NATIONAL TRANSPORTATION SAFETY BOARD

FOR RELEASE:
P.M.'S OF DEC 21 1972

HIGHWAY ACCIDENT REPORT

TANK-TRUCK COMBINATION OVERTURN ONTO VOLKSWAGEN MICROBUS FOLLOWED BY FIRE: U.S. ROUTE 611, MOSCOW, PENNSYLVANIA SEPTEMBER 5, 1971

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
REPORT NUMBER: NTSB-HAR-72-6

FILE NO. SS-H-17

HIGHWAY ACCIDENT REPORT

TANK-TRUCK COMBINATION OVERTURN ONTO VOLKSWAGEN MICROBUS FOLLOWED BY FIRE: U.S. ROUTE 611, MOSCOW, PENNSYLVANIA SEPTEMBER 5, 1971

ADOPTED: OCTOBER 18, 1972

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C. 20591
REPORT NUMBER: NTSB-HAR-72-6

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. NTSB-HAR-72-6	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Highway Accident Report - TANK-TRUCK COMBINATION OVERTURN ONTO VOLKSWAGEN MICROBUS, FOLLOWED BY FIRE: U.S. ROUTE 611, MOSCOW, PA., SEPTEMBER 5, 1971.		5. Report Date October 18, 1972 6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
9. Performing Organization Name and Address National Transportation Safety Board Bureau of Surface Transportation Safety Washington, D. C. 20591		10. Work Unit No. 11. Contract or Grant No. 13. Type of Report and Period Covered HIGHWAY ACCIDENT REPORT September 5, 1971
12. Sponsoring Agency Name and Address NATIONAL TRANSPORTATION SAFETY BOARD Washington, D. C. 20591		14. Sponsoring Agency Code

15. Supplementary Notes

This report contains Highway Safety Recommendations H-72-43 thru H-72-47.

16. Abstract At about 11:40 p.m. on September 5, 1971, a northbound tractor-semitrailer (tank), traveling at 55 to 60 m.p.h. in the center southbound lane of U. S. Route 611, approached the crest of a hill within the city limits of Moscow, Pa. Approaching from the opposite direction, also in the center southbound lane, was a 1971 Volkswagen Microbus traveling at an estimated speed of 30 m.p.h.

The tractor-semitrailer, which was loaded to 75% of its volumetric capacity, came over the hillcrest while simultaneously attempting to negotiate an 11° turn to the right. All right wheels raised off the road surface, and the truck began to overturn to its left. The VW driver attempted evasive action by steering to his right, but a 4-ft.-high curb prevented this maneuver. The trailer overturned onto the VW, crushing it and killing its four occupants. An unauthorized passenger in the tractor cab received minor burns, and the truckdriver sustained 3rd-degree burns over 40% of his body in the postimpact fire which was fed by fuel escaping through a severed fuel tank crossover line on the tractor.

The National Transportation Safety Board determines that the cause of this crash was the upset of the tractor and cargo-tank semitrailer due to grossly excessive speed in a turn and to the resultant dynamic surge of the liquid cargo. Contributing factors included: the failure of the truckdriver to comply either with the posted speed limit or with State laws and Federal regulations prohibiting coasting out of gear and the failure of his employer to investigate his past driving record.

17. Key Words	18. Distribution Statement
Tank-truck combination overturn, liquid surge, driver licensing, coasting out of gear, motor carrier employment investigations, drug usage, National Driver Register Service, fuel-tank crossover line failure.	Released to public; distribution unlimited.

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	32	

NTSB Form 1765.2 (11/70)

Foreword

The accident described in this report has been defined as a major accident by the National Transportation Safety Board under the criteria established in the Safety Board's regulations.

This report is based on facts obtained from the Safety Board's investigation and from the official report of the Bureau of Motor Carrier Safety. Other sources of information included the Pennsylvania Department of Transportation and the Moscow, Pa., police and fire departments.

The conclusions, the determination of probable cause, and the recommendations herein are those of the Safety Board.

TABLE OF CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20591
HIGHWAY ACCIDENT REPORT

Adopted: October 18, 1972

Tank-Truck Combination Overturn Onto Volkswagen Microbus, Followed By Fire: U.S. Route 611, Moscow, Pennsylvania, September 5, 1971

I. SYNOPSIS

At about 11:40 p.m., on September 5, 1971, a northbound tractor-semitrailer (tank), traveling at 55 to 60 m.p.h. in the center southbound lane of U.S. Route 611, approached the crest of a hill within the city limits of Moscow, Pa. Approaching from the opposite direction, also in the center southbound lane, was a 1971 Volkswagen Microbus traveling at an estimated speed of 30 m.p.h.

According to witnesses, the tractor-semitrailer, which was loaded to 75 percent of its volumetric capacity and traveling at an excessive speed, came over the hillcrest while simultaneously attempting to negotiate an 11° turn to the right. The right wheels raised off the road surface and the truck began to overturn to its left. The Volkswagen driver attempted evasive action by steering to his right, but a 4-foot-high curb prevented this maneuver. The trailer overturned onto the Volkswagen, crushing it and killing its four occupants. The fire which ensued was fed by diesel fuel escaping from the tractor's fuel tanks.

After impact, both vehicles slid north 151 feet until their motion was first retarded by a roadside utility pole and was then stopped by a gasoline station's fuel pumps. Fuel from the gasoline pumps did not ignite.

An unauthorized passenger in the tractor cab received minor burns and the truckdriver sustained third-degree burns over 40 percent of his body.

As the partially loaded tractor-semitrailer attempted to negotiate the curve, the total lateral forces on the vehicle were greater than those normally expected from centrifugal force. The additional force which upset the tank-truck combination is directly attributable to liquid surge within the tank. Standard centrifugal-force formulas indicate that a tractor-semitrailer loaded with a solid cargo to the same gross combination weight and having the same center-of-gravity height as the truck in this accident would remain in an upright position on the same 11° curve at speeds up to 64 m.p.h.

The National Transportation Safety Board determines that the cause of this crash was the upset of the tractor and cargo-tank semitrailer due to grossly excessive speed in a turn and to the resultant dynamic surge of liquid cargo. A primary contributing factor was the failure of the truckdriver to comply either with the posted speed limit or with State laws and Federal regulations prohibiting coasting out of gear. Additional contributing factors included the failure of the HAC Farm Lines Agricultural Cooperative Association to comply with Federal requirements regarding employment investigations, the failure of the New Jersey driver-licensing system to detect that the truckdriver's license was already under suspension before issuing a temporary license, and the failure of Federal Highway Safety Program standards to require effective State action in withholding a temporary license.

The cause of the fatalities to the four occupants of the Volkswagen, whose actions did not contribute to the accident, was the great disparity in weight between the truck and their vehicle, the position of the truck in the wrong lane, and its overturning tendency. The truck-driver and his passenger were burned in the fire, the severity of which was increased by the failure of an unprotected fuel-tank crossover line on the tractor.

II. FACTS

The Accident Location

U. S. Route 611 is a major north-south highway which links the New York-New Jersey metropolitan area with northeastern Pennsylvania and upstate New York. Interstate Highway I-81E parallels U.S. Route 611 from Stroudsburg, Pa., to Scranton, Pa., which is 9 miles north of Moscow. At the time of the accident, I-81E directly west of Moscow had not been completed and the portion of U.S. Route 611 routed through Moscow served as the only highway link between the completed southerly portion of I-81E and Scranton.

At the scene of the accident, U.S. Route 611 is bounded on the west by a hardware store, a gas station, and the Moscow Fire Department, and on the east by a street-level parking lot. (See Photograph 1.) A 4-foot-high concrete curb, which tapers down to 8 inches, separates the west side of the highway from the business establishments. The posted speed limit for both northbound and southbound traffic is 35 m.p.h.

This section of U.S. Route 611 is divided into three lanes: one 11-foot-wide northbound lane, one 11-foot-wide southbound lane, and, to the extreme right, one 8-foot-wide southbound lane used for parking. (See Figures 1-A, 1-B, and 1-C and Photograph 2.) A single solid white line separates the two southbound lanes, and a double solid white line separates the northbound lane from the southbound lanes.

On the night of the accident, the highway was well-illuminated by overhead streetlamps. The road surface, which is concrete, had been recently resurfaced with bituminous asphalt.

Impact occurred in the extreme right, southbound lane of the highway, 40 feet north of the northern curbline of the intersecting Pennsylvania Route 690 West (Church Street). The centerline of Route 690 West is in alignment with the crest of the hill over which the tractor-semitrailer passed just prior to the accident.

