abstract

On June 5, 1980, about 12:47 a.m., a northbound Central Texas Bus Lines, Inc., charter bus occupied by the driver and 32 passengers accelerated out of control while descending a long, curved, steep grade on State Route 7 about 1 mile south of Jasper, Arkansas. The bus failed to negotiate a left curve, and ran off the right pavement edge into a drainage channel. The bus continued for 280 feet, impacted a berm at a concrete culvert, was redirected across the highway, and vaulted down a steep embankment. Twenty bus occupants, including the driver, were killed and 13 passengers were injured.

The National Transportation Safety Board determines that the probable cause of this accident was a combination of circumstances which resulted in the driver's inability to control the bus as it descended a steep, winding grade. These circumstances included driver fatigue, reduced fuel flow from a nonstandard fuel pump which adversely affected the busdriver's ability to downshift, and the improperly maintained airbrake system. Contributing to the accident was the management decision which permitted dispatching of a driver with inadequate time to complete the trip within permissible hours and the carrier's inadequate preventive maintenance program for this bus.

17. Key Words Charter bus; fuel pump; airbrake system; wheel air chambers; downshift; fatigue; arteriosclerotic cardiovascular disease; low blood-sugar; warning signs; physiological factors; hours of service; downgrade; horizontal alignment; warning signs		18. Distribution Statement This document is available to the public through the National Technical Information Service Springfield, Virginia 22161 *(Always refer to number listed in item 2)*	
19. Security Classification (of this report) UNCLASSIFIED	20. Security Classification (of this page) UNCLASSIFIED	21. No. of Pages 41	22. Price

NTSB Form 1765.2 (Rev. 9/74)

CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT

Adopted: January 21, 1981

CENTRAL TEXAS BUS LINES, INC., CHARTER BUS
STATE ROUTE 7
NEAR JASPER, ARKANSAS
JUNE 5, 1980

SYNOPSIS

On June 5, 1980, about 12:47 a.m., a northbound Central Texas Bus Lines, Inc., charter bus occupied by the driver and 32 passengers accelerated out of control while descending a long, curved, steep grade on State Route 7 about 1 mile south of Jasper, Arkansas. The bus failed to negotiate a left curve, and ran off the right pavement edge into a drainage channel. The bus continued for 280 feet, impacted a berm at a concrete culvert, was redirected across the highway, and vaulted down a steep embankment. Twenty bus occupants, including the driver, were killed and 13 passengers were injured.

The National Transportation Safety Board determines that the probable cause of this accident was a combination of circumstances which resulted in the driver's inability to control the bus as it descended a steep, winding grade. These circumstances included driver fatigue, reduced fuel flow from a nonstandard fuel pump which adversely affected the busdriver's ability to downshift, and the improperly maintained airbrake system. Contributing to the accident was the management decision which permitted dispatching of a driver with inadequate time to complete the trip within permissible hours and the carrier's inadequate preventive maintenance program for this bus.

INVESTIGATION

The Accident

About 7:05 a.m., on June 4, 1980, a bus operated by Central Texas Bus Lines, Inc., of Waco, Texas, departed its domiciled terminal in Dallas, Texas, for Branson, Missouri, with a charter group of 32 persons, primarily senior citizens. Between noon and 12:30 p.m., the fuel pump failed, and the disabled bus was stopped at the roadside about 15 miles outside Talihina, Oklahoma. The problem was determined to be a broken fuel pump shaft. Because a standard replacement fuel pump was not available locally, the Vice President and General Manager of Central Texas Bus Lines, at the company headquarters in Waco, Texas, reportedly authorized the installation of a nonstandard electric fuel pump and allowed the bus to continue to Branson where a standard pump was to be installed. The nonstandard pump was installed and the trip was resumed, after a delay of 4 to 4.5 hours.

About 7 p.m., the bus arrived at the Queen Wilhelmina Campground near Mena, Arkansas, where the passengers and the busdriver ate dinner. Passengers reported that the busdriver and some passengers wanted to remain at the campground overnight, but the tour director decided to continue to Branson, where the group had confirmed motel reservations. The bus departed the campground at about 8:25 p.m.

The exact route the bus took from the campground could not be determined, but the bus probably entered State Route 7 from Interstate 40 at Russellville, Arkansas, 64 miles south of Jasper, Arkansas. Passengers reported that a passenger who was seated at the front of the bus with a roadmap assisted the busdriver with directions.

About 12:45 a.m., on June 5, 1980, the northbound bus approached a hillcrest on State Route 7 about 3.3 miles south of Jasper. Before reaching the hillcrest, the bus passed between two sets of large signs. The first set bore the legend "STEEP GRADE - TRUCKS 15 MPH NEXT 3 1/2 MILES," and the second set: "VERY CROOKED AND STEEP NEXT 3 1/2 MILES - TRUCKS 15 MPH." The signs were posted on each side of the two-lane highway and the sets were about 0.2 mile apart; the second set was 0.15 mile south of the hillcrest. There were rumble strips in the pavement immediately before the second set of signs.

As the bus crested the hill and began its descent, most of the passengers were sleeping or resting. One passenger stated that he was awake, but resting, when he was aroused by a grinding noise which he recognized as transmission gear clashing. He characterized the noise, which continued for a minute or more, as a rapid, intermittent clashing of gears. He soon felt the bus accelerate and begin swaying. Another passenger stated that soon after she noticed some large signs on Route 7, she felt the bus accelerate and heard a "humming" noise. She said that another passenger spoke of smelling an odor characterized as "an electric or rubber burn smell." Another passenger stated that she was awakened by side-to-side motion which she said felt like "rapid travel through several curves." She also reported hearing a noise which sounded like an attempt by the busdriver to get the transmission into gear. Several other passengers reported the gear clashing noise and the acceleration and swaying of the bus. No one reported feeling any braking forces. No information was available about the driver's action when the bus first began its descent. Passengers aroused by the transmission noise and bus motion said the driver was awake, alert, and attempting to control the bus.

About 2 miles north of the hillcrest, the bus entered a 0.2-mile-long construction zone. The construction zone began with a 10-degree right curve followed by a straight section which was followed by a 10-degree left curve. A runaway vehicle escape ramp was being constructed on the straight section of the existing roadway, and the traveled way had been realigned to the west of and roughly parallel to the escape ramp. The bus traversed the construction zone but failed to negotiate the 10-degree left curve and ran off the right pavement edge into a drainage ditch which paralleled the road. A steep hillside with several rock outcroppings formed the right bank of the ditch, and as the right wheels of the bus entered the ditch, the bus tipped and its right side began scraping along the hillside. The bus continued forward for about 280 feet. (See figure 1.)

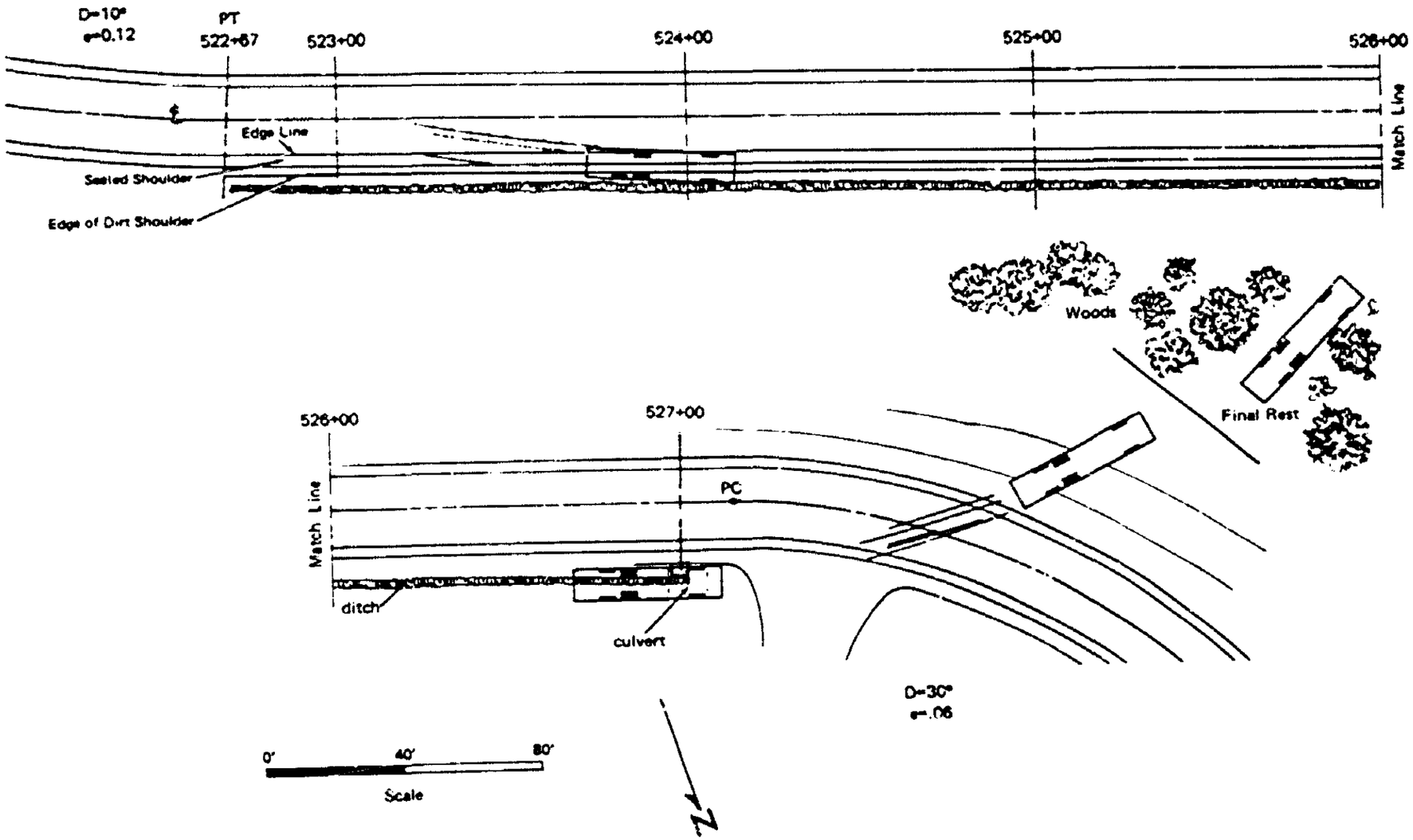


Figure 1.--Plan of accident site.

About 120 feet north of where it first contacted the hillside, the right-side window area struck a large rock outcropping. The bus then struck and mounted a 3-foot-high berm located at a concrete culvert headwall, and the busdriver and two passengers were ejected. The impact redirected the bus diagonally to the left across the pavement and off the left pavement edge. Two more passengers were ejected during this travel. The bus launched into a vault as the roadside terrain descended rapidly. The front of the bus struck several trees with bole diameters ranging from 9 to 13 inches. Two of these trees were sheared; three were uprooted. The bus came to rest (see figure 2) with its front against a large rock about 38 feet below pavement level where several more passengers were ejected.

Injuries to Persons

Injuries	Driver	Passengers	Others	Total
Fatal	1	19	0	20
Nonfatal	0	13	0	13
None	0	0	0	0
Total	1	32	0	33

Vehicle Information

The 1967 Silver Eagle Model No. 01, 3-axle bus, VIN 7090, was manufactured in Belgium by Bus and Car, Inc., for Eagle International, Inc. The bus was equipped with a 568-cubic-inch diesel engine, 6-speed manual transmission, air-activated drum brakes, and power steering. The bus was originally purchased by Continental Trailways in 1967 and was sold to Central Texas Bus Lines, in 1979, which used the bus for charter service. The hubodometer reading of 53,793 miles was the mileage traveled by the bus since it was purchased by Central Texas Bus Lines. The bus was painted white and silver with red stripes along both sides.

The bus had a seating capacity of 48 passengers and a gross vehicle weight rating (GVWR) of 38,000 pounds. The probable vehicle weight at the time of the accident was 33,747 pounds. The driver's seat was equipped with a lapbelt, which the driver was not using at the time of the accident. No passenger restraints were available.

