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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

HIGHWAY ACCIDENT REPORT

SISKIYOU UNION HIGH SCHOOL DISTRICT SCHOOLBUS/AUTOMOBILE COLLISION AND ROLLOVER, I-5, ASHLAND, OREGON

MAY 9, 1975

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16. Abstract

On May 9, 1975, a 1972 schoolbus carrying 20 persons crashed through a section of guardrail on the northbound portion of Interstate 5 in Ashland, Oregon. The vehicle fell down a steep slope and rolled about its longitudinal axis before it came to rest in an upright position about 213 feet from the edge of the pavement. Except for one sidepost-roof bow connection, the roof separated from the bus body. Nineteen of the 20 occupants were ejected through the gap created by the roof separation. Of the 19 occupants ejected, 3 were killed and 15 were injured. The only occupant who remained in the bus was not injured.

The National Transportation Safety Board determines that the probable cause of this accident was: (1) The failure of the schoolbus driver to select the proper gear to descend the steep grade, and (2) the maladjustment of the brakes on the bus.

As a result of its investigation of this accident, the National Transportation Safety Board made recommendations to the National Highway Traffic Safety Administration and to the State of California.

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FOREWORD

This report is based upon an investigation by the National Transportation Safety Board under the authority of the Independent Safety Board Act of 1974. The Safety Board was assisted in its investigation by the U.S. Department of Transportation, the California Highway Patrol, the Oregon State Police, and the Sheller-Globe Corporation.

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NATIONAL TRANSPORTATION SAFETY BOARD
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HIGHWAY ACCIDENT REPORT

Adopted: January 7, 1976

SISKIYOU UNION HIGH SCHOOL DISTRICT SCHOOLBUS/AUTOMOBILE COLLISION AND ROLLOVER, I-5 ASHLAND, OREGON MAY 9, 1975

SYNOPSIS

On May 9, 1975, a 1972 schoolbus carrying 20 persons crashed through a section of guardrail on the northbound portion of Interstate 5 in Ashland, Oregon. The vehicle fell down a steep slope and rolled about its longitudinal axis before it came to rest in an upright position about 213 feet from the edge of the pavement. Except for one sidepost-roof bow connection, the roof separated from the bus body. Nineteen of the 20 occupants were ejected; 3 were killed and 15 were injured. The only occupant who remained in the bus was not injured.

The National Transportation Safety Board determines that the probable cause of this accident was: (1) the failure of the schoolbus driver to select the proper gear to descend the steep grade, and (2) the maladjustment of the brakes on the bus.

FACTS

The Accident

On May 9, 1975, at 10:40 a.m., a Siskiyou Union High School District (California) schoolbus left Mount Shasta, California, on a school-sponsored field trip to Brookings, Oregon. The bus traveled north on Interstate 5 (I-5) for about 50 miles before reaching the California-Oregon border and the beginning of a 5-mile steep climb to the Siskiyou Summit. Two passengers stated that the driver had difficulty down-shifting at least twice. No other passengers interviewed had noticed that the driver had had any difficulty with shifting.

It was reported that on the ascent to the summit, the bus was in third gear and in the low range of the 2-speed rear axle, and traveling at an estimated speed of 25 to 35 mph. The bus crested the upgrade and began its travel across the relatively flat summit in fourth gear and in high range.

The driver entered the 7-mile downgrade without downshifting and used the air-actuated brake system heavily to control the speed of the bus by continually pumping the brake pedal. Shortly after the bus began its descent, the driver pushed the 2-speed rear axle button into the low-range position. She depressed the clutch pedal, eased off the accelerator pedal, and released the clutch pedal. Passengers in the bus heard "chattering" sounds, indicating that the rear axle did not engage. The driver, who probably recognized that the rear axle did not shift, pulled the rear axle button back out. She repeatedly applied the brake pedal and simultaneously attempted to shift the transmission into third gear; she was unsuccessful, so she returned the shift lever to the fourth gear position. Each time she attempted to downshift, the passengers heard the sounds of the gears clashing beneath the bus.

About 2 1/2 miles into the downgrade, the buzzer and light, which indicated that the service brake system was experiencing low air pressure, activated. The driver reacted by applying the brakes. She pumped the pedal twice and it depressed to the floor. She continued to pump the pedal as she attempted to force the gear shift lever into the third position. The passengers heard grinding noises. The gear shift lever reportedly remained in the neutral position. When she released the clutch pedal, the buzzer and light, which indicated low oil pressure, activated.

The driver flicked the ignition switch off and on. Both lights and buzzers deactivated while the ignition switch was off. Only the low air pressure warning devices reactivated as the ignition was returned to the "on" position.

Some passengers saw the driver pull out the emergency/parking brake handle, but others did not. There was no feeling of deceleration in the bus.

As the driver continued her attempts to control the vehicle, she called out, "We have no brakes, we have no gears, we have nothing." A teacher in the rear of the bus immediately ordered the students to get down on the floor, which they did.

As the bus continued to descend through a series of curves, the driver repeatedly attempted to shift gears while steering the bus and blowing the horn. She did not make use of any of the bus' lights.

Vehicles ahead moved to the right and out of the path of the unrestrained bus. The bus appeared to accelerate and rock back and forth as it rounded the curves and moved through a construction zone

on the highway. The driver managed to steer the bus successfully through the curves. When the bus approached a rest area about 5 1/2 miles from the summit, (See Figure 1.) its speed is estimated to have been 70 mph. 1/

The bus began to gain on an automobile ahead in the left lane which was traveling at 60 mph. Another automobile was in the right lane and somewhat ahead of the car in the left lane. The busdriver repeatedly blew the horn, but neither automobile responded. The driver of the automobile in the left lane stated that she had her windows rolled up and neither she nor her passenger heard the horn. She said that the heater was in use but the radio was not.

The bus struck the automobile in the left lane. The front wheels of the bus overrode the trunk of the automobile. The entangled vehicles continued north for about 275 feet. The vehicles disengaged and the automobile spun clockwise toward the east edge of the roadway. The automobile rotated 180° clockwise and ended up parallel to and against the curb, facing south. It then moved north along the curb and stopped. (See Figure 2.)

The bus moved to the left, struck the median guardrail, and arced toward the east edge of the roadway. The right front of the bus struck the guardrail and curb. The bus was airborne before crashing down the side slope, which had a downgrade of 49 percent at this point. The bus rolled over twice and traveled 213 feet before stopping. (See Figures 3 and 4.) The front axle of the bus had disengaged from the chassis and the roof assembly had separated from the body of the bus. All but one passenger of the schoolbus were ejected. The driver, who was not wearing her seatbelt, was ejected. Three persons including the driver died and 15 others were injured. There was no fire.

Postcrash Activities

Activities at Accident Site -- The local fire department arrived 10 minutes after the crash and began to assist passengers. The state police and ambulances arrived soon thereafter. The injured were transported to hospitals in Ashland and Medford, Oregon.

An insurance adjustor arrived on the scene 1 1/2 hours after the crash. He observed that the bus ignition was in the "on" position, that the transmission gearshift lever was in neutural, that the 2-speed

1/ Estimates of witnesses who observed the bus from various locations in the rest area.

