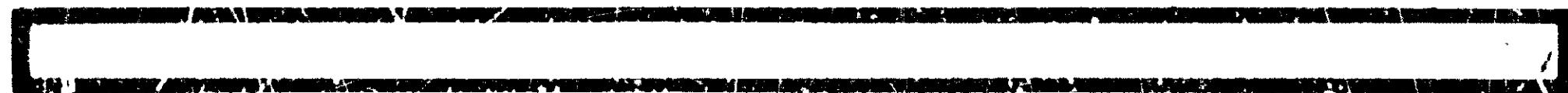
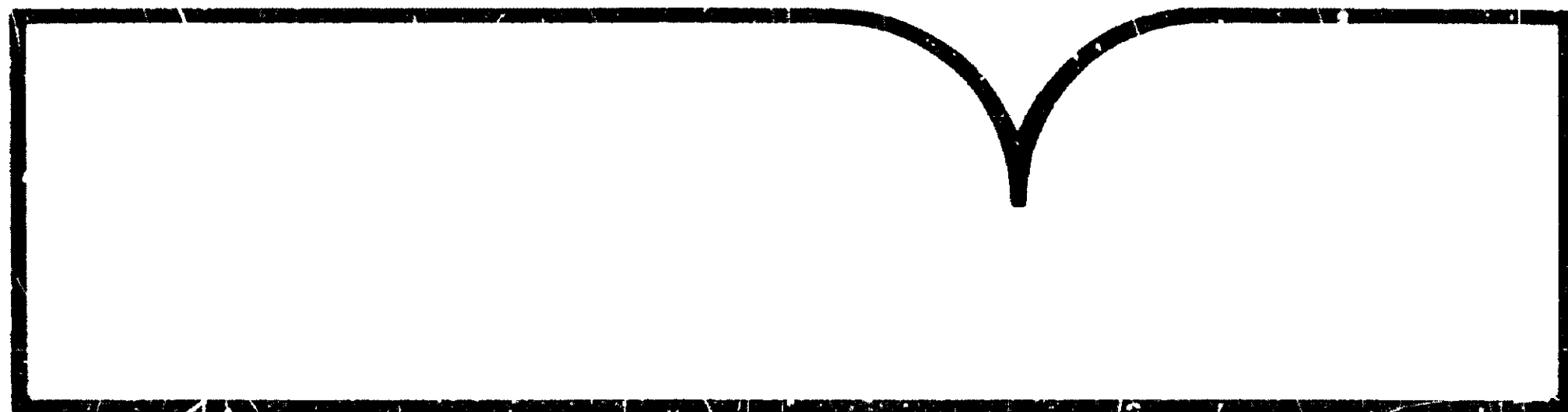


PB83-916201

Highway Accident Report - Multiple
Vehicle Collisions and Fire, Caldecott
Tunnel Near Oakland, California, April 7, 1982

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

3 May 83



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<p>16. Abstract About 12:12 a.m. P.s.t. on April 7, 1982, several vehicles on westbound California State Route 24 entered the north, No. 3 Bore of the Caldecott Tunnel near Oakland, California. A Honda car driven by an intoxicated driver struck the raised curbs inside the tunnel and came to rest at the left edge of the roadway about one-third of the way through the tunnel. It was struck soon afterward by a following gasoline tank truck and tank trailer and then by an AC Transit bus which subsequently struck the tank trailer. The busdriver was ejected, and the empty bus continued west, exited the tunnel, and struck a concrete road support pier. The tank trailer overturned, and gasoline was spilled inside the tunnel. A fire erupted and heavy black smoke quickly filled the tunnel. The tank truck and tank trailer, the Honda car, and four other vehicles that had entered the tunnel were completely destroyed by the fire. Seven persons were killed, and two people were treated for minor smoke inhalation. The tunnel incurred major damage.</p> <p>The National Transportation Safety Board determines that the probable cause of this accident was a combination of events involving (1) the erratic driving by the intoxicated driver of a passenger vehicle which stopped in a through traffic lane creating a traffic obstacle; (2) the inattention of the truckdriver causing his vehicle to strike the passenger vehicle; and (3) the busdriver's overtaking the truck too rapidly to enable him to avoid striking the passenger vehicle when it unexpectedly appeared in the path of his bus.</p>					
17. Key Words Fire; gasoline trailer rollover; tunnel; hazardous materials; gasoline tank truck and trailer; routing of hazardous materials; intoxicated driver; communication in tunnel; surveillance of tunnel occupants; prohibition of hazardous materials in tunnel; Uniform Traffic Control Devices; ventilation systems; fire department notification.		18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161			
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Abstract continued

Contributing to the cause and the severity of the accident was the presence of a flammable cargo tank truck and cargo tank trailer in the tunnel and the damage to the overturned trailer which permitted a loss of flammable cargo and a fire.

Also contributing to the severity of the accident and injuries were the lack of adequate monitoring capabilities and variable message signs or traffic signals at the entrance of the tunnel and within the tunnel, and the lack of a communication system between the tunnel personnel and tunnel occupants, which if present, might have facilitated occupant evacuation.

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**NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594**

HIGHWAY ACCIDENT REPORT

Adopted: May 3, 1983

**MULTIPLE VEHICLE COLLISIONS AND FIRE
CALDECOTT TUNNEL
NEAR OAKLAND, CALIFORNIA
APRIL 7, 1982**

SYNOPSIS

About 12:12 a.m. P.s.t., on April 7, 1982, several vehicles on westbound California State Route 24 entered the north, No. 3 Bore of the Caldecott Tunnel near Oakland, California. A Honda car driven by an intoxicated driver struck the raised curbs inside the tunnel and came to rest at the left edge of the roadway about one-third of the way through the tunnel. It was struck soon afterward by a following gasoline tank truck and tank trailer and then by an AC Transit bus which subsequently struck the tank trailer. The busdriver was ejected, and the empty bus continued west, exited the tunnel, and struck a concrete road support pier. The tank trailer overturned, and gasoline was spilled inside the tunnel. A fire erupted and heavy black smoke quickly filled the tunnel. The tank truck and tank trailer, the Honda car, and four other vehicles that had entered the tunnel were completely destroyed by the fire. Seven persons were killed, and two people were treated for minor smoke inhalation. The tunnel incurred major damage.

The National Transportation Safety Board determines that the probable cause of this accident was a combination of events involving (1) the erratic driving by the intoxicated driver of a passenger vehicle which stopped in a through traffic lane creating a traffic obstacle; (2) the inattention of the truckdriver causing his vehicle to strike the passenger vehicle; and (3) the busdriver's overtaking the truck too rapidly to enable him to avoid striking the passenger vehicle when it unexpectedly appeared in the path of his bus.

Contributing to the cause and the severity of the accident was the presence of a flammable cargo tank truck and cargo tank trailer in the tunnel and the damage to the overturned trailer which permitted a loss of flammable cargo and a fire.

Also contributing to the severity of the accident and injuries were the lack of adequate monitoring capabilities and variable message signs or traffic signals at the entrance of the tunnel and within the tunnel, and the lack of a communication system between the tunnel personnel and tunnel occupants, which if present, might have facilitated occupant evacuation.

INVESTIGATION

The Accident

About 12:12 a.m. P.s.t., 1/ on April 7, 1982, a 1978 Honda Accord westbound on State Route 24 entered the one-way No. 3 (North) bore of the Caldecott Tunnel near Oakland, California. (See figures 1 and 2.) Witnesses in front of and behind the Honda later stated that the Honda moved to the left lane of the two lane roadway, struck the left curb, and was redirected into the right lane and then back to the left lane before slowing and coming to a stop adjacent and parallel to the left curb. Two drivers passed the Honda while it was slowing, and three others passed it after it had stopped. Two of the three who passed it after it had stopped said that the Honda's emergency flashers were operating. The third stated that when she passed the stopped Honda, the Honda driver was standing at the front of the car. The passersby said they saw damage to the side of the Honda.

A 1977 Kenworth tank truck towing a 1977 Clough full tank trailer 2/ filled with gasoline entered the tunnel shortly after the Honda. The tank truck was followed by a 1975 Grumman Flexible Alameda/Contra Costa (AC) Transit passenger bus occupied only by the driver. The bus was followed by a Ford pickup truck occupied by the driver and his mother.

The pickup truck driver later stated that his truck and the bus had passed each other several times during the previous several miles and that the bus was traveling approximately 55 mph as it entered the tunnel in the right lane. He stated that he did not see the tank truck traveling ahead of the bus as the bus and tank truck entered the tunnel. The bus completed a 2,400-foot radius curve to the right. The curve had a sight distance of 485 feet. As the bus entered a 1,740-foot straight section of the tunnel, it was about 150 yards in front of the pickup truck. The pickup driver stated that the bus' stop lights went on and the bus made a sharp movement to the left lane. When the bus moved to the left lane, the pickup driver saw the tail and clearance lights of the tank truck on the right side of the road ahead. He stated the bus moved to the left edge of the travel lanes and struck the left wall of the tunnel, the bus then bounced back, and the right front of the bus struck the left side of the tank trailer. The pickup truck driver said he never saw the Honda.

The tank truck driver stated he was traveling 40 to 45 mph in the right lane when he observed the stopped Honda near the left curb. He then saw the bus in his rearview mirror as it appeared to be overtaking him. He watched the bus in the left lane and saw puffs of smoke from its tires as the busdriver applied the brakes just before the bus hit the Honda. According to the tank truck driver, the bus then careened into his truck's trailer. The two vehicles separated, and the tank truck stopped a short distance ahead in the right lane with the tank trailer on its right side. The busdriver was ejected from the bus during the collisions, and the empty bus continued west on the left side of the road until it struck a support pier just beyond the west end of the tunnel.

The pickup truck driver, who had stopped his vehicle when he witnessed the collision between the bus and the tank trailer, noticed a small fire at the tank truck and backed his vehicle to the nearest emergency station phone. While his mother went to the phone to advise tunnel personnel of the accident, he started walking to the east toward the stopped and approaching traffic to advise them they could not get through the tunnel and they should back out. A beer truck, occupied by its driver and a passenger, had stopped close behind the Ford pickup. There were approximately 8 or 9 passenger cars

1/ All times herein are Pacific standard time.

2/ Hereafter referred to in the report as the tank truck.

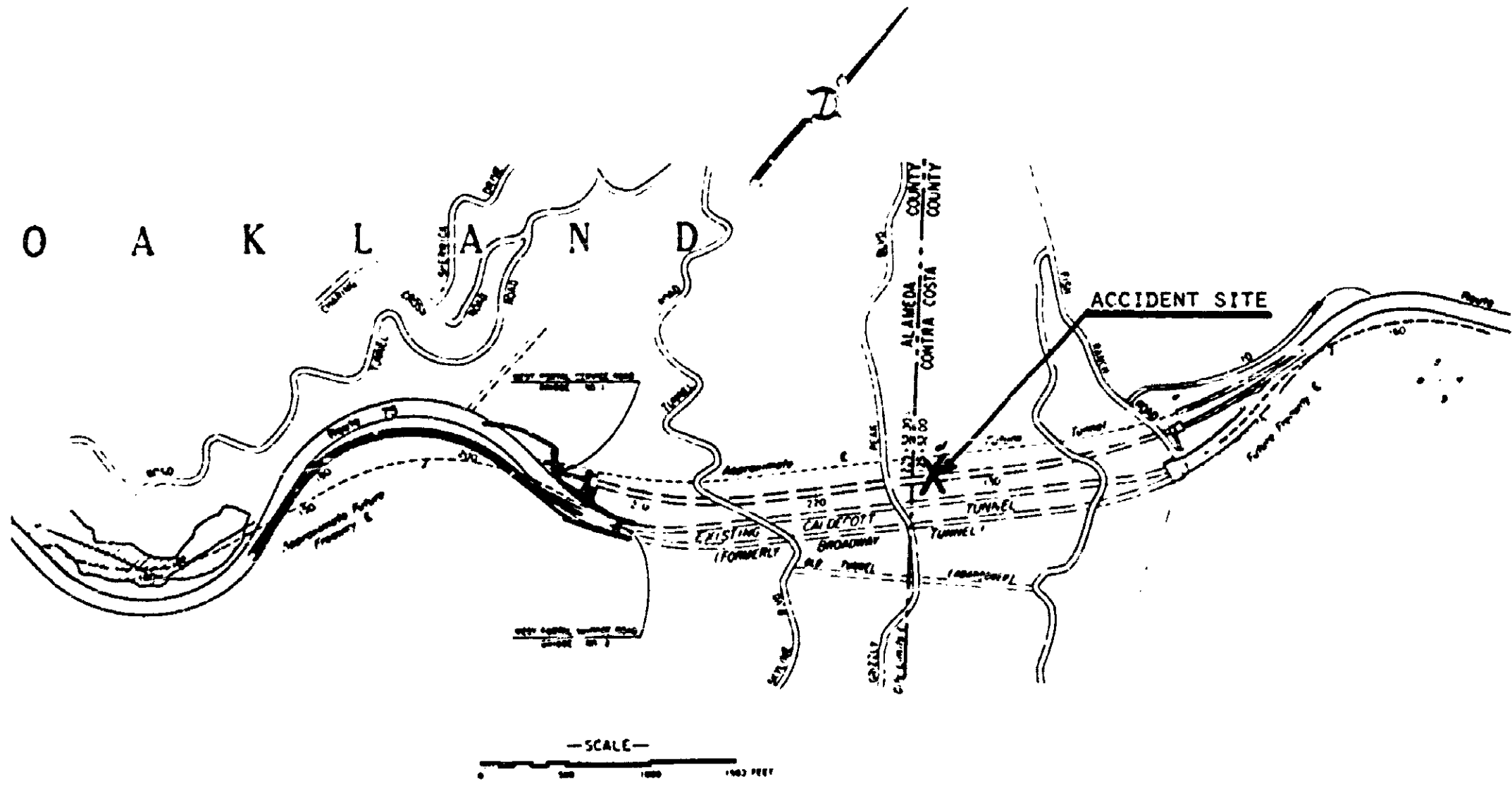


Figure 1.—Caldecott Tunnel Plan View.