Postaccident inspection of the bus identified the following preaccident defects:

Fuel Pump.--The nonstandard fuel pump installed in Oklahoma was an electric centrifugal pump which had a constant flow rate of 22 gallons per hour at 1 psi and an outlet pressure of 4 to 8 psi. (See figure 3.) It had been installed so as to bypass the original equipment diesel fuel pump which had a broken shaft. The replacement fuel pump was the type normally used for gasoline automobile engines. The original equipment diesel fuel pump was a speed-sensitive, vacuum-mechanical, positive-displacement pump with a 110 to 115 gallon per hour flow rate and an outlet pressure of 70 psi at 2,100 rpm.

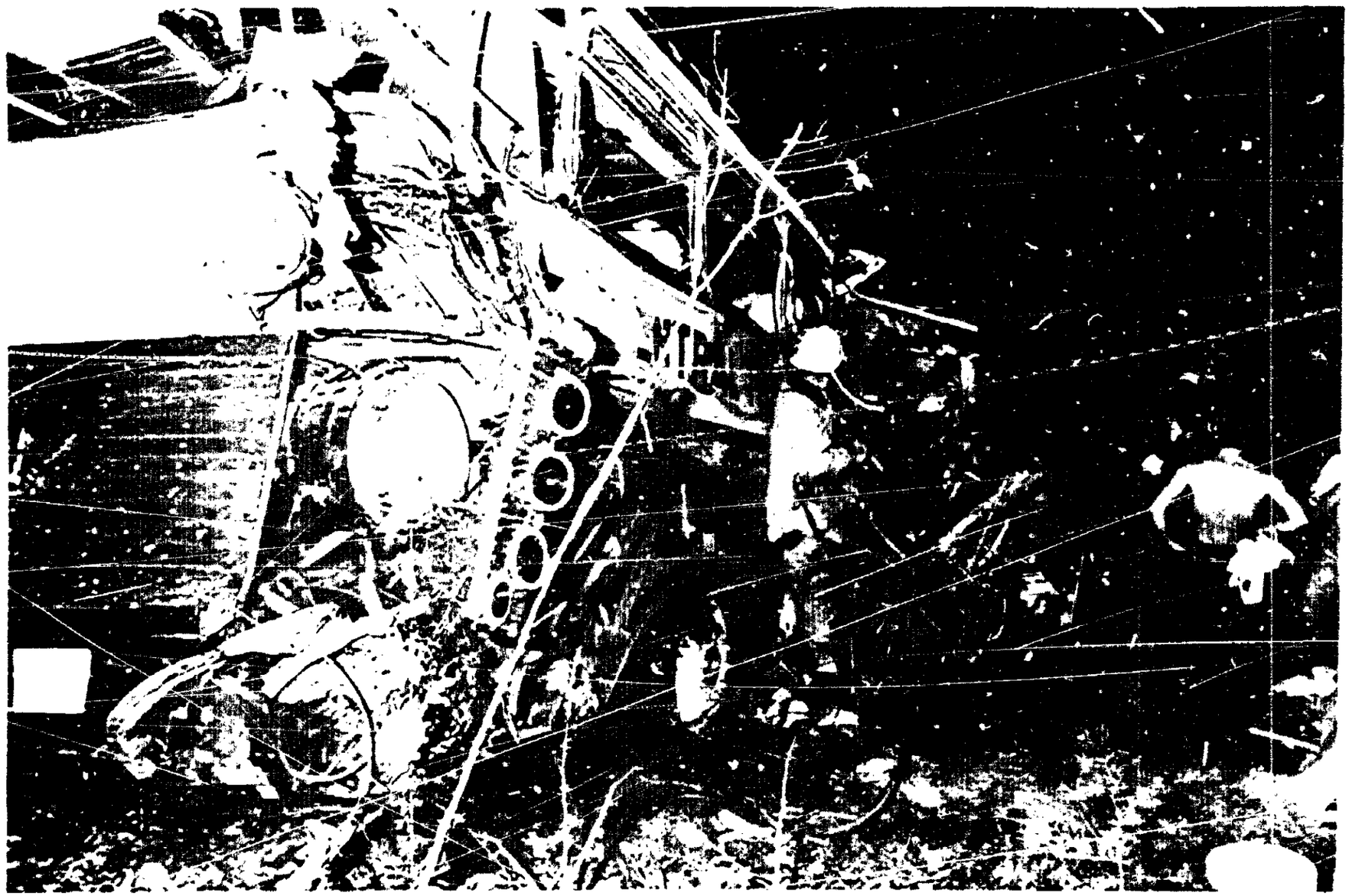


Figure 2.--Bus at accident site.

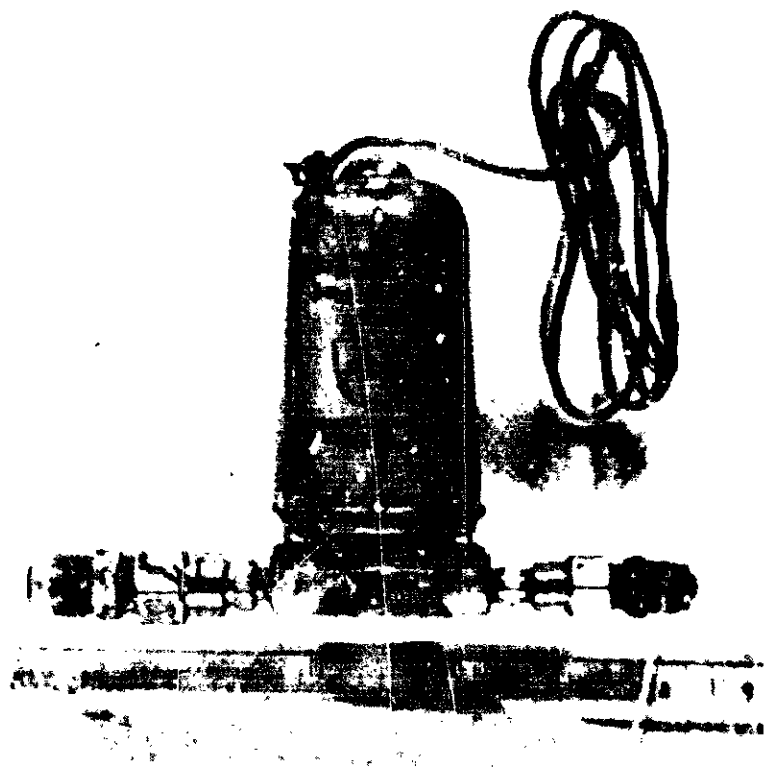


Figure 3.--Nonstandard electric fuel pump and attaching hardware used on accident vehicle.

Transmission, Shift Linkage, and Clutch.--The bus, as manufactured, was equipped with a 4-speed manual Spicer transmission. The 6-speed manual Spicer transmission was installed in 1979, after the bus was purchased by Central Texas Bus Lines. The original transmission linkage had been modified to accommodate the larger unit by cutting the two linkage rods, in the left tag axle area, overlapping each rod and welding. After the accident, the transmission was removed and disassembled by representatives of Spicer Division, Dana Corporation. Transmission gear assemblies and shift mechanisms functioned properly. No excessive wear was noted. A broken return spring was found on the fifth and sixth gear plunger mechanism. This was determined to be a preaccident fatigue fracture that would not have affected the transmission operation significantly.

The transmission gears were in the neutral position. The tow truck operator stated that he did not change the bus gear positions before removing the bus wreckage. Inspection of the front of the bus showed that collapsed components were binding the gearshift linkage so tightly that the gear selector lever was virtually immovable. Abrasion marks on both the gearshift linkage and the corresponding structural member indicated that preaccident binding may have existed. A monthly maintenance record dated January 12, 1980 contained a complaint from an unidentified driver: "trans linkage still sticks." There was no other record to indicate that the condition had been corrected.

The bus had a rebuilt Spicer clutch and pressure plate assembly with dual 14-inch-diameter asbestos discs. There was no excessive wear or internal discrepancies; however, the release rod had been machined to provide clearance for the throwout bearing. The clutch linkage was slightly out of adjustment and also was bound by collapsed body structure components.

Airbrakes.--There was no discernible air pressure in the airbrake system reservoirs. Air leaks induced by crash damage were plugged, and the airbrake system was charged by external air sources to 120 psi to enable a system check, which revealed the following discrepancies:

1. The top brakeshoe on the left drive axle was scored.

2. The wheel bearing seal on the right drive axle was ruptured, and the wheel bearing inner race was badly burnished.

3. The brake linings and drum on the right drive axle were contaminated by grease, which contained external debris.

4. There was no brake lining contact with the drum on the left tag axle when air was applied. The air chamber diaphragm had a 0.3-inch tear which resulted from a large rupture of the rubber material on the inside surface. The inside surface was also abraded and exhibited a wear pattern typical for a high-time diaphragm. (See figures 4 and 5.)

5. The right front-axle rotochamber was leaking air, but brake application occurred when air was applied. There was a 0.1-inch tear in the rotochamber diaphragm. (See figures 6, 7, and 8.)

6. Slack adjustor travel was 1.875 inches on the left drive axle and 2.5 inches on the right drive axle. The left tag axle had no slack adjustor travel. All other axle positions had slack adjustor travel within 1 1/2 inches. The manufacturer's recommended maximum slack adjustor travel for the Type-30 brake chamber is 2 inches.

The tow truck operator said that the spring brakes of the bus were on when the bus was pulled up the embankment. He said that he pulled the clevis pin to release the spring brakes when the bus was back on the roadway and that the adjustment on the slack adjustors was not changed. The airbrake system on the bus was designed so that the spring brakes would activate when the air pressure in the system went below 60 psig.

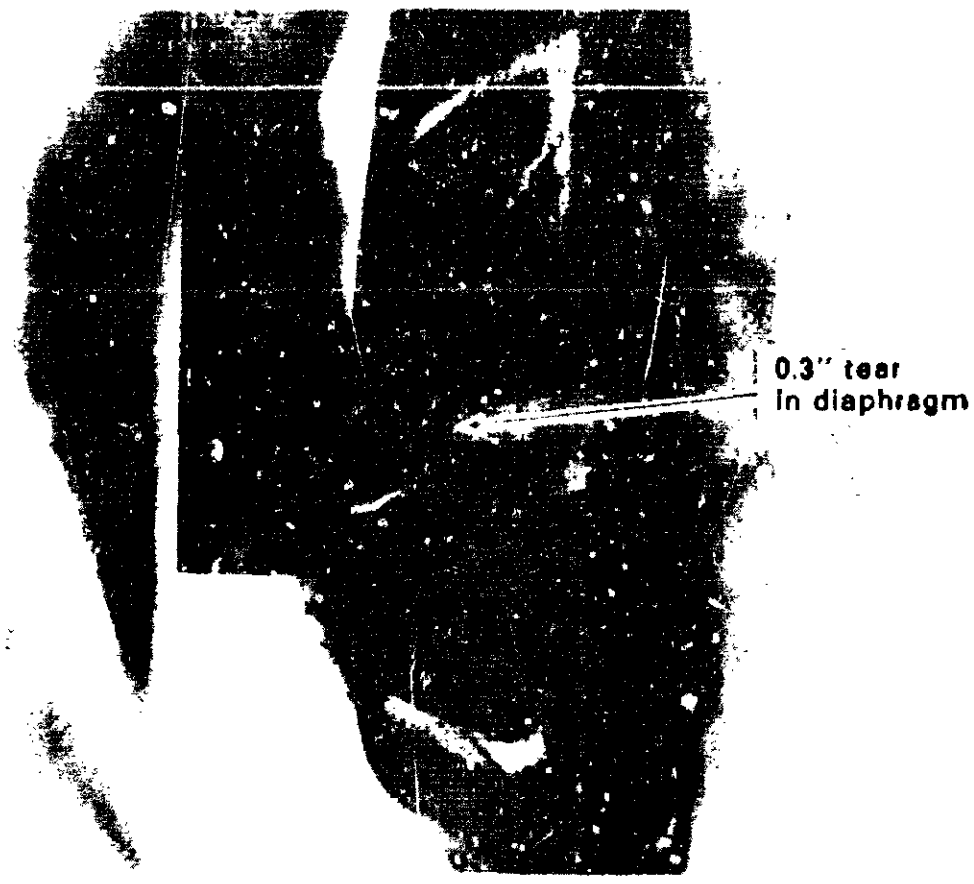


Figure 4.--Exterior tear of air chamber diaphrugm on left tag axle.