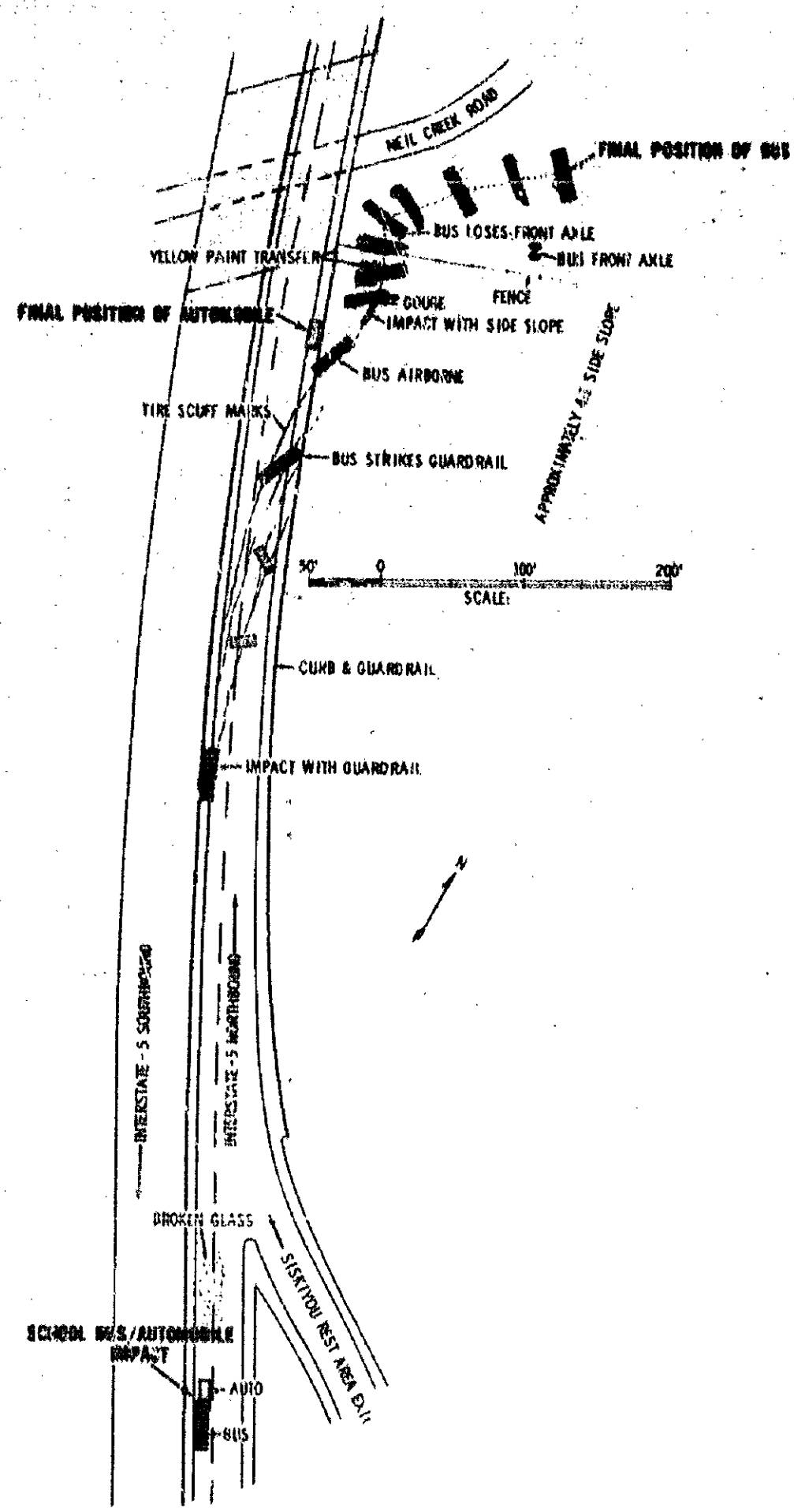

Figure 1. Schoolbus/Automobile collision and Rollover, Ashland, Oregon, May 9, 1975

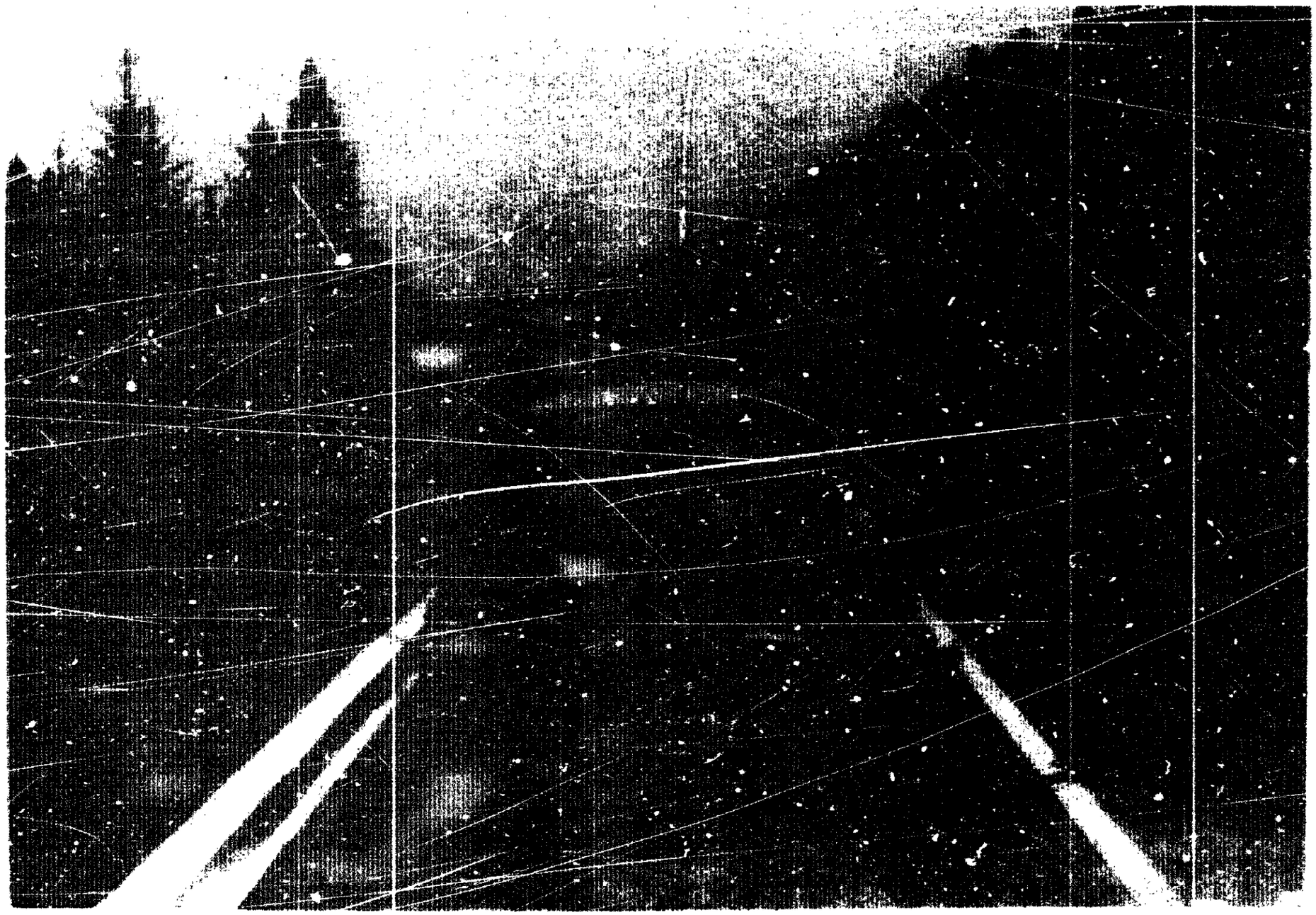

Figure 2. Final position of automobile.