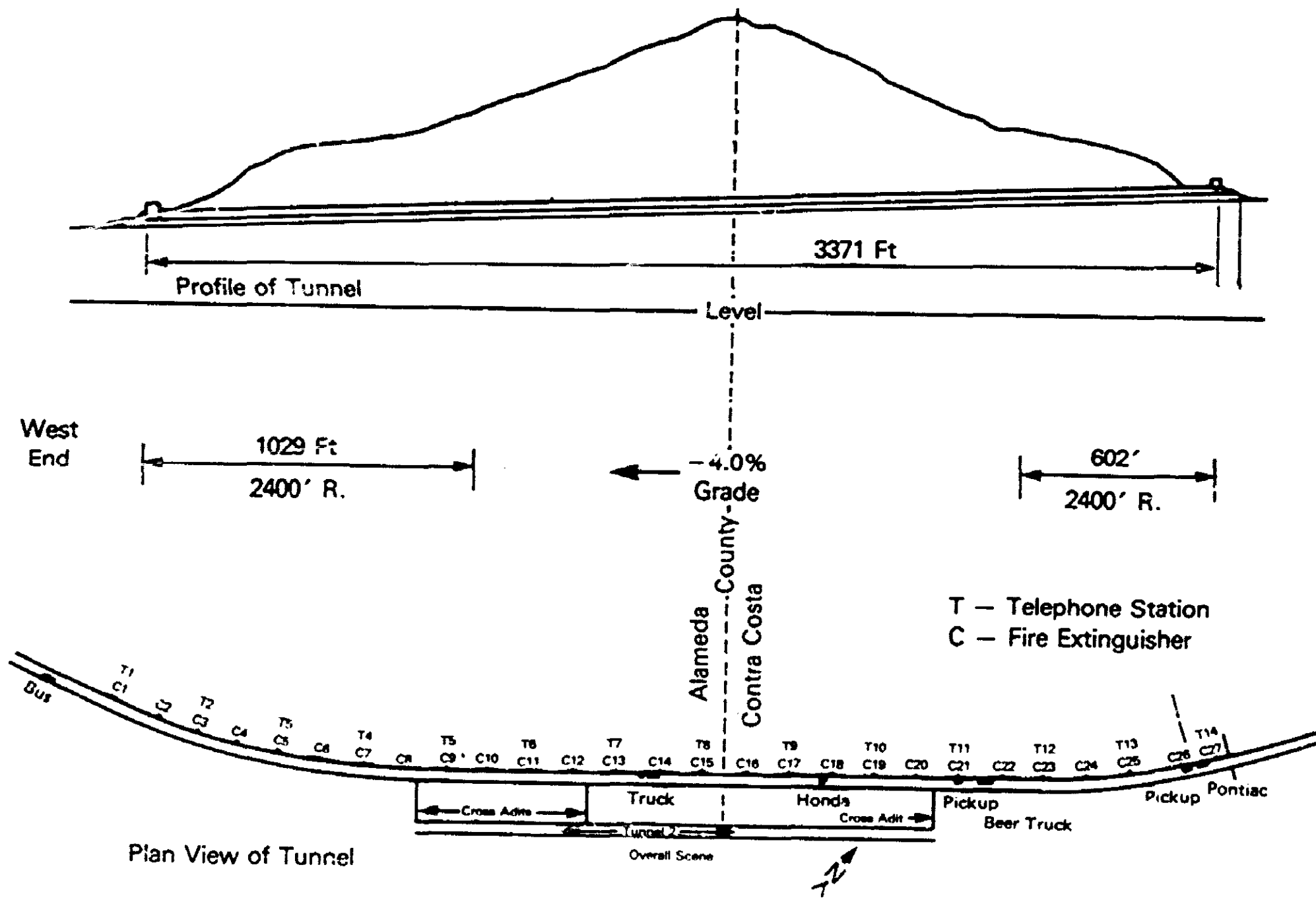


Figure 2.—Plan and profile of California State Route 24 through the Caldecott Tunnel. (Final resting positions of vehicles.)

immediately to the rear of the beer truck. These motorists later stated that at this time they were not aware of any hazards from the fire, and their main concern was the possibility of being struck from behind by following vehicles. The fire near the tank truck was reported as "about the size of a barbeque fire" at this time.

Shortly thereafter, as the motorists to the rear of the beer truck awaited their turn to back out, they observed that "thick black smoke appeared to be coming up from the road and moving rapidly toward them." Some of the motorists reported that as they were trying to escape, they observed the passage of two walls or "waves" of smoke and heat. The first "wave" of smoke reached the motorists when they were within 200 to 250 feet of the rear of the beer truck. They rolled up their windows and started to back their vehicles as fast as they could. Before all of the motorists had backed out of the tunnel, a second heavy concentration of black, hot smoke overtook them and they had difficulty seeing and breathing. The motorists said that the second "wave" was darker, thicker, and hotter than the first wave. The thick smoke overtook the Ford pickup truck driver as he was walking eastward, and he was unable to get back to his mother who was using the phone. Another driver, who had backed his Toyota pickup truck until it was stopped by a Pontiac car that was turned around in the roadway, found it necessary to abandon his vehicle, grope through the smoke to the wall, and feel his way out of the tunnel. The two occupants of the Pontiac stayed in their car. As the thick black smoke from the second "wave" reached the end of the tunnel, the smoke went straight up in the air. There were "loud explosions," the lights went out, and the tiles started falling from the walls and ceiling of the tunnel. Motorists reported that the intense heat and smoke prevented any of the onlookers at the east portal from returning inside and rescuing any of the trapped motorists. Meanwhile, the tank truck driver had run from his truck out of the west end of the tunnel. (See figure 2 for vehicle rest positions.)

Emergency Response

At the time of the accident, five California Transportation Department (CalTrans) employees were in the control room at and above the west portal of the Caldecott Tunnel. About 5 to 8 minutes before the accident, the crew had returned from their routine inspection of the tunnel and had reported to the supervisor that all roadways were operating normally.

About 12:12 a.m., the tunnel crew reported hearing a "series of loud backfires or popping sounds that got progressively louder." The crew reported that the sounds continued until there was a final "thud which shook the building." At this time, the console operator observed on his television monitor a bus, accompanied by a shower of sparks, strike a road support pier at the west portal of Bore No. 3. The console operator's phone buzzer sounded within 1 minute following the bus collision, and the operator heard a woman's voice saying, "there was a whole bunch of accidents in the tunnel." The phone then either went dead or the party left the phone. The console operator then contacted the California Highway Patrol (CHP) Oakland dispatcher about 12:13 a.m., and reported "an accident in Bore No. 3."

The tunnel crew immediately proceeded to investigate the "noise." At 12:13 a.m., two men responded to the east portal and one man responded to the west portal. Another man went down the stairway from the console room that leads to an access door at the west end of the tunnel, entered the tunnel, observed the tank truck driver running out of the tunnel about 12:14 a.m., and was informed that a gasoline tank truck was on fire in the tunnel. He returned to the control room and again called the CHP and requested that the fire department be called.

The tunnel crewman at the west end checked the damaged bus for victims, found none, then entered Bore No. 3 and drove his tow truck to within 150 yards of what appeared to be a "tractor on fire," and observed that the fire filled the tunnel. (See figure 3.) He stated that he also observed burning gasoline flowing westward in the north lane gutter approximately 10 to 15 feet in front of the tractor. The rear portion of the vehicle also was engulfed in flames. Since no one was in sight, he backed out of the tunnel and about 12:16 a.m. used the emergency phone at the west portal to call the console operator and report the fire. He stayed at the west end of the tunnel until the first fire units arrived.

The east end tunnel crew later stated that they drove tow vehicles through Bore No. 1 and stated they arrived at the east portal within approximately 4 minutes of the collision (12:16 a.m.). The crewmen reported that when they arrived, the approach lights to the tunnel were out and large black clouds of smoke were pouring out of the entrance. They began moving some 100 onlookers back at least 100 yards from the east portal.

Shortly after 12:16 a.m., two CHP patrolmen who were at Old Tunnel Ramp Road, several hundred yards from the west portal of Bore No. 3, heard two "explosions" coming from the vicinity of the west portal of the tunnel and proceeded to investigate. When the patrolmen arrived, they met the driver of the tank truck who identified himself and told them that his trailer had "flipped over" and that there were 8,800 gallons of gasoline in the tank truck. One patrolman then walked into the west opening of Bore No. 3, rounded the curve, found that the heat was too intense to permit a further search, and exited the tunnel.

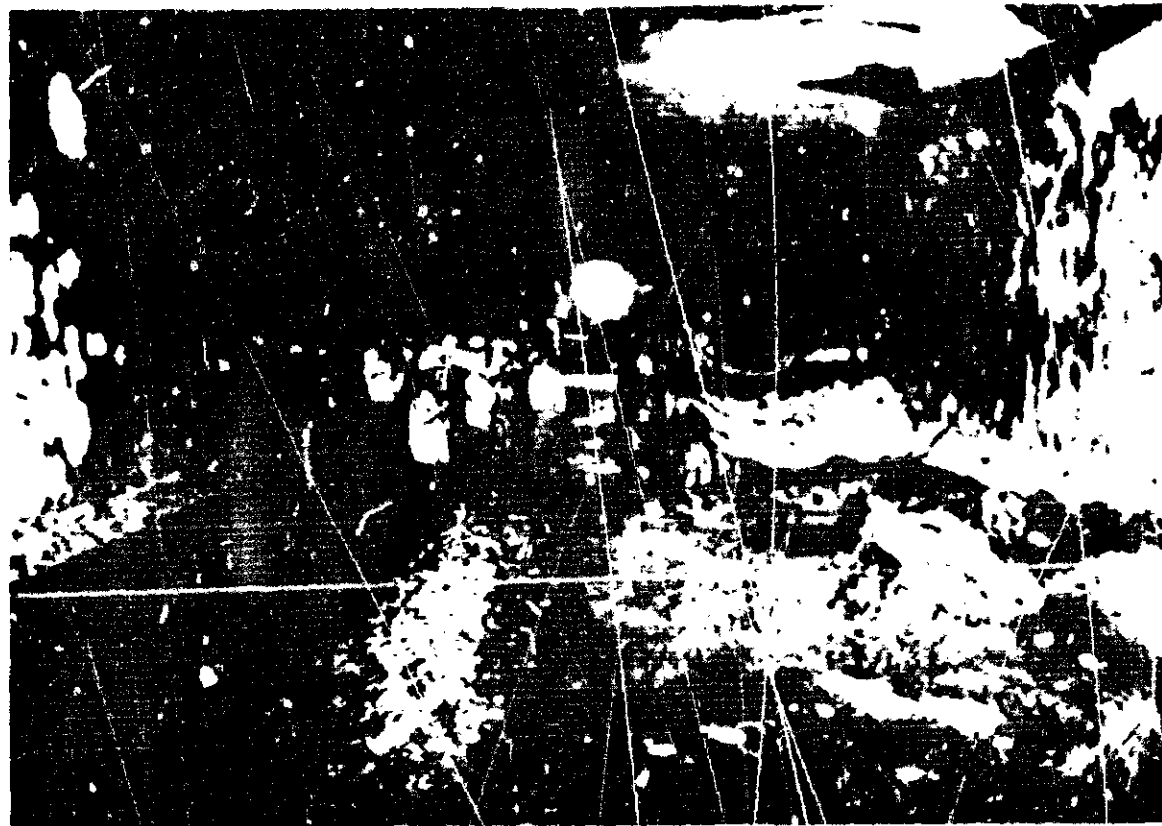


Figure 3.--Tank truck and trailer after fire.

At 12:20 a.m., the CalTrans console operator again called the CHP Oakland dispatcher and requested that they notify the fire department. The CHP dispatcher in turn contacted Oakland Fire Alarm at 12:21 a.m. Four units from the Oakland Fire Department arrived on scene at 12:27 a.m. and established a command post approximately 100 feet from the west portal; one unit proceeded through Bore No. 1 toward the east end of Bore No. 3.

At 12:26 a.m., the CHP dispatcher contacted the Orinda Fire Department, which dispatched three units to the east portal at 12:28 a.m. The Orinda fire officer-in-charge was informed by motorists that there were at least 6 to 8 motorists still in the tunnel. The Orinda Fire Department advised the CalTrans east end crew and the Oakland Fire Department that because of the heavy smoke, they could not reach the fire.

Both the Oakland and Orinda fire chiefs "struck a second alarm" between 12:27 and 12:29 a.m. In response to the second alarm, four units from Oakland accompanied by an assistant chief reached the scene at 12:33 a.m. Orinda Fire Department under a mutual aid agreement requested fire support from the Moraga and the Consolidated Fire Departments.

The Oakland Fire dispatcher contacted Highland Hospital to prepare for a "possible major medical disaster." Also, the Caidecott console operator contacted the tunnel superintendent at 12:28 a.m. He proceeded to the tunnel and on his arrival, took charge of the CalTrans operations.

At 12:31 a.m., a fire officer arrived at the console room to direct the fan ventilation. ^{3/} The console operator reported to the fire officer that the fans were not turned on, and the officer decided to leave the fans off for fear smoke would back up towards the west portal where personnel without protective equipment could be caught unprepared.

The front end of the tank truck came to rest in the right lane, 17 feet east of an 18-inch by 36-inch storm drain inlet. Gasoline leaking from the damaged trailer tank ignited and flowed westward down the 4-percent grade along the right lane curb 280 feet past the storm drain. The fire left a light concrete spall pattern along the curb/roadway surface.

The Oakland Fire Department determined that the fuel that entered the storm drain flowed 16 feet through a 6-inch galvanized steel pipe beneath the roadway surface to a connector box located 35 feet from the front end of the tank truck. About 1:00 a.m., the Oakland fire chief ordered the north and south control valves of the tunnel drain closed in order to contain the excess fuel/water runoff within a 5,000-gallon holding tank between the valves.

About the same time he ordered the control valves closed, the Oakland fire chief decided that the danger of an explosion was over, and a two man sweep team with complete protective equipment entered the tunnel to search for possible survivors. There were no survivors, and seven bodies were located: the bus driver, the Honda driver, the two occupants of the beer truck, the two occupants of the Pontiac car, and the Ford pickup passenger who had phoned the control room.

^{3/} Under the CalTrans fire response procedure, the fire department has responsibility for setting the fan ventilation to equalize the draft.

At 1:09 a.m., the CalTrans supervisor arrived at the east portal and took charge of CalTrans operations and conducted an immediate assessment of the structural damage. Based on his findings, firefighters were cleared to enter the tunnel. Between 1:30 a.m. and 2:00 a.m., firefighters laid hoses from the nearest stand pipes in the center bore through the middle and eastern adits^{4/} (approximately 120 feet) and began fighting the fires. At 2:54 a.m., the chief reported that the fires were under control.

At 1:39 a.m., a fire unit had reported "a strong odor of gasoline" and a slight slick or film on the northwest quadrant of Temescal Lake, located west of the tunnel. A survey taken later of the lake area using a flammable gas detector concluded that no dangerous concentrations of gasoline vapors were present, that only an estimated 200 gallons of gasoline had entered the lake, and that no gasoline had entered the Oakland sewer system.

Injuries to Persons

<u>Injuries</u>	<u>Drivers</u>	<u>Passengers</u>	<u>Pedestrains</u>	<u>Total</u>
Fatal	3*	3	1	7
Serious	2	0	0	2
None	<u>1</u>	<u>0</u>	<u>0</u>	<u>1</u>
Total	<u>6</u>	<u>3</u>	<u>1</u>	<u>10</u>

* One driver fatality was a trauma victim. All other injuries were fire related.

Vehicles

The cargo tank truck and tank trailer were owned and operated by the Armour Oil Company, San Diego, California. The 1977, W900A Kenworth cargo tank truck was equipped with a Detroit diesel 8V71 engine, an Allison automatic transmission and 11 x 24.5 tires (43.5 inches diameter). The 4,500-gallon aluminum tank, MC 306AL, was manufactured in May 1977 by the Clough Equipment Company. The tank was equipped for top or bottom loading with hose tubes on the right side only (see figure 4). The last truck maintenance record dated March 11, 1982, indicated an odometer reading of 599,299 miles.

Clough Equipment Company also manufactured the 1977 full trailer, model MC 306AL, and the 5,400-gallon aluminum cargo tank. The tank was also equipped for top or bottom loading and had hose tubes on both sides. The full trailer had 11 x 24.5 tires (43 1/2" diameter). The combination vehicle was carrying 8,800 gallons of gasoline at the time of the accident.

Both the truck and trailer cargo tanks had been pressure tested on March 10, 1982, as required by 49 CFR 173.33, Qualification, Maintenance, and Use of Cargo Tanks.

The 1975 Grumman Flexible 53-passenger bus, model 53102-S-1, was owned and operated by AC Transit Company of Oakland, California. The bus was equipped with a Detroit diesel rear mounted engine, a V-S-Z-812236-5 transmission, and 12.5 x 22.5 tires. (See figure 5.)

4/ Small cross tunnels that connect the bores of the tunnel.