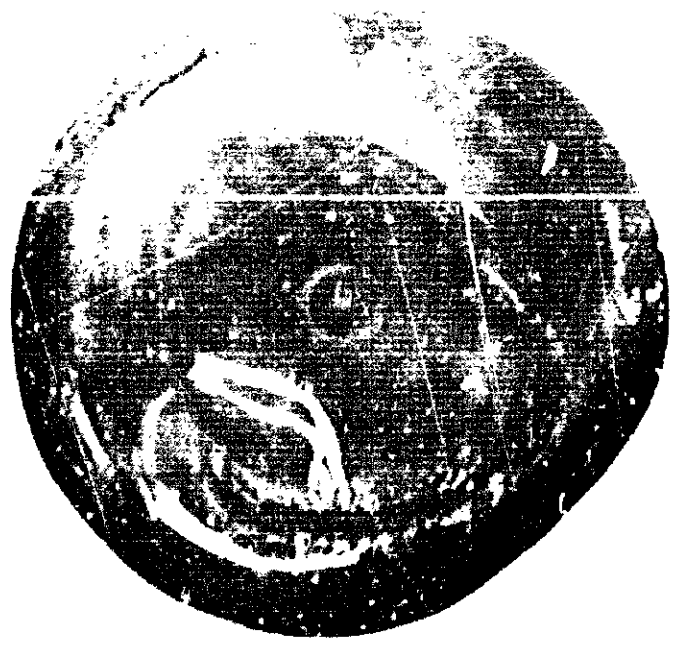


Figure 5.--Interior rupture and abraded surface of air chamber diaphragm.

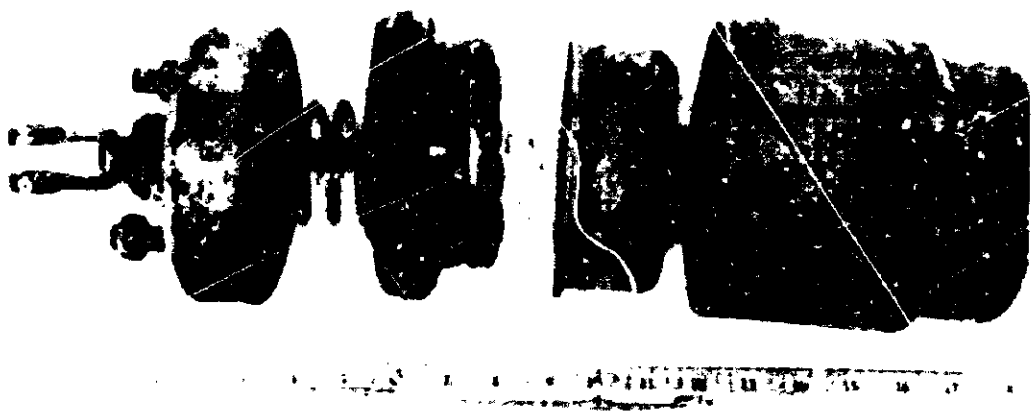


Figure 6.--Brake actuator from the right front-axle rotochamber.

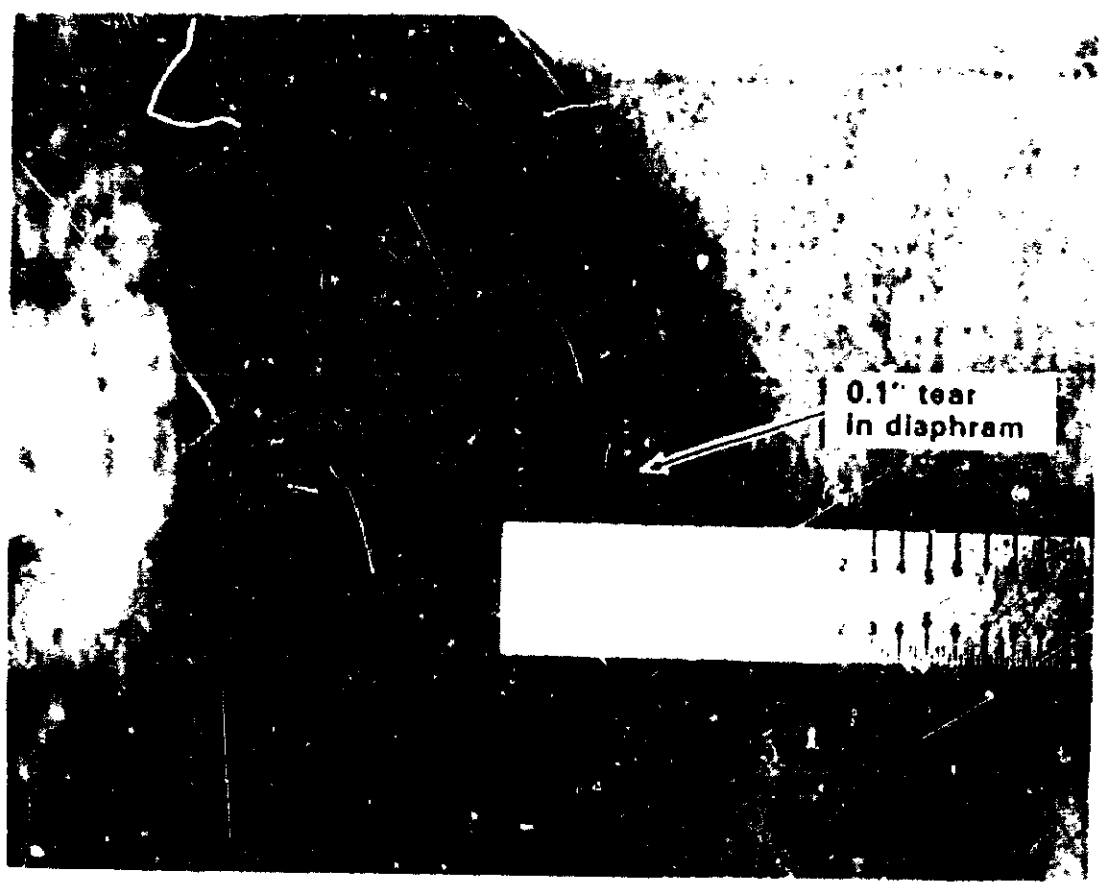


Figure 7.--Exterior tear of rotochamber diaphragm.

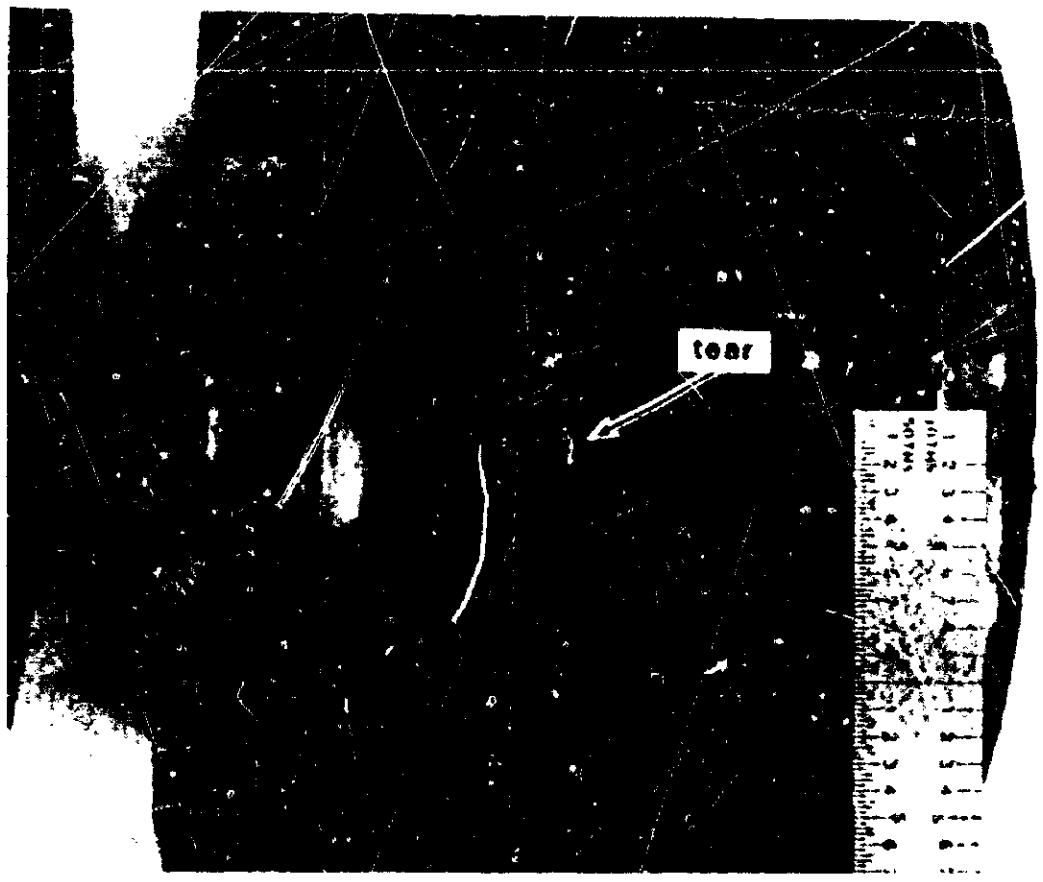


Figure 8.--Interior tear of rotochamber diaphragm.

The bus was equipped with eight Goodyear radial tires, size 12.75 R22.5. Tread thicknesses ranged from 5/32 to 16/32 inch, which exceeded Federal Motor Carrier Safety Regulations (FMCSR) requirements of 4/32 inch tread on tires on the steering axle and 2/32-inch tread on other wheels. Tire inflation pressures ranged from 85 to 112 psi and showed no irregularities which might have influenced vehicle handling. All tires were in good condition except the outside tire on the right drive axle which had an accident-related 1 1/2-inch-wide circumferential groove in the tread section.

The bus, which was subject to annual Texas State vehicle safety inspections, was last inspected on March 3, 1980. The only discrepancy reported--misadjusted headlights--was corrected. An examination of the bus company's shop maintenance and driver complaint records for the accident bus for the 12-month period prior to the accident revealed the following:

Record Date	Driver Complaint	Date of Repair	Repairs Made
5/19/79	Bad bearing in rear bogie wheel. Bad brakes on front wheels.	6/3/79	Adjusted brakes and installed steneo oiler on right bogie wheel.

Record Date	Driver Complaint	Date of Repair	Repairs Made
6/12/79	Check right-rear bogie wheel for oil leak	6/12/79	No entry
6/13/79	Wheel seal still leaking on right-rear brake	No entry	No entry
6/16/79	Right-rear bogie needs attention	7/25/79	Replaced differential pinion seal
8/14/79	Left driver grease seal leaking and foot-feed spring is bad	11/29/79	Relined left drive wheel brake
8/19/79	Rear end is leaking out of left hub. Foot-feed hangs	No entry	No entry
10/21/79	Pulls left while braking	11/29/79	Relined left drive wheel brake
12/21/79	White smoke pouring from exhaust	No entry	No entry
1/12/80	Transmission linkage still sticks - Adjust brakes and clutch	2/22/80	Replaced clutch plate and pressure plate
3/11/80	Steering wheel is loose - adjust brakes	No date	Mechanic's name entered but no details
4/12/80	Losing air pressure when bus is running	No date	Mechanic's name entered but no details

No deficiencies pertinent to this accident had been reported by the accident bus driver.