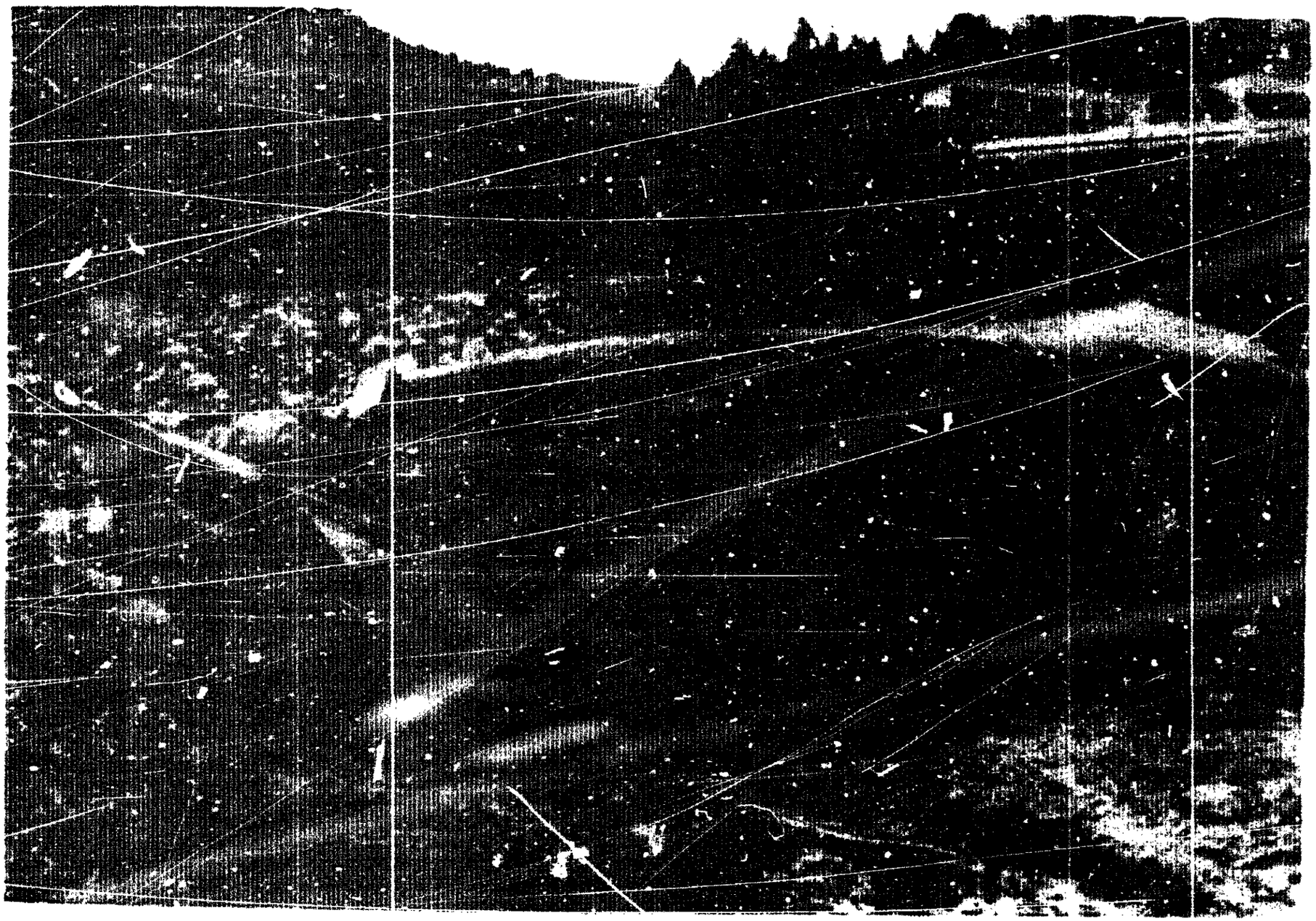

Figure 3. Final position of schoolbus.

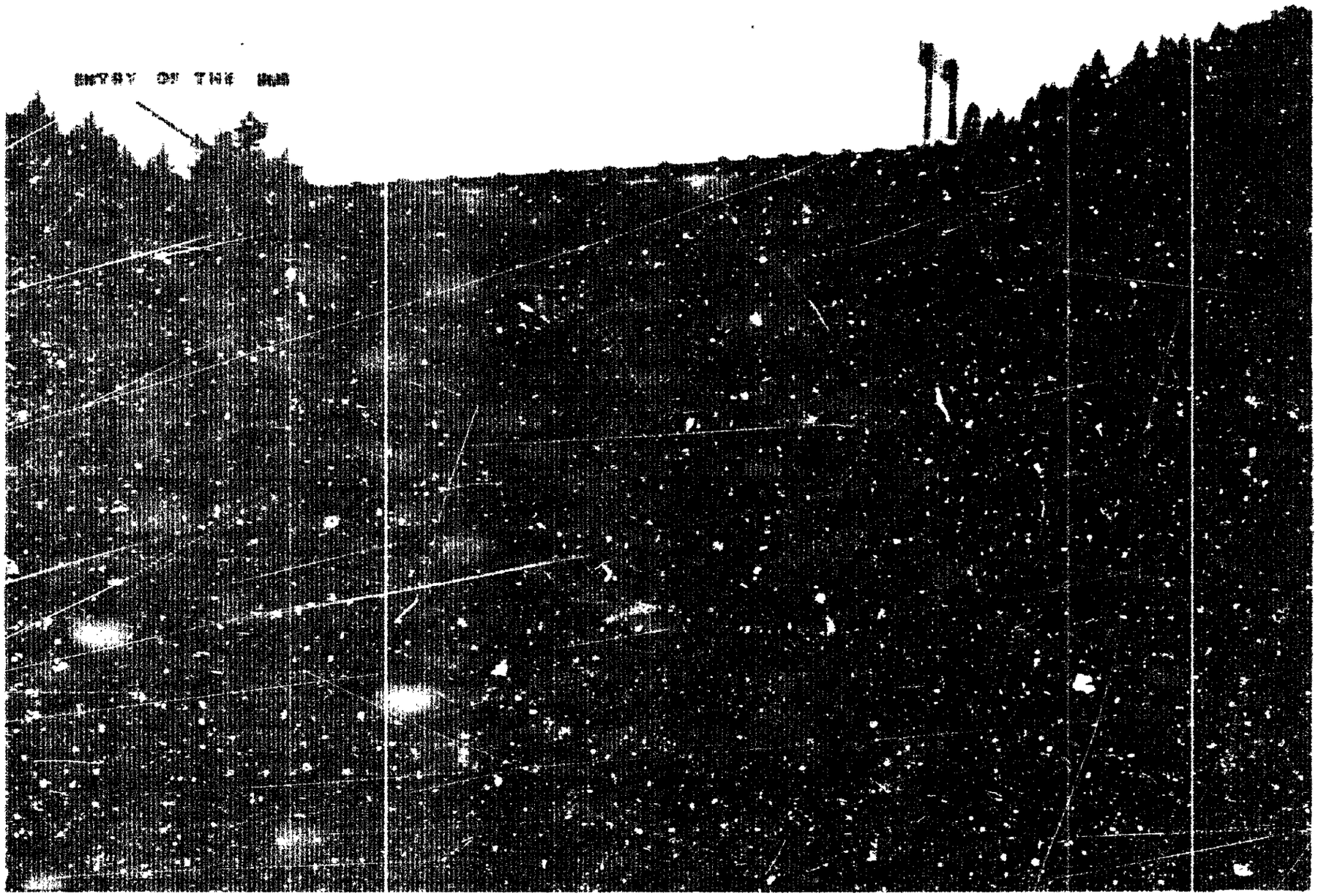

Figure 4. View of the side slope from the point of rest of the schoolbus. Note (arrows) the gouges on the slope.

rear axle button was in the low-range position (even though a passenger stated that the driver's last action with the button was pulling it back into the high-range position), and that the emergency/parking brake handle was in the "off" position. He stated that he manipulated both the gearshift lever and the emergency/parking brake handle. He pulled the brake handle out momentarily and pushed it back in. He heard no sounds to indicate that the system was operative. The air reservoir for the emergency/parking brake was found to be without air at a later inspection.

When a tow truck started to pull the bus from its rest position, the operator noticed that the rear wheels were not rolling. The tow truck operator checked the wheels and found that they were locked. To unlock the wheels, he backed off on the brake's slack adjuster. Consequently, any determination of the precrash adjustment of the brakes on the rear wheels was negated.

Police on the scene did not determine the brake adjustments on the rear wheels of the bus.

The bus was removed to Medford. The roof of the bus was disconnected from its one remaining attachment and was dragged on its top up the rocky slope before being removed from the site.

Inspection of Schoolbus -- A postcrash inspection of the mechanical components critical to safe operation of the bus was conducted the day after the accident by representatives of the California Highway Patrol, the Federal Highway Administration Bureau of Motor Carrier Safety (BMCS), and a National Highway Traffic Safety Administration (NHTSA) Multidisciplinary Accident Investigation Team.

The inspection revealed that the primary damage to the bus' structure was the separation of all but one of the left sideposts, and the total separation of all right sideposts from their attachments with the roof assembly. Although the roof came off, the roof assembly remained essentially intact. (See Appendix A for additional details on crash damage.)

The inspection also revealed that the air compressor was in working order, that the air lines and tanks were without leaks, and that the emergency/parking brake was intact and operable. The clutch was in working condition. Proper operation of gauges and warning devices was verified. The postcrash inspection of the rear axle's transmission and gear box showed no unusual damage to their components.

Because of crash damage and because the operator of the tow truck had changed the adjustment of the rear brakes, their adjustment at the time of the accident could not be determined. However, the right rear and right front wheels were pulled and the brake drums and lining examined.

The drum surfaces were unscored and in good condition, and the brake linings were unglazed. The brake lining thickness on the right front wheel measured 3/8 to 7/16 inch (original thickness was 1/2 inch) and the right rear linings measured 11/16 inch (original thickness was 3/4 inch.) After a readjustment of the slack adjuster on the right rear wheel, the brake system was tested and found to be intact and operable.