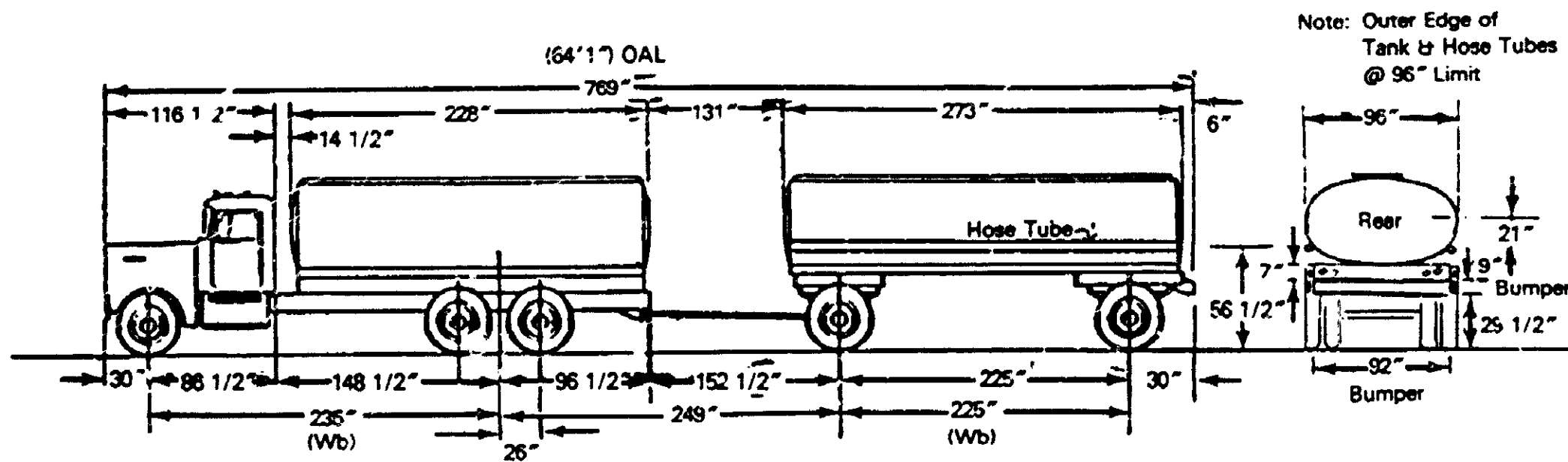


Figure 4.—Sketch of cargo tank truck and cargo tank trailer.

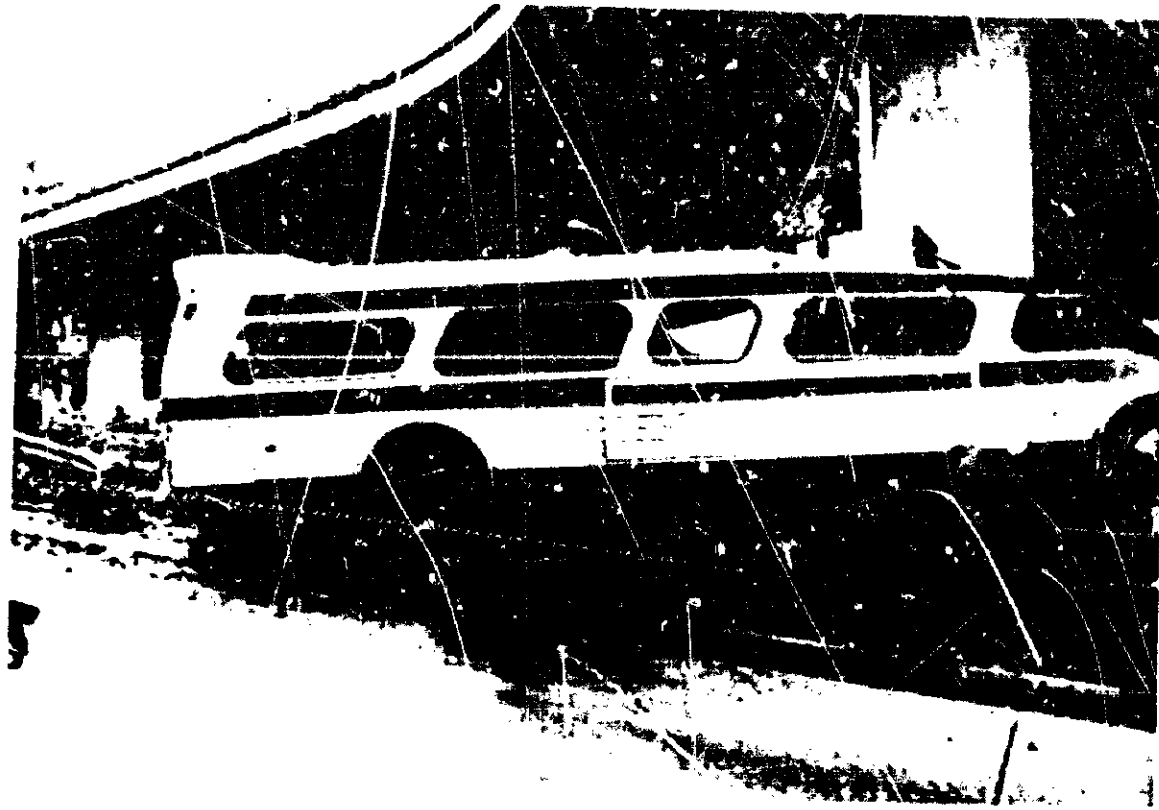


Figure 5.—AC Transit bus after impact.

The 1978 Honda Accord, VIN SJE 3004356, was owned and operated by a resident of San Leandro, California. It was gold in color and was equipped with 155 SR13 tires. (See figures 6 and 7.)

The 1976 Kenworth Tractor and Utility Semi-trailer carrying beer, the 1976 Ford pickup with a motorcycle in the cargo bed, the 1980 Toyota pickup, and a 1980 Pontiac Phoenix were in the tunnel at the time of the accident. They were not involved in the collisions but were destroyed by the fire.

On Thursday, April 8, 1982, Safety Board investigators performed a preliminary inspection of all of the accident vehicles except the bus while the vehicles were still in their rest positions in the tunnel. The bus had been moved to a salvage yard because it was a distraction to motorists. On Friday, April 9, 1982, the bus was examined in the salvage yard in Alameda. And on Monday, April 12, 1982, Safety Board investigators thoroughly examined all seven vehicles at a salvage yard in Alameda, California, following their removal from the tunnel. (See appendix A.)

Damage to Vehicles

Tank Truck.—The tank truck came to rest upright, 1,732 feet from the east portal, with its right side 50 inches away from and parallel to the right curb. The towbar was still attached to the truck pintle hook and to the trailer's front axle turntable. The trailer's rear axle was resting on its right end 100 inches from the right curb. The only remaining cargo tank shell material included a 70-inch by 96-inch bottom sheet section from the rear compartment of the tank truck and a 40-inch by 21-foot section from the right side of the trailer tank. All other low melting point and combustible materials had been consumed by the fire.

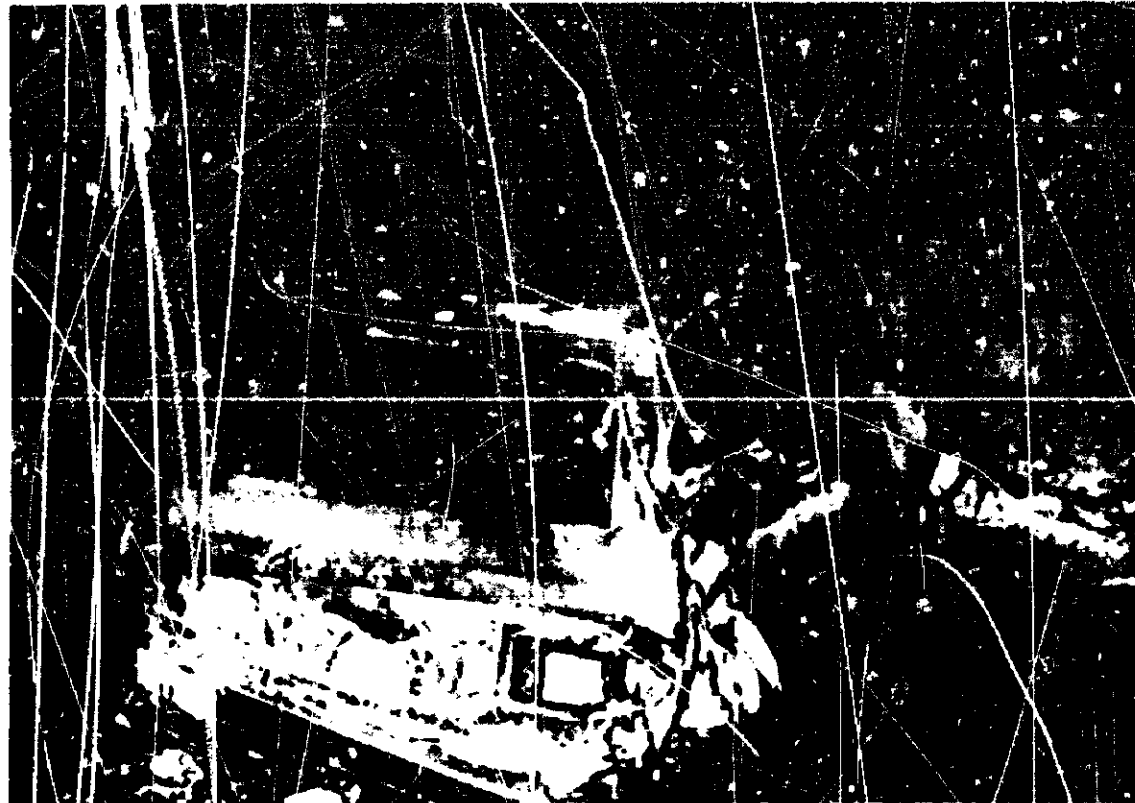


Figure 6.—Right rear of Honda in tunnel.



Figure 7.—Left rear of Honda at salvage yard.

The forward end of the two 14-foot safety cables between the truck and trailer were still properly attached to the truck. They were both wrapped three-quarters of a turn counterclockwise around the truck pintle hook. Both cables were also still properly attached to the front trailer axle; however, the left cable had broken 7 1/2 feet from the front end. The right cable was intact.

The front trailer axle was in an inverted position and resting between the towbar and the right curb. The spring-to-axle "U" bolts on the left side were still attached to the axle but the 4-leaf spring pack was missing. The right air bag pedestal and spring pack were still properly attached to the axle by the "U" bolts. The front ends of the main leaf springs on the right were deformed to the right and had separated from the spring shackle.

The front trailer axle turntable was rightside up, tipped toward the right, and still properly attached to the towbar. The two left main spring leaves were still attached to the front shackle and were not deformed. The left air bag pedestal was found under the left side of the turntable. The ends of the left shackle bolt and shock absorber mounting bolt were ground to a 45° angle.

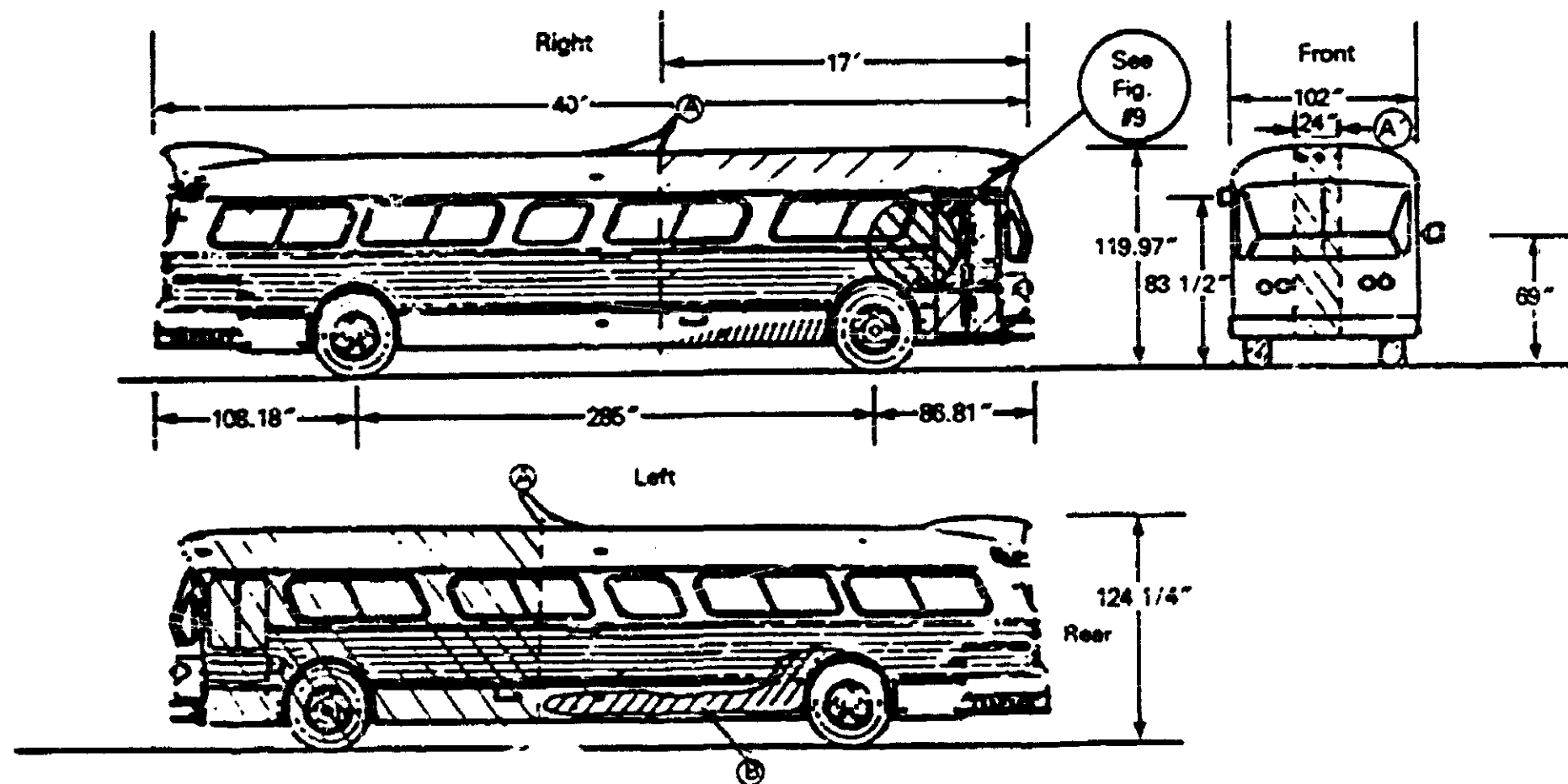
AC Transit bus--The force of the collision of the bus with the structural pier caused a 17-foot rearward displacement of the center front components. (See figure 5.) As a result of a 24-inch-wide area of penetration along the longitudinal center of the bus (see figure 8), passenger seats were rotated and pushed outward and the plywood floor was completely destroyed. The center of the front axle beam was bent approximately 6 inches rearward with axle and suspension attachment devices displaced and destroyed. Top-mounted identification lamps and the sheet metal located below the windshield were pushed 17 feet rearward. Both ends of the front bumper were deformed rearward, and the bumper was separated at the center. Lateral rubber markings measuring 10 inches and 4 inches were located on the bottom forward face of the bumper at the right end and left end, respectively.

The only evidence of vehicle-to-vehicle contact rearward of the right front wheel of the bus was a small scuffed area at the right rear corner approximately 5 feet high. The bottom skirting from the right front wheel to approximately the midpoint of the bus was buckled upward. (See figure 5.)

The two-part forward entrance door had separated from the vehicle. The vertical window side frames of the right door were deformed rearward. Safety Board investigators did not locate the rear half of the entrance door. The forward front or right entrance door post and hinge bar were displaced 17 feet rearward. The upper end of the right door post was neither scratched nor bent. There was a horizontal scratch pattern on the panel between the entrance door post and the first right side window (item D, figure 9). This panel and the rear entrance door post were deformed inward. There was a horizontal scratch pattern on the side panel 44 to 49 inches above the ground (item F, figure 9). A 5-inch by 8-inch rectangular scrape and indentation was observed above the right front wheel (item C, figure 9). Rubber deposits were found on the upper surface of the bottom side panel flange (item G, figure 9).

A cut was found in the sidewall of the right front tire and was in alignment with a wheel abrasion mark and hubcap dent (item J, figure 9). Rubber deposits were found on the outer face of the disc wheel in the wheel lug bolt circle area.

There was no sheet metal sideswipe damage at the forward left corner of the bus. (See figure 8.) The outer projections of the disc wheel lugs on the left front wheel were ground down.