The maintenance record for the bus prior to April 1979 had been destroyed by the previous owner as permitted by FMCSR 396.3(d) which requires an owner to retain such records for only 6 months after the vehicle is sold.

Central Texas Bus Lines operates 38 buses and employs 66 over-the-road drivers. The company engages in interstate commerce involving transportation of passengers and general freight under Interstate Commerce Commission (ICC) Docket No. 110688. The company is, therefore, subject to the FMCSR.

From June 24 to June 27, 1980, the U.S. Department of Transportation, Bureau of Motor Carrier Safety (BMCS) Regional Office in Fort Worth, Texas, conducted a safety compliance survey of Central Texas Bus Lines. The survey noted 24 violations of the FMCSR. The company was rated as being in acceptable compliance with FMCSR Part 391, "Qualifications of Drivers," Part 393, "Parts and Accessories Necessary for Safe Operations," and Part 394, "Notification, Reporting and Recording of Accidents." The company was rated as being in "marginal" 1/ compliance with Part 392, "Driving of Motor Vehicles," Part 395, "Hours of Service of Drivers," and Part 396, "Inspection, Repair and Maintenance." No evaluation of the company's compliance with other parts of the FMCSR was made. The survey report noted that Central Texas Bus Lines management had "verbally committed themselves toward more complete compliance with respect to the FMCSR in the future." The survey's overall evaluation of the company's safety compliance was "conditional" 2/ and recommended that Central Texas Bus Lines be resurveyed in 9 months. The last previous compliance survey of the bus company was conducted in 1969.

Vehicle Damage

The front of the bus was crushed rearward and was skewed to the right. The right-front corner was crushed about 4.5 feet rearward. Several panels in the right-front area and both windshields were missing. The right-forward roof structure was displaced about 2 feet inboard and rearward. The center-front and right side of the bus had several semicircular imprints. (See figure 9.)

Sheet metal along the right side of the bus was severely buckled and crushed inward. The passenger loading door had been torn from its supporting structure as it was twisted rearward. All right-side windows were missing, and the window pillars were displaced inward. The roof was buckled inward as much as 2 feet in some locations. Body structural members had been forced rearward and had contacted the outside tire of the right drive axle. The rear window was missing and its frame was distorted. The right taillight assembly was missing.

The suspension and chassis components incurred minimal damage. The displaced steering linkage had punctured the front-axle airbrake reservoir. The transmission-to-axle driveshaft spline had been displaced forward about 6 inches. The air conditioning compressor drive was disconnected.

The forward interior of the bus was severely damaged. The steering column, accelerator, gearshift lever, and clutch had been displaced rearward and were not operable. About three-fourths of the right-side passenger seats and two left-side passenger seats were missing. Rescue personnel had removed some seats during rescue operations, but their recall of specific details was inadequate to differentiate between seats torn loose in the accident and seats removed during rescue operations.

1/ BMCS regulations do not define "marginal" as it applies to the survey results. According to a BMCS official, the dictionary definition of "less than satisfactory" is understood.

2/ BMCS regulations do not define "conditional" as it applies to the survey results. According to a BMCS official, the dictionary definition of "dependent upon some condition" is understood.

Figure 9.--Right-side vehicle damage.

Driver Information

The 60-year-old busdriver was employed by Texas Electric Bus Line in 1950. Texas Electric Bus Line was later purchased by Central Texas Bus Lines, and the busdriver remained with that company. He held a valid Texas chauffeur license which had no restrictions. His Texas driving record 3/ listed three convictions for moving traffic violations, all speeding, on January 14, 1977, August 28, 1977, and December 18, 1979. His employment record showed that he was involved in two minor accidents in 1978 and 1979.

The busdriver held a current medical certificate dated January 25, 1979, as required by the FMCSR. His physical examination report showed no history of cardiovascular disease or other pathological disorders. His vision, without corrective lenses, was 20/50 and 20/40 in the right and left eyes, respectively, but showed correction to 20/30 in both eyes. The busdriver was certificated as qualified only when wearing corrective lenses. Passengers said the busdriver was wearing eyeglasses throughout the trip.

The daily logs show that the driver was on duty for the 7 consecutive days before June 4, 1980, (May 28 through June 3) and had worked 63.4 hours during that period. He logged 11.08 hours on June 3, 1980, 6.35 hours of which were driving. The busdriver's wife stated that he arrived home about 6 p.m. on June 3, 1980, ate a full meal, and went to bed about 10 p.m. She said he normally retired between 9:30 and 10 p.m.

On June 4, 1980, the driver arose at 4:30 a.m., ate breakfast, and left his home about 5:15 a.m. There are conflicting statements concerning his arrival time at the bus terminal; one person said he arrived at 5:30 a.m., while another person stated that he arrived at 6:50 a.m. He departed the terminal about 7:05 a.m. and drove for about 5.5 hours before the fuel pump failed. The trip was delayed 4 to 4.5 hours while the driver located a mechanic, obtained a replacement fuel pump and supervised the pump's installation. The driver then drove about 2 hours until the group stopped 1.5 hours for dinner. The busdriver had been driving about 4.25 hours since the dinner stop when the accident occurred.

The accident occurred at least 18 hours after the busdriver reported for duty. Subtracting the 1.5-hour dinner break, the busdriver had been on duty 16.5 hours or more. During this time, he had been driving about 11.5 hours. The busdriver's 63.4 hours on duty during the 7 consecutive days preceding the beginning of this trip and the 16.5 hours on duty on June 4, 1980, totaled about 80 hours on duty in 8 consecutive days.

The FMCSR restrict the number of hours of service of drivers. Part 395.3(a) states " . . . no motor carrier shall permit or require any driver used by it to drive nor shall any such driver drive more than 10 hours following 8 consecutive hours off duty or drive for any period after having been on duty 15 hours following 8 consecutive hours off duty." Part 395.3(b) states " . . . no motor carrier shall permit or require any driver used by it to be on duty, nor shall any such driver be on duty, more than 60 hours in any 7 consecutive days . . . provided, however, that carriers operating vehicles every day in the week may permit drivers to remain on duty for a total of not more than 70 hours in any period of 8 consecutive days."

3/ The State of Texas purges all entries over 5 years old from all drivers' records.

Furthermore, FMCSR 392.6, Schedules to Conform with Speed Limits, states that: "No motor carrier shall schedule a run nor permit or require the operation of any motor vehicle between points in such a period of time as would necessitate the vehicle being operated at speeds greater than those prescribed by the jurisdiction in or through which the vehicle is being operated." Since the adoption of the national speed limit of 55 mph, the BMCS has interpreted this to set a limitation of about 450 miles per day.

The busdriver's wife said that her husband had not wanted to make this trip but the tour director had called him personally and asked him to do it. The busdriver's wife said that her husband preferred his usual daily routes to charter tours because of the time consumed by the tours.

The busdriver's wife said she thought her husband had driven along Arkansas State Route 7 only once previously--in a private automobile during daylight hours about 2 to 3 years earlier. She could not recall if he had ever traveled the route while driving a bus.

Roadway Information

Arkansas State Route 7 is a north-south primary highway which traverses the State from Louisiana to Missouri. In the accident area, the two-lane asphalt concrete highway carried average daily traffic of 2,155 vehicles in 1979. About 7.3 percent of these vehicles were trucks. The highway had a design speed of 40 mph; the speed limit was 55 mph.

The 20-foot-wide highway was constructed along its present alignment in 1953. It was constructed with 4-foot-wide dirt shoulders. Since that construction, one-half the shoulder width had been stabilized. At the accident site, the right side of the highway was in a cut section where drainage was provided by a 1-foot-wide, 2-foot-deep ditch located 19 feet right of the roadway centerline. Drainage from this ditch ran to the opposite side of the road through a 24-inch-diameter, reinforced concrete pipe under the roadway. The berm created by this diversion was struck by the bus. The ditch at the pipe headwall was 3 feet deep.

The bus ran off the road at the end of a 10-degree left curve. The curve was followed by a 300-foot-long tangent section and then a 30-degree right curve which began 24 feet north of the drainage pipe headwall. There was an 8.42-percent downgrade approaching the 10-degree left curve and a 7-percent downgrade through the short tangent section. Skid inventory data taken on April 25, 1979, at 40 mph on sections of the roadway near the accident site yielded a wet coefficient of friction of 0.52.

The right front-axle and right drive-axle tires of the bus left scuffmarks leading into the ditch. The left front tire scuffmark began 1 foot east of the highway centerline and continued 80 feet onto the shoulder. The mark described an 833-foot-radius arc to the left along the direction of travel. Dual tire scuffmarks were located 2 feet and 3 feet east of the left front scuffmark and began 37 feet before crossing the edgeline and continuing onto the shoulder. A sight line along these scuffmarks opposite to the direction of travel indicated that the bus traveled across the inside of the curve in the southbound traffic lane. The right wheel marks stayed in the ditch up to the berm impact. Fragments of glass and bus body

components were found throughout this distance. There were red paint transfers on rock outcroppings on the embankment. North of the berm were several tire scuffmarks and pavement gouges which went northwest diagonally across the highway. These marks described a slight arc to the left (facing the travel direction). There were no marks beyond the west stabilized shoulder which indicated that the bus vaulted. The front of the bus came to rest 115 feet from and 38 feet below the shoulder.

The accident site was about 2.2 miles north of the hillcrest. (See figure 10.) The State had recently completed construction of a brake check area 0.9 mile north of the hillcrest, but the area was neither marked, signed, nor in use at the time of the accident. The brake check area was to be opened when a vehicle escape ramp under construction 1.1 miles farther north was completed. The ramp was being built on the existing alignment of Route 7, and the roadway had been realigned west of and roughly parallel to the ramp. The detour was opened to traffic the day before the accident. (See figures 11 and 12.)

The profile grade from the hillcrest to the accident site was an average of 6.8 percent descending. The minimum grade, 4.64 percent descending, occurred just before the brake check area. The maximum grade before the highway realignment was 7 percent descending, but the new alignment created an 8.42 percent descending grade approaching the 10-degree curve. The horizontal alignment from the hillcrest to the accident site consisted of numerous curves and tangent sections. The curves ranged in degree of curvature from 2 to 16 degrees. (Profile grade from the accident site northward to Jasper also was an average of 6.8 percent descending but curves were more severe, ranging from 15 to 35 degrees. There was a 35-degree curve before the highway entered Jasper.)

The highway crown at the tangent section of highway at the accident site was 0.033 ft/ft and the maximum superelevation was 0.11 ft/ft. The ratio of the slope into the ditch was 1:4 (horizontal to vertical) which exceeded the existing American Association of State Highway and Transportation Officials (AASHTO)-recommended ratio of 4:1. 4/

Highway striping from the hillcrest to the accident site consisted of reflectorized solid white edgelines on either edge of the pavement and a solid yellow painted centerline. The centerline was broken to permit passing in one direction when sight distance was adequate. The northbound transition into the detour at the escape ramp was marked with intermittent dashes of white reflectorized edgeline and double yellow centerline; both the edgeline and centerline consisted of 15-inch-long dashes placed about 12 feet apart. There were three 7-foot-long by 3-foot-wide arrows of white reflectorized tape on the northbound lane at both the beginning and end of the construction zone.

During the onscene investigation, Safety Board investigators drove the preaccident route of the bus at night to evaluate highway signing. From the point where the bus probably entered State Route 7 at Russellville, there were standard

4/ American Association of State Highway and Transportation Officials, "A Policy on Geometric Design of Rural Highways" (Blue Book), p. 129.