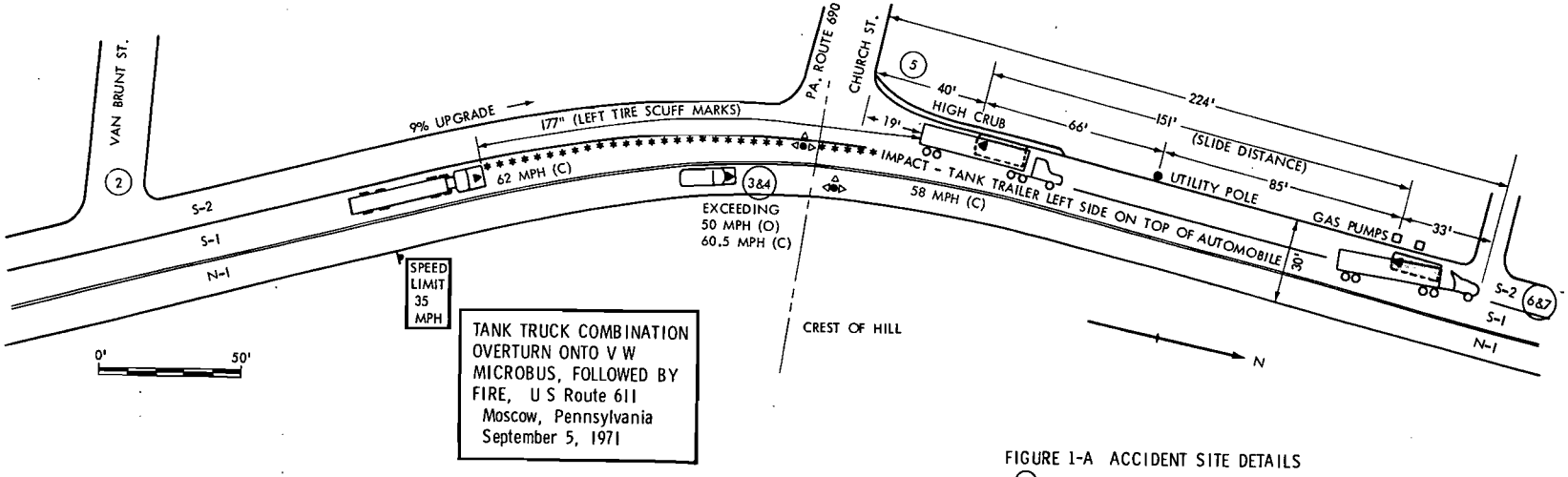
Approaching the point of impact from the north, the usable roadway (traversed by the Volkswagen Microbus) varies in width from 30 to 37 feet. The highway is straight and slightly upgrade southbound; the elevation at the impact point is 5.8 feet higher than at a point on the highway 500 feet north of impact. However, for all practical purposes, the 200 feet immediately north of the point of impact is level.

Approaching the impact point from the south, the usable roadway (traversed by the tractor-semitrailer) varies in width from 32 to 37 feet. From 2,000 to 700 feet south of impact, U.S. Route 611 has an average downgrade of 6.23 percent. In this downhill portion of the highway, an 8° curve to the left is followed by a short straight stretch of road, which is, in turn, followed by a 5-1/2° curve to the right. (See Photographs 3, 4, and 5.)

From 700 to 50 feet south of the point of impact, the highway has an upgrade of 9 percent. This upgrade portion of U.S. Route 611 includes the Market Street intersection (railroad underpass) on the east side and the Van Brunt Street intersection on the west side. (See Photographs 6 and 7.)

At the crest of this hill, 50 feet south of the impact point, the grade of the highway changes from a 9-percent upgrade to level in 76 feet. In the middle of the hillcrest, the road curves 11° to the right.

The Erie-Lackawanna Railroad runs parallel to and directly east of U.S. Route 611. As the highway curves 5-1/2° to the right, the track



TANK TRUCK COMBINATION OVERTURN ONTO V W MICROBUS, FOLLOWED BY FIRE, U S Route 611
Moscow, Pennsylvania
September 5, 1971

FIGURE 1-A ACCIDENT SITE DETAILS
(#) WITNESS LOCATIONS
(O) OBSERVED SPEED (MPH)
(C) CALCULATED SPEED (MPH)

FIGURE 1-B PLAN VIEW OF ROADWAY

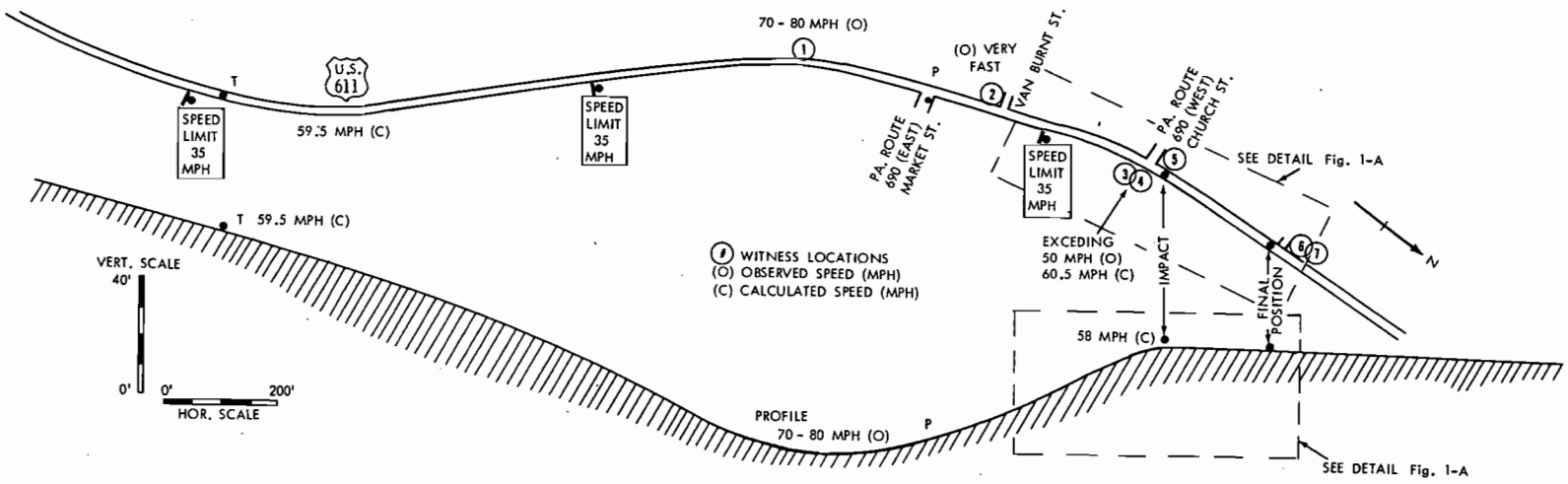
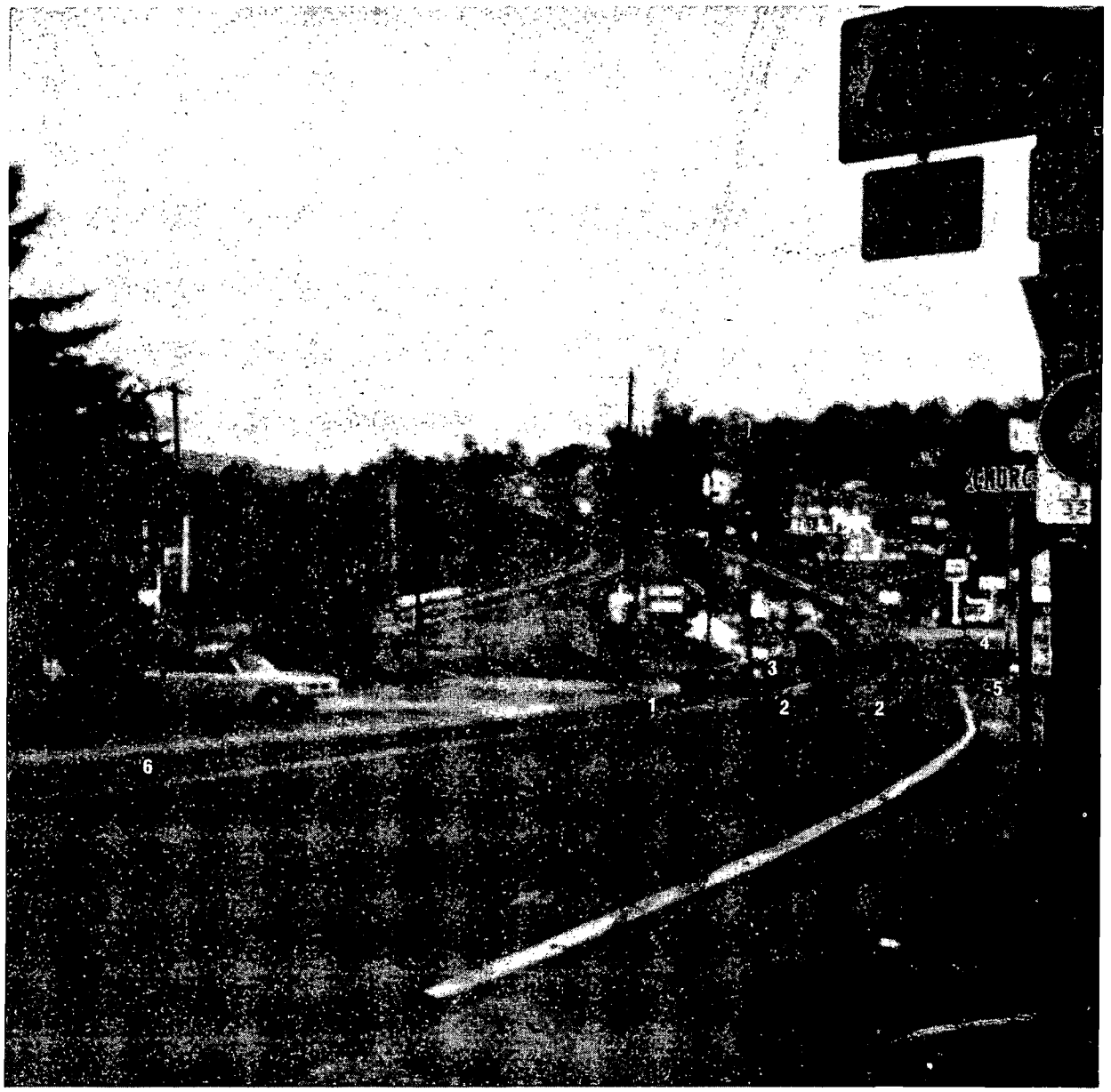


FIGURE 1-C PROFILE OF ROADWAY

TANK TRUCK COMBINATION OVERTURN ONTO VW MICROBUS, FOLLOWED BY FIRE, U. S. ROUTE 611
Moscow, Pennsylvinia
September 5, 1971