- Ⓐ Post Crash Location of Front Surface Sheet Metal Parts
- Ⓑ Width of Front Surface Sheet Metal Parts Deformation
- Ⓒ 1. Longitudinal Scratch Pattern Between 22" and 43" Above Ground
- 2. Rubber Transfer 22" Above Ground Just Forward of Rear Wheel Well
- 3. Wheel Well Trim Torn Rearward 29 1/2" Above Ground

Figure 8.—Sketch of AC Transit bus with impact damage illustrated.

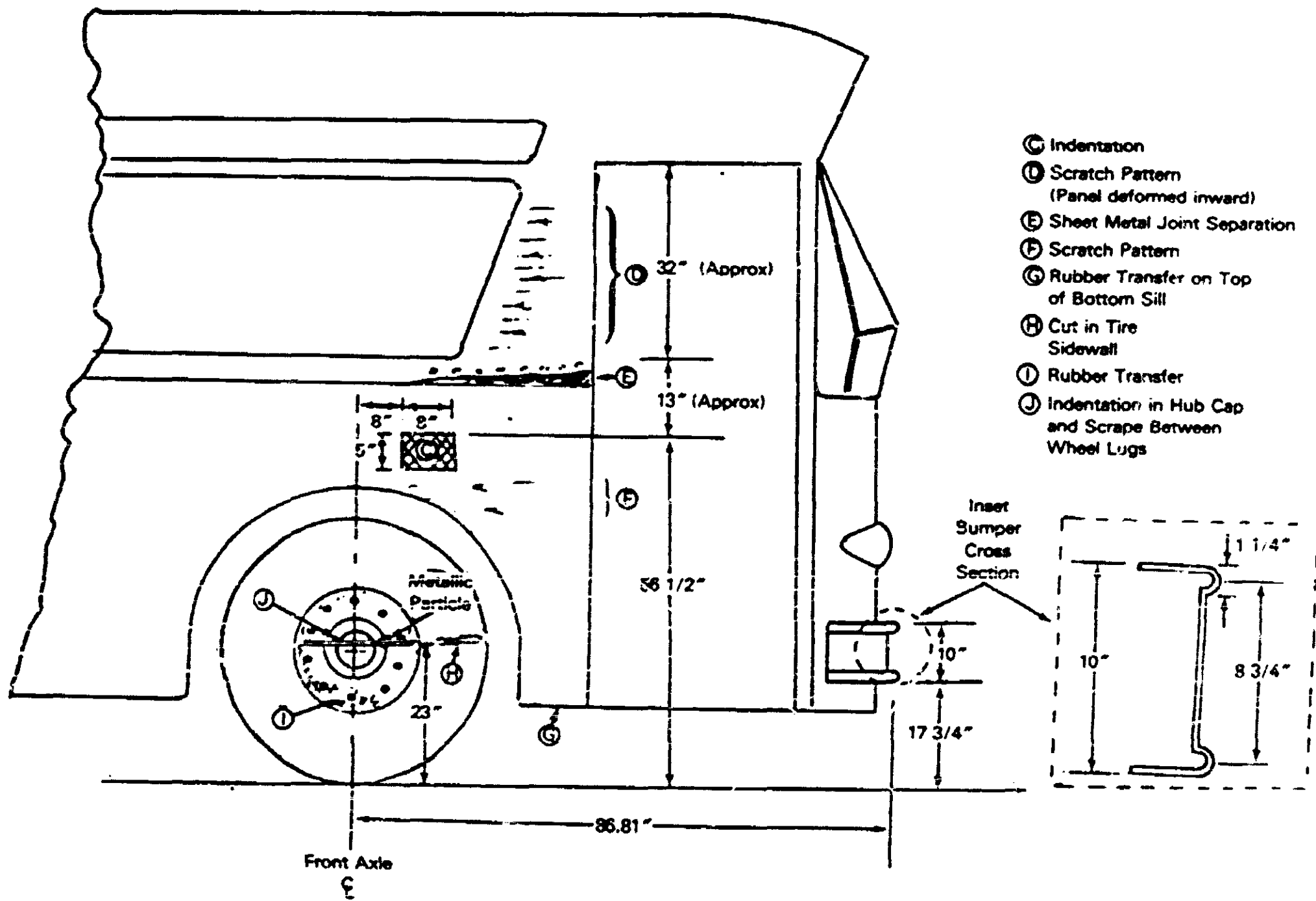


Figure 9.—Sketch illustrating right front end components of AC Transit Bus.

There was a horizontal scratch pattern on the left side from the rear wheelwell to approximately the midpoint of the distance between the axles. Scratches were found 22, 25, and 28 inches above the ground. There were black marks approximately 18 inches long and 22 inches above the ground, directly forward of the rear wheelwell. The trim at the forward edge of the rear wheelwell was kinked and deformed rearward 29 1/2 inches above the ground.

The bus was equipped with six Firestone tires, the tread depths on the front tires were 16/32 to 18/32 inch and 4/32 to 5/32 inch on the rear tires. All tires were inflated.

Investigators checked the wheels, air valves, and brake chambers. The left rear brake drum wear surface was in good condition, and the brake shoes had more than adequate lining. Investigators started the engine and found that the air compressor began functioning at 90 p.s.i. and cut out at 105 p.s.i. The "no load" engine governed speed was 2,350 rpm. This engine rpm and the transmission and axle gear ratios would permit a governed road speed of 68 mph. The throttle linkage between the driver's pedal and the engine was jammed in the open position. The fuel tank, air conditioning unit, instrument panel gauges, some passenger seats, the driver's seat, and other miscellaneous components were separated from the bus. The driver's seat lap belt was clean, intact, and fully retracted; however, when the retraction mechanism was tested, it did not operate properly to fully retract the belt. No evidence of fire exposure and no preexisting mechanical deficiencies were observed.

The Honda Accord.---The Honda Accord was found 1,196 feet west of the east portal at a 45° angle to the roadway, with the right front wheel against the north (right) curb. All combustible and low melting point materials had been consumed by fire. (See figures 6 and 7.) All four corners, both rear wheel suspensions, and the right rear roof quadrant had been deformed by impact.

The left front was deformed vertically inward (12 inches of the left front of the car and 33.5 inches of the left side of the car). (See figures 10 and 11.) The lower right front fender components were deformed inward and upward. The right rear fender deformations (item N, figure 11) were primarily inward and forward with minor downward bending.

The right rear hatchback post and rain gutter were deformed inward up to a point 43 1/2 inches above the road. The upper half of the hatchback side window post was deformed inward at a greater attitude than the lower half. The roof (item R, figure 11) had been deformed slightly downward and had also incurred heat damage. The right rear wheel (item M, figure 11) had been pushed forward and deformed with the front toed inward at a 45° angle. The rectangular-shaped damage to the left rear fender (item O, figure 11) was 8 3/4 inches long in the vertical direction and 22 1/2 inches from the rear bumper. The entire left rear fender (item P, figure 11) and a portion of the rear panel below the bumper was dented. The bottom of the left wheel (item Q, figure 11) was toed inward.

Other Vehicles

The Tractor and Utility Semi-trailer (beer truck) was found 754 feet west of the east portal facing west with its right wheels 4 feet from the north curb. The 1965 Ford pickup was located 807 feet west of the east portal facing west with its right wheels against the north curb. The 1980 Toyota pickup was found 136 feet west of the east portal with the right wheels about 8 feet from the north curb. The 1980 Pontiac Phoenix

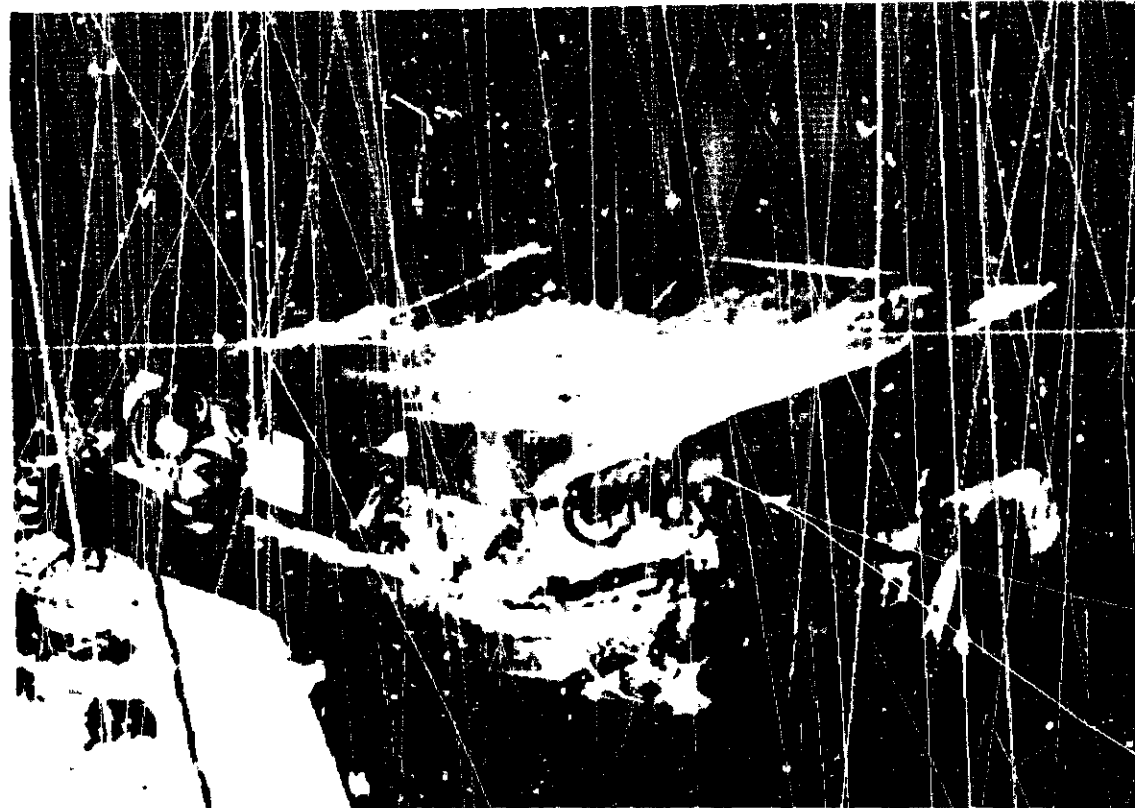


Figure 10.—Left front corner of Honda.

Sedan was standing 118 feet west of the east portal facing east at about a 45° angle with the left rear wheel about 8 feet from the north curb. All of these vehicles incurred extensive fire damage. There was no evidence of impact damage to any of these vehicles.

Fire Damage to the Tunnel

On April 8, 1982, CalTrans engineers conducted a damage assessment of the tunnel, and the report, in part, stated:

...the tunnel arch, the main component of the tunnel, was not seriously affected. In the eastern 1,900 feet of the tunnel, tiles, some of the concrete, fluorescent lights, emergency phones, the firefighting water supply system, signs, alarms, conductors, and the commercial broadcast antenna were destroyed or damaged, [see figure 3], the concrete ceiling slab, was severely spalled above the gasoline truck, the steel plates in the ceiling (guillotine damper plates) over the exhaust and intake vents were warped and bent, the roadway slab was spalled, especially near vehicles and the initial estimated damage to the tunnel was \$2,700,000.

Company Information

Alameda/Contra Costa Transit District.--The Alameda/Contra Costa Transit District (AC Transit) is an autonomous transit district created and financially controlled by the California State legislature. AC Transit provides service to the counties of Alameda and Contra Costa and the municipalities therein. Company drivers are required by the California Vehicle Code to possess California Class 1 or Class 2 licenses. As an

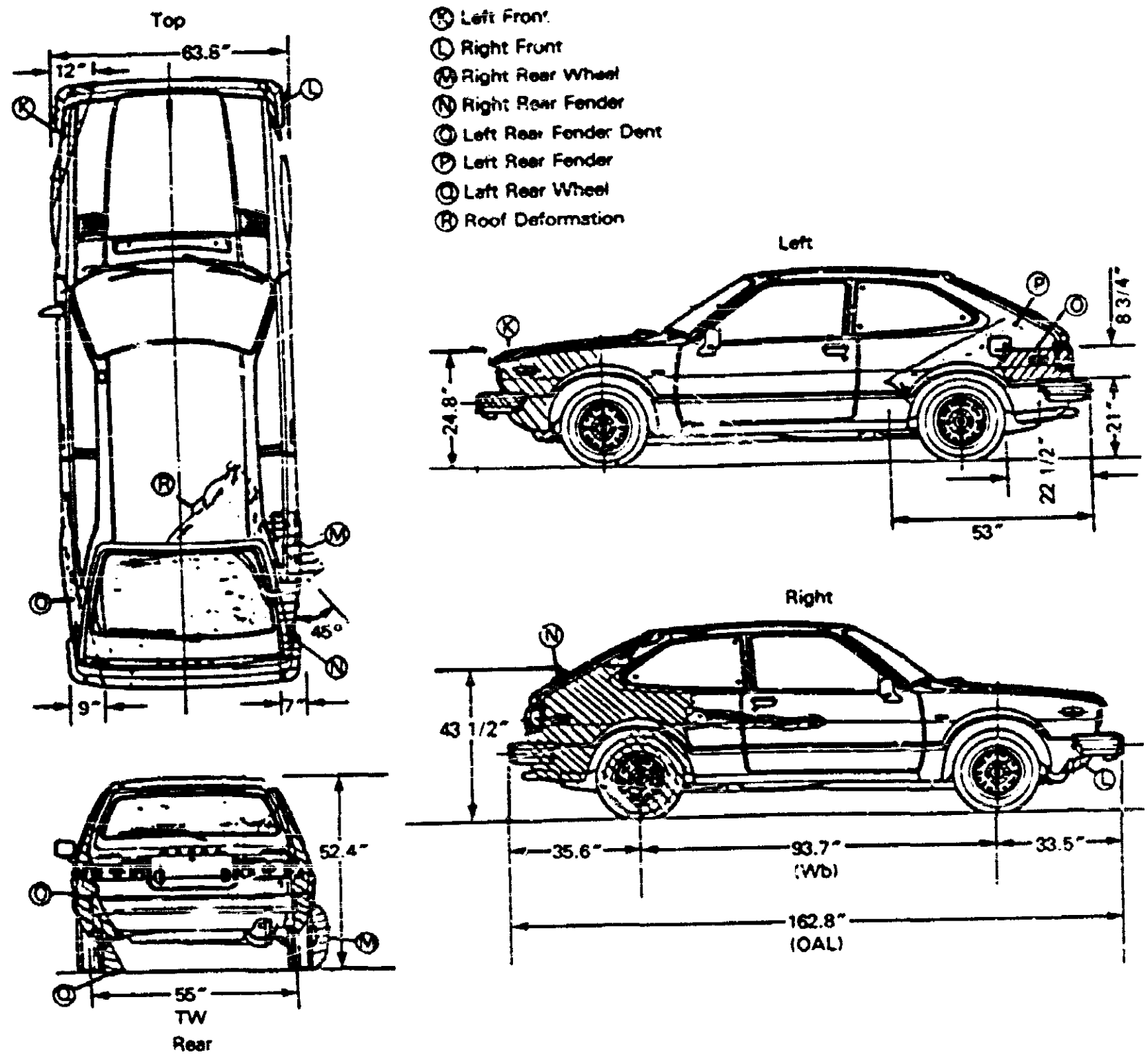


Figure 11.—Areas of damage to 1978 Honda.

intrastate, local transit company, it is not subject to the Federal Motor Carrier Safety Regulations (FMCSR).

Armour Oil Company.--Armour Oil Company is a privately owned carrier/broker of petroleum products. The carrier operates eight terminals throughout California, Arizona, Nevada, Utah, Oregon, and Washington. The Armour Oil Company operates interstate and is therefore subject to FMCSR.

Driver information

Busdriver.--At the time of the collision, the 54-year-old busdriver held a valid California Class 1 driver's license with no restrictions.