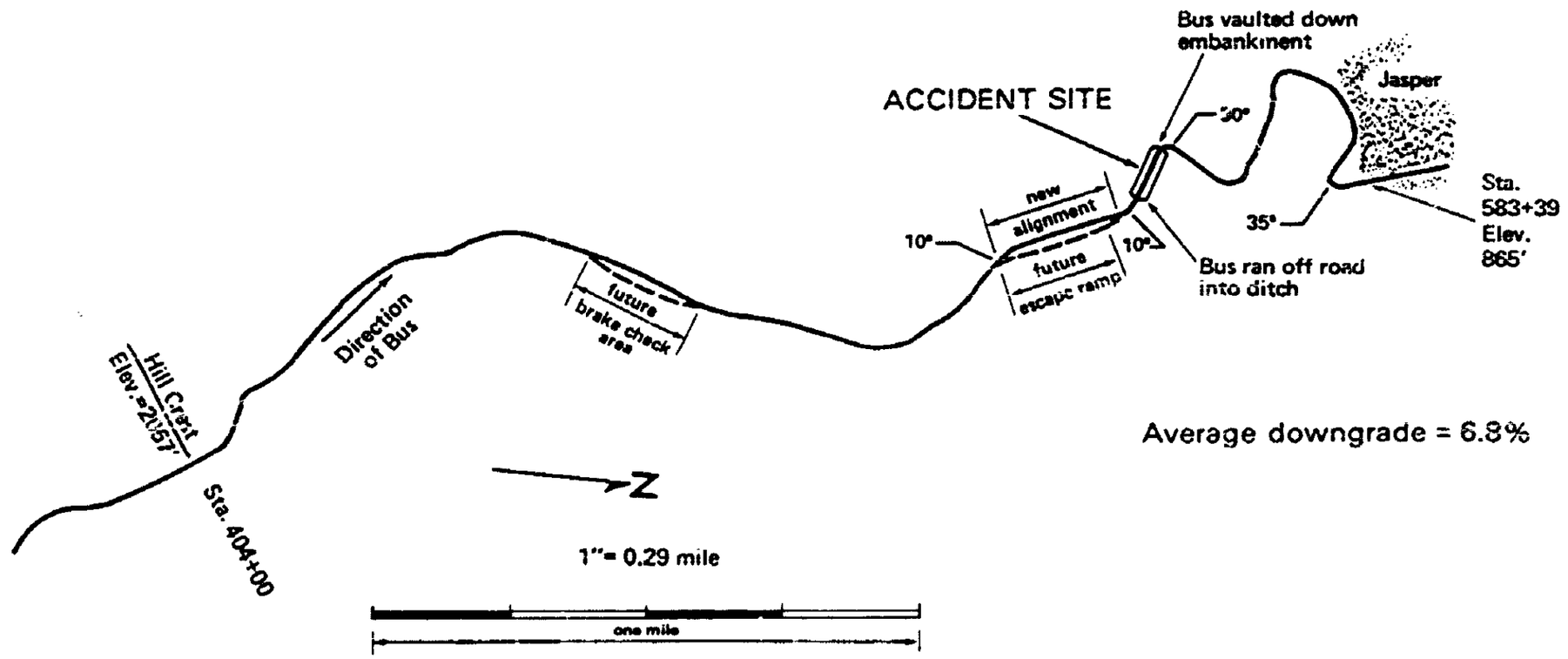


Figure 10.--Plan view of roadway.

Figure 11.--Transition from existing alignment to new alignments. Pavement on right had been removed for construction of escape ramp.

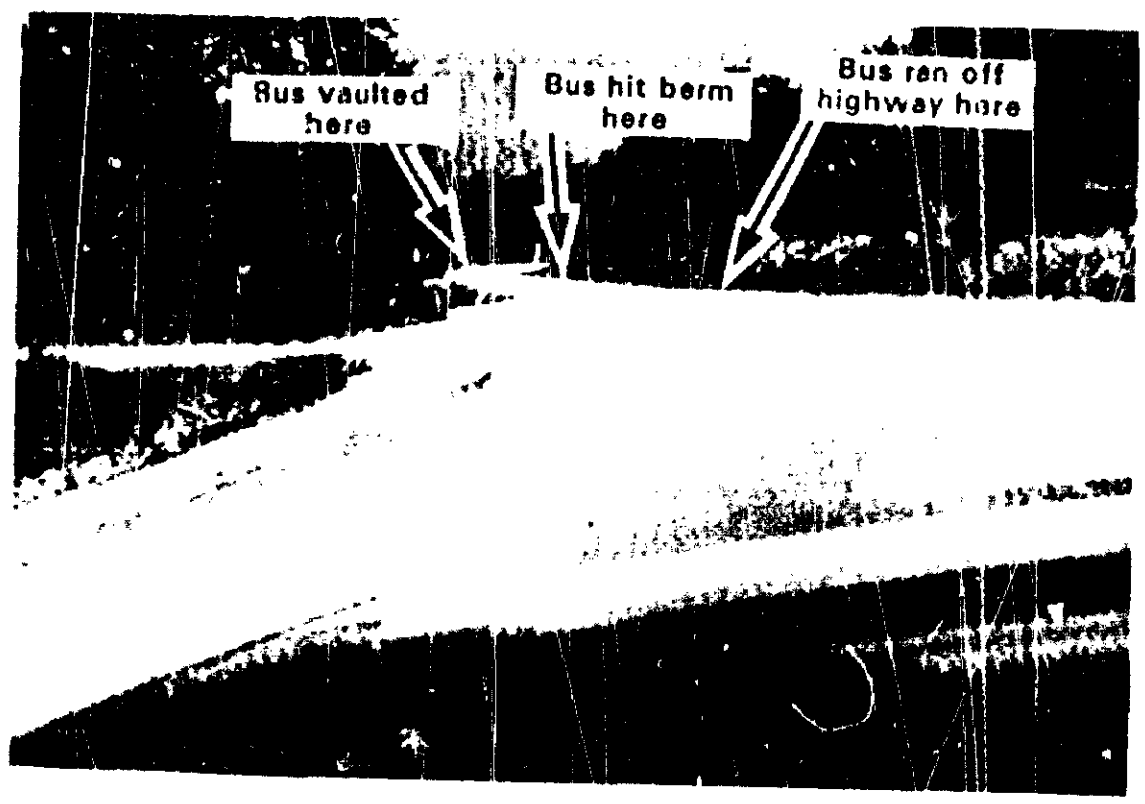


Figure 12 --Transition from new alignment to existing alignment. The hill symbol sign was installed after the accident, replacing a hill message sign which was struck by the bus.

signs all along the highway to warn of grades and curves. In addition, there were signs with special legends, such as "CROOKED AND STEEP NEXT 63 MILES, PASS WITH CARE." From the hillcrest northward to the accident site, there were numerous hill and curve warning signs which were supplemented by additional construction signing. (See appendix B for a list of signs leading to the accident site.) Appropriate advisory speed signs were posted, but no speed limit was posted, thus making the maximum allowable speed limit 55 mph. The investigators reported that the signing became monotonous and that some of the signs did not accurately predict the situations about to be encountered. The brake check area was not completed. It had been paved but was not signed or marked. It was unlikely that a driver would recognize it at night. The signing at the construction zone conformed to the Manual on Uniform Traffic Control Devices (MUTCD).

There was no guardrail on the embankment and none was required under AASHTO guidelines for fill sections and for the general design standards employed on this highway.

Information from the Arkansas State Police at Harrison, Arkansas, and from the Arkansas Governor's Highway Safety Representative through the State Traffic Engineer revealed that there were 11 single-vehicle, ran-off-road accidents involving northbound traffic in the area between the hillcrest and Jasper from January 1, 1976, to December 31, 1978. Ten of these accidents occurred within a 1.5-mile-long area from near the location of the recent escape ramp to the bottom of the hill; five occurred on the 35-degree curve immediately before entering Jasper. Seven of the accidents involved trucks or vehicles towing trailers. Only one involved wet pavement. Of the drivers involved, two were local residents, two lived elsewhere in Arkansas, and six were nonresidents.

Meteorological Information

The temperature was 75° F with 76 percent relative humidity. The dewpoint was 67° F. The wind was out of the southwest at 7 to 8 mph. Weather reporting stations at Ft. Smith, Arkansas (44 miles southwest of Jasper), and Springfield, Missouri (52 miles north of Jasper), reported 100 percent cloud cover with a 25,000-foot ceiling. There was no precipitation and the highway was dry.

Medical and Pathological Information

An autopsy of the busdriver performed by the Arkansas Chief Medical Examiner found the cause of death to be injuries sustained in the accident. The autopsy also revealed that the busdriver had moderate arteriosclerotic cardiovascular disease. Microscopic examination of the heart tissue did not reveal acute myocardial infarction and thrombosis was not noted. Results of alcohol and drug toxicological screens were negative.

The body of the busdriver was refrigerated about 4 hours after the accident. Analysis of a vitreous humor sample, drawn 34 hours after the time of death, showed a glucose level of "7 mg percent which represents hypoglycemia," according to the autopsy report. "Together with the low glucose level, the moderate arteriosclerotic cardiovascular disease cannot be excluded as a human factor in the accident," states the report.

Survival Aspects

The accident sequence lasted for about 5 to 6 seconds after the bus left the road. As the bus scraped along the embankment flanking the ditch, the windshield and right bus windows were shattered causing glass fragments to be propelled into the bus and permitting partial ejection of some occupants. Accelerative forces caused bus occupants to be thrown about within the vehicle.

The bus was subjected to major impacts when it struck the berm and through the ensuing vault. The combination of tree and ground impacts subjected the occupants to both horizontal and vertical loads. Several bus passengers were ejected during and at the end of the sequence. Rescuers stated that several of the occupants who remained in the bus were stacked up in the right-front area of the bus interior.

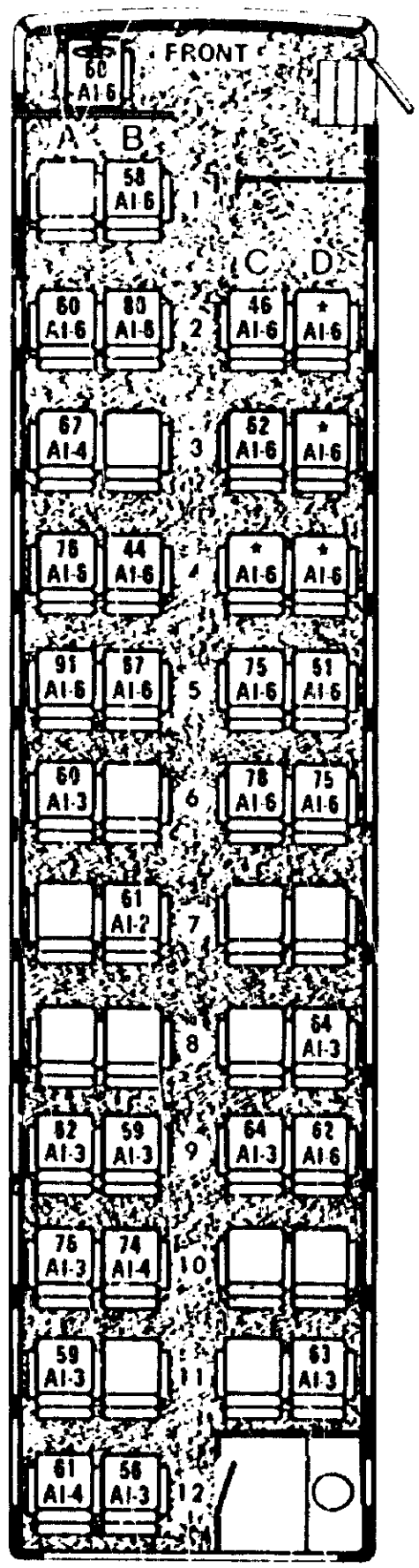
Nearby residents heard the crash and immediately notified the Arkansas State Police. The Boone County Hospital in Harrison, about 20 miles from the accident scene, received the first call for help at 1:10 a.m. Ambulances in the vicinity were dispatched as quickly as they could be contacted. The first of six ambulances arrived at the scene at 1:35 a.m.; the last arrived at 3:15 a.m. Several persons, including two doctors and two nurses, arrived at the scene before the first ambulance arrived. The first ambulance transporting injured bus occupants arrived at the Boone County Hospital at 2:30 a.m. Police reported that all bus occupants had been removed from the scene by 5 a.m. According to rescue personnel, no one who survived the crash died at the scene.