The left front wheel was deformed and its brake chamber was damaged extensively. The right front brake chamber was intact and operable. However, the brake chamber's push rod was adjusted to 1 1/2 inches of travel. That was 1/8 inch beyond the travel (1 3/8 inch) at which readjustment is recommended by the manufacturer.

The suspension systems, wheels, tires, transmission, differential, and fuel tank were inspected visually. The only abnormalities noted were impact-related damage. All tires had acceptable tread depth.

Accident Site

I-5 is a north-south, limited-access route. The highway is a 4-lane, divided roadway. Between the trip's point of origin and the accident site, the highway runs through a mountainous, rural area.

On the morning of the accident, the weather was clear and the road surface was dry.

The sequence of crash events in this accident began on Siskiyou Summit. (See Figure 5.) The altitude at the summit is 4,130 feet, but it drops 2,870 feet within 10 miles. The roadway has an average downgrade of 6 percent. Two advisory signs, which warn motorists of the 7 miles of 6-percent downgrade ahead, are posted on the summit. There are 19 curves between the summit and the accident site. The mountainous terrain did not permit construction of escape routes for errant vehicles on this roadway. Although errant vehicles are not uncommon, the accident history of this highway for the past 3 years shows no record of accidents similar to this one.

The segment of roadway at the accident site has a downgrade of 5.8 percent, a superelevation of minus 6 percent, a 2-degree curve to the right, and is divided by a 2-foot median which has a W-beam guardrail on either side. The roadway's left shoulder measures 8 feet and the right shoulder 7 feet. The left lane is 12 feet wide and the right lane is 21. On the right edge of the road are an asphalt concrete curb and a W-beam guardrail. The height of the curb at the point where the bus left the roadway is 4 inches and the height of the guardrail is 22 inches.

The compacted, earth-fill slope along the downgrade side of the highway was steep -- an average downgrade of about 27 percent.

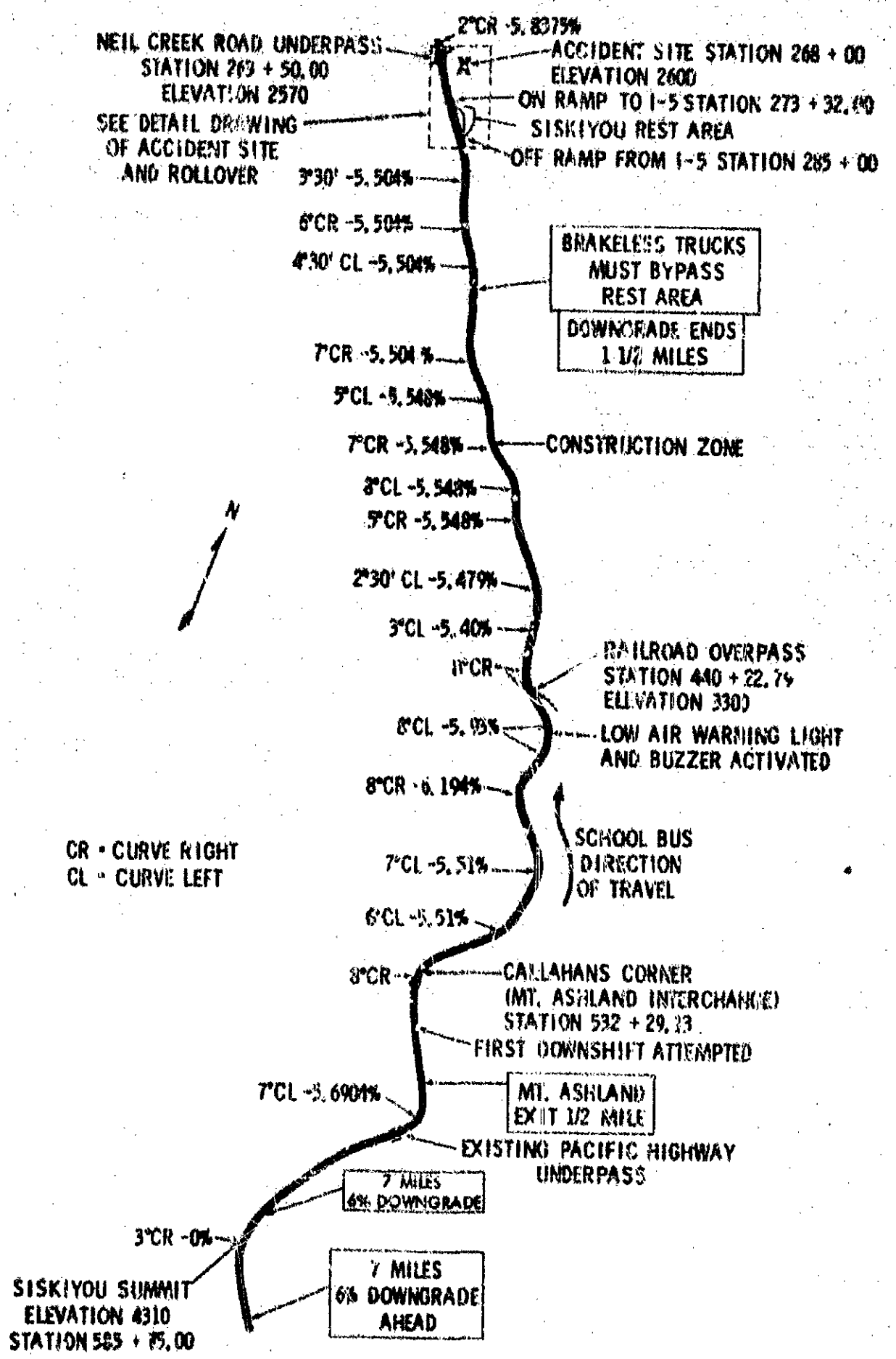

Figure 5. Northbound Interstate 5 from the Siskiyou Summit to the accident site.

Marks on the Roadway

There were no marks on the roadway to indicate that the schoolbus had been braked heavily at any point before or during the accident.

Several arc-shaped tire marks were found along the paths which each vehicle followed after they disengaged from one another. (See Figure 6.) The marks were identified as scuff marks caused by the lateral movement of rotating tires. The two arc-shaped marks, attributed to the left front and left rear tires of the schoolbus, averaged 270 feet in length and followed radii of 342 feet and 377 feet respectively. A shadow of a tire mark attributed to the right rear duals was found across the right shoulder and measured about 8 feet in length.

A single tire mark, made by the left rear tire of the automobile, measured about 400 feet from the point of impact between the vehicles to the damaged median guardrail. Skidmarks of 120 feet in length were made by the automobile as it moved rearward along the curb to its final position.

Vehicles

Schoolbus -- The schoolbus was a 1972, 66-passenger, Superior-built body mounted on a 1972 Chevrolet chassis, with 2 axles and dual wheels on the rear. It was equipped with a 366 CID, V-8 gasoline engine; a manual 4-speed transmission; and a rear axle (6.50/8.85 ratio) with a 2-speed planetary gear, electric shift.

The bus had standard air brakes with Type 12 brake chambers on the front wheels and Type 30 chambers on the rear. The manufacturer's recommended maximum stroke is 1 3/4 inches for Type 12 chambers and 2 1/2 inches for Type 30 chambers. A spring-activated emergency/parking brake with a separate air tank was installed on the rear axle. The spring brakes, which operated off the service brake components, were activated by pulling the handle on the instrument panel. The odometer read 39,899 miles.

The maintenance records made available to all the parties involved in this investigation indicate that the brake linings on the bus were of original (factory) installation. The minimal wear after more than 39,000 miles of travel cannot be explained.

The bus was owned by the Siskiyou Union High School District and was operated by the Mount Shasta High School. Inspection of the bus was conducted by the regular driver and maintenance was performed at his discretion. Maintenance records reveal that the odometer read 11,000 miles when the brakes were adjusted last. The bus had no previous history of brake failure, according to the regular driver.