The California Department of Motor Vehicles (DMV) records indicated that the busdriver had been convicted of two traffic violations--failing to obey a traffic control sign in March 1978, and exceeding the state speed limit (55 mph) in July 1978. Both violations occurred while he was driving a privately owned vehicle. The DMV records also indicated that the busdriver had been involved in two motor vehicle accidents. One occurred in November 1978, while he was operating an AC Transit vehicle. No citation was issued, and AC Transit records indicate that no fault was attributed to the driver. In July 1980, in Oakland, California, the driver's personal vehicle impacted the rear end of a stalled vehicle. No citation was issued at the time; however, the driver's license was suspended because of his failure to prove financial responsibility (California Vehicle Code (CVC) Section 16070). The suspension began on December 14, 1980, and was lifted in January 1982, when the driver established financial responsibility. The suspension specifically exempted the operation of a vehicle owned and insured by another in the course of employment, and the driver continued to operate an AC Transit vehicle during this time. The suspension record was placed in the driver's personnel file.

At the beginning of his employment, the busdriver had received the AC Transit required 250 hours of practical driving instruction and 85 hours of classroom instruction in the safe operation of this type of vehicle. AC Transit records indicated that he had received periodic check rides and had been graded as satisfactory.

The busdriver's usual workday routine was to travel to the Emeryville AC Transit Yard, travel on a Bay Area Rapid Transit (BART) bus to Walnut Creek, relieve a driver for his 8-hour route, return the bus to Emeryville, and then return home. The busdriver had been off duty for 2 days before the accident. On April 6, he relieved the busdriver for Coach No. 8016 at 4:36 p.m., at the Walnut Creek BART station. He concluded his route in Martinez about 11:53 p.m., April 6, 1982, and began to dead-head back to the Emeryville lot. Witnesses reported passing, pacing, or being passed by the bus between Martinez and the Caldecott Tunnel at speeds of 55 to 65 m.p.h.

The AC Transit District personnel files indicated that during his 5-year employment the busdriver was under periodic doctors care for hypertension and high blood pressure. These files also record that during the past 3 years he had made 20 appointments with physicians or clinics. Fourteen of these appointments were confirmed through contact with the doctors involved and were for either the direct care of hypertension or for symptomatic treatment (gastroenterites, dizzy spells, and fainting spells). Both his 1979 and 1981 company-required, physical examinations revealed blood pressure readings high enough that on both occasions he was advised to consult his own physician regarding treatment for hypertension. During the latter part of 1980, he had recorded blood

pressure readings of 150/100 and 180/110. ^{5/} During the 3-year period, and specifically 1981, he showed a significant increase in "miss-outs" at work; AC Transit records indicate that he missed work 40 days in 1981. The dates of missed employment generally coincide with recorded medical visits.

Tank truck driver.--The 44-year-old Armour Oil Company tank truck driver possessed a valid California Class 1 license, with no restrictions, appropriate for the class of vehicle he was driving. California DMV records indicated that the driver had not been convicted of any traffic violations and had not been involved in any motor vehicle accident in the past 5 years. Employment records obtained from Pacific Intermountain Express (PIE), the last company he worked for before Armour Oil, indicated that he had not been involved in any accidents. He received a check ride from PIE, but there is no other indication of professional tank truck driver training. He stated that he had not received formal instruction in tank truck operation. His only tank truck driving experience was during the 2 years he was employed by Armour Oil Company.

The tank truck driver had been off duty for 7 days before the accident. About 8:00 p.m., April 5, he went to bed and was up early on April 6. About 5:00 p.m., he was called by the Armour Oil Company dispatcher to report to work. He left his residence in Sacramento, California, and drove to the Armour Oil Terminal in Martinez, arriving at 7:15 p.m. He started his shift at 7:30 p.m., inspected his vehicle, and began his delivery route. He made one delivery and returned to the Land and Sea Refinery in Martinez and refilled with 8,800 gallons of gasoline for delivery to a service station on Fruitvale Avenue in southeast Oakland, California. He had been awake for 16 hours before the collision and had driven for 6 of those hours. Witnesses reported observing the tank truck between Lafayette, California, and the Caldecott Tunnel east entrance, traveling at speeds at or less than the posted maximum speed limit of 55 mph.

There were no precrash physical disabilities recorded in the personnel records of the Armour Oil Company driver.

Honda Driver.--The 34-year-old Honda driver held a valid California Class 3 license with no restrictions, the appropriate license for the vehicle she was operating. The California DMV records indicated that she had neither been involved in any traffic accidents nor been convicted of any violations in the past 3 years. The extent and type of her driver training, if any, are unknown. She had been off work on April 5 and 6. On April 6, she had slept from midnight to approximately 6 a.m. She visited with friends and family and engaged in light activities until departing about 4:30 p.m. to meet friends in Walnut Creek. She was visiting and drinking with friends at four different locations from 5:45 p.m. until after 10:00 p.m.

The Honda driver's associates were interviewed to determine whether or not she had any precrash physical impairments. None were identified.

There were no witnesses to her departure or travel on State Route 24 until she was within the tunnel, where witnesses reported seeing the vehicle weaving, striking one or more curbs in the tunnel, and coming to rest at the south side of the left lane against the curb.

^{5/} Dorland's illustrated Medical Dictionary indicated 140/90 as a definition of hypertension. CFR regulations utilize 160/90 as a limit for driver qualification.

Medical and Pathological Information

The Contra Costa County Coroner's autopsy report on the AC Transit busdriver conducted on April 7, 1982, stated that he died of extensive thermal burns with related external and internal organ damage and possible smoke inhalation. There was no indication of any traumatically induced injuries. His carbon monoxide reading was 4.1 percent saturation^{6/} and his blood alcohol level (BAL) reading was 0. The examination indicated rather marked atherosclerosis, "with the left anterior descending coronary narrowed beyond approximately 70 percent and the right descending coronary narrowed beyond approximately 80 percent. No areas of complete occlusion were noted."

The autopsy report on the Honda driver indicated that she succumbed to extensive thermal burns with related external and internal organ damage, and possible smoke inhalation. There was no indication of any traumatically induced injuries. She had a carbon monoxide saturation of 13.1 percent and the BAL reading was 0.17 percent. California presumptive BAL limit for legal intoxication is 0.10 percent.

The autopsy report on the 53-year-old driver and the 30-year-old male passenger in the 1976 Kenworth beer truck indicated that both succumbed to thermal burns and both had a carbon monoxide saturation of 31 percent. The autopsy report on the 58-year-old female passenger in the 1965 Ford pickup truck indicated that she succumbed to thermal burns and had a carbon monoxide saturation of 20.5 percent. The autopsy report on the male driver and female passenger of the 1980 Pontiac Phoenix, indicated that both succumbed to thermal burns. Determination of carbon monoxide saturation was not possible because of a lack of tissue samples for the 68-year-old couple. The CHP determined that it was not necessary to make any postcrash toxicological tests of the tank truck driver, since he did not display any symptoms of instability.

Highway and Tunnel Information

Westbound State Route 24 from Orinda consists of four 13-foot-wide concrete lanes with periodic on and off ramps. The roadway is bordered to the south by a solid yellow edgeline, an asphalt median strip, a metal beam guardrail, and a BART perimeter fence. The roadway is bordered to the north by a solid white edgeline, a 5-foot asphalt shoulder, and an open area. A "MAXIMUM SPEED LIMIT 55" sign is posted about 6.7 miles east of the tunnel. A 50-mph speed limit sign is posted about 727 feet east of the tunnel. There are no signs prohibiting hazardous material cargoes or passing in the tunnel, and there are no lane control signals in the tunnel or at the entrance. The first of three large overhead tunnel directional signs which read at the time of the collision "two left lanes closed" is posted 1.4 miles east of the tunnel. The tunnel consists of three one-way, two-lane bores and operates with up to four lanes in one direction and a minimum of two lanes in the other direction, depending on traffic demand. At the time of the collision, the 3,371-foot-long north No. 3 bore, where the accident occurred, was the only bore open to westbound traffic.

^{6/} The USAF Safety Kit, 1973, in an opinion authored by major Robert R. McMaken, Chief Aerospace Pathology Branch AFIP, Washington, D.C., stated that: Values of carboxyhemoglobin saturation of less than 5 percent are usually insignificant, and values of 5 percent to 10 percent may be reached in persons who are exposed to carbon monoxide in quantities commonly found in cigarette smoke. Greater than 10 percent carboxyhemoglobin saturation indicates significant exposure to carbon monoxide. Victims who die in a postcrash fire commonly have carboxyhemoglobin saturation values of 20 percent to 25 percent, but much higher levels may be seen.

The No. 3 (north) bore (see figure 12) has a two-lane, 28-foot-wide roadway and is 34 feet 6 inches wide between the sidewalls of the bore. There is a 4-foot-wide walkway on the north side and a 2 1/2-foot-wide walkway on the south side. The walkways are 8 to 9 inches above the surface of the roadway. The minimum vertical clearance above the roadway is 17 feet with a maximum clearance of 18 feet 4 inches along the bore centerline.

The westbound traffic approach to the tunnel is on a 4.6-percent upgrade. A 4.0-percent downgrade begins 30 feet into the tunnel. A 2,400-foot-radius right curve begins about 640 feet east of the east portal and ends 602 feet into the bore which permits a 485-foot line of sight. There then begins a 1,740-foot-long tangent section which is followed by another 2,400-foot radius right curve which continues westward out of the bore. Concrete bridge piers, each 2 feet by 6 feet, are located 185 feet west of the portal and support an overhead service roadway. Metal "W" beam guardrail start about 60 feet west of the west portal and continue west for about 200 feet. In the curved portions of the bore, the road has a 5-percent superelevation, and in the tangent section, there is a 1.5-percent normal crown.

The pavement of the roadway is Portland cement concrete with a longitudinal grooved pattern that was in fair to good condition at the time of the accident. Raised reflectorized pavement markers delineate the lanes and are spaced at 24-foot intervals. Between each of the raised markers, there are four ceramic markers spaced 3 feet apart. There were no edgelines at the time of the accident.

The arched walls of the bore are Portland cement concrete covered with 4.25-inch green square tiles; the walls vary in thickness from 6 feet at the bottom to 2 feet at the top. On each side of the tunnel at the junction of the ceiling and the walls is a continuous longitudinal line of 8-foot-long fluorescent lights. For 300 feet at the entrance and exit to the bore, three fluorescent lamps are used in the fixtures with all three illuminated during the day and one at night. These lights are automatically controlled and dimmed by a photoelectric unit. Only one fluorescent lamp is used in each fixture throughout the rest of the tunnel.

Fresh air is taken in at the west portal building and carried along through a duct above the roadway. The air is discharged into the roadway area through 5-foot by 1-foot openings spaced at 15 feet intervals at one side of the ceiling and is drawn out through exhaust portals on the opposite side of the ceiling. The air is carried to the west portal building and discharged upward. For each duct, there are two fresh air blowers and two exhaust blowers that have a total capacity of one-half million cubic feet per minute. The exhaust air is tested automatically, and if a specified concentration of carbon monoxide accumulates, the ventilating machinery will automatically speed up until the concentration is lowered to a desired level. The ceiling between the roadway and the ventilation ducts is 5 1/2-inch thick Portland cement concrete.

There are 14 emergency stations at 250-foot intervals along the north wall of the tunnel. Each station is indicated by a 21-inch by 20-inch illuminated panel that extends out from the tunnel wall with the words "EMERGENCY," "TELEPHONE", a station number (stations are numbered from west to east) and, "FIRE ALARM." (See figure 13.) Above each illuminated panel is a 29-inch by 20-inch neon sign which when activated reads "STOP MOTOR." These "STOP MOTOR" signs are activated from the control room if the level of carbon monoxide exceeds the capacity of the blowers. Each recessed emergency station, measuring 3 feet 6 inches by 2 feet 8 inches, contains a box for fire

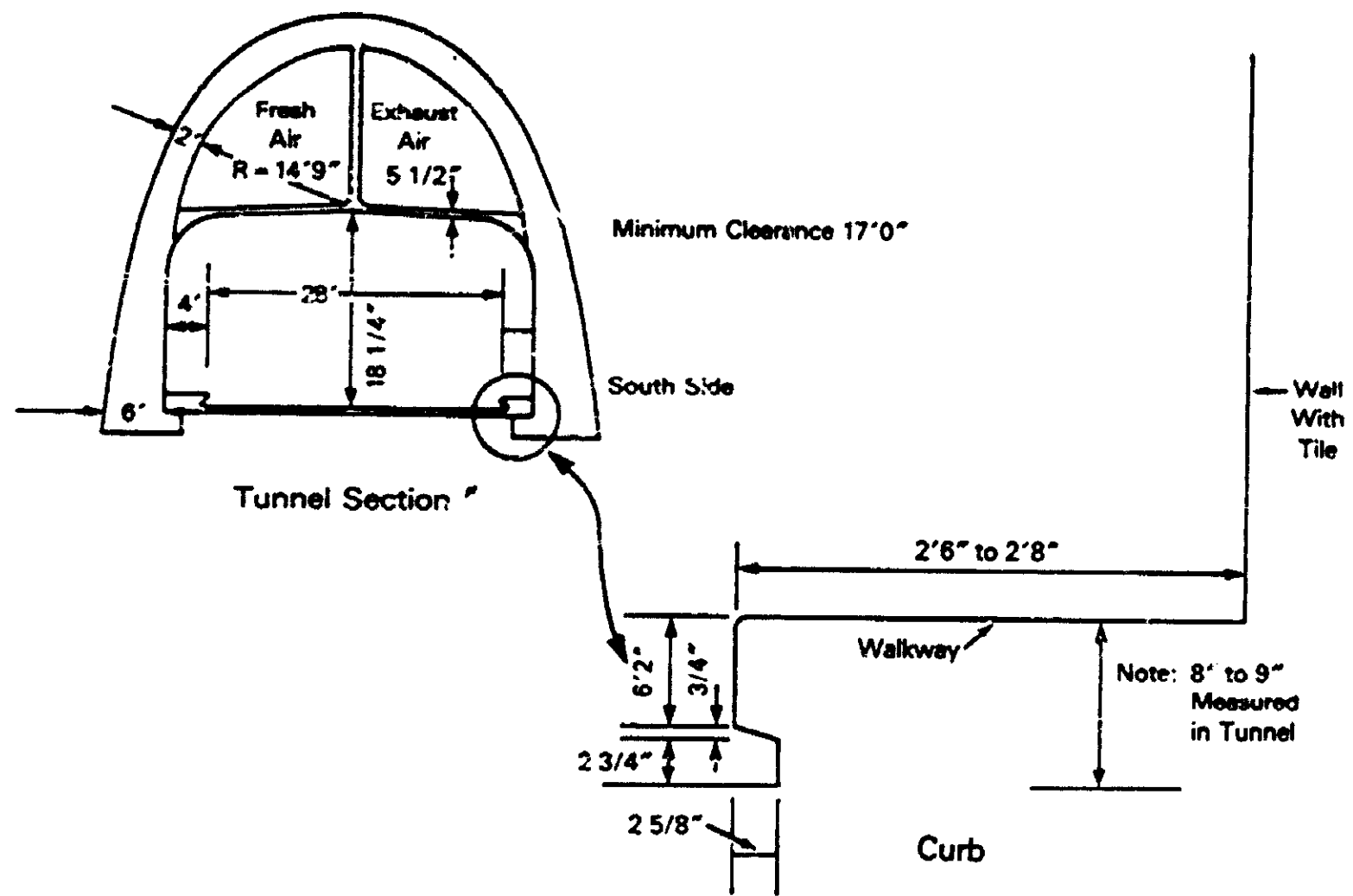


Figure 12.—Cross section of Bore No. 3.