The ages of the bus occupants ranged from 44 to 91 years. (See figure 13 for the age, seat position, and degree of injury to the bus occupants.)

Tests and Research

The type-16 air rotochamber mounted at the right-front wheel of the bus leaked when the airbrake system was charged from 60 to 120 psi during field inspection of the bus. With brakes applied, shoe to drum contact was noted, and the brake slack adjustment was within specifications. To assess the effect of air leakage on the rotochamber's performance, the rotochamber was removed for independent laboratory testing. The Approved Engineering Test Laboratories (AETL) reported its output force tests on the right-front rotochamber, with the actuator set at the 1-inch stroke position as it had been on the bus, to be as follows:

Air pressure (psig)	Actual output force (lbs)	Theoretical output force (lbs)
60	924.9	1,178
90	1,395.0	1,767
120	1,864.0	2,256



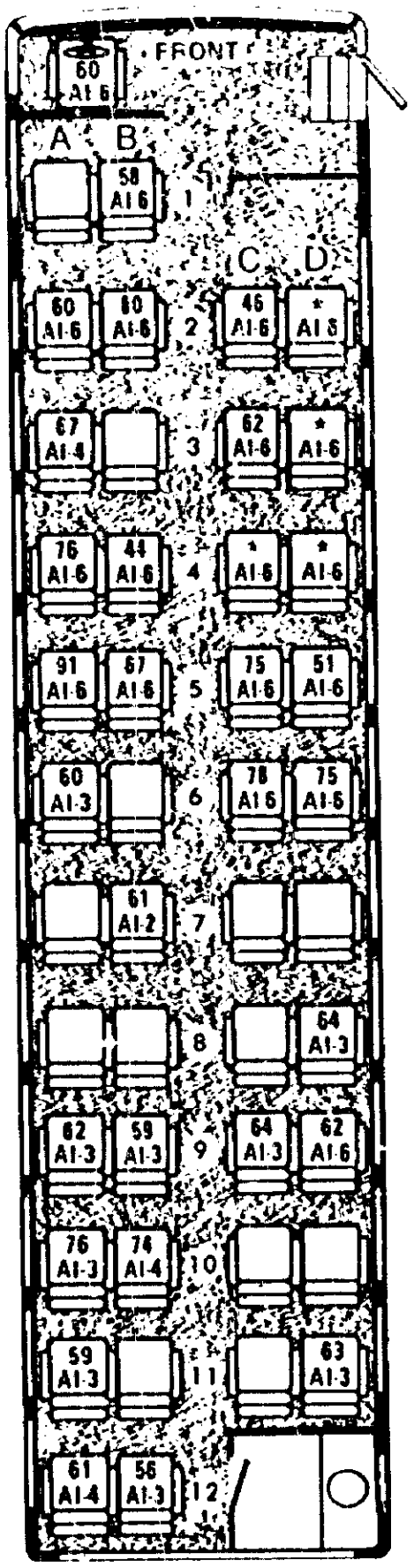
Seated position of one passenger (age unk., AI-6) could not be determined

LEGEND

AIS	Severity Code
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Unsurvivable
9	Unknown
*	Age Unknown

NOTE:
AIS - Abbreviated Injury Scale (AAAM)
AI - Abbreviated Injury

Figure 13.--Bus occupant seating diagram and injury classification.



Seated position of one passenger (age unk., AI-6) could not be determined

LEGEND

AIS	Severity Code
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Unsurvivable
9	Unknown

* — Age Unknown

NOTE:
AIS - Abbreviated Injury Scale (AAAM)
AI - Abbreviated Injury

Figure 13.--Bus occupant seating diagram and injury classification.

The test results indicated that the maximum output force for the air chamber was reduced approximately 21 percent. No air leakage was observed at the zero- and 2-inch stroke mounted positions; however, the shop air compressor had to run continuously at the 1-inch-stroke position to maintain adequate line pressure. The rotochamber was removed from the test fixture and was disassembled to determine the source of the air leak. A small tear, approximately 0.1 inch long, was found in the rubber diaphragm of the rotochamber, which permitted the high-pressure air to escape. (See figures 7 and 8.)

The Safety Board's metallurgical laboratory conducted metallurgy examinations of the fractured metal fitting from the air compressor governor unit on the bus, and the broken fifth and sixth gear return spring from the Spicer transmission on the bus. The laboratory found no evidence of fatigue in the air compressor fitting. Fractures were typical of overload separation and probably were crash-induced. The transmission gear return spring had a 50-percent fatigue fracture. The fracture made over the remainder of the break was overload, stemming from the fatigue crack.

ANALYSIS

The Accident

The horizontal alignment of the roadway from the crest of the hill to the accident site consisted of numerous curves and tangent sections. The curves ranged in degree of curvature from 2 to 16 degrees. The two curves immediately preceding the accident curve were both 10 degrees. While it is clear that the busdriver lost control of the vehicle after cresting the hill, there is insufficient evidence to enable the Safety Board to establish where the loss of control occurred on the 2.2-mile section of roadway traveled by the bus. Similarly, the exact sequence of events, such as brake applications or attempts to downshift, cannot be established. Notwithstanding the degraded brake system on the bus and the driver's failure to complete the downshift, the Safety Board concludes that the busdriver's response to warning signs, roadway geometry, and vehicle acceleration was delayed until the speed of the bus rendered braking ineffective and downshifting virtually impossible.

There were several factors supporting this conclusion. They related to the physical condition of the busdriver, the mechanical condition of the bus, and the driving environment which combined to produce the events which precipitated this accident. The degree to which each factor contributed to the accident cannot be accurately assessed. The speed at which the bus ran off the road, the roadside geometry, and the crash dynamics were all factors that contributed to the severity of the accident.

Busdriver's Physical Condition

The autopsy on the busdriver indicated that he may have been hypoglycemic because of the glucose level found. The pathologist also noted that "together with the low glucose level, the moderate arteriosclerotic cardiovascular disease cannot be excluded as a human factor in the accident." However, autolytic action before the body was refrigerated could have reduced the glucose level in the vitreous by

as much as 50 percent. 5/ Several other factors--bacteria, the presence or absence of preservative chemicals in the sample, and temperature during transfer to the laboratory--also could have affected the results by reducing the glucose level. Therefore, the Safety Board concludes that there is insufficient information to quantify the busdriver's blood-glucose level at the time of the accident or to cite low blood-sugar as a factor in this accident. The busdriver did not have any known history of hypoglycemia.

Arteriosclerotic cardiovascular disease, as diagnosed by the medical examiner, may have affected the busdriver's alertness. Two forensic pathologists consulted by the Safety Board agreed that the cardiovascular problem could have been a factor if the busdriver was physically fatigued. The busdriver had logged 63.4 hours of service in the 7 consecutive days before the accident and had been on duty at least 16.5 hours up to the time of the accident after only 6 hours sleep. The busdriver had been subjected to additional stress as a result of the fuel pump breakdown. The accident occurred about 20 hours after the busdriver had last slept. In the 20 hours, the busdriver had been on duty at least 16.5 hours and had been driving about 11.5 hours. The only respite during those 20 hours was the 1.5-hour dinner stop.

Further, the busdriver's wife stated that her husband usually went to bed between 9:30 and 10 p.m. The accident occurred nearly 3 hours after his usual time for retiring. Leukel 6/ states that there is a high frequency of automobile accidents which occur during hours when the involved driver is usually asleep. He attributes the cause to acute fatigue.

The late hour, the many hours on duty, and the stresses of the day preceding the accident lead the Safety Board to conclude that the busdriver was fatigued. Further, the Safety Board concludes that the fatigue was the predominate factor in the busdriver's reduced alertness and his failure to respond quickly to warning signs, the highway geometry, and vehicle acceleration.

Mechanical Deficiencies

The original fuel pump on the bus was a speed-sensitive, positive-displacement pump that increased fuel volume and pressure to accommodate increased engine loads and speeds. The small electric replacement fuel pump had only 20 percent of this fuel flow capability and could not supply sufficient fuel to the engine.

The probable effects on engine response because of the reduced fuel flow capacity would have been as follows:

a. The engine generally would have run with low power at all speeds. Engine power would have been less at greater than idle speed since the fuel injectors would not have been completely filled during the fuel cy .e. Therefore, the vehicle would have climbed hills slower and taken much longer to reach cruising speeds.

5/ Estimate by Arkansas State Medical Examiner.
6/ Leukel, Francis, Essentials of Physiological Psychology, C.V. Mosby Co., 1978, pp. 183-184.

b. The system would have experienced some problems reaching the proper engine rpm to accommodate downshifting because of the reduced fuel supply and poor engine response.

There was no evidence to indicate that the busdriver had any difficulty shifting gears during the trip before the emergency condition arose. If shift linkage binding did exist, it was overridden by poor engine response and was not a factor in this acident.

The right drive axle wheel brake linings and drum were contaminated by grease, and air leaked from the right-front axle and left tag axle air chambers. Slack adjuster travel on the right drive axle was 0.5 inch more than the recommended 2 inches. The braking force generated by a wheel at the road surface is directly proportional to the coefficient of friction between the brake drum and the lining. Grease contamination on one or both of these items greatly reduces the coefficient of friction. It is estimated that the braking force on this wheel was reduced by 75 percent because of the grease contamination, assuming that all other factors remained unchanged. 7/ The contamination factor coupled with the excessive slack adjustment could have resulted in no braking force at the right drive wheel. Also, the left tag-axle wheel brake drum did not show evidence of recent brake lining contact. Air loss through the 0.3-inch tear in the air chamber diaphragm probably prevented sufficient air pressure in the air chamber to actuate the wheel brake mechanism. Careful examination suggested that the tear existed before the accident.

The deficiencies in the brake system hardware of the bus, lead the Board to conclude that as the downgrade became steeper and as the bus began to accelerate, the braking capacity was not sufficient to prevent the vehicle from accelerating downgrade. The air pressure dropped below 60 psig at some point because the spring brakes had activated, but the Safety Board is not able to determine when or where in the accident sequence the spring brakes activated. None of the passengers reported being aware of any braking forces before the crash.

Delayed responses by the busdriver and vehicle acceleration led to a condition where the driver could not synchronize engine rpm with transmission gears because of inadequate fuel pump performance. The loss of adequate braking capacity was compounded by the busdriver's use of the brakes in attempting to control the vehicle speed. The result was a runaway vehicle over which the busdriver had only steering control. Calculations based on measurements of the scuffmarks indicate that the speed of the bus was about 86 to 93 mph as it ran off the road. This speed exceeded the maximum speed of about 80 mph at which the bus could have negotiated the 10-degree left curve.

Highway

When Arkansas State Route 7 was constructed on its present alignment, it met the AASHTO design criteria for a two-lane, low-type rural highway. Present standards, based on the year 1999 design hour volume of 473 vehicles, would

7/ CRC Handbook of Chemistry and Physics, Chemical Rubber Publishing Co., Student 44th Edition, pp. 2222 and 2223.

suggest upgrading to a high-type 8/ highway with a pavement width of 24 feet and 10-foot-wide shoulders. These standards are often acceptably modified in mountainous terrain, however. 9/

The 2-foot-deep drainage channel on the cut slope side had a side slope ratio of 1:4 (horizontal to vertical) which far exceeded the AASHTO-recommended slope ratio of 4:1. Also, the channel bottom width of 1 foot was less than the recommended bottom width of at least 4 feet. These characteristics, coupled with the narrow, 4-foot-wide shoulder, made this ditch a hazard because the cross section did not permit the busdriver to redirect the errant vehicle back onto the roadway. The channel would be less of a hazard if the side slopes were corrected to conform to AASHTO recommendations.