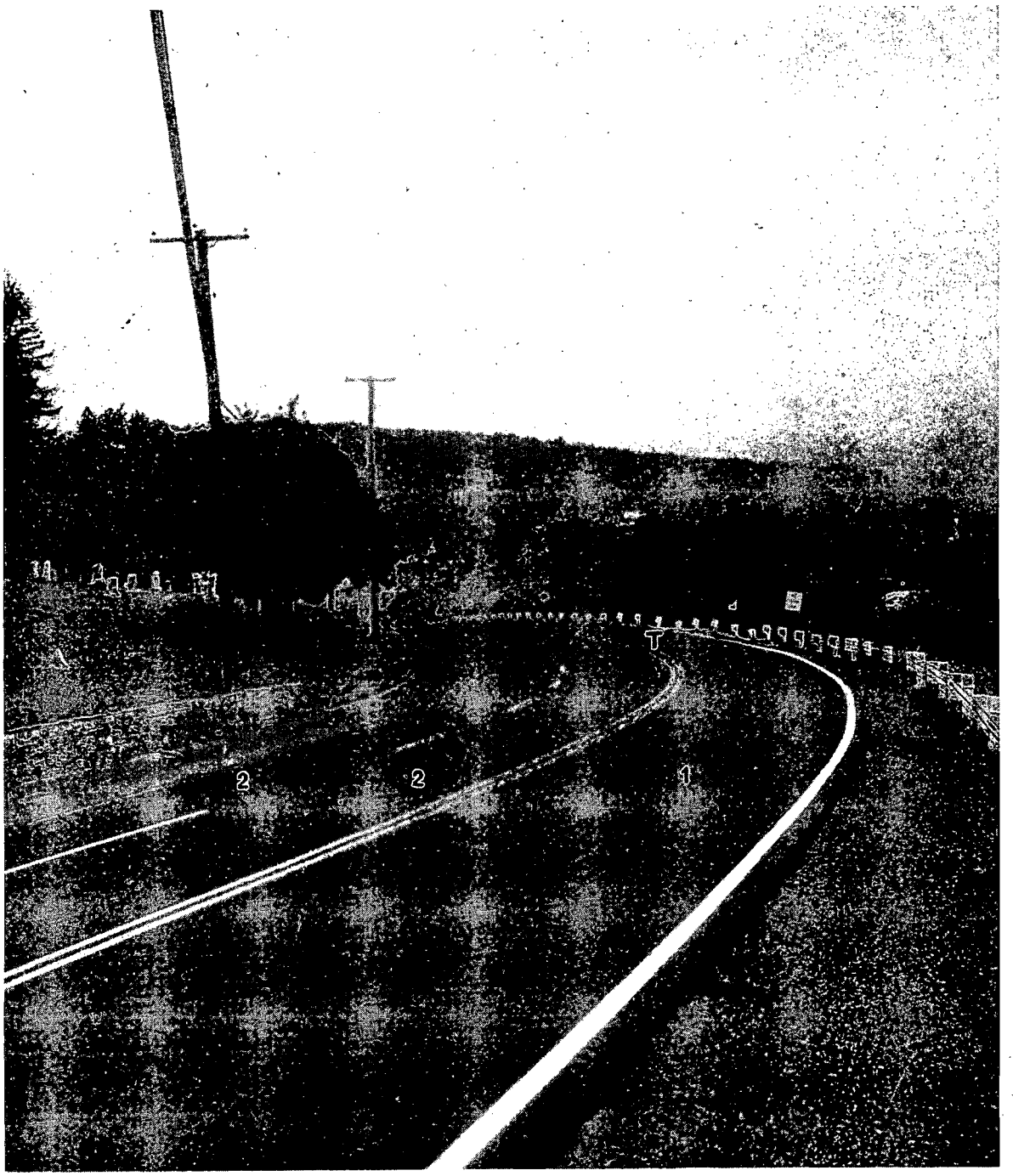
Photograph 1. The accident site (picture taken from the vehicles' final position facing south).

(1) Gasoline-pump mounting base
(2) Utility pole struck by tractor
(3) Impact point
(4) Hillcrest
(5) Right southbound lane
(6) Center southbound lane
(7) Northbound lane
(8) Pennsylvania Route 690 West (Church Street)
(9) Location of Witnesses



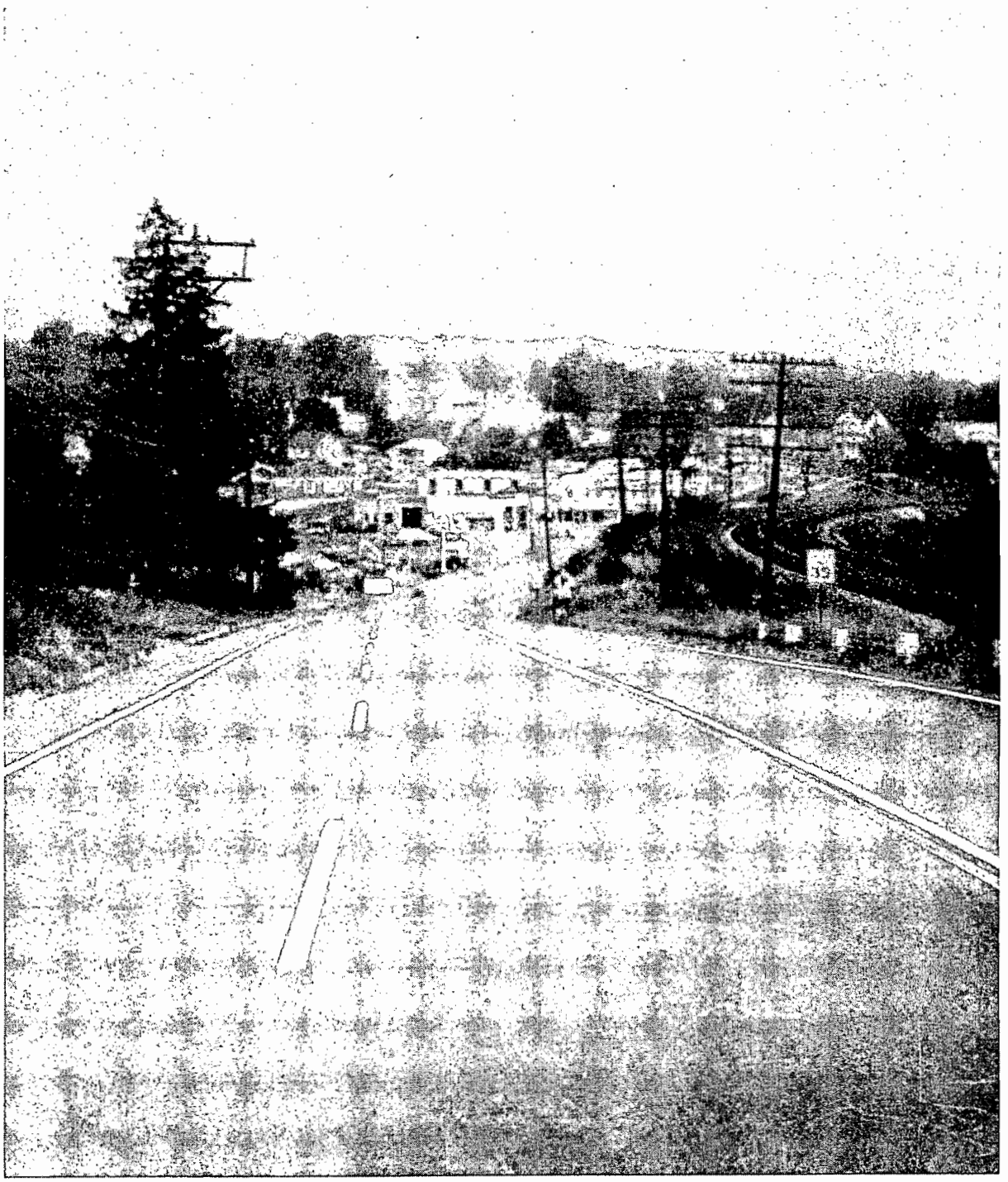
Photograph 2. U.S. Route 611 (picture taken from the Church Street intersection facing south).

(1) Northbound lane
(2) Southbound lanes
(3) Market Street (railroad underpass)
(4) Location of Witness 1
(5) Location of Witness 2
(6) Location of Witnesses 3 and 4