Figure 13.—Tunnel emergency stations.

extinguishers (a 4-pound CO₂ extinguisher, a dry chemical extinguisher, and 2 1/2 gallons of water with a stored pressure extinguisher), a water valve, a fire alarm, and a telephone to the control room. A public address speaker was originally installed at each emergency station, but these speakers had been removed. The fire alarm system was designed so that, when activated, it would alert both the Oakland and Orinda fire departments. At present, however, the alarm rings only in the tunnel control room.

There are 13 additional recessed openings, also located on the north wall of the tunnel which contain fire extinguishers and miscellaneous maintenance equipment. These openings are also numbered. (See figure 2.)

Adits or passageways located on the south wall connect the main bores at three locations. The adits are equipped with 6-foot by 2.5-foot nonlocking, self-closing doors located 875, 1,885, and 2,372 feet west of the east end of the tunnel. There are no signs to identify the adits. The doors of the adits are copper-clad on the side facing the tunnel, and when covered with soot and oxidized, they tend to blend with the light green color of the tile that covers the walls. (See figure 14.)

Video camera monitors were installed at each bore portal to allow tunnel operators to monitor traffic on the approaches and exits to the bores. Although provisions had been made when the tunnel was built to install television cameras inside the tunnel for more thorough observation, the cameras were never installed.

A control room is located in the portal building above the ventilation equipment at the west end of the tunnel where operators are on duty 24 hours a day to observe the fire alarm annunciators, the carbon monoxide recorders, the television monitors, and the operation of the fan, and to answer the tunnel telephones.



Figure 14.—Adits that connect the bores.

Traffic Volumes

On April 28, and 29, 1982, CalTrans conducted traffic volume counts on State Route 24 to determine the average daily traffic (ADT) immediately east of the tunnel. The count indicated that 63,700 vehicles traveled the westbound route daily; of the 1,126 trucks, 26, including 8 flammable materials tankers, carried hazardous materials.

Accident History

The Safety Board reviewed accident records to determine the number of accidents that have occurred in the limits of the three bores of the Caldecott Tunnel. According to these data, 39 accidents occurred in a 3-year period ending December 31, 1981, resulting in 18 injuries and no fatalities; 16 of these accidents involved westbound motorists. Twenty accidents were rear-end collisions; 9 involved a stopped vehicle; 8 involved a slowing vehicle; and 3 involved a vehicle changing lanes. Eight accidents were sideswipe accidents, seven of which involved a vehicle changing lanes. Eight were hit-object accidents, of which three involved vehicles changing lanes. Two were broadside accidents, and one was an overturn accident.

Metecrological Information

On April 6, at 11:45 p.m., weather observations at the Oakland, California Airport, 10 miles from the accident site, were as follows: clear skies with 20-mile visibility; temperature -- 50° F; and a 310° wind at 10 knots. At 12:45 a.m., shortly after the accident, the weather observations were the same.

Survival Aspects

Restraints--A lap restraint was available to the busdriver, but he was not using it and was ejected during the collisions. The Armour Oil tank truck had a lap restraint available at the driver's position, and the driver stated he was wearing the lap restraint at the time of the collision. The Honda was equipped with lap and shoulder restraints for front seating positions. The Honda driver was reported to have been standing in front of her vehicle before the collisions.

Emergency Exits.--The Caldecott Tunnel has three adits which connect the bores of the tunnel and which provide egress from the tunnel. ^{7/} In addition, a stairwell from the CalTrans control booth to the tunnel is located approximately 40 feet east of the west portal. None of the exits were identified or marked, and none were used. The survivors stated that they were not aware of the existence of these exits. The busdriver and Honda driver were both found lying in the roadway 337 feet west of adit No. 3 (refer to figure 2 for adit locations), or 57 seconds ^{8/} away from adit No. 3, had they been able to walk. The beer truck occupants were found 128 feet east of adit No. 3, or 22 seconds away in walking time. The pickup truck passenger was 72 feet east of adit No. 3, 12 seconds away in walking time. The Pontiac occupants were 120 feet west of the east end of the tunnel, 20 seconds away in walking time.

Tests

A CalTrans engineer conducted an analysis of the fire's development in regard to temperatures encountered during the entire period of the fire. His complete report is a part of the public docket, but the information is summarized here.

Examination of copper wires, aluminum castings, plastic light covers and signs, glass, glazed tile and concrete spalling as well as the various component metals of the burned vehicles at different heights above the road provided a maximum and minimum temperature determination at various points in the tunnel.

The upper levels in the tunnel experienced a temperature of 1,914° + 35° F near the origination of the fire at emergency stations No. C 13 and C 14. The temperature near the road was about 1,650° F. To the west of station No. 13 the fire cooled very quickly as air was moving from the west through the tunnel.

Temperatures above 1,190° F at the ceiling extended as far east as station No. 22, where they dropped below 1,116° F to station No. C 27 at the east entrance. The heat became more stratified as it moved toward the east entrance. The vehicles furthest east were exposed to temperatures of 1,400° F to 1,600° F above the vehicle headlight level and red copper oxide on some vehicle wiring indicated temperatures as high as 1,900° F supported by the burning of fuel in these vehicles.

^{7/} In "Tunnels: Planning, Design and Construction", Volume 2, 1982 authored by T.M. Megaro et. al., cross passages are recommended for emergency exit purposes.

^{8/} Utilizing a walking speed of 4 mph or 5.9 feet per second.

Average temperatures, time, supply of fuel, size of tunnel, thermal expansion, and the route of air transfer were considered to establish an estimated air flow speed through the tunnel. This data provided the basis for determining that the air flow into the tunnel at the west end was approximately 15.5 mph, over the hottest portion of the fire between stations No. 14 and No. 18 it was approximately 71 mph with a gradual reduction of airflow to about 32 mph at the east entrance.

"Fire ball explosions" or "Bleves" in the tunnel were discounted because of lack of sufficient oxygen and other environmental circumstances and exploding tires were believed to be the source of "explosions" heard by witnesses. [Drain covers were observed displaced from gas vapor explosions.]

The engineer's analysis was supported by the estimates of the firefighting personnel at the west end of the tunnel, who estimated air flow into the tunnel at about 8 to 10 mph. Air expansion over the hottest part of the fire increased the air speed as the combustion products moved toward the east portal, and the estimated speed of the smoke and air was nearly 30 mph at the east portal. This rate of burning gas movement was significant early in the fire and helped establish the time period during which escape or rescue from the tunnel was possible.

Other Information

Types of Tunnels

Based on emergency response and monitoring capabilities, tunnels can be classified as follows:

Active.--Traffic over the full length of the tunnel is closely monitored using guards within the tunnel, video monitors, loop detectors, combinations or all of these to survey developing situations, permitting immediate action. Immediate action could include use of signals and signs to stop movement of traffic or keep vehicles from entering the tunnel and verbal directions or guidance from trained guards, public address systems, or through vehicle radios. These systems also have emergency response capabilities to fight fire, or assist inoperable vehicles. The Baltimore Harbor Tunnel, Hampton Road Tunnel, and Port Authority of New York and New Jersey Tunnels are examples of active tunnels.

Reactive.--A reactive tunnel is a tunnel that is manned but does not have traffic monitoring capability. With this type of system, assistance is delayed especially if motorists are incapacitated; it takes longer to physically close lanes of traffic, and the public has to assess the situation and develop its own guidance. These tunnels have a limited capability to respond to an emergency. The Caldecott Tunnel is an example of a reactive tunnel.

Passive.--A passive tunnel is a tunnel that is unmanned, unmonitored, with limited or no communication for emergency response personnel. In this type of tunnel, motorists are completely dependent on

their own resources and on the response of emergency services that may not be immediately adjacent to the tunnel. The motorist may not even be provided with firefighting capabilities in the tunnel. The District of Columbia's Center - Leg Tunnel as reviewed was an example of a passive tunnel.

Hazardous Materials Route Selection

In response to a Safety Board inquiry, the Armour Oil Company ^{9/} replied that its management does consider that the company's transportation of gasoline renders it subject to the Federal Motor Carrier Safety Regulations, 49 CFR Parts 386-399, and, specifically, to 49 CFR Section 397.9, regarding "routing." The company said that its choice of which route will be used is the product of a combination of input and decisionmaking from the drivers involved, as well as from management. Highway 24 was considered by Armour to be the only feasible route to follow since the only practical alternative, Highway 4, is a two-lane rural highway which twists and curves, is without shoulders in many areas, and which contains varying lane widths.

The company said that Highway 4 has a reputation of being accident-prone and that 70 accidents or incidents occurred on Highway 4 between the beginning of 1978 and the end of March 1982. For the first 4 miles heading westbound, Highway 4 is a six-lane divided highway between Highway 680 and Highway 80. The roadway then narrows down to two lanes, one in each direction. Highway 4 heading westbound is poorly banked and has narrow lanes, no shoulders, and numerous places where the roadway narrows even further to accommodate over-crossing railroad trestles.

Travel to Oakland using Highway 4 requires an interchange onto Highway 80 heading southbound and then another interchange onto either Highway 24 east or Highway 580 east. The company said that in either case, the driver must fight through the heavy traffic which is historically encountered near the entrance/exit to the Bay Bridge on the East Bay side. Many of its drivers have indicated that this is a most difficult portion of roadway to drive due to the heavy traffic and the fact that three major highways are merging at one point.

The selection of Highway 4 would make it likely that Highway 17 would also have to be traveled to reach most destinations in Oakland. The complaints about Highway 17 include complaints that it is subject to heavy traffic flow and that there are numerous bumps and potholes on the road which have been characterized by Armour's drivers as being "capable of having the tendency to pull the steering wheel out of the driver's hands."

Another of Armour's considerations in choosing Highway 24 over Highway 4 is the location of the oil refinery where the tankers load. Armour Oil Company is almost centrally located on Highway 4 between Highways 680 and 80. When pickups are required at the refineries west of the Armour Oil Company, those nearest Highway 80, the drivers will take Highway 4 to Highway 80 to avoid backtracking. Some refineries, however, are located right near the Highway 4/Highway 680 Interchange, and, for pickups made at this location, Highway 600 to Highway 24 is taken because it is considered the safest road, as well as being the most convenient one for pickups occurring in that area.

^{9/} Letter dated February 25, 1983 from Stephen J. Vondorach at Tott and Newton, Legal representatives for Armour Oil Company.

Safety Board investigators conducted a visual survey of land use adjacent to highways to assess other alternative highway routes that could be used to avoid the Caldecott Tunnel. The State of California also calculated and tabulated accident histories and traffic volumes for these routes (see figure 15). A route northwest of the tunnel from Martinez (gasoline loading dock area) to a common point near the delivery area in southeast Oakland was reviewed. It consisted of segments of Route 4 (B) and Route 80 (F) and short segments of other routes. Another route south of the Caldecott Tunnel that was considered consisted of segments of Route 680 (D and E), Route 580 (C), Route 238 (C), and Route 17 (G). Distance, volume of traffic, and accident frequency were considered and it was determined that the northwestern route compared favorably with Route 24 (A) through the tunnel. 10/

In 1973, the Department of California Highway Patrol issued "Explosives Routes and Stopping Places" which showed highway and stopping places to be used by transporters carrying explosives. The map for the Oakland area indicated that Route 4, I-80, I-680, Route 50, and Route 17 should be used. Route 24 was not shown as a route to be used by trucks transporting explosives.

Following its investigation of a tank truck accident resulting in an anhydrous ammonia release and the death of 6 and injury of 146 motorists in Houston, Texas, the Safety Board on April 25, 1977, issued Safety Recommendation I-77-1. Addressed to the Federal Highway Administration (FHWA), it proposed the development of guidelines for the use of State and local governments to assist them in the selection and designation of routes for the transportation of hazardous materials through or around their jurisdictions. After studying the problem, the FHWA issued a document titled: "Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials" (FHWA-IP-80-15). This document is now available and should be useful in assisting the State of California in developing a document concerning the routing of hazardous materials through and in California.

Armour Oil Company should also find this document and the forthcoming guidance and regulations from the State of California useful in further evaluating the criteria for determining their safest delivery routes.

ANALYSIS

The Accident

The Honda driver's erratic driving was probably due to the driver's being under the influence of alcohol (BAL 0.17 present). Several witnesses observed the movements of the Honda before it came to rest in the left travel lane. These witnesses stated that they passed the Honda successfully while it was stopping or after it had stopped, but that quick evasive movements were required to do so. However, there was no witness who observed the entire accident sequence. Safety Board investigators, therefore, relied heavily on the physical damage to the vehicles to reconstruct the details of the accident.

Based on impact damage to the Honda, the bus, and the tank truck and trailer, the Safety Board believes that the tank truck collided with the Honda before the subsequent collisions between the bus and the Honda and between the bus and the tank truck.

10/ Accident and travel data on the routes in the area of the Caldecott Tunnel were taken from California's "Task Force Report on Transportation of Gasoline and Other Flammable Materials" (May 1982) and additional computer data provided by CalTrans.

Route Segments

- A - Route 24 Between Route 680 and Route 17 - 15.4 Miles
- B - Route 4 Between Route 680 and Route 80 - 12.7 Miles
- C - Route 580 and Route 238 Between Route 680 and Route 17 - 12.3 Miles
- D - Route 680 Between Route 4 and Route 24 - 6.8 Miles
- E - Route 680 Between Route 24 and Route 580 - 16 Miles
- F - Route 80 Between Route 4 and Route 17 - 14.9 Miles
- G - Route 17 Between Route 80 and Route 238 - 13.6 Miles

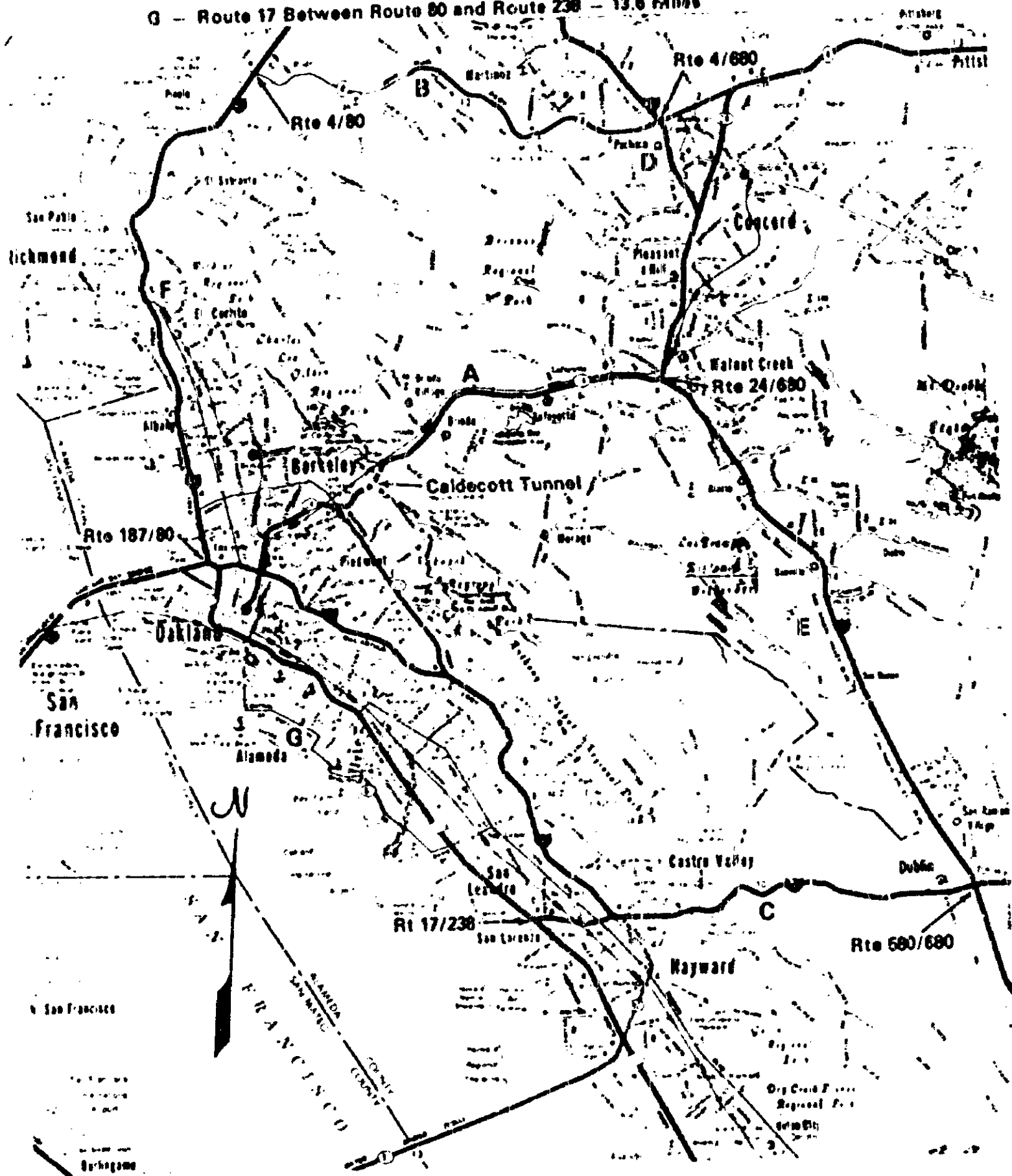


Figure 15.--Highway map of the Oakland Caldecott Tunnel area.