If the escape ramp had been completed and open for use at the time of the accident, it is possible that the busdriver would have used it. It is estimated that the bus was already out of gear and going at about 80 mph when it passed the entrance to the ramp. The brake check area which the bus passed earlier had been paved but was not signed or marked. It is not known whether the driver was already experiencing difficulty with the bus when he passed the brake check area or if he would have used it. Without signing, however, the area would have been difficult to recognize at night. On July 28, 1980, the Safety Board recommended that the Arkansas State Highway and Transportation Department install signing at and open the brake check area. The Safety Board recommended the installation of additional signs in the brake check area to advise drivers to check their brakes, use low gear, and maintain brake capacity as they continued their descent, and the installation of a diagrammatic sign showing horizontal alignment and length and steepness of grade. Since the accident occurred, the State of Arkansas has installed mandatory brake check signs and changed highway warning signs to include an illustrative sign showing highway geometry. (See appendix C.)

Current FHWA guidelines and the MUTCD do not address the signing and illumination of brake check areas. The standard and MUTCD should be expanded to include positive guidance on these subjects. The "Interim Guidelines for Design of Emergency Escape Ramps" (FHWA Technical Advisory T5040.10) suggest that brake check areas should be at the hillcrests. However, this suggestion is not based on studies or research, and research should be conducted to develop guidelines for optimum location.

In the accident area, Arkansas State Route 7 has a design speed of 40 mph, but because no speed limit was posted, the maximum allowable speed was 55 mph. Since it is almost impossible for any vehicle to travel this and other parts of the roadway at the 55-mph speed limit, studies should be conducted in conjunction with the overall highway improvement program to determine if the overall speed limit should be reduced and, if so, by how much. The following MUTCD guidelines should be considered in establishing a speed zone: 10/

8/ A highway with major arterial highway or interstate characteristics
9/American Association of State Highway and Transportation Officials, "A Policy on Geometric Design of Rural Highways" (Blue Book), p. 261.
10/ "Manual on Uniform Traffic Control Devices," U.S. Department of Transportation, Washington, D.C., p. 2B-6.

1. Road surface characteristics, shoulder condition, grade, alignment and sight distance.

2. The 85-percentile speed and pace speed.

3. Roadside development and culture, and roadside friction.

4. Safe speed for curves or hazardous locations within the zone.

5. Parking practices and pedestrian activity.

6. Reported accident experience for a recent 12-month period.

The MUTCD states that a continuous centerline and edgeline is warranted throughout a detour. Although this was not done at the detour on State Route 7, the 15-inch-long strips of centerline, spaced about 12 feet apart, provided adequate guidance. The pavement arrows at the start and end of the transition provided additional guidance. The lack of a continuous edgeline was not critical but would have provided additional helpful guidance, especially at night.

Crash Dynamics

Calculations indicate that the bus was traveling about 63 mph when it impacted the berm. The bus was traveling about 49 mph as it reentered the pavement and about 45 mph when it launched into the vault. Much of the residual energy was dissipated in the multiple tree impacts which probably mitigated impact forces when the bus landed.

The unyielding roadside features contributed to the accident severity. After exiting the pavement, the right wheels descended the 1:4 slope into the ditch, and the bus immediately tipped onto its right side against the opposite embankment. There was no chance for the busdriver to redirect the bus back onto the highway. The right side of the bus struck rock outcroppings on the embankment about at the window level. Shattered windows, the windshield opening, and the tearing away of the passenger loading door created openings through which some of the bus passengers could have been ejected during the accident dynamics. The energy of the bus required considerable time and distance to be dissipated. This subjected the bus to multiple impacts and sustained deceleration which, in turn, subjected the bus occupants to sustained and fluctuating g-forces beyond human tolerances.

The absence of guardrails is not considered a factor in the severity of this accident. Guardrails presently in use are not designed to redirect vehicles the size of the accident bus, traveling the speed calculated for the bus, or approaching the guardrail at a large angle, as the bus would have if guardrail alignment had paralleled the pavement.

Safety-Related Factors

The day the charter tour began was the busdriver's eighth consecutive day on duty. Inasmuch as he had already logged 63.4 on-duty hours, he had only 6.6 hours

of on-duty time available before being in violation of FMCSR 395.3(b). The tour plan called for the bus to travel from Dallas to Branson, a distance of over 500 miles, in 1 day. The trip obviously could not have been completed in 6.6 hours or less, or within the 10-hour authorized driving time. Therefore, the Safety Board concludes that both the busdriver and Central Texas Bus Lines should have realized that they would be in violation of the FMCSR and, further, that the the busdriver should not have begun, nor have been permitted to begin, this charter tour.

When the tour group stopped at the Queen Wilhelmina Campground for dinner at 7 p.m., the busdriver, realizing that he was already in excess of his total hours on duty, and that he could not reach Branson before being in excess of his 15 hours on duty and 10 hours driving time, should have refused the tour director's decision that they proceed to Branson. If the tour group had remained overnight as the busdriver and some passengers wanted, the busdriver would have been refreshed and would have traversed the steep winding hills in the daylight on the following day. This may have prevented the accident.

The safety compliance survey of Central Texas Bus Lines conducted by the BMCS revealed that the bus company was marginal in its attention to the FMCSR relating to vehicle maintenance, driver hours of service, and the safe operation of motor vehicles. The record of driver complaints and sporadic repairs indicate that the accident bus was probably subjected to maintenance only when required by a breakdown. The discrepancies in the bus brake system--improperly adjusted slack adjusters, contaminated brake linings, and substantial air leaks from wheel chambers--should have been detected and repaired during routine inspection and maintenance. While it is possible that one or more of the discrepancies may have occurred shortly before or during the charter trip, others were of a longer term nature and should have cued maintenance personnel to the need for a thorough inspection of the brake system. The BMCS compliance survey has called these failures to the attention of the Central Texas Bus Lines management and elicited verbal commitments toward stricter compliance. The Safety Board agrees with the BMCS that a followup survey is indicated and encourages the BMCS to ensure that management, maintenance personnel, and drivers employed by Central Texas Bus Lines fully comprehend and come into full compliance with all facets of the FMCSR.

The management decision to replace the fuel pump with a nonstandard fuel pump and for the bus to continue to its destination was ill-advised because it was made without all of the facts being considered. The bus was domiciled and chartered out of Dallas but the Vice President and General Manager making the decision was headquartered in Waco. He was not aware of the drivers' hours of service limitations nor did he know the route the bus was going to follow to reach its destination. Both the Vice President and General Manager and the busdriver either neglected to consider or ignored the impact the delay caused by the repairs would have on the busdriver's already extended hours on duty and the adverse effect the long hours on the road before reaching the destination would have on the busdriver's physical alertness and driving ability. At the time the bus broke down, the driver had already been on duty 5 1/2 hours and driving for 5 hours. He had only 1 hour available to complete his 70-hour aggregate time on duty for an 8-day period and 5 hours to complete the 10-hour driving limitation as established by the

FMCSR. By the time the repairs were completed, the busdriver had been on duty 10 hours. Seven hours later he was still on duty and driving when the accident occurred.

It could not be determined if either the Vice President and General Manager in Waco or the busdriver were technically capable of anticipating the effect the nonstandard fuel pump would have on the operational efficiency of the bus traveling in the mountainous terrain. The Vice President and General Manager was not aware of the route the bus would travel nor did he inquire. Management has this responsibility and should have considered all aspects of the operation before making such a decision. The decision ultimately contributed to the busdriver's fatigue and reduced attention to his driving tasks which resulted in the circumstances causing the accident.

There were no standard fuel pumps available near where the bus broke down. The bus should have remained immobile until a standard fuel pump was obtained and installed or until another bus was dispatched to take the tour. Consideration of the comfort and convenience of the 32 passengers, many of whom were elderly, may have been a factor in the decision to use the nonstandard electric fuel pump and continue the trip.

Brake Check Areas

Because of previous accidents on this hill, an escape ramp was being constructed 1,000 feet south of the accident site. A brake check area 1 mile north of the summit was not signed or marked. The signing planned for the brake check area was to have been advisory but was made mandatory as a result of a recommendation made by the Safety Board. The MUTCD does not recommend any specific signing for brake check areas, and practices throughout the country vary. National standards for such signing should be established.

The location of the brake check area (turnout or pull-off area) 1 mile past the crest of the hill is not in accord with the general recommendations of the MUTCD or the "Interim Guidelines for Design of Emergency Escape Ramps" (FHWA Technical Advisory T5040.10) which suggests that it should be at the hillcrest. Again, practice varies throughout the country and it has not been positively shown that brake check areas should be at a hillcrest. Research should be accomplished to develop guidelines for optimal location.

Brake check areas and escape ramps are generally not lighted. The "Interim Guidelines for Design of Emergency Ramps" states that illumination is desirable for the ramp and its approach; however, no mention is made of brake check areas. The Safety Board believes that better usage of brake check areas would result if they were illuminated. Lighting would be especially desirable if diagrammetric signing of the hill is installed in these areas.

CONCLUSIONS

Findings

1. The busdriver's response to warning signs, roadway geometry, and vehicle acceleration was delayed until the speed of the bus rendered braking ineffective and downshifting virtually impossible.

2. Fatigue was the predominant factor in the busdriver's reduced alertness and his failure to respond promptly to warning signs, the highway geometry, and vehicle acceleration.

3. The speed at which the bus ran off the road, the roadside geometry, and the crash dynamics were all factors that contributed to the severity of the accident.

4. There is insufficient information to quantify the busdriver's blood-glucose level at the time of the accident or to cite low blood-sugar as a factor in this accident.

5. Arteriosclerotic cardiovascular disease may have affected the driver's alertness.

6. The nonstandard fuel pump installed on the bus during the trip could not supply sufficient fuel to the engine.

7. The braking force on the right drive-axle wheel was reduced by 75 percent because of grease contamination on the brake linings and drum.

8. The contamination factor coupled with excessive slack adjustment could have resulted in no braking force at the right drive wheel.

9. Air loss through a preexisting 0.3-inch tear in the air chamber diaphragm on the left tag-axle wheel probably prevented sufficient air pressure in the air chamber to actuate the wheel brake mechanism.

10. Because of the deficiencies in the brake system of the bus, the braking capacity was not sufficient to prevent the vehicle from accelerating downgrade.

11. Delayed responses by the busdriver and vehicle acceleration led to a condition where the driver could not synchronize engine rpm with transmission gears because of inadequate fuel pump performance.

12. The loss of adequate braking capacity was due to the busdriver's use of the brakes in attempting to control the vehicle speed.

13. The drainage channel was a hazard because the cross section did not permit the busdriver to redirect the errant vehicle to the roadway.

14. When drivers who are unfamiliar with the roadway reach the hillcrest 2.2 miles south of the accident site, they may not be adequately notified about the highway situation ahead.

15. The bus was moving at a calculated speed of 86 to 93 mph when it ran off the road. This speed exceeded the maximum speed of about 80 mph at which the bus could have negotiated the 10-degree left curve.

16. The absence of guardrails is not considered a factor in the severity of this accident.

17. The busdriver and Central Texas Bus Lines should have realized that dispatching the busdriver on this charter trip would lead to a violation of FMCSR 395.3(b) regarding the driver's on-duty hours during the charter trip.

18. The discrepancies in the bus brake system should have been detected and repaired during routine inspection and maintenance.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was a combination of circumstances which resulted in the driver's inability to control the bus as it descended a steep, winding grade. These circumstances included driver fatigue, reduced fuel flow from a nonstandard fuel pump which adversely affected the busdriver's ability to downshift, and the improperly maintained airbrake system. Contributing to the accident was the management decision which permitted dispatching of a driver with inadequate time to complete the trip within permissible hours and the carrier's inadequate preventive maintenance program for this bus.