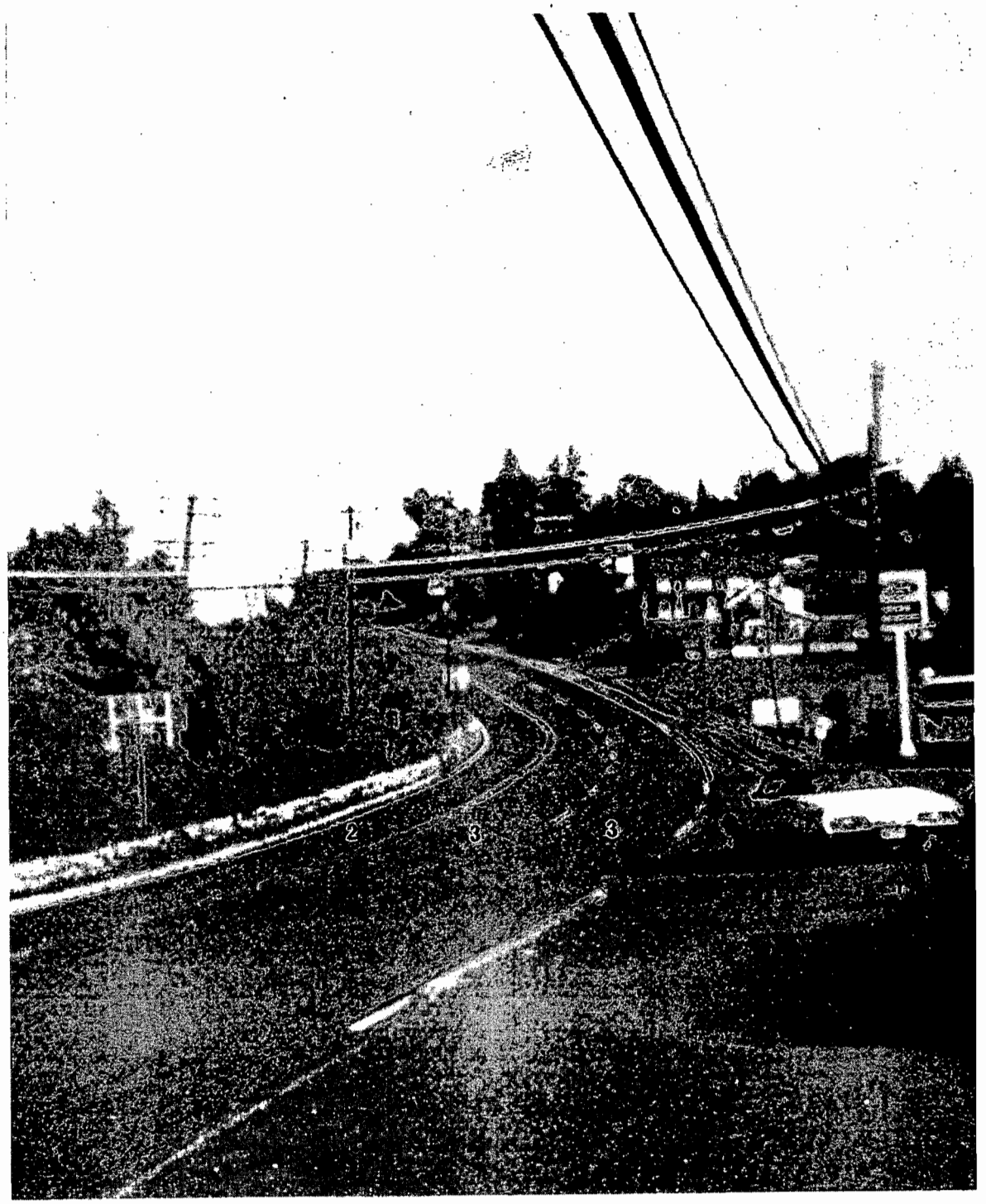


Photograph 3. U.S. Route 611 (picture taken 2,000 feet south of the impact point facing north).

(1) Northbound lane
(2) Southbound lanes
(T) Location of tractor-semitrailer when the pickup truck entered U.S. 611 from Market Street

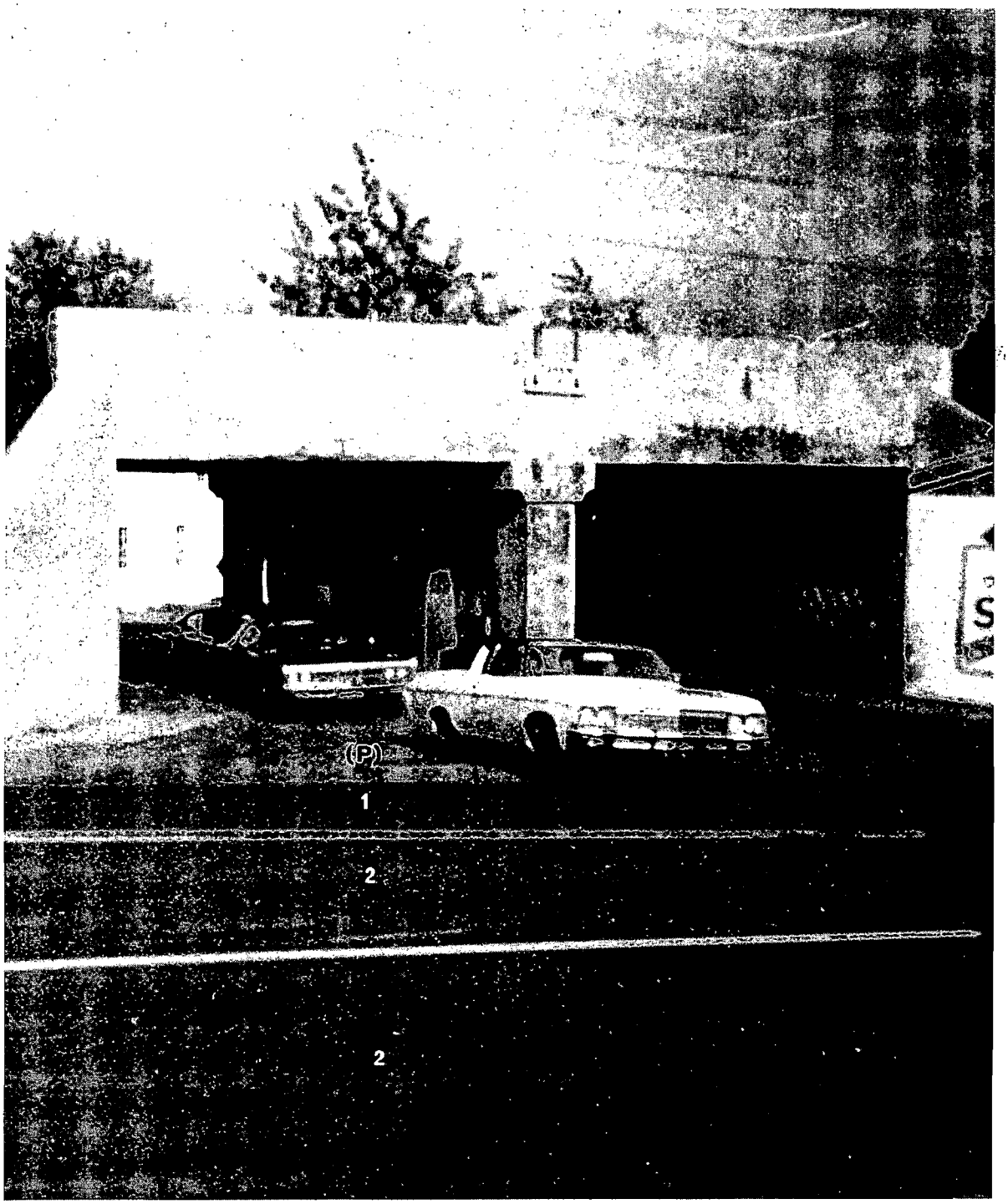


Photograph 4. U.S. Route 611 (picture taken 1,400 feet south of the impact point facing north).



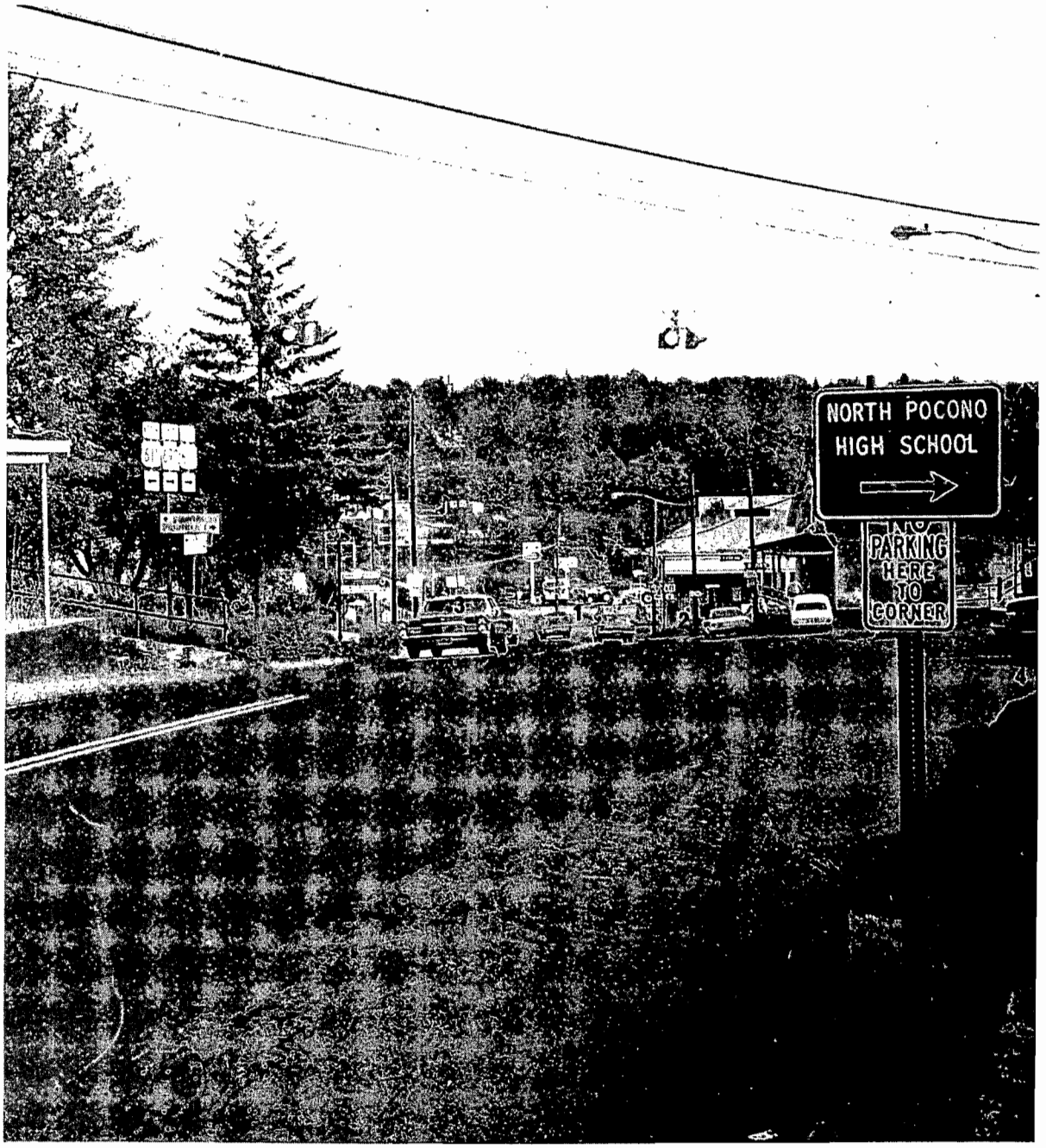
Photograph 5. U.S. Route 611 (picture taken 700 feet south of the impact point facing south).