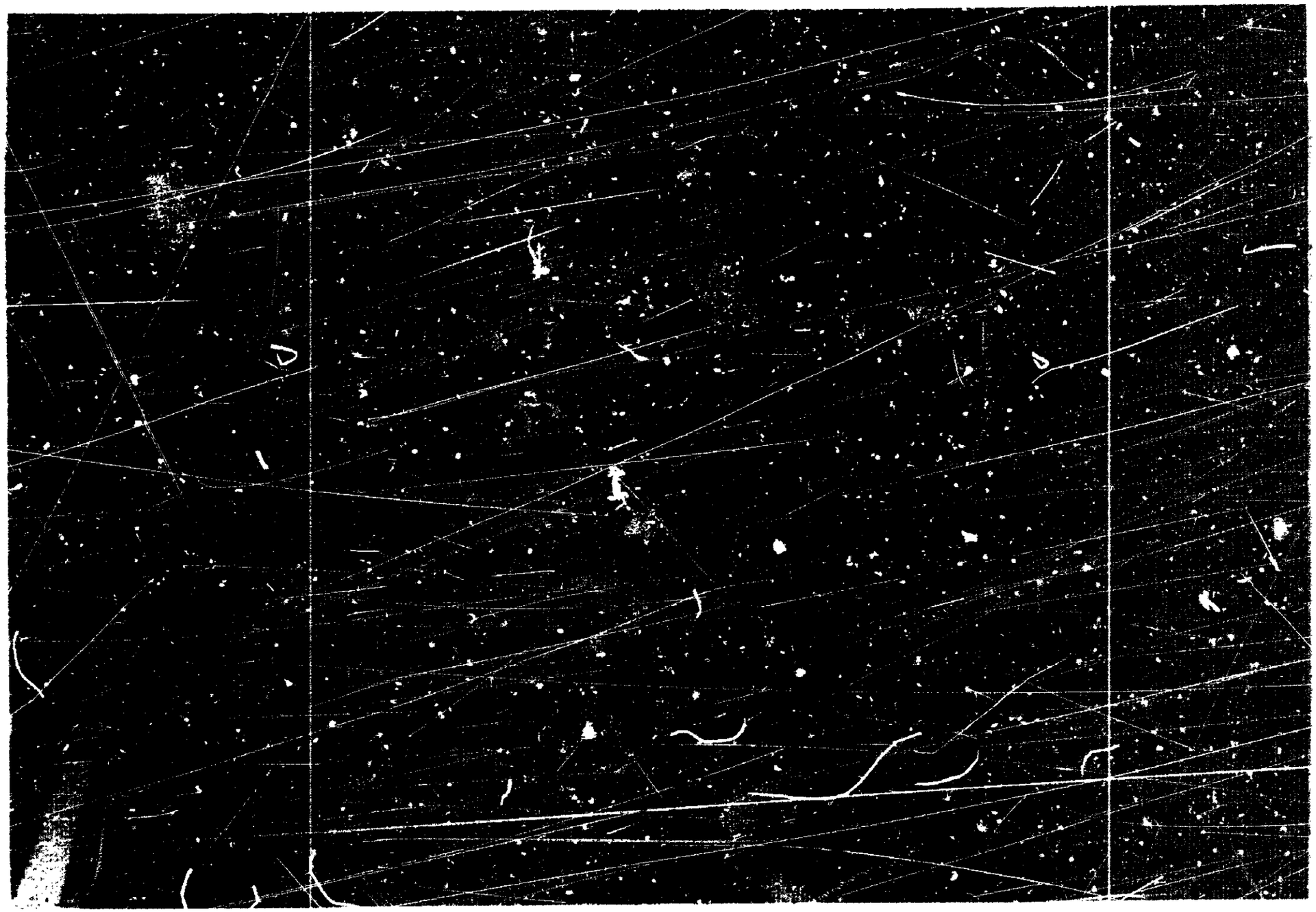

Figure 6. View of roadway at the accident site, looking north. Ⓐ schoolbus tire scuff marks. Ⓑ Automobile tire scuff marks.

Schoolbuses in the State of California are required to pass annual mechanical inspections, and each school is required to maintain records on its own drivers and vehicles. The bus was last inspected on July 12, 1974, when the odometer read 27,514 miles; the only defects noted were three worn tires. After the tires were replaced, the inspector certified the bus as serviceable. The inspector, a motor carrier specialist of the California Highway Patrol (CHP), later stated that during this inspection, he visually checked the complete brake system and found it to be operative and free of any malfunction. He also stated that the brake adjustments were within the manufacturer's recommended tolerance.

Failure to maintain buses adequately was revealed in a similar accident 2/ which involved a bus operated by a California School District. That school district and the Mt. Shasta High School were cited by the California Highway Patrol as being in violation of California law. 3/ The law requires that schoolbuses be "systematically inspected and maintained." The law does not specify how often schoolbuses should be maintained. 4/ The vehicle manufacturer's schoolbus maintenance guidebook 5/ suggests that schoolbuses be inspected and maintained at least every month, and receive a major inspection and a road test twice a year.

Automobile -- The automobile was a 1974 Pontiac Catalina, 4-door sedan. There was no evidence that the car was defective in any way. Neither the driver or her passenger sustained any injuries. The car was damaged extensively in the rear. There was no significant damage to the rest of the car.

Vehicle Operators and Occupants

Schoolbus Driver -- The schoolbus driver, 40 years old, held a valid California Schoolbus Driver Certificate without restrictions. She had complied with all the requirements for the certificate, including a training course for schoolbus drivers, which was completed in August 1973. Her driving record showed no accidents or violations.

2/ National Highway Traffic Safety Administration, "School Bus/Off-Road Fatal," October 8, 1974, Colevilla, California. DOT-HS-01-176#4.

3/ California Administrative Code, Title 5, Department of Education Division 13, Chapter 4, Schoolbuses, Article 4, Section 14243.

4/ Federal Highway Safety Program Standard (F.H.S.P.S.) No. 17, "Pupil Transportation Safety," sets minimum requirements for State pupil transportation safety programs and states that school vehicles shall be maintained through a systematic preventive maintenance program and be inspected at least semiannually.

5/ General Motors Corp., "Schoolbus Inspection and Maintenance Guide," Detroit, Michigan, 1970.

The driver had 13 years of experience in the operation of schoolbuses. During 8 of those years, she was employed by the Mount Shasta Elementary School District.

The schoolbus she had driven daily for the Mount Shasta District was not similar to the accident bus. It was an older and larger vehicle which was equipped with a 5-speed manual transmission, a single-speed rear axle, air service brakes, and a spring-activated (by driver or upon loss of air pressure) emergency/parking brake system. She had driven the bus involved in the accident on one other field trip. The regular driver of the bus, although available, was not assigned to this trip.

The schoolbus driver was required by the State Department of Education to complete a schoolbus driver training course before she could obtain or renew her schoolbus driver certificate. The course included material on the 2-speed rear axle and on mountain driving techniques. The material included the suggestion that a schoolbus should proceed down a grade in the same gear it would use to climb it, and it included a discussion of the Monarch Pass accident, 6/ which was similar to this accident.

The CHP officer charged with the responsibility for the safety supervision of schoolbus drivers in Siskiyou County stated after the accident that he had ridden with the driver on her regularly assigned bus and found her to be "quite competent." He noted that she was "inclined to use downshifting and compression when traversing downgrades" on her route.

The driver was without any known disabilities which could have affected her driving.

Automobile Driver -- The driver of the automobile held a valid California driver's license without restrictions. Her California driver's record revealed no traffic accidents or violations.

Schoolbus Passengers -- There were 18 students and 1 teacher aboard the bus. (Figure 7 shows the precrash and postcrash positions of the bus occupants. See Appendix B for a list of the injury severity.)

ANALYSIS

Schoolbus Driver Performance

An examination of the accident events indicates that the schoolbus driver made four operational errors: (1) she did not respond to the

6/ National Highway Traffic Safety Administration, "Monarch Pass, Colorado Schoolbus Crash," 1971. DOT-HS-600779.