RECOMMENDATIONS

During its investigation of this accident, the National Transportation Safety Board recommended, on July 28, 1980, that the State of Arkansas:

Install signing on State Route 7 that requires northbound trucks, buses, and cars with trailers to pull off and check their brakes at the brake check area south of Jasper. (Class I, Urgent Action) (H-80-45)

Install a sign(s) in the brake check area to inform the drivers of these vehicles of the roadway alignment ahead. The sign(s) should include percentage of grades, length of grades, horizontal curvature, maximum safe speeds, and other pertinent information which will aid motorists to safely negotiate the roadway ahead. (Class I, Urgent Action) (H-80-46)

On September 2, 1980, the State of Arkansas informed the Safety Board that these recommendations had been complied with on August 27, 1980. (See appendix C.) Because of the amount of information to be listed on the sign suggested by recommendation H-80-46, the State chose the message "Highway 7 Very Crooked and Steep Next 2 Miles" in lieu of listing specific grades and curvature. Also, all signs on this section of Highway 7 have been replaced and the escape ramp has been opened.

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

—to the State of Arkansas:

Correct the drainage channel hazard at the accident site and, whenever feasible, take action to ensure that all highway drainage channels conform to the recommendations of the American Association of State Highway and Transportation Officials. (Class II, Priority Action) (H-81-10)

--to the Federal Highway Administration:

Develop national standards for the signing of brake check areas. (Class II, Priority Action) (H-81-11)

Conduct research to develop guidelines for the location and illumination of brake check areas. (Class II, Priority Action) (H-81-12)

--to the Bureau of Motor Carrier Safety:

Maintain strict surveillance of the Central Texas Bus Lines, Inc., operations and maintenance procedures to ensure that all facility survey deficiencies are corrected. (Class I, Urgent Action) (H-81-13)

Issue an ON GUARD Bulletin, with emphasis on distribution to charter bus companies, outlining the particulars of this accident relating to drivers' hours of service and other safety-related matters, and recommending that charter bus contracts include a statement that all tours will be restricted on a daily basis to the mileage that can be safely traveled at legal speeds and within the authorized 10-hour driving time. (Class I, Urgent Action) (H-81-14)

Give appropriate consideration to the identification of violations and enforcement of the Federal Motor Carrier Safety Regulations pertaining to Hours of Service of Drivers, Maintenance of Vehicles, and other carrier safety matters in developing the annual BMCS Work Schedule. (Class II, Priority Action) (H-81-15)

—to the National Tour Brokers Association:

Inform member tour brokers of the particulars of this accident and encourage them in their contract negotiations with passenger carriers who have Interstate Commerce Commission operating authority to emphasize the importance of the carrier's compliance with all safety regulations. (Class II, Priority Action) (H-81-16)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PATRICIA A. GOLDMAN
Member

/s/ G. H. PATRICK BURSLEY
Member

January 21, 1981

APPENDIX A

INVESTIGATION

1. Investigation

The National Transportation Safety Board was notified of the accident at 5:30 a.m. on June 5, 1980. An investigative team from Washington, D.C., arrived at the accident scene at 11 p.m. on June 5, 1980. The Investigator-in-Charge was on temporary duty in Kansas City, Missouri, and arrived at the accident scene at 2:30 p.m. on June 5, 1980. Representatives of the Bureau of Motor Carrier Safety, Arkansas State Police, Arkansas State Highway and Transportation Department, Newton County Sheriff's Office, Eagle International, Inc., and Dana Corporation (Spicer Transmission Division) participated in the investigation. Smith's Transfer Corporation in Harrison, Arkansas, provided facilities for the postaccident bus inspection.

2. Deposition/Hearing

There were no depositions or hearings held in connection with this investigation.

APPENDIX B
SIGNING

Advance signing for northbound traffic for the hill and the construction site in place at the time of the accident were as follows:

Distance in miles from the accident site	Sign legend (*denotes construction signing)	Remarks
2.72	STEEP GRADE TRUCKS 15 MPH NEXT 3 1/2 MILES	located on both sides of the highway
[2.51]		[rumble strips]
2.50	VERY CROOKED AND STEEP NEXT 3 1/2 miles TRUCKS 15 MPH	located on both sides of the highway
2.45	Left Curve sign	
2.36	HILL TRUCKS USE LOWER GEAR TRUCKS 15 MPH	
[2.35]		[crest of hill]
2.30	Winding Road sign with 35 mph advisory plate	
2.07	HILL 3 MILE GRADE TRUCKS USE LOWER GEAR TRUCKS 15 MPH	
2.30	Right Curve sign with 40 mph advisory plate	
1.80	Winding Road sign with 40 mph advisory plate	
1.65	*ROAD CONSTRUCTION 1,500 FEET	Mounted on barricade
1.60	*ROAD CONSTRUCTION 1,000 FEET	Mounted on barricade

APPENDIX B

1.50	Right Curve sign with 50 mph advisory plate	
1.49	ROAD CONSTRUCTION 500 FEET	Mounted on barricade
[1.48]		[rumble strips]
1.44	VERY CROOKED AND STEEP NEXT 2 1/2 MILES TRUCKS 15 MPH	
1.41	*ROAD CONSTRUCTION 2 MILES	Mounted on barricade
1.24	VERY CROOKED AND STEEP NEXT 2 MILES TRUCKS 15 MPH	Located on left side of the highway
1.18	HILL 2 MILE GRADE TRUCKS USE LOWER GEAR TRUCKS 15 MPH	
1.05	Large Arrow sign (left)	Mounted on barricade. Temporary sign for an eroded slope.
0.90	Left Curve sign with 45 mph advisory plate	
0.65	Reverse Curve sign with 40 mph advisory plate	
0.48 to 0.40	*5 barricades	Left side was on a horse. ~~Right~~ side is at grade.
0.42	*DETOUR *Large Arrow (left)	Mounted on barricade
0.41	*ROAD CLOSED	Mounted on barricade
0.40	*2 vertical panels	
0.32	Left Curve sign with 20 mph advisory plate	Mounted to right of escape ramp

APPENDIX B

0.28	VERY CROOKED AND STEEP NEXT 1 1/2 MILES TRUCKS 15 MPH	Mounted on right of escape ramp
0.23 to 0.15	*6 vertical panels 2 barricades	Left side of barricade was on a horse; right side was at grade.
[0.14]		[end of construction]
0.11	U Turn Sign with 25 mph advisory plate	
0.08	HILL 1 MILE GRADE TRUCKS USE LOWER GEAR TRUCKS 15 MPH	The sign was demolished by the bus.
--	END CONSTRUCTION	
--	Large Arrow sign (right)	Left side of road just north of point where bus went over embankment.

APPENDIX C

RESPONSE FROM THE STATE OF ARKANSAS

ARKANSAS
STATE HIGHWAY COMMISSION

HENRY GRAY, DIRECTOR
P O BOX 2261
LITTLE ROCK, ARKANSAS
72203

September 2, 1980

Mr. James B. King
Chairman
National Transportation Safety Board
Washington, D. C. 20594

Dear Mr. King:

This is to advise that safety recommendations H-80-45 and 46 as submitted in your letter of July 28, 1980, were completed August 27, 1980. Due to the amount of information listed on the sign for H-80-46, we used the message "Highway 7 Very Crooked and Steep Next 2 Miles" in lieu of listing specific grades and curvature. Enclosed are photographs of the installed signs. In addition, all signs on this section of Highway 7 have been replaced and the escape ramp has been opened.

If additional information is needed, please advise.

Yours truly,

Henry Gray
Director of Highways
and Transportation

Enclosures

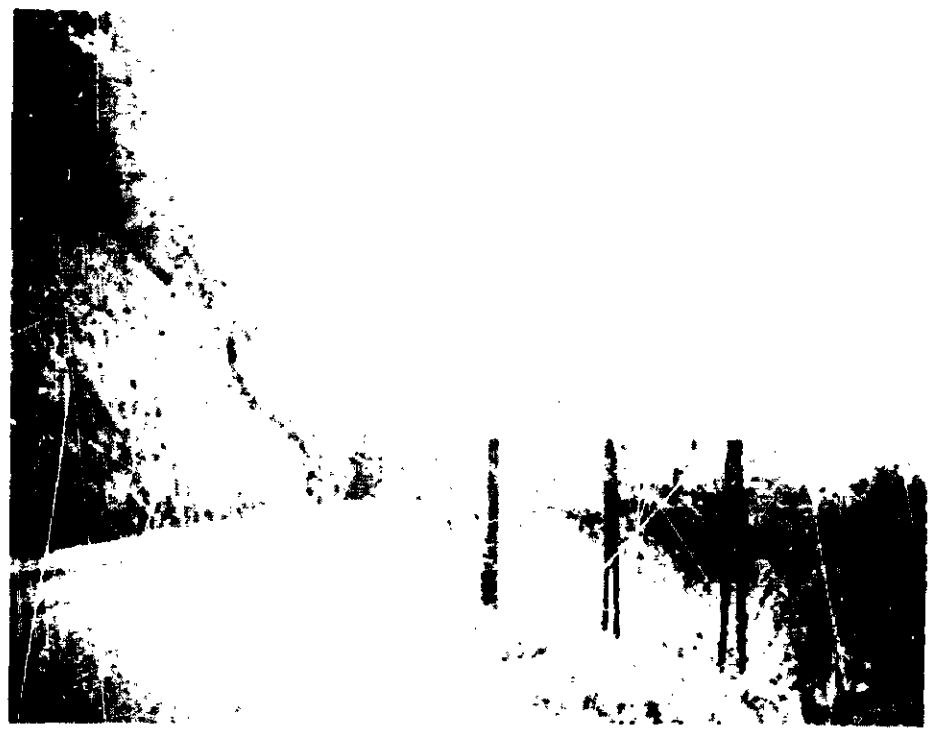


Figure C1.—Brake check area signing.

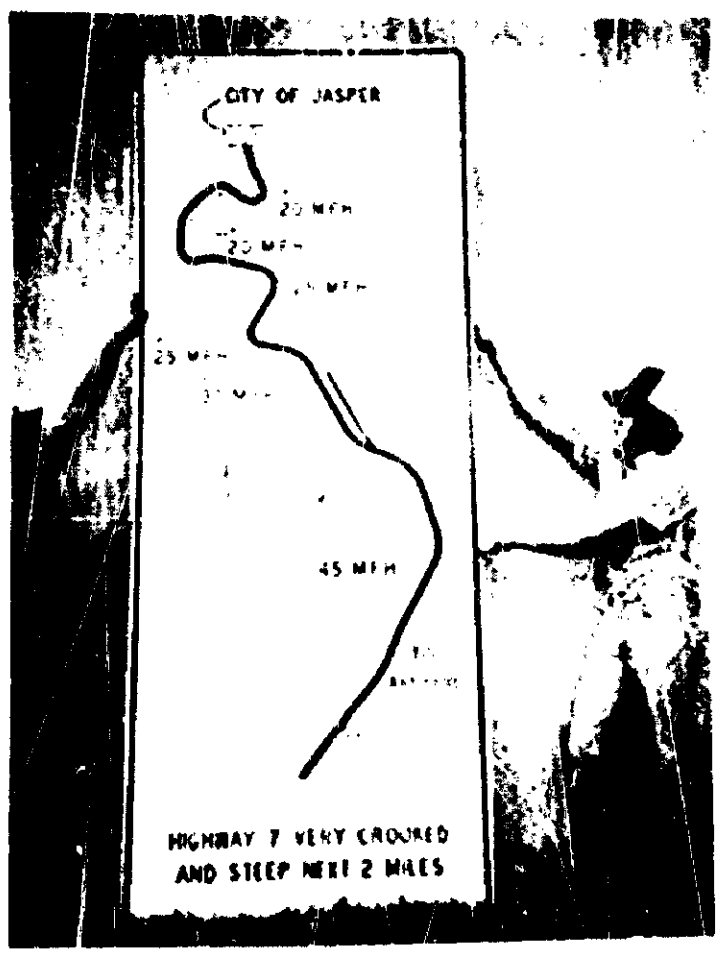


Figure C2.—Diagrammatic sign at brake check area.

*U.S. GOVERNMENT PRINTING OFFICE: 1981-0-341-030/10