The tank truck driver stated that he was initially traveling in the right lane about 45 mph as his truck approached the Honda, which was stopped at the left curb. He said that he was watching the bus in his rearview mirror as it was overtaking him. (A motorist who had been traveling near the bus before approaching the tunnel entrance stated that the bus was probably traveling about 55 mph as it entered the tunnel.) The Safety Board believes that the tank truck was partially in the left lane, and that when the truckdriver saw the Honda, he began to steer the truck back to the right lane.

The damage to the tank truck and Honda indicated that the major impact between the tank truck and the Honda occurred when the left front tire of the tank trailer struck the right rear corner of the Honda (see figure 16). This impact drove the right side of the Honda rear bumper downward, the sheet metal forward, the right rear wheel forward in the wheel well, squeezed the Honda against the left curb, and displaced the left rear wheel inward (see figure 7). As a result of the impact, the left front suspension of the tank trailer was separated rearward from the trailer chassis, and the left side of the Honda then impacted the tunnel wall, increasing the damage at the left front (see figure 10), and also damaging the left side at the rear.

The bus, which was observed to have moved to the left of the tank truck, was confronted with the Honda in front of it. The left front bumper of the bus struck the rear bumper of the Honda causing it to rotate between the left tunnel wall and the bus with intermittent contact between the Honda and the left side of the bus. As the bus moved ahead, the Honda then moved diagonally across the road to its final position at the right curb. There was no evidence such as scraped paint, paint transfers, or scratches in the aluminum paneling at the left front corner of the bus to indicate that that portion of the bus had made contact with the right rear damaged area of the Honda.

Following the bus' impact with the Honda, the right front of the bus struck the left side of the tank trailer. Extensive fire damage to the tank truck and trailer and major frontal impact of the bus with the highway support pier did not permit an accurate comparison of the contact areas on, or the damage to, the bus and the tank trailer.

Separation and realignment of the front trailer suspension and axle permitted the left front trailer suspension bolts to contact and drag on the road surface and initiated a 270° lateral counterclockwise rollover of the trailer. The tank truck remained on its wheels, whereas the tank trailer, still attached to the tank truck, came to rest on its right side.

The busdriver's ejection from the bus at the time of collision with either the Honda or the tank trailer indicated that he was not utilizing the lap restraint that was available at his seat. The bus continued towards the left, climbed the curb, and the left front wheel lugs and side mirror contacted the tunnel wall intermittently until the bus exited the tunnel. Initial contact with the "W" beam guardrail outside of the tunnel damaged the bus' left side. The bus penetrated the guardrail and impacted a highway support pier, which deformed front end components 17 feet rearward. (See figure 5.)

The bus was not slowed significantly by its limited contact with the south wall. The jamming of its throttle in the wide open position may have occurred at impact with the Honda or the tank trailer, thus causing the bus to gain speed as it passed the tank truck and proceeded out of the tunnel. This would have permitted a speed as high as the governed speed of 68 mph at impact with the concrete pier.

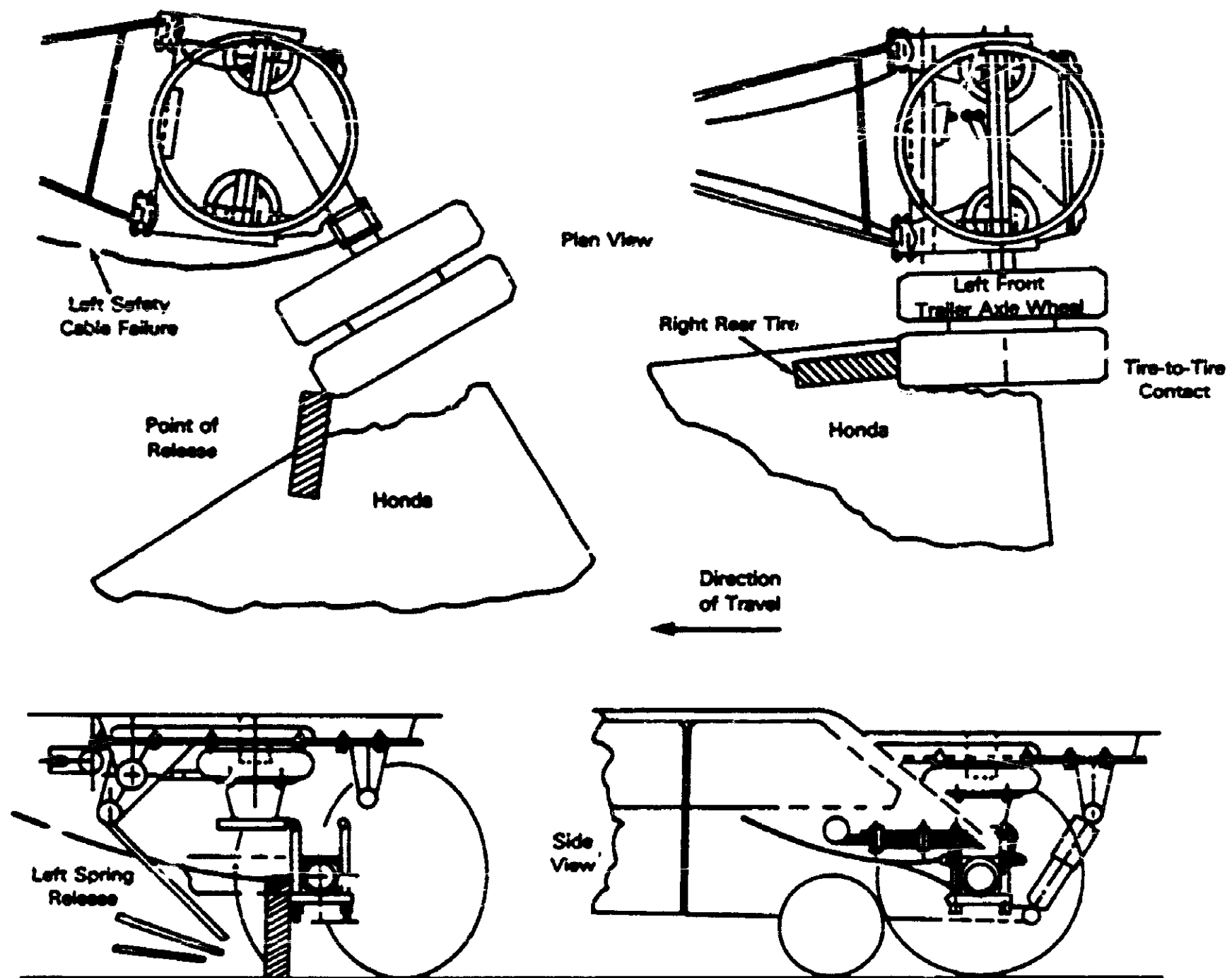


Figure 16.--Front trailer axle interaction with Honda right rear.

The truckdriver does not recall a collision between his vehicle and the Honda. Based on the impact damage, the Board believes that the tank trailer did collide with the Honda, and that, perhaps, given the difference in mass between his truck and the Honda and the immediacy of the subsequent collision with the bus, the truckdriver may not have been aware of the collision with the Honda.

Vehicles

Postcrash examination of all the vehicles failed to disclose any preimpact mechanical failure of parts that may have contributed to the collisions, but did indicate that some suspension damage and possibly some left front sheet metal damage of the Honda may have occurred during its initial contacts with the curbs and tunnel walls before the vehicle collisions.

In earlier reports, the Safety Board has expressed its concern about the stability of cargo tank trucks and cargo tank trailers involved in accidents. The Safety Board therefore deliberated as to whether there was a need to undertake an analysis to determine whether the accident results would have been similar had a cargo tank truck or a cargo tank trailer of a different design, such as a design used in other parts of the country, been involved in this accident. It was concluded that such an analysis would not have been a relevant area of investigation in this accident. The cargo tank trailer in this accident sustained impact damage that displaced the front suspension system, permitting the front of the tank trailer to drop to the road. Irrespective of its design features, no vehicle could be expected to remain stable following such a loss of a supporting axle, so design features were not causal in this accident.

Surveillance and Early Warning of Motorists

The lack of adequate monitoring capabilities, traffic signals at the entrance and within the tunnel, and a communications system in the Caldecott Tunnel contributed to the severity of the accident.

The driver of the third vehicle that observed the stopped Honda before the vehicle collisions stated that after he exited the tunnel and before he exited the freeway (one-fourth mile away) he heard a "rumbling sound that reminded him of an earthquake." Assuming the noise he heard was from the collisions, a time and distance calculation determined that the Honda was stopped in the tunnel at least 24, but less than 38 seconds before being struck by the truck and the bus. Prior to stopping, the vehicle was slowing for 2 to 15 seconds.

Had the tunnel been equipped with internal television monitors and traffic signals, the tunnel operator could have responded to the initial Honda accident by reducing vehicle speed limits and switching signals to red within the first 10 seconds. The truck and bus would probably still have been outside the tunnel and the drivers could have observed red signals at the portal entrance or signals within the tunnel and stopped before colliding with the Honda. The following vehicles also could have been warned of the emergency situation and probably could have stopped before entering the tunnel. After the initial impact involving the gasoline truck, it was at least 3 minutes before the tunnel was engulfed in fire.

The Ford pickup driver's mother, two occupants immediately behind her in the beer truck, and two elderly people 120 feet from the end of the tunnel did not escape the smoke and fire and died. All the fatalities other than the busdriver were found in or near their vehicles, suggesting that they had decided to remain with their vehicles and wait for

help or had panicked. In a tunnel emergency, rescue personnel may be hampered in reaching stranded victims. Motorists need to be informed about life-threatening situations and about possible exits in order to evacuate the tunnel in such instances. Location of the victims following the accident indicated that all were close enough to an exit door to have walked to safety in less than 1 minute. The Safety Board believes that adit doors should be clearly marked as exits to afford motorists the opportunity to escape. Signs indicating direction and distance to emergency exits may also be warranted. In addition, had the tunnel been equipped with television monitors and/or guards, a public address system and/or a motorists radio station override system, the motorists could have been given an early warning of the situation, been told to evacuate the tunnel and not wait for emergency response personnel, and been informed of the location of the adit doors. The Safety Board believes that had the tunnel been equipped with suitable monitoring and communication systems, the five victims who were not involved in the collisions could have survived. While the pickup driver provided some warning, communication from a person of more authority might have mitigated the circumstances.

The Caldecott Tunnel fire demonstrates the need for active monitoring of vehicular tunnels and immediate notification of fire to the predesignated responding jurisdictions. Notification was not received by the Oakland Fire Department until 9 minutes after the accident. The console operator did not follow the CalTrans procedures which require fire department notification by calling first the Berkeley Area 911 emergency assistance operator who would then contact the Orinda and Oakland Fire Departments. To avoid delays in responding to emergency situations, fire alarm systems in tunnels should be designed to provide immediate notification to the responding jurisdictions.

Medical Records

AC Transit records indicate that on the two occasions the busdriver took his Medical Certificate examinations to qualify for a Class 1 license, he was able to pass the blood pressure tests. On both occasions, however, the examining physician noted hypertension and referred him to his personal physician for treatment.

The laws of the State of California require any physician treating a patient with a disorder characterized by losses of consciousness to report that disorder to the local health officer. This health officer must in turn report this to the DMV (Health and Safety Code, Section 410). Physicians performing Medical Certificate examinations must also forward results to the DMV and the employer.

Copies of the busdriver's medical certificate examination reports were forwarded to both the employer and the DMV. However, since the examination revealed conditions within the prescribed limits, neither AC Transit nor DMV pursued the matter any further. During subsequent 11/ medical examinations which revealed severe hypertension, the patient complained of dizziness and fainting spells. The only indication in the available medical records that the busdriver's blood pressure was within acceptable limits was on the two occasions he was officially examined for his Medical Certificate, and then it was high enough to cause the examiner to recommend that the driver see his personal physician.

Based on the evidence available regarding the busdriver's physical condition, the Safety Board believes that AC Transit should review its standards regarding driver

11/ U.S. Army Clinic, Letterman Hospital, and four physicians named on AC Transit records.

physical qualifications with a view to formulating more restrictive standards. The busdriver in this collision had a history of absences from work and substantiated medical problems which had been reported to the company and which may have indicated a need for a more aggressive followup of his qualifications to continue driving.

Inasmuch as the physical standards for drivers, as prescribed by 49 CFR Part 391, are continuing ones (as is also the case for California drivers with Class 1 and 2 licenses ^{12/}) and health can deteriorate rather quickly, it is necessary that the drivers be periodically reexamined to see that their qualifications are maintained and not just achieved on the day of the examination. Employers should be attentive to information received from examining physicians that indicates a potentially debilitating physical condition of an employee and should closely monitor the driver's condition, and, if warranted, should remove him as a driver until he is physically qualified.

Health problems are not the only reason why employers should monitor driver records once drivers are hired and their necessary qualifications have been established. During the Safety Board's investigation of two previous accidents involving transit buses, ^{13/} a review of the driver records maintained by the company revealed patterns of negligent driving and disclosed that the data were readily available to the company supervisors had they inquired, and that the records contained evidence of previous indications of the same type of behavior as caused this accident. A random check of company-maintained driver records revealed that 15 percent of the company drivers were not legally licensed, and that because of their poor driving records, 30 percent of such drivers would not qualify as intercity busdrivers in interstate transportation. To help transit carriers accomplish this monitoring, the American Public Transit Association (APTA) should study the problem and develop possible solutions to better protect the passengers of the transit transportation system. High qualifications should be required of all drivers of commercial passenger-carrying vehicles, not just of drivers of those vehicles operating in interstate under the FMCSR.

The medical problems of the busdriver raised questions as to both the cause and the time of his death. Cardiac arrest might have occurred during the stress of the collisions, thus reducing the busdriver's ability to take evasive action. The relatively low carbon monoxide content in his blood suggested he was not breathing long within the fire and smoke environment of the tunnel. His death may have been a result of trauma incurred during the collision sequence or at ejection, which may have been masked from the pathologist by the extensive burning of the body. This raised the question of survivability of the accident. Had he been wearing his seat belt and not been ejected, the driver might have been able to retain at least partial control of the vehicle and avoid impact with the tank trailer and bridge pier. This might have provided the opportunity to bring the bus to a stop and prevent any injury to the driver. Had the driver been unable to avoid the bridge pier, it is doubtful the seat restraint could have prevented his injury and death during the crash. If he died due to a heart condition, even if he had been belted, the consequences would have remained the same, except his body would not have been ejected and burned.

Traffic Operations

Changing lanes and passing both are permitted in the Caldecott Tunnel. The Safety Board's literature review and survey of tunnel authorities indicated that changing lanes

^{12/} California Vehicle Code 12804.