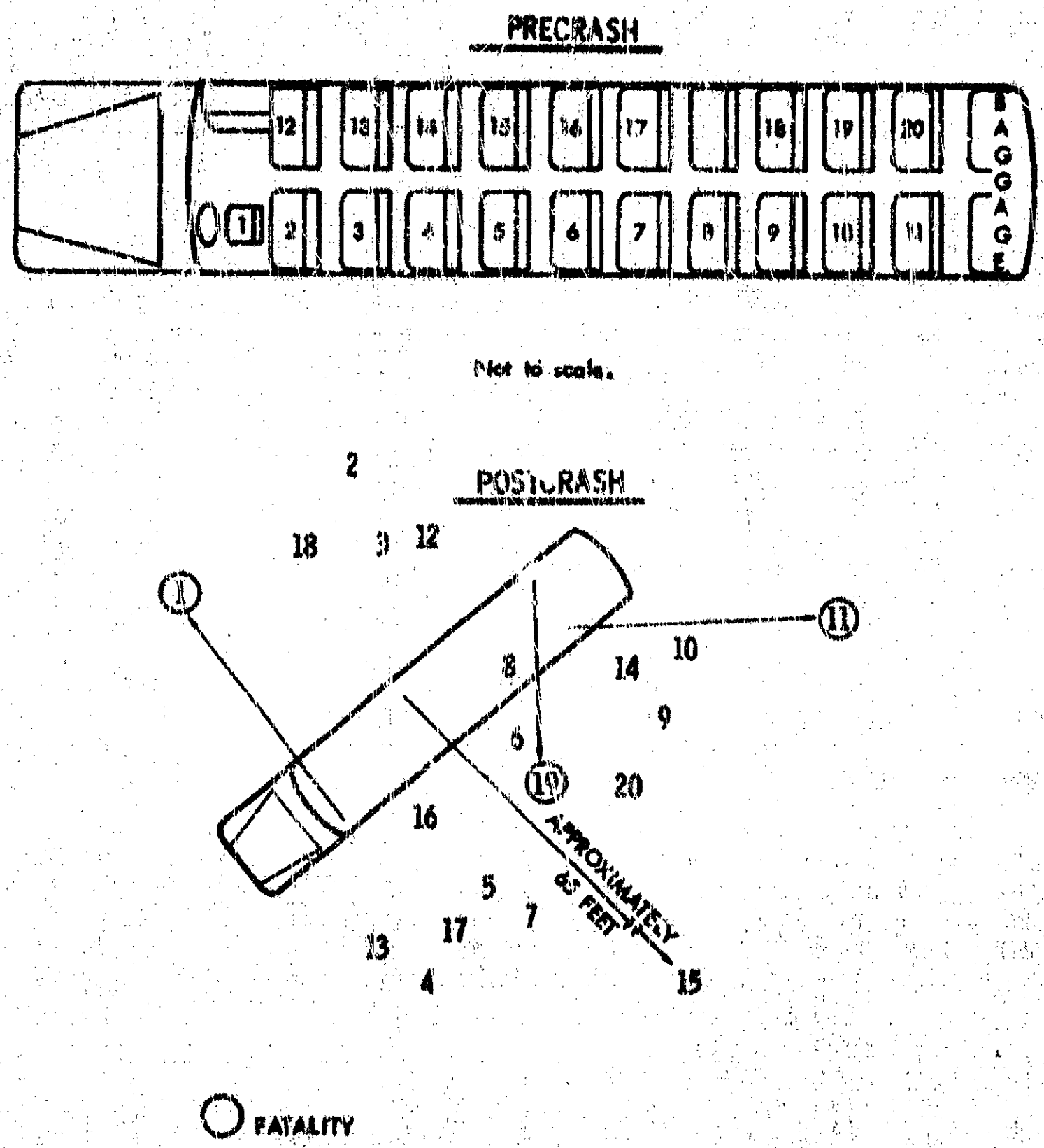

Figure 7. Precrash and postcrash positions of schoolbus occupants.

advisory signs on the summit; consequently, she entered the steep downgrade in fourth gear and in high range, instead of in a lower gear and lower range; (2) she constantly pumped the brake pedal; (3) she did not use the correct procedure when she attempted to shift the 2-speed rear axle to the low range; and (4) when she was unsuccessful in shifting the transmission into a lower gear, she left it in neutral, which made the bus a freewheeling vehicle.

Although the signs on the summit do not advise drivers of heavy vehicles to select the gear that offers maximum engine braking, its message would imply that course of action to drivers of heavy vehicles who are experienced in mountain driving. The reason for her failure to downshift before she entered the steep downgrade is unknown, because she was experienced.

It is possible that the driver believed she could control the speed of the bus by using the brakes rather than by downshifting to decrease speed. This would explain why she applied and released the brakes frequently during the first part of the descent.

The procedure used by the driver in her attempt to downshift the 2-speed rear axle and, subsequently, the manual transmission did not include acceleration of the engine. To execute a synchronized downshift successfully, it is necessary to accelerate the engine in order to speed up the drive shaft. This procedure is peculiar to downshifting 2-speed rear axles and manual transmissions, and would be opposite to the natural instincts of an inexperienced driver. However, since the busdriver was experienced with heavy vehicle manual transmissions, it is not possible to explain the uncharacteristic performance of the driver during the initial critical events of the accident.

The automobile struck by the schoolbus had passed the schoolbus near the top of the descent and had continued on down the grade at an admitted speed of 60 mph.

If the driver of the automobile had heard the schoolbus horn, recognized the hazard approaching from the rear, and steered into the right lane in time, the runaway schoolbus might have avoided the automobile and continued to the end of the downgrade without the collision and subsequent loss of control.

If she had heard the schoolbus horn, she was required to move into the right lane and remain there until the schoolbus had passed. However, the driver said that she did not hear the horn. Section 11-303 b) of the Uniform Vehicle Code states: "Except when overtaking on the right is permitted, the driver of an overtaken vehicle shall give way to the right

in favor of the overtaking vehicle on audible signal and shall not increase the speed of his vehicle until completely passed by the overtaking vehicle." There is no legal requirement for detection of vehicles approaching from the rear through other than audible signals.

Good defensive driving techniques, however, as taught in driver training courses and advocated in driver safety education publications, propose that drivers constantly scan the roadway to the front and on both sides and look in the rearview mirrors to alert themselves to the presence of vehicles all around them. If the automobile driver had followed these techniques, she may have seen the approaching schoolbus in time to get out of its way.

Brake System

There was no sudden loss of braking in this accident, but a gradual loss of effectiveness in an already maladjusted brake system. This statement is supported by: (1) the driver's frequent manipulation of the brakes, (2) the maladjusted slack adjuster, (3) the bus' 28,000 miles of travel without brake adjustment, and (4) the extreme demand made on the brakes because the driver had not downshifted to reduce speed.

Despite the driver's experience and training, which had included the proper operation of air-operated service brakes, she applied the brakes repeatedly while traveling down the steep grade. This caused the temperatures of the brake drums and linings to increase and resulted in a loss of air pressure. The frequent brake applications were futile because they did not provide enough time between applications to dissipate the heat buildup in the brake drums.

The thermal expansion of the brake drums lengthened the stroke of the brake chamber push rod necessary to force the brake linings against the drums. The minimal stroke available on the bus might have accommodated braking of the vehicle under routine schoolbus operations. However, there was not enough stroke to compensate for the drum's thermal expansion. Thus, it is likely that the reserve stroke in the brake chamber was exhausted; this resulted in a reduction of braking capability even though an adequate supply of air pressure may have been in the system at the time. Although it is not known when brake fade occurred, the actions of the driver suggest that there may have been a loss of braking before the warning buzzer for low air pressure sounded.

It could not be established if the driver attempted to use the emergency/parking brake to retard the speed of the bus after the loss of the service brakes. Even if she had, her attempt would have been futile, because the emergency/parking brake was operated with components common to the service brakes, and that system already had been degraded.

Brake maladjustment may be discovered only when a bus is driven under conditions such as those preceding this crash or when the brake systems are examined thoroughly. Since the maladjustment was not discovered before the crash, it is obvious that the maintenance of critical components of schoolbuses, such as the brake system, require a planned program of periodic inspection and maintenance. This is of particular importance in areas where buses traverse mountainous terrain.

Rollover Sequence

To compute the exact velocity of the bus before it hit the automobile and median guardrail is impossible. However, the dynamics of the vehicle as it arced toward the roadway edge, the tire marks on the roadway, and the relatively minor damage inflicted on the bus by the curb and guardrail suggest that the bus was moving toward the roadway edge at a speed of no more than 65 mph.

The right front of the bus struck the guardrail, which yielded. The right front wheel struck and mounted the exposed curb at an angle of about 50°. Lifting upward, the vehicle vaulted in a northeasterly direction over the side slope. The bus traveled horizontally in the air for 56 feet, yawing to the left. It dropped 16 feet and hit the ground.

The left front bumper and wheel first contacted the ground. The force of that impact probably weakened the front axle/chassis connection. Gouging out a wide, 46-foot-long ditch in the slope, the bus rolled counterclockwise about its longitudinal axis onto its left front roof corner.