(1) Location of Witness 1
(2) Northbound lane
(3) Southbound lanes



Photograph 6. The intersection of Market Street with U.S. Route 611.

(1) Northbound lane
(2) Southbound lanes
(P) Point where the pickup truck entered the highway



Photograph 7. U.S. Route 611 (picture taken from the point of impact facing south).

(1) Location of Witness 1
(2) Location of Witness 2
(3) Location of Witnesses 3 and 4
(4) Church Street intersection
(5) 4-foot-high curb

embankment obstructs the view of a northbound driver. In other words, as a driver comes down the 6.23-percent grade, he cannot see traffic entering the highway from Market Street.

Environmental Factors

On the night of the accident, the weather was clear, with no precipitation or fog, and the road surface was dry. The ambient temperature was 78° F. Traffic was light and moving without interruption, with no known abnormal distracting influences present. Two yellow caution signals suspended over the Church Street intersection were flashing to both northbound and southbound traffic on U.S. Route 611.

Vehicles and Cargo

The southbound vehicle, a white 1971 Volkswagen Microbus, had New Jersey license tag SJL 338. After the accident, the odometer read 15,304. The estimated gross weight of the Volkswagen was 3,398 lb., as loaded at the time of the accident. The gross weight included the driver, his wife, two small children, two dogs, hand luggage, and the vehicle.

The Volkswagen was demolished. (See Photograph 8.) The roof, engine compartment, seats, and floor were disoriented, crushed, and twisted in such a manner that any meaningful evaluation of mechanical failure was not practicable. There was no evidence to suggest that the mechanical condition of the Volkswagen contributed to the accident.

Fire damage was confined to the fuel tank and engine-compartment area of the Volkswagen. The upholstery, paint, and seats in the rear of the vehicle were burned, but the paint, seat cushions, baggage, upholstery, clothing, and other flammable materials in the center and front end were not.

The northbound vehicle, a tractor-semitrailer combination, consisted of a 1969 Mack tractor, with three axles and diesel power, and a 1967 tandem-axle, stainless-steel (insulated), clean-bore (no baffles or bulkheads), 5,600-gallon tank semitrailer, maunfactured by the Dairy Equipment Company.

The tractor cab was deformed rearward and downward. (See Photograph 9.) Fire, confined to the inside of the cab, consumed all flammable materials. Impact damage rendered the steering column inoperable.

The diesel fuel tanks of the tractor were empty following the accident. The flexible fuel-tank crossover (equalizer) line had broken at its attachment to the left-front, rear-spring hanger (see Photograph 10) and the fuel had drained out of both tanks.

All accident damage observed during the postcrash inspection of the trailer confirmed that the tank had rolled over toward the left onto the Volkswagen. The primary physical damage to the tank was on the left side, at the front. (See Photograph 11.)

The semitrailer cargo consisted of approximately 4,200 gallons of a 60-percent-liquid sugar solution weighing 45,460 lb. The density of this liquid-sugar cargo was 10.8 lb. per gallon. There was no measurable loss of cargo.

Appendix A presents additional details concerning the tractor-semitrailer dimensions and accident damage.

Accident Chronology

Seven witnesses observed either one or both of the vehicles prior to the crash. The location of the witnesses is shown in Figures 1-A, 1-B, and 1-C.

According to Witness 1, the tractor-semitrailer came down the 6.23-percent downgrade at 70 to 80 m.p.h. Witness 2 reported that as the tank-truck combination reached the bottom of the grade and started to ascend the 9-percent upgrade, it drifted partially into the

Photograph 8. Volkswagen Microbus accident damage.

(1) Steering wheel (front of vehicle)
(2) Engine compartment (rear of vehicle)

Photograph 9. Tractor accident damage.

Note that the damage is confined to cab roof and door.

Photograph 10. Tractor diesel-fuel crossover line (left side)

(1) Front fuel-tank head
(2) Left front tire
(3) Left front rear-spring hanger
(4) Crossmember
(5) Crossover-line failure

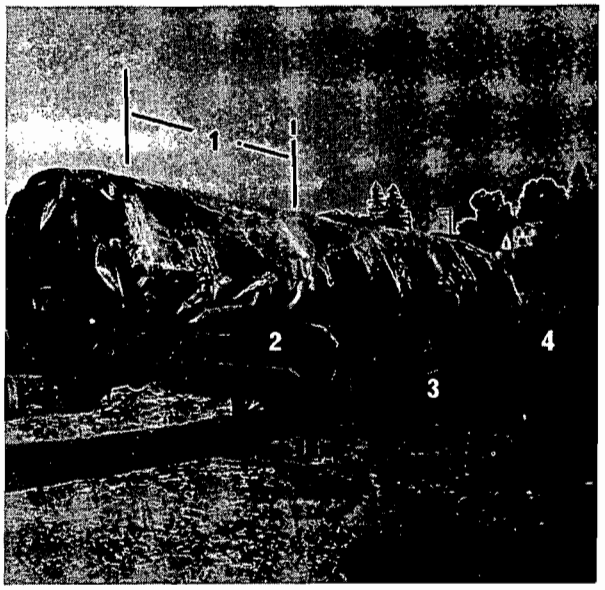
center southbound (S-1) lane. As it ascended the upgrade, the tractor-semitrailer continued to drift leftward until the entire vechcle was in the S-1 lane. Witnesses 3 and 4 reported that the tractor-semitrailer passed their pickup truck at a speed estimated to be in excess of 50 m.p.h. The pickup truck was in the northbound (N-1) lane as the tank-truck combination passed them in the S-1 lane.

This passing maneuver reportedly occurred just south of the hillcrest. Witnesses 3 and 4 reported that while the tank-truck combination was adjacent to the pickup, its right-side wheels were 12 to 14 inches above the pavement. The wheels started to return to the pavement, lifted again, and the entire combination rolled over onto the Volkswagen.

As the tractor-semitrailer was ascending the upgrade, the Volkswagen was traveling south at 30 m.p.h. When the tank-truck combination came over the hillcrest in the S-1 lane in a partial-upset attitude, the Volkswagen turned towards its right (away from the truck). As the vehicles came alongside each other, the tank-truck combination completed its rollover onto the Volkswagen.

Fire erupted immediately upon impact. As the tractor slid on its left side, the upper windshield header struck a utility pole 66 feet north of impact. The two burning vehicles continued to slide an additional 85 feet until the tractor cab made contact with two gasoline-station gas pumps. (See Figure 1-A.) The southernmost pump was completely severed from its mounting base, and the northernmost pump was bent to a 70° angle toward the west. (See Photograph 12.)

Although the diesel fuel that escaped from the broken fuel-tank crossover line was feeding



Photograph 11. Tractor-semitrailer accident damage.

(1) Damage from the Volkswagen impact
(2) Left-rear outside drive tandem fender (with tire contact point)
(3) Left-side manhole ladder
(4) Trailer tandem fender

the fire, the gas pumps did not ignite. The design of these pumps is such that when they are shut off the gasoline in the pumps drains back into the underground storage tank.

The vehicles came to rest within 25 feet of the building housing the Moscow Fire Department. Fire spread across the highway. The fire damage incurred by the gas-station sign, which is approximately 10 to 12 feet high, indicates that the flames reached a height of 15 to 20 feet above the road. According to the fire chief, firemen were applying chemical foam and water to the fire within 45 seconds after the vehicles came to rest. As a result, the fire was extinguished quickly.

The fire chief ordered the tractor battery cables cut to eliminate any potential fire reignition source. Quite accidentally, the cable cutters used to sever the battery cables made contact with the tractor frame. Since the cable cutters were thus simultaneously in contact with the frame and the battery cables, the engine started and ran. Witness reported that none of the tractor's drive wheels rotated while the engine was running.

An unauthorized passenger riding in the tractor cab escaped through the windshield. Responding to the truckdriver's calls for help, he returned and helped the driver escape from the burning vehicle. While assisting in the driver's evacuation, the passenger was burned.

In order to set the tank-truck combination back on its wheels, a hole was first chopped into the right side of the tank, and the cargo was pumped off. Wreckers were then used to pull the tank-truck combination off the Volkswagen and to set it back on its wheels.