^{13/} Field Accident Investigation Reports LAX-80-F-H012 and LAX-80-F-H016.

and passing is prohibited by most tunnel authorities while other authorities encourage trucks to remain in one lane. The accident data of the Caldecott Tunnel indicate that 13 of the 39 accidents which have occurred in the three bores involved vehicles changing lanes. The Safety Board believes that CalTrans should consider prohibiting passing and lane changes in the Caldecott Tunnel as well as other tunnels in the State.

Ventilation in Bore No. 3

CalTrans procedures require that the console operator turn the fans on high as soon as a fire alarm is tripped or a report of a fire is received. The CalTrans console operator did not turn on the ventilation fans when he received a fire report at 12:15 a.m.; nor did the carbon monoxide (CO) detection system automatically activate the fans during the fire. However, based on the estimates of natural air movement produced by circumstances similar to the "Stack Effect" ^{14/} in Bore No. 3 during the fire, the transverse lateral ventilation system in the west end of Bore No. 3 would have had little, if any, effect in reducing the intense and rapid smoke buildup during the first 3 minutes. This was verified shortly after 3:00 a.m. when the ventilation fans were turned on and CalTrans reported that the fans were ineffective in reducing any of the smoke.

In rear-end car collisions where fuel tanks rupture, and fires of lesser intensity occur, smoke and heat would be generated more slowly than was the case in this accident. In such instances, the ventilation system would be useful in reducing smoke and/or fire in a life-threatening environment. CalTrans should insure that all tunnel operating personnel are trained in and comply with the emergency procedures regarding fan operation, and should assure that all such emergency equipment is operational through periodic tests and maintenance.

In the Caldecott Tunnel, fans are located at the west portal. They thus were not near the fire in this accident. In this accident, temperatures of 1,900° F occurred for 20 minutes. Only recently have fan systems been designed to withstand temperatures over 1,000° F. This fire demonstrates the need under some circumstances for deluge systems to cool fans or fans that can withstand high temperatures.

Hazardous Materials Routes

The Safety Board reviewed the tank truck driver's planned route of travel (east on Route 4 to I-680, south to State Route 24, west on Route 24 to State Route 17, and then southwest on Fruitvale Avenue to 24th Street) and determined that alternate routes either to the north or the south of the planned route would have avoided the tunnel.

The "Explosions Routes and Stopping Places" map issued by the CHP in 1973 also specifies alternate routes north and south of the Caldecott Tunnels for explosives transportation and does not permit the use of Highway 24 through the tunnel.

^{14/} The Stack Effect is the natural air movement in buildings during a fire and is characterized by a strong draft from the ground floor to the roof of tall buildings. The Stack Effect is often responsible for the wide distribution of smoke and toxic gases in high rise buildings. The magnitude of this effect is a function of the building height, the air tightness of exterior walls, air leakage between floors of the building, and the temperature difference between the inside and outside; Fire Protection Handbook, Fourteenth Edition, National Fire Protection Association, Chapter No. 5, "Smoke Movement in Buildings."

A further consideration in route selections is that east of State Route 13, the BART system runs in the median of State Route 24 for about 7 miles, with two stations between the east and westbound roadways. At certain locations, the westbound roadway is elevated 10 to 15 feet above the BART system, separated only by a concrete median barrier and a chain link fence. The Safety Board has investigated a previous accident 15/ in which a tank trailer rolled over median barriers, ruptured, and as a result gasoline was spilled and ignited. An accident of this type would endanger BART passengers, and, according to the Oakland fire officials, firefighting efforts would be difficult because of the lack of hydrants.

The 49 CFR Section 397.9 (a) states that:

(a) Unless there is no practicable alternative, a motor vehicle which contains hazardous materials must be operated over routes which do not go through or near heavily populated areas, places where crowds are assembled, tunnels, narrow streets, or alleys. Operating convenience is not a basis for determining whether it is practicable to operate a motor vehicle in accordance with this paragraph. This paragraph does not apply to radioactive materials.

The Armour Oil Company management acknowledged its responsibility under 49 CFR Parts 386-399 for safe route selection for the shipment of hazardous materials. It did survey the area for feasible, alternate routes. Also, the company involved the responsible drivers in its decisionmaking and decided that Route 24 through the Caldecott Tunnel was the safest and most convenient route and that there was no feasible alternate route.

In retrospect, considering the inadequacy of motorist protection and the consequences of the fire within the tunnel, it is easy to find fault with the Company's decision. It is difficult to envision an area along the alternate route where a similar accident would result in losses of similar magnitude. Consequently, the Safety Board feels that additional evaluation of hazardous materials delivery routes should be made by both the carriers and agencies of the State of California to provide guidance and regulations that are compatible with Federal regulations. The carriers and agencies should make use of the recently published FHWA Implementation Package, "Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials" (FHWA-IP-80-15) to provide hazardous materials cargo truckdrivers with the most recent information available so that they will be able to make the safest route selection.

After the Caldecott Tunnel fire, CalTrans and the CHP jointly established a task force composed of representatives from State government and industry. Some of their findings pertinent to this accident were:

1. There are virtually no existing prohibitions or restrictions on the movement of cargo tank vehicles transporting flammable liquids on California State highways.
2. While the likelihood of a fire involving the contents of a tank truck within a tunnel is extremely remote, in the event of such a fire, there is substantial risk of injury or death to all other motorists within the tunnel, a risk of much higher order than if a similar incident occurred on an open highway.

15/ Highway Accident Report -- "Multiple Vehicle Collision and Fire, U.S. Route 101, Los Angeles, California, March 3, 1980" (NTSB-HAR-80-5).

3. There is a void in existing law with regard to the State's ability to regulate vehicular traffic within tunnels. While local entities have specific statutory authority to regulate vehicular traffic within tunnels, the State has no similar authority.

Based on the above findings, the task force recommended:

1. That legislation be enacted giving the California Department of Transportation the authority to prohibit or restrict the movement of cargo tank vehicles displaying flammable liquid placards in tunnels on State highways.
2. That the Department of Transportation in cooperation with affected local authorities should make a survey of all tunnels, as hereafter defined, on State highways to determine the relative risks of injury to the public from cargo tank vehicles transporting flammable liquids in tunnels as opposed to utilizing alternative routes.
3. As part of the survey of tunnels, the Department should consider the need for or advisability of installing motorist warning systems at the tunnels.
4. If after study, the Department prohibits or restricts the movement of cargo tank vehicles, then the Department will also undertake an evaluation of the prohibition or restriction one year after it is implemented to determine if any problems have been created because of the ban and make a finding to either continue or discontinue the ban.

The findings and recommendations presented by the task force generally appear sound and viable. The Safety Board believes that applicability of 49 CFR Section 397.9 to a great number of the movements appears to have been overlooked by the task force and should be reviewed by CalTrans as a step in dealing with the problem. Determination of alternative routes should include an assessment of compatibility with other transportation systems, especially rapid transit systems. A hazardous materials tank truck with its high center of gravity (and some van type trucks) can override barriers such as exist along Route 24 and block the path of an oncoming high speed train.

The Safety Board has noted that rapid transit systems which are under construction in the medians of interstate routes in the Chicago and Washington, D.C. areas may give rise to similar problems. A survey and a risk analysis of these systems should be made by the U.S. Department of Transportation, which is providing the bulk of the funding for this construction.

The Safety Board notes that the task force limited its recommendation regarding restriction of movements in tunnels to flammable materials cargoes. The Board believes that restricting the movements of other types of hazardous materials cargoes regardless of vehicle type should also be considered. The State of California has begun to act on the findings of the task force, and the governor recently signed into law A.B. 2457, a bill requiring the California Department of Transportation (CDOT) to adopt regulations governing the transport of flammable materials through tunnels in tank trucks. He also signed S.B. 2066, prohibiting hazardous material cargoes from traveling through the

Caldecott Tunnel near Oakland California, except between the hours of 0300 and 0500. The ban on hazardous materials cargoes traffic in the tunnel will remain in effect until CDOT promulgates its new regulations. A CDOT spokesman noted that, since repairs on the tunnel are not yet complete, traffic through the tunnel is still generally limited. A.B. 2457 requires CDOT to seek assistance from the California Highway Patrol in developing the regulations; CDOT hopes to issue draft rules in early 1983.

CONCLUSIONS

Findings

1. The initial accident involved a westbound Honda car operated by an intoxicated driver impacting the curbs in the Caldecott Tunnel which disabled the Honda in the left traffic lane where it was an obstacle to following traffic.
2. Several passenger cars passed the stopped Honda before the subsequent vehicle collisions.
3. A tank truck and tank trailer proceeding westbound through the tunnel and moved into the left lane of travel.
4. The initial vehicular impact was between the left front tank trailer wheel and the right rear of the Honda before the truck moved back into the right lane.
5. The front left bumper of the AC Transit bus which was also proceeding westbound through the tunnel struck the rear bumper of the Honda.
6. The Honda was rotated along the south wall of the tunnel by the impact with the trailer and bus and came to rest against the right curb of the tunnel.
7. The final vehicular interaction occurred when the right side of the bus struck the left side of the tank trailer.
8. Following the impact with the bus, the tank trailer upset, and gasoline was spilled in the tunnel.
9. A small fire began near the tank trailer and developed into a major blaze filling the east end of the tunnel within approximately 3 minutes.
10. Occupants of vehicles which had come to a stop because of the accident and fire failed to recognize the fire as a danger to themselves and did not take the prompt action necessary to escape from the tunnel.
11. Had this tunnel been equipped with internal television monitors and with traffic signals at the entrance and in the tunnel, the tunnel operator could have activated warning signs to halt the bus and the tank truck before they collided with the Honda.
12. In the absence of traffic surveillance and communication equipment, the tunnel crew was hampered in obtaining information and was unable to provide warnings or advice to motorists during the critical 3 minutes following the accident.

13. If they had been properly warned and directed, most of the motorists could have evacuated the tunnel successfully during the 3 minutes following the accident.
14. Adits between the Bores were not marked as exit routes from the tunnels.
15. There was a delay in notifying the responding jurisdictions of the fire and emergency as a result of tunnel employees not following CalTrans emergency notification procedures.
16. The driver of the AC Transit bus was receiving treatment for high blood pressure and had symptoms which were not compatible with his continued possession of a Class 1 or Class 2 California operator's license.
17. Changing lanes and passing were permitted in the Caldecott Tunnel. A survey of tunnel authorities indicated that changing lanes and passing is prohibited in most tunnels.
18. The fire produced temperatures in the vicinity of the accident vehicles which reached 1,900° F, and remained at this level for at least 20 minutes.
19. At the time of the accident, the State of California did not have authority to prohibit truck transportation of flammable cargoes and other hazardous materials (except explosives) in tunnels within the State. Although local governments had such authority, there were no prohibitions applicable to the Caldecott Tunnel.
20. Since the carrier owning the tank truck engaged in interstate operations, the truck's movement was subject to the provisions of 49 CFR Section 397.9, which requires motor vehicles carrying hazardous materials to avoid tunnels when there is a practical alternate route.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was a combination of events involving (1) the erratic driving by the intoxicated driver of a passenger vehicle which stopped in a through traffic lane creating a traffic obstacle; (2) the inattention of the truckdriver causing his vehicle to strike the passenger vehicle; and (3) the busdriver's overtaking the truck too rapidly to enable him to avoid striking the passenger vehicle when it unexpectedly appeared in the path of his bus.

Contributing to the cause and the severity of the accident was the presence of a flammable cargo tank truck and cargo tank trailer in the tunnel and the damage to the overturned trailer which permitted a loss of flammable cargo and a fire.

Also contributing to the severity of the accident and injuries were the lack of adequate monitoring capabilities and variable message signs or traffic signals at the entrance of the tunnel and within the tunnel, and the lack of a communication system between the tunnel personnel and tunnel occupants, which if present, might have facilitated occupant evacuation.

RECOMMENDATIONS

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

—to the Director of the California Department of Transportation:

Evaluate and revise, where necessary, equipment requirements and emergency procedures at the Caldecott Tunnel to provide early warning of an emergency to motorists in the event of a life-threatening emergency. (Class II, Priority Action) (H-83-10)

Develop a state-wide emergency response plan and train tunnel employees in all phases of emergency operations, including smoke and toxic fumes management and immediate emergency response notification, and periodically conduct drills to determine employees' ability to perform the above operations under stress. (Class II, Priority Action) (H-83-11)

Provide easily identifiable exit markings for adits in the Caldecott Tunnel. (Class II, Priority Action) (H-83-12)

Prohibit passing and lane changes in vehicular tunnels in California. (Class II, Priority Action) (H-83-13)

In cooperation with appropriate local authorities, survey all vehicular tunnels, and upgrade, where necessary, tunnel traffic controls, communication systems, firefighting equipment, and towing capabilities. (Class II, Priority Action) (H-83-14)

Ban the movement of hazardous materials through vehicular tunnels where the relative risks of the tunnel route are higher than alternate routes. (Class II, Priority Action) (H-83-15)

—to the Secretary of the U.S. Department of Transportation:

Review the Federal Highway Administration and the Urban Mass Transportation Administration programs that encourage joint use of rights-of-way and determine if construction of rapid rail systems in highway rights-of-way presents an unnecessary risk to the public from hazardous materials truck movements on adjacent roadways; if so, modify the safety criteria appropriately. (Class II, Priority Action) (H-83-16)

—to the Alameda/Contra Costa Transit District:

Closely monitor the health of drivers with known medical problems, and when their health may adversely affect their ability to safely transport passengers, remove them from duty. (Class II, Priority Action) (H-83-17)

—the American Trucking Association:

Inform its members of the circumstances of this accident, and stress the use by drivers of trucks transporting hazardous materials of alternate routes which avoid tunnels. (Class II, Priority Action) (H-83-18)

—to the American Public Transit Association:

Establish guidelines to assist public transit operators to better provide safe transportation for their passengers by ensuring that their drivers are physically qualified at all times to perform their jobs. (Class II, Priority Action) (H-83-19)

—to Armour Oil Company:

Review the delivery routes traveled by its hazardous materials transporters and make changes as necessary to insure compliance with Federal Motor Carrier Safety regulations, and give top priority to the safe driving environment. (Class II, Priority Action) (H-83-20)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ DONALD D. ENGEN
Member

G. H. PATRICK BURSLEY, Member, filed the following concurring and dissenting statement:

I concur in the report and the recommendations but believe that the probable cause should be:

The National Transportation Safety Board determines that the probable cause of this accident was the inattention of the truck driver which resulted in his vehicle striking a passenger vehicle stopped in a through traffic lane and the bus driver's overtaking the truck too rapidly to enable him to avoid striking the passenger vehicle when it unexpectedly appeared in the path of the bus.

Contributing to the severity of the accident was the presence of a flammable cargo in the tank truck and cargo tank trailer and the damage to the overturned trailer which led to the escape of the flammable cargo and the ensuing fire in the tunnel.

Also contributing to the severity of the accident and injuries was the lack of adequate tunnel monitoring capabilities in the control room and the lack of communication systems for use by tunnel operating personnel in communicating with tunnel occupants to facilitate evacuation.

/s/ G.H. PATRICK BURSLEY
Member

May 3, 1983

APPENDIX

APPENDIX A

INVESTIGATION AND HEARING

Investigation

The National Transportation Safety Board learned of this accident through the news reports at 6:45 a.m. e.s.t., on April 7, 1982. An investigator was dispatched to the scene from Los Angeles and arrived at 11:30 a.m. P.s.t.

The Chairman of the Safety Board, an Investigator-in-Charge, and team members from the Bureau of Technology and Accident Investigation were dispatched from Washington, D.C.

Investigative groups of the various areas of expertise were not formed because of delays encountered in obtaining access to the scene, witnesses, and vehicle wreckage until the California Highway Patrol (CHP) had completed its criminal investigation. To a limited degree, Safety Board investigators were permitted to observe CHP investigative activities and 2 months later received a copy of the California Highway Patrol MAIT Team report.

Depositions and Hearings.

Depositions were not taken and a hearing was not held in this investigation.