The force of that impact imposed primary loadings on the joints between the side body posts and roof assembly, at the left and right front corner of the bus. Those posts experienced compression on the front face and tension on the rear, causing them to fail. This permitted greater loads on the remaining joints during the subsequent dynamics of the rollover sequence. The effect of that condition was the failure of those joints from front to rear in a zipper-like sequence.

On the downslope end of the gouge, the bus moved perpendicular to the roadway. The bus completed a half roll as it hit the ground first with its hood and the right front corner of the roof, and then with the rear section of the roof. Enough force was created in the latter impact to deform the rear cap substantially, to imprint the second-from-the-rear roof bow into the roof panel, and to leave paint transfers on the ground. Vertical loadings were applied to the sidepost/roof assembly connections during these dynamics.

The bus then lifted off the ground. While it was airborne, the bus completed another half-roll counterclockwise about its longitudinal axis, and sliced into the ground with its right side wheels. The bus rocked to the left, and the left side wheels landed and dug into the slope. The front axle and wheels separated from the bus and rolled down the slope. The roof probably shifted laterally, first to the right and then to the left, during this phase of the rollover sequence.

Leaning downslope, the bus once again became airborne and rolled 360° counterclockwise around its longitudinal axis. There were no physical signs of contact between the bus and the ground in the last 80 feet before it came to rest.

The occupants of the bus were subjected to a low longitudinal force when the bus struck the rear of the automobile, and they tumbled within the interior of the bus as the bus rolled down the side slope. No occupants were ejected before the end of the bus' last roll. The roof assembly shifted to the right of the body structure and created a gap through which the majority of the passengers were ejected as the bus abruptly came to a halt in an upright position.

The two fatally injured passengers suffered traumatic neck injuries. The driver suffered fatal traumatic head and chest injuries either within the bus as it rolled or as she was being ejected onto the ground. The survivors only remember tumbling inside the bus. They were unable to relate contacts within the bus with the injuries they sustained, and no evidence was found of contact between the occupants and the bus interior which could be related to their injuries. The only occupant to remain within the vehicle suffered no injury.

Although the evidence in this accident does not demonstrate conclusively that the ejectees sustained serious injury after being thrown from the bus, highway safety research 7/ has established that keeping the occupant inside the vehicle clearly reduces the probability of serious injury. Ejection injury has been demonstrated to be more severe than nonejection injury. 8/

The structure of the bus after the roof detached itself was not reduced in volume or invaded. The roof was distorted, but the structure of the roof did not fail. The crash loading which initiated the zipper-like failure at the joints was not sufficient to dislodge seats from the floor.

7/ National Highway Traffic Safety Administration, "Ejection Risk in Automobile Accidents." DOT-HS-053-3-619, 1974.

8/ Ibid.

It, therefore, could be argued that because the primary ejection route was opened up by the failure at the joints of the roof assembly and side body pillars, a change of design of those joints in this particular bus would be justified to prevent similar occurrences in the future. It can also be argued that the impact loads sustained by the bus during rollover were so severe that it might not be practical to redesign the bus to withstand such loads. The impact loads in this accident are not known. But this accident, the Monarch Pass crash, and the Aragon collision 9/ all demonstrate that the most consistent points of maximum strain and of failure during schoolbus rollovers are the roof assembly/sidepost connections, the window header area, the window sill area, and the bow/floor interface.

In testing 10/ schoolbus bodies, NHTSA's contractor (Dynamic Science Division of Ultrasystems, Inc., Phoenix, Arizona) fabricated two buses with improved structural components and evaluated them. The testing demonstrated that improved schoolbus structural performance can be achieved within practical limits.

CONCLUSIONS

1. The most experienced driver of the accident bus available was not assigned to this trip.

2. The driver should have seen and responded to the advisory signs on the summit and been aware of the magnitude and length of the downgrade ahead.

3. The driver's decision to remain in fourth gear and in high range for the descent was contrary to her training and put undue strain on the brakes.

4. Also contrary to her training were her on-off applications of the brakes, which accelerated the loss of air pressure and contributed to the overheating of the brake linings and drums.

5. The brake which could be examined was maladjusted. Although the other brakes could not be examined, it is probable that they were similarly maladjusted.

6. The thermal expansion of the brake drums, coupled with the maladjusted brakes, rendered the service brake ineffective.

9/ National Transportation Safety Board, "Collision of a Southern Railway Work Train With a Polk District Schoolbus At Aragon, Georgia, October 23, 1974," 1975. NTSB-RHR-75-1.

10 National Highway Traffic Safety Administration, "Schoolbus Safety Improvement Program," DOT-HH-046-3-694, 1975.

7. It is not known whether the driver applied the emergency/parking brake. However, because of their common components, that brake would have become ineffective at the same time as the service brake.

8. It is unknown if the loss of braking preceded the decision of the driver to attempt a downshift on the steep grade, or if the failure to downshift precipitated the loss of braking.

9. It cannot be determined why the busdriver did not use the correct gear-shifting procedure required to downshift the 2-speed rear axle and the manual transmission successfully.

10. The roof failure was precipitated by a rearward load at the top of the windshield which caused rearward failure of one or more joints between the sideposts and the longitudinal cap of the sideposts. After this, the joints failed in rapid sequence as loads were applied to each joint.

11. The impact loads on the bus body were not sufficient to reduce the bus volume enough to prevent survival of the occupants.

12. The ejection of bus occupants was permitted by the roof failure.

13. Schoolbus cross-sectional integrity must be assured in rollover environments regardless of the design alternatives. Such structural assurance is within current technologies and practical limits.

14. The maladjustments of the service brakes probably would not have been detected by a driver operating a schoolbus in routine service, but could be detected by a thorough brake system examination.

15. Schoolbus maintenance programs require careful monitoring, as critical schoolbus components require thorough vehicle inspections at regulated, scheduled intervals.

16. If the driver of the automobile had been alert to all of the traffic conditions about her, she probably would have seen the approaching bus in time to take evasive action and open a path for the runaway schoolbus.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was: (1) the failure of the schoolbus driver to select the proper gear to descend the steep grade, and (2) the maladjustment of the brakes on the bus.

RECOMMENDATIONS

As a result of the investigation of this accident, the National Transportation Safety Board submitted a Safety Recommendation to the National Highway Traffic Safety Administration (See Appendix C.) and to the State of California. (See Appendix D.)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JOHN H. REED
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

January 7, 1976

APPENDIX A

SCHOOLBUS DATA

Specifications of the Schoolbus

The schoolbus was a 66-passenger 1972 Superior body mounted on a 1972 Chevrolet chassis. It was equipped as follows:

Engine:	366 CID, V-8, gasoline engine, producing 235 net HP @ 4,000 rpm
Odometer:	39,899 miles
Transmission:	Manual 4-speed
Wheelbase:	254 inches
Rear Axle:	Chevrolet 2-speed planetary gear, electric shift, 17,000-pound capacity (6.50/8.85 ratio)
Front Axle:	F707 with power steering 7,000-pound capacity
Unladen Weight:	14,560 pounds
Brakes:	Air (7 1/4 cubic inch compressor with one combination wet and dry and two dry air reservoir tanks). The front brakes were type 12 clamp-type brake chambers, S-cam shoes, 1/2-inch linings, and a manufacturer's recommended maximum brake chamber push rod stroke of 1 3/4 inches. The rear brakes were type 30 clamp-type brake chambers, S-cam shoes, 3/4-inch linings, a manufacturer's recommended maximum brake chamber stroke of 2 1/2 inches, and Anchorlok (spring actuated) emergency/parking brake system with separate air tank for brake release.
Clutch:	Manual with mechanical linkage
Tires:	10:00/20, 12-ply. Two tires on the front axle and four on the rear.

Low Air Pressure Warning:	A buzzer sounds and a red light lights up when air pressure is below 60 p.s.i.
Low Oil Pressure Warning:	A buzzer sounds and red light on dash lights up when oil pressure fades. Equipped with on-off switch.
Lights and Horn:	Electric
Body Structure:	The structure is formed by the welding of 11 side body pillars and 2 "A" pillars above the window line to the roof assembly. The sideposts are centered between each passenger window and welded to a lower side body sill. The roof assembly consists of 2 longitudinal roof stringers and intermediate and full length roof bows 13" apart. Internal and external panels cover both the roof bows and sideposts. The body had 22 passenger seats, each measuring 39 inches in width.

Summary of Crash Damage to the Schoolbus

The chassis frame was not bowed or buckled. The body remained attached to the chassis. The left side of the bus body showed signs of torsional twisting--the front in a clockwise motion and the rear in a counterclockwise motion. The right side of the body exhibited no indications of torsional twisting.