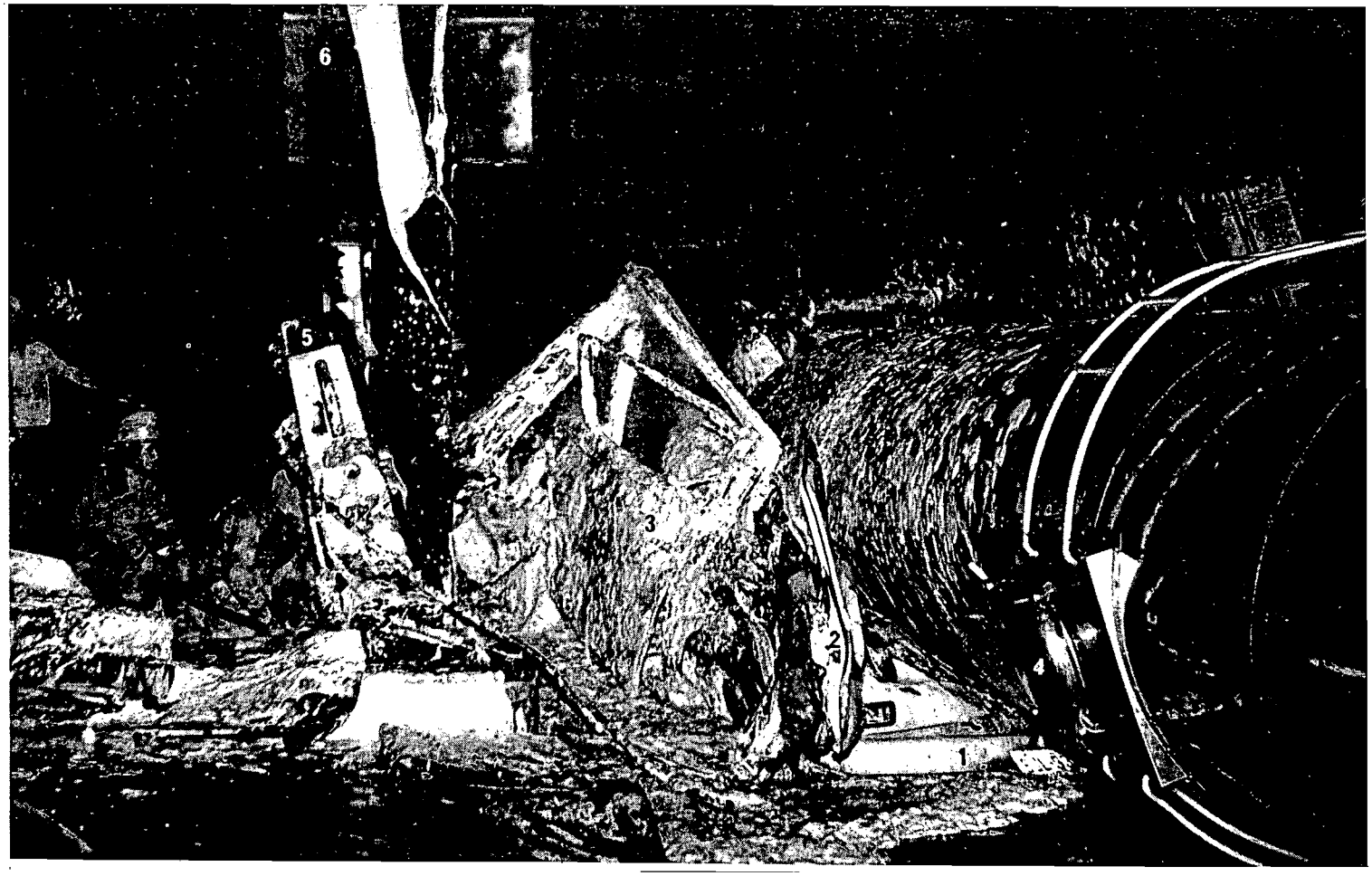
The tractor transmission was found in the neutral position. Coasting out of gear is a violation of Section 1026 of the Pennsylvania Vehicle Code and Section 392.2 of the Federal Motor Carrier Safety Regulations. The one set of spring-type parking brakes as found on one of the drive axles were in the applied position. The tractor was lifted at its rear and towed to a nearby salvage yard with its front wheels on the roadway.

After the trailer was lifted off the Volkswagen, two wreckers were used to pry the crushed vehicle open. The bodies of the four occupants were then removed.

Vehicle Occupants

The driver of the Volkswagen Microbus was a 28-year-old U.S. Army captain. His 26-year-old wife was occupying the right front seat of the Volkswagen, holding her 5-month-old son in her lap. A second son, aged 2, was sitting in a child-restraint seat attached to the middle rear passenger seat. The Volkswagen also contained two pet dogs (position unknown).

The driver of the truck, a male, aged 28 years, was a resident of Bordentown, New



Photograph 12. Accident vehicles in final position.

(1) Volkswagen front bumper
(2) Volkswagen right front door
(3) Volkswagen left rear door
(4) Tank-semitrailer manhole (top of tank)
(5) Gasoline pump
(6) Fire damage

Jersey, and had been driving tractor-semitrailers since 1965. He possessed a temporary New Jersey operator's license (No. D476 401779 01434), although his driving privilege was suspended in the State of New Jersey on July 11, 1971. The suspension was still in effect when the accident occurred. The temporary license had been obtained from the motor-vehicle licensing office in Burlington, New Jersey. His Bureau of Motor Carrier Safety medical certificate, dated May 14, 1969, had expired on May 14, 1971, and was therefore invalid. In addition, his motor carrier employer's driver qualification file did not have the previous employer and state-investigation information as required by Section 391.23 of the Motor Carrier Safety Regulations.

The employment record of the driver as a truckdriver, as known to the Board, is as follows:

1965 - 1967	: Tractor-semitrailer driver for an interstate motor carrier. During his tenure with this carrier, the driver was involved in three accidents, the last of which occurred in August 1967 and resulted in termination of his employment.
January 1968 - March 1968	: Tractor-semitrailer driver for an interstate motor carrier. There is no record of any accidents during this period of employment. Reason of record for termination was listed as "dissatisfaction."
May 1968 - August 1968	: Tractor-semitrailer driver for an interstate motor carrier. There is no record of any accidents during this period of employment. Reason of record for termination of employment was listed as "failure to report for work."
August 1968 - May 1969	: Tractor-semitrailer driver for an interstate motor carrier (predecessor of the company for which he was working the day of the accident). There is no record of any accidents during this period of employment. Reason of record for termination was not listed. A representative of this carrier, however, did indicate in an interview that this driver was unable to get along with management.
May 1969 - August 1971	: Tractor-semitrailer driver for an interstate carrier. During this period of employment the driver was involved in four accidents. Reason of record for termination of employment was a "rash" of chargeable accidents.
August 16, 1971 - to the date of accident	: Tractor-semitrailer driver for an interstate motor carrier. There was no record of accidents prior to the subject accident of this report.

The truckdriver's driving record (1962-1971) is replete with violations. During this period, his driver's license was suspended by the State of New Jersey on six occasions and his driving privileges were suspended in the State of Pennsylvania twice. There were 12 entries on his driving record for speeding and two for driving

while his license was under suspension. (See Appendix B). His Driver's Daily Log Book was not up to date, in violation of Motor Carrier Safety Regulations; the last entry was made on August 31, 1971.

A postcrash inspection of the tractor cab revealed a plastic bottle which contained 17 pills, identified later by the State of New Jersey Crime Laboratory in Trenton as containing both amphetamines and barbiturates. The driver had been receiving prescriptions for such pills at the rate of 120 per month for the purpose of weight control. This driver is 5 feet, 6 inches tall, and weighs 140 pounds.

III. ANALYSIS

Crash Dynamics

In Figures 1-A, 1-B, and 1-C, the eyewitnesses' estimates of the speed of the tank-truck combination prior to impact are indicated by (0). Based on these estimates, calculated speeds were plotted in order to provide a better understanding of the precrash dynamics of the tractor-semitrailer. These calculated speeds were determined by using physical laws regarding time and distance relationships in addition to accepted SAE performance-prediction formulas. (See Appendix C.)

The maximum speed that the tractor-semitrailer could have attained in gear was 60 m.p.h. Since Witness 1 estimated the speed of the vehicle to be 70 to 80 m.p.h. at the bottom of the 6-percent downgrade, the truckdriver probably shifted to neutral at or near point "T". (See Figures 1-B and 1-C and Photograph 3.) Point "T", which is 1,617 feet south of the point of impact, is in the middle of the 8° curve to the left.

With the transmission in neutral, the tractor-semitrailer would have accelerated at approximately 1.5 feet per second per second as it continued to descend the 6-percent grade. At 70 m.p.h., a centrifugal force of 24,100 lb., coupled with lateral surge loadings of unknown magnitude, probably caused the vehicle to drift into the S-1 lane. Because the railroad embankment on the east side of the road obstructed his view, only after reaching the bottom of the hill could the truckdriver have seen that the pickup truck occupied by Witnesses 3 and 4 had entered U.S. 611 in the N-1 lane. (See Photograph 6.) The presence of the pickup truck and the leftward-acting centrifugal force dictated that the truckdriver attempt to stay in the S-1 lane.

As the out-of-gear tractor-semitrailer ascended the 9-percent upgrade, forces resulting from grade and wind resistance combined with the vehicle's own rolling resistance to retard speed at the rate of 2.4 feet per second per second. Scuff marks made by the tractor-semitrailer's tires indicate that the vehicle started to overturn to the left 35 feet into the 11° curve to the right near the top of the upgrade. The scuff marks also indicate that the vehicle then traveled 177 feet on its left side wheels, as confirmed by Witnesses 3 and 4.

At the point where the scuff marks begin, the speed of the tank-truck combination is calculated to have been 62 m.p.h. At this point, the vehicle was being subjected to a 34,000-lb., lateral centrifugal force to the left. Since the force necessary to upset the vehicle is calculated to have been 44,450 lb., the difference of 10,450 lb. must have been contributed by leftward-acting dynamic liquid surge. Of course, until the tank-truck combination actually did overturn, the liquid surge loading was slightly less than 10,450 lb.

The surge probably started its traverse action back at point "T" where the vehicle rounded the 8° turn to the left. The liquid sloshed transversely a number of times as the tractor-semitrailer descended the downgrade. At the bottom of the hill, the centrifugal force towards the left probably increased the sloshing. As the vehicle entered the 11° curve at the top

of the hill, the 34,000-lb. centrifugal force combined with the surge to force the vehicle up on its left wheels.

Thus balanced on its left wheels, the tractor-semitrailer was subject to the upward force produced by the speed of the truck as it crossed the hillcrest. This vertical upward force represented a negative loading of approximately 12,000 lb., which reduced the force necessary to upset the vehicle from 44,450 lb. to 36,800 lb. This reduction in vehicle stability was all that was needed to upset the vehicle as it went over the hillcrest.

Under all of the same conditions, with the same radius of curve and negative loading induced by the hillcrest, a hypothetical tractor-semitrailer loaded with a solid cargo to the same weight and having the same center-of-gravity height could have negotiated the curve at 64 m.p.h. without upsetting. By the process of elimination, the dynamic surge forces of the liquid cargo are the only forces which could have been responsible for the vehicle overturn.

Appendix C presents a summary of the tractor-semitrailer stability factor calculations.

Analysis of the precrash dynamics of the tank-truck combination, is based on the 55- to 60-m.p.h. speed just prior to impact.

The dynamics of liquid surge forces of partially filled tank-trucks are extremely complex, and it is recognized that this analysis is an oversimplification. The fact remains that the tank-truck combination did overturn and all lateral forces known to be acting on the vehicle other than those of liquid surge were insufficient to produce overturn.

Tractor Fuel-Tank Crossover Line

This accident demonstrates once again the vulnerability of diesel fuel-tank crossover lines. The failure of the crossover line (see Photograph 10) permitted all the tractor's diesel fuel to drain from the sidemounted tanks and to contribute to the postimpact fire. This is an extremely important safety issue, which has been raised by the Safety Board in previous accident investigations.

Section 393.67(c)(5) of the Motor Carrier Safety Regulations states in part: "A diesel fuel crossover line must be protected against damage from impact and must not extend more than two inches below the fuel tank or its pump."

In this case, the crossover line was considerably better protected than most crossover lines. The outlet was located in the fuel tank head, not at the bottom of the tank. Neither the outlet fitting nor the hose extended 2 inches below the tank or pump. Nevertheless, the fuel-tank crossover line failed. The Safety Board notes that kits are currently available to eliminate completely the necessity for a crossover line.

Location of Gasoline-Station Pumps

Although the location of and the resultant damage to the gas-station fuel pumps did not contribute to the severity of this accident (from a fire standpoint), the advisability of such a location is highly questionable. In addition to the potential fire hazard of a gasoline-pump island located at the curbline of a roadway (6,000 average daily-vehicle count), the accident potential is aggravated by vehicles being fueled in one of the three available traffic lanes.

Tractor-Engine Start During Removal

The fact that the drive wheels did not rotate when the starting circuit was accidentally shorted by the fireman's cable cutters supports the conclusion that the tractor transmission

was in neutral. With the spring brakes in the applied position on one drive axle, the inter-axle differential would have caused the wheels of the drive axle without spring brakes to rotate had the transmission been in gear. With the transmission in neutral, the accidential shorting of the starting circuit merely started the engine, much the same as if the starter button on the dash had been pushed.

Hillcrest Stopping Sight Distance

The abrupt change in grade (9 percent to level in 76 feet) at the hillcrest adversely affected the stopping sight distance of the drivers of both vehicles involved in this crash. Had the Volkswagen driver been aware of the truck's presence sooner, he might have been able to take earlier and possibly successful evasive action.

The posted speed limit of 35 m.p.h. was too high. Using the existing hillcrest dimensions to determine the stopping sight distance by accepted formulas and figures,[1] the sight distance for either direction at the hillcrest is computed to be 110 feet; AASHO recommends a speed limit of 30 m.p.h. for a minimum stopping sight distance of 200 feet (the lowest values indicated by AASHO). By extrapolation, the speed limit for vehicles approaching the hillcrest involved in this accident should be reduced to 16.5 (or, rounded off, to 15) m.p.h.

The 11° horizontal curve and the right angle intersection of Pennsylvania Route 690 West (Van Brunt Street) compounds the hazardous nature of the hillcrest. Eventually, when Interstate 81-E becomes operational, a major portion of the traffic using U.S. 611 will be diverted. Until such time, potential changes to the area might well include barrier-type lane separations, a stop-go traffic signal to replace the yellow caution signal, and an advisory 15 m.p.h. posted speed limit for both north and southbound traffic approaching the hillcrest.

Driver of the Tank-Truck Combination

Of the many entries on the truckdriver's combined New Jersey and Pennsylvania driving records, 12 were convictions for speeding violations and two were failures to keep to the right. These are the same type of violations which are causal factors in this accident. No correlation was made of the accidents which appear on five previous employment record files to those accidents recorded by the State Motor Vehicle authorities; however, it is probable that he had more than the three recorded accidents.

The implication of drug usage in this accident is strong but not conclusive. A doctor dispensed 120 pills containing amphetamines and barbiturates to the truckdriver on August 22, 1971, and only 17 pills were found on September 5. Although it is conceivable that a quantity of pills was left at home, it is equally conceivable that the truckdriver had consumed 104 pills in 15 days, an average of approximately seven pills per day. Medical authorities suggest that such pills be taken only at a rate of three or four per day.

The actual effect on the driver's alertness and responsiveness is not determinable. Due to his critical injuries, no tests were made to determine if he was under the influence of any drugs.

On May 29, 1972, the driver was found guilty of four counts of involuntary manslaughter by the Court of Common Pleas-Criminal (Lackawanna County, Scranton, Pennsylvania).

---

[1] American Association of State Highway Officials (AASHO), *A Policy on Geometric Design of Rural Highways*, 1965, p. 204-206.

Driver-Licensing Procedures

> "The basic purpose of driver licensing systems —laws, regulations, and procedures— is to promote and preserve highway safety, to assure that only those applicants who qualify will be licensed, to deny the privilege to those who do not, and to remove the privilege from drivers who, through repeated accidents and violations, demonstrate their unfitness to drive."

This quotation is from the Board's report[2] concerning the crash of a chartered bus on Interstate 78 near New Smithville, Pa. In that accident, a driver, also licensed in the State of New Jersey, had his driving privilege suspended on five separate occasions, yet was still operating a commercial vehicle.

The truckdriver in this accident had his operator's license suspended six times by the New Jersey Motor Vehicle Department and twice by the Pennsylvania Motor Vehicle Department. In every instance but one, his driving privileges were restored in one to three months following the suspension. On July 11, 1971, 2 months prior to this accident, his driver's license was suspended. This suspension was in effect at the time of the accident. However, on August 16, he was reemployed as a truckdriver by the carrier for whom he was working at the time of the accident. At the time of the accident, the truckdriver held a temporary New Jersey driver's license, No. D 476 401779 01434, issued in Burlington, New Jersey.

The number appearing on this temporary license is the same as that on his New Jersey driving record. It is reasonable to assume that the Burlington, New Jersey, licensing office searched the files to obtain the proper number for the temporary license. At that time, the licensing personnel should have noted (or the system failed to reveal) that the license was under suspension and that the driver had accumulated a substantial record.

In the New Smithville report, the Board stated:

> "The driver's accident record, traffic violations record, licensing history, medical background and condition are issues of interagency and intra-agency coordinative interest - the 'right hand' must know what the 'left hand' is doing if the system is to function properly."

These comments are equally applicable to this accident. Communication within a State motor-vehicle department should be such that a known habitual violator of traffic laws will be identified, his record reviewed and analyzed by a qualified driver-improvement analyst, and appropriate corrective action taken.

Federal Highway Safety Program Standard 10, "Traffic Records," and Standard 5, "Driver Licensing," require States to maintain programs which would apparently have prevented the issuance of a license to this driver. The traffic-records standard requires "rapid audio or visual responses upon receipt at the records station of any priority requests for status of driver license validity." The driver-licensing standard requires that "at time of issuance or renewal each driver's record must be checked." The issuance of a license to this driver is evidence that one or both of these standards were not being complied with by the State of New Jersey. The Secretary of Transportation has statutory authority to enforce compliance with these standards.

Employment Record

The fact that the truckdriver had been employed as a commercial vehicle driver by six

---

[2] National Transportation Safety Board, "Charterd Bus Crash on U.S. Route 22 (Interstate 78) near New Smithville, Pennsylvania, July 15, 1970," NTSB-HAR-71-8.

different companies, and dismissed because of his accident record in two instances, and because of an irresponsible attitude in two others, suggests that his current employer failed to investigate his previous driving and employment records. Section 391.23 of the Motor Carrier Safety Regulations requires that a motor carrier inquire as to a prospective driver's record for the preceding 3 years. The inquiry is to include previous employment records and the State motor vehicle department records in every state in which the driver held a license. The required investigation must be made within 30 days of the driver's employment date.

This accident occurred 23 days after the truckdriver had been given his job with the HAC Farm Lines Agricultural Cooperative Association. The motor carrier's driver-qualification file did not contain any of the required information. Considering that the predecessor of this company had previously employed and dismissed the driver, it is doubtful that the required inquiry would have been completed in the 7 days which remained.

In view of his driving and employment history, the truckdriver should not have been reemployed by the HAC Farm Lines.

IV. CONCLUSIONS

1. The truckdriver's previous driving record should have prevented him from obtaining a temporary license to drive a commercial motor vehicle.
2. The failure of the State of New Jersey driver-licensing system to preclude the issuance of a temporary license to the driver already under suspension implies that the New Jersey system is not in compliance with Federal Highway Safety Program Standard No. 5, "Driver Licensing," and/or Standard No. 10, "Traffic Records." The failure of this system to act in accord with one or both of these standards denied to the four innocent victims in this crash a form of protection intended to be provided on a nationwide basis by Public Law 89-564.
3. The HAC Farm Lines Agricultural Cooperative Association did not comply with the regulations requiring applicant investigations and inquiries when the truckdriver was employed.
4. The actions of the driver of the Volkswagen did not contribute to this accident.
5. The high curb on the west side of U. S. Route 611 prevented any reasonable chance that the Volkswagen had to avoid this accident through driver action. The crash with the truck was nonsurvivable.
6. The tank-truck combination was being operated at a speed too fast for the highway-design limitations, and in excess of the capability of the vehicle to maintain stability.
7. The 70-m.p.h. speed of the tank-truck combination was attainable because the transmission was in neutral.
8. Liquid surge forces acting on the partially filled tank caused the tractor-semitrailer to upset.
9. The tank-truck combination would not have upset even at its high speed if the trailer had contained a solid cargo.
10. The 35-m.p.h. speed limit at the accident scene was in excess of acceptable AASHO limits for the geometry and limited stopping sight distance of the hillcrest
11. The failure of the tractor fuel-tank crossover line contributed to the severity of the fire.
12. The ignition and initial source of fuel for the fire which erupted upon impact is not known.
13. The critical condition of the truckdriver precluded any tests for determining drug influence.
14. The location of the gasoline pumps on the

curbline presented a potentially hazardous situation.