A hole, measuring 3 inches in diameter, which occurred from a downward force into the engine compartment, was found on the hood. The hood also showed several striations of different angles on its surface.

The left front bumper was deformed rearward and upward at an angle of about 66° from its original position. Numerous horizontal striations on the outside (left) edges of the bumper were also in evidence. The headlights and grill area were intact. The right front bumper and fender exhibited little damage. The left front fender was deformed rearward with angled striations on its surface.

The front door was deformed rearward and outward. Three exterior panels on the right side were separated at the joints. On the left side, exterior paneling was buckled in several locations and deformed inward on the lower portion of the body. Striations were in evidence at different

angles along the length of the bus body. The right rear corner of the body was crushed inward. All side body pillars on the rear of the bus were bent 20° from the horizontal.

The left rear bumper was deformed upward on the underside. White paint striations were found on the bumper from the left leading edge and around to the rear. The panel on the left rear corner was deformed downward and around the bumper.

The gasoline and air reservoir tanks were intact. There was no chafing of, or kinks in, the air hoses.

The front axle was disengaged from the bus; the U-bolt connections were sheared. The left rear outside wheel exhibited a dent near the center of the rim.

The components in the engine compartment exhibited no signs of damage. The fan was intact and the radiator undamaged.

An examination of all 24 side body pillars and both side roof rails at their joints revealed:

(1) Two of the sidepost/roof connections failed, leaving the entire weld on the side roof rail.

(2) Seven of the sidepost/roof connections failed, leaving both a portion of a weld on the side roof rail and a tearing away of the parent metal.

(3) Fifteen of the sidepost/roof connections failed, solely by the tearing away of parent metal on the side roof rails. The welds at those joints held.

In summary, 8.3 percent of the joints failed in mode (1), 29.2 percent in mode (2), and 62.5 in mode (3).

Separating and crushing of roof panels was minimal. The primary crushing of the roof occurred at the left front corner, right front corner, and downward on the exterior rear panel. The front cap of the roof assembly experienced some buckling. The left front warning lamp was intact, the right front damaged.

The interior of the bus was relatively intact. The floor was undamaged and all but nine seats showed no signs of deformation or failure at their anchorages. No forward deformation was found, although several experienced some lateral deformation. Only one seat was completely disengaged from the floor, but was not displaced from its position during the rollover dynamics of the bus.

Interior wall paneling was relatively intact with the exception of two joints, one separation on the right side and one on the left side. The left wall was deformed outward and the right wall in the rear of the bus inward.

APPENDIX B

INJURY DATA

Bus Occupant	Location	AIS 1/ Injury
1. Female, 41	(See Figure 7.)	5
2. Male, 15		2
3. Male, 16		1
4. Male, 15		1
5. Male, 15		1
6. Male, 19		No injury
7. Male, 16		2
8. Male, 17		No injury
9. Female, 45		4
10. Female, 16		3
11. Female, 16		5
12. Male, 17		1
13. Male, 16		1
14. Male, 15		1
15. Male, 16		3
16. Male, 16		4
17. Male, 17		3
18. Female, 16		1
19. Female, 16		5
20. Female, 18		4

1/ A numerical description of the overall severity of injury in persons who have sustained injury to more than one area of the body (1, minor; 2, moderate; 3, severe, not life-threatening; 4, severe, life-threatening; 5, critical, survival uncertain).

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPENDIX C

ISSUED: September 18, 1975

Forwarded to:

Honorable James B. Gregory
Administrator
National Highway Traffic Safety
Administration
Washington, D. C. 20590

SAFETY RECOMMENDATION(S)

H-75-22

On May 9, 1975, a 1972 schoolbus carrying 20 persons crashed through a section of guardrail on the northbound portion of Interstate 5 in Ashland, Oregon. The vehicle fell down a steep slope and rolled about its longitudinal axis before coming to rest in an upright position about 224 feet from the edge of the pavement. With the exception of one sidepost/roof bow connection, the roof was completely separated from the bus body. Nineteen of the 20 occupants were ejected through the gap created by the roof separation; 3 were killed and the rest were injured.

On September 11, 1971, a 1971 schoolbus carrying 48 persons left State Highway 50 on the eastern approach to Monarch Pass, Colorado, and rolled over 2 1/2 times. The left sideposts separated at the window sill, which caused the roof to separate from the side structure along that side of the bus. Of the 37 occupants who were ejected through the gap created by the separation, 9 were killed; the 28 others sustained more severe injuries than the 9 occupants who remained in the bus.

These accidents demonstrate the need for schoolbuses to maintain their cross sectional structural integrity under rollover conditions in order to contain occupants and to assure that they have space to survive.

The schoolbuses involved in these accidents represent the two most common designs currently used by schoolbus manufacturers. The roof of the Ashland bus was welded to side pillars mounted to the bus floor. The roof of the Monarch Pass bus was constructed around a continuous sidepost/roof bow. Two major bus manufacturers use the type of roof assembly that was used on the Ashland bus; four other manufacturers use the type of roof assembly that was used on the Monarch Pass bus.

Schoolbus cross sectional integrity must be insured in rollover environments regardless of the design alternatives incorporated. The most effective way to develop performance requirements to accomplish this objective would be

dynamic rollover testing. Similar comments were made by the National Transportation Safety Board on May 5, 1975, to the National Highway Traffic Safety Administration's proposed rulemaking Docket No. 75-2, Notice 01, "Schoolbus Rollover Protection."

Therefore, the National Transportation Safety Board recommends that the National Highway Traffic Safety Administration:

> Initiate a program of dynamic rollover testing of schoolbuses to provide data, in combination with data already obtained from static testing, to be used to develop a performance requirement that will insure reasonable structural integrity in rollover environments. (Class I.)

REED, Chairman, McADAMS, THAYER, and BURGESS, Members, concurred in the above recommendation. HALEY, Member, did not participate.

By: John H. Reed
Chairman

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

APPENDIX D

ISSUED:

Forwarded to:

Honorable Edmund G. Brown, Jr.
Governor
State of California
Capitol Building
Sacramento, California 95814

SAFETY RECOMMENDATION

H-76-1

At 11:45 a.m. on Friday, May 9, 1975, a Siskiyou Union High School District (California) schoolbus carrying 19 passengers was northbound on Interstate 5 near Ashland, Oregon.

The busdriver entered a steep downgrade with the bus in fourth gear and in high range, and used the air service brakes heavily to control the bus' speed. When the bus had descended about seven-tenths of a mile, improperly adjusted brakes and thermal expansion of the drums caused the brakes to fade. The driver attempted to downshift the 2-speed rear axle but was unsuccessful. She continued alternately to apply and to release the brakes. This caused a rapid loss of air pressure. As the bus gained momentum, the driver attempted unsuccessfully to shift the transmission from fourth to third gear.

Soon after the buzzer warning of low air pressure sounded, the passengers were instructed to get down on the floor. The driver blew the horn to warn vehicles ahead as she intermittently attempted to shift gears and brake the vehicle. The driver of an automobile, also northbound in the left lane, did not hear or see the bus before it struck the rear of the car and shoved it in a 180° arc to the east. The bus slipped sideways, vaulted a curb and a guardrail section, and rolled over twice down a steep slope. The roof separated from the bus and swung off as the bus came to rest upright some 213 feet from the edge of the roadway.

Nineteen of the bus' 20 occupants were ejected. Three occupants were killed and 15 others were injured.

APPENDIX D

Although the State of California has requirements under Title 5 of the Administrative Code of California for the systematic inspection and maintenance of schoolbuses, the law does not specify how often schoolbuses should be inspected or maintained. A systematic preventative maintenance program should be set up on a time- or mileage-basis, or a combination of both, to minimize vehicle breakdown en route and the possibility of part failure that could lead to a crash. The schoolbus in this accident had not been so maintained. It is important to have such requirements and it is equally important to insure that they are complied with.

Therefore, the National Transportation Safety Board recommends that the State of California:

> Insure the implementation of all the provisions of Federal Highway Safety Program Standard No. 17, "Pupil Transportation Safety," especially the provisions relating to the systematic preventative maintenance and the semiannual inspection of schoolbuses. (H-76-1) (Class II, Priority Followup)

REED, Acting Chairman, McADAMS, THAYER, BURGESS, and HALEY, Members, concurred in the above recommendation.

By: John H. Reed
Acting Chairman