15. The Moscow Fire Department performed quickly and well in extinguishing the fire, and thereby minimized the severity of this accident.

V. PROBABLE CAUSE

The National Transportation Safety Board determines that the cause of this crash was the upset of the tractor and cargo-tank semitrailer due to grossly excessive speed in a turn and to the resultant dynamic surge of liquid cargo. A primary contributing factor was the failure of the truckdriver to comply with either the posted speed limit or with State laws and Federal Regulations prohibiting coasting out of gear. Additional contributing factors included the failure of the HAC Farm Lines Agricultural Cooperative Association to comply with Federal requirements regarding employment investigations, the failure of the New Jersey driver-licensing system to detect that the truckdriver's license was already under suspension before issuing a temporary license, and the failure of the Federal Highway Safety Program standards to require effective State action in withholding a temporary license.

The cause of the fatalities to the four occupants of the Volkswagen, whose actions did not contribute to the accident, was the great disparity in weight between the truck and their vehicle, the position of the truck in the wrong lane, and its overturning tendency. The truckdriver and his passenger were burned in the fire, the severity of which was increased by the failure of an unprotected fuel-tank crossover line on the tractor.

VI. RECOMMENDATIONS

The National Transportation Safety Board recommends that:

1. The National Highway Traffic Safety Administration (NHTSA) request legislation to revise its National Driver Register Service to make convictions of all hazardous traffic offenses committed in any State known to any other State as well as the resident State of the driver. Commercial motor vehicles drivers' records should be made available to all motor carrier employers seeking to conduct a Driver's Record investigation as required by the Motor Carrier Safety Regulations (391.23). (Recommendation No. H-72-43).
2. The Secretary of Transportation initiate action to determine whether the State of New Jersey is in compliance with Federal Highway Safety Program Standards No. 5 and No. 10, and, if not found in compliance, to take appropriate action authorized under Public Law 89-564. (Recommendation No. H-72-44).
3. The Bureau of Motor Carrier Safety (Federal Highway Administration), in cooperation with affected industries, as represented by the Tank Truck Technical Council, conduct an investigation designed to resolve the overturn stability problems created by liquid surging of partially loaded tank-truck combinations. The ultimate objective of such a research program should be the promulgation of Federal regulations to limit the effects of surge to a specific degree. Such regulations might be based on acceptable liquid cargo outage and/or dampening requirements, consistent with safe tank-truck operation. (Recommendation No. H-72-45)
4. The Bureau of Motor Carrier Safety modify Section 393.65 of the Motor Carrier Safety Regulations (as revised 2-4-72) to eliminate the fuel-crossover line and other lines and fittings which are subject to damage as a result of their exposed location on the bottom of tanks, close to the road.[3] (Recommendation No. H-72-46)

[3] Same as Recommendation H-72-32 in Board's Report, "Automobile-Truck Collision Followed by Fire and Explosion of Dynamite Cargo on U.S. Route 78 near Waco, Georgia, on June 4, 1971."

5. The State of Pennsylvania institute a traffic engineering study of the existing hazardous conditions on U. S. Route 611 between stations 382 and 384 and take the action necessary to implement the findings of such a study. (Recommendation No. H-72-47)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JOHN H. REED
Chairman

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

/s/ WILLIAM R. HALEY
Member

Francis H. McAdams, Member, was not present and did not participate in the adoption of this report.

October 18, 1972.

APPENDIX A

TANK-TRUCK COMBINATION DIMENSIONS AND ACCIDENT DAMAGE

I. TRACTOR

1969 Mack Diesel
Serial number - U68ST2340
Mileage - 252,324
License plate number - New York 72-120
Company equipment number - 171
Wheelbase - 144"
Location of 5th wheel - 8.5" ahead of drive bogie centerline.

(a) *Tractor weight calculation (based on Manufacturer's information).*

	Tare	Loaded
Front:	6,580	8,080
Bogie:	7,390	31,290
	13,970 lb.	39,370 lb.

(b) *Location of tractor center of gravity.*

Based on manufacturer-supplied dimensional and weight information, the tractor's center of gravity is located 33" above the road and 67.5" ahead of the bogie centerline.

(c) *Tractor tires.*

Front: 10:00/20 Goodyear, tread depth 6-7/32"
Rear: 10:00/20 Inland, tread depth 9-17/32"

(d) *Road-speed factors.*

With the diesel engine governed at 2,100 r.p.m., the 4.17 rear-axle ratio, and the 10:00 tires, the maximum attainable in-gear road speeds were as follows:

3d gear: 21 m.p.h.
4th gear: 36 m.p.h.
5th gear: 60 m.p.h.

II. TANK-SEMITRAILER

1967 Kari Kool
Manufacturer - Dairy Equipment Company
Model number - 34-100
Serial number - CTK2193 (stainless steel)
License plate number - New Jersey TK0801
Capacity - 5,600 gal.
Tandem axle suspension - Webb 5540
Clean bore - no baffles or bulkheads

(a) *Semitrailer size information (supplied by manufacturer).*

Inside diameter	65"
Outside diameter	69"
Length (less heads)	378"
Tank nose to kingpin	22"
Kingpin to trailer tandem centerline	326"
Height of tank top above road	127"

(b) *Semitrailer weight calculations (based on manufacturer's information).*

	Tare	Loaded
Front:	3,200	25,400
Tandem:	7,100	30,363
	10,300 lb.	55,763 lb.

(c) *Location of semitrailer center of gravity.*

Based on manufacturer-supplied information and calculations, the loaded center-of-gravity height was 80.7" above the road and 159" ahead of the semitrailer tandem centerline.

(d) *Semitrailer tires.*

All front trailer tandem axle tires were General recaps, with tread depths varying from 6/32" to 9/32". The left rear tandem axle tires had tread depths of 1/32". One tire was a General, the other was a Goodyear. On the right rear tandem axle were a Goodyear tire, with a tread depth of 9/32", and a Goodyear recap, with a tread depth of 12/32".

(e) *Semitrailer accident damage.*

Primary accident damage was to the left side at the front. The tank shell (insulating jacket) was damaged from the front to a point 10-1/2 feet in back of the front in the 1 o'clock to 4 o'clock position (as viewed from the front).

The tractor drive tandem left fender was rotated upward about its attachment to the upper coupler subframe. A black rubber smudge mark was found on the underside of the left fender of the trailer, directly above the left outside-rear tractor tire.

The left-side trailer manhole ladder had been pulled downward and outward. The trailer tandem left fender was rotated upward about its attachment to the trailer tandem subframe. The left rear trailer tandem brake drum was cracked axially through its wear surface.

The damage to the right side of the trailer was confined to the forward 6 feet in the 10 o'clock to 12 o'clock position (as viewed from the front).

The Kingpin had been torn loose at the upper coupler wear plate during the process of righting the trailer. The tank's inner shell was deformed inward at points adjacent to the deformation in the insulating jacket.

APPENDIX B

SUMMARY OF TRUCKDRIVER'S RECORD, 1962 - 1971

Nature of Citation	Number of Citations (in Pa. and N.J.)
Speeding violations	12
Accidents	3
Traffic signal	1
Failure to keep right	2
Following too close	1
Unauthorized use of registration plates	2
Failure to appear	2
Warning	1
Driving while under suspension	2
License suspended	8
License restored	8
Total	42

Distribution by Years

1962 - 5
1963 - 3
1964 - 0
1965 - 2
1966 - 11
1967 - 5
1968 - 2
1969 - 8
1970 - 3
1971 - 3
Total: 42

CALCULATION RESULTS[1]

APPENDIX C

I. SUMMARY OF TIME, DISTANCE, AND SPEED CALCULATIONS

Tank-Truck Combination						Pickup	
Location of Truck	Distance from Impact, feet	Time to Impact, feet	Station Location	Speed, m.p.h.	Acceler-ation, ft/sec^2	Station Location	Speed, m.p.h.
When the pickup entered 611	1,617	15.5	366.60	59.5	Downhill +1.55	378.56	0
Bottom of hill	702	7.3	375.85	70.0			
Beginning of tire scuff mark	197	2.25	380.90	61.6	Uphill −2.4		
Truck passed pickup	142	1.5	381.45	60.5		381.45	25
Impact	0	0	382.87	58.0			

II. TANK-TRUCK COMBINATION STABILITY CALCULATIONS

(a) Outage

Tank capacity	5,600 gal.
Cargo	4,200 gal.
Outage	1,400 gal.

75% full or 25% outage

(b) Height of liquid level in tank - 19.37" below top of tank.

[1] Detailed calculations are available in the public records of the National Transportation Safety Board.

(c) Center-of-gravity height..

Tank - 88.5" (7,100 lb.)
Cargo - 83.1" (46,073 lb.)
Trailer subframe - 28" (3,200 lb.)
Tractor - 33" (13,970 lb.)
Trailer as loaded - 80.7" (56,373 lb.)
Tank-truck combination as loaded - 71.2" (70,340 lb.)

(d) Tank-Truck combination stability factor as loaded-0.632.

III TANK-TRUCK COMBINATION ACCIDENT DYNAMIC CALCULATIONS

(a) Force necessary to upset tank-truck combination as loaded – 44,450 lb.
(b) Speed necessary to upset tank-truck combination as loaded in the 11° curve – 70.3 m.p.h.
(c) Centrifigual force of tank-truck combination in the 11° curve at 61.6 m.p.h. (start of scuff mark) – 34,000 lb.
(d) Surge loadings (start of scuff) – 10,450 lb.
(e) Centrifugal force of tank-truck combination in 5°30' curve to right at 70 m.p.h. (speed at bottom of hill) – 24,100 lb.
(f) Upward (vertical negative) loading as tank-truck went over the hillcrest – 12,050 lb.
(g) Lateral force necessary to upset combination when subjected to 12,050 negative loading – 36,800 lb.