ESCAPE WORTHINESS OF VEHICLES FOR OCCUPANCY SURVIVALS AND CRASHES. SECOND PART: APPENDICES

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Second Part: Appendices

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Final Report

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WASHINGTON, D.C. 20590

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16. Abstract

This is a final report of the results of a multidisciplinary study of the factors involved in escape of occupants from crashed vehicle environments in which the vehicle is incapacitated on land, submerged in water, or involved in fire. This effort continues the studies initiated under NHSB Contract FH-11-7303, the final report for which is available from the National Technical Information Service. The present report consists of two parts in two volumes.

The report presents analyses of police accident reports, fire department run reports and other data on motor vehicle collision fires and submergences. Analytical modeling and other analytical techniques are provided for predicting escape times from passenger cars and buses, for predicting vehicle collision-submergence water-entry conditions and sinking times, and for estimating strength available for the operation of escape exits. Other techniques allow prediction of ignition times and burning rates of vehicle interior materials. A considerable amount of other data related to vehicle interior (enclosure) fire behavior and toxic product generation, flammable characteristics of various fabrics and interior materials, fuel modification, effectiveness of fire extinguishers, and fuel system design practices are also included. The report includes a selective bibliography (799 entries).

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APPENDIX A

BIBLIOGRAPHY

This bibliography presents the useable citations from a survey of approximately 10,000 items of published information. For convenience of use, the bibliography has been divided into thirteen arbitrarily designated categories, with each category containing all of the acquired, associated subjects pertinent to that general area of activity. While in some instances, all desired information might be contained in one category (e.g., Studies of Emulsified and Gelled Safety Fuels), in others, more than one category must be reviewed to assemble all pertinent data (e.g., bus escape also involves strength capabilities and compartment integrity).

This bibliography represents the general state of the art as it is represented in the open literature. It does not represent an exhaustive study of all research that may have been done, since no concerted effort was made to survey foreign sources, and since it is known that a number of studies have been done by industry which have not appeared in the open literature.

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APPENDIX B

INVESTIGATION REPORTS

This appendix includes in-depth reports on nine collision fires, two submergences, and four special reports on an apparently low-velocity, restrained passenger, fatality collision without fire, a dual-fuel vehicle (propane/gasoline), non-collision fire, an extensively investigated non-collision interior materials fire, and a collision-fire case involving particular escape problems but for which the investigation could not be completed.

The first eleven reports included here represent only about one-third of the total investigations attempted. The remainder of the investigations had to be abandoned, principally because of the survivors' refusal to cooperate upon instruction from their attorneys. The apparently high incidence of this legal complication in these cases as compared to those done by multidisciplinary teams is explained by the injury severity in these cases. Almost all of the abandoned cases were of fatal severity, and almost all involved contemplated civil action. Even in those few cases which were not fatal, the enormity of the contemplated liability costs for long hospital treatment and extensive plastic surgery prompted attorneys and insurance companies to deny access to their clients. Consequently, the interview data on escape worthiness which was most critical to the purposes of these investigations, as compared to normal collision investigations, could not be obtained and the cases were abandoned.

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SUMMARY OF AUTOMOBILE ACCIDENT

Case Number 1

A. IDENTIFYING DATA:

Location: Near Wheatley exit on Interstate Highway 40, near Wheatley, Arkansas, August 14, 1970 at 3:30 p.m.

Vehicles: Vehicle #1 - 1966 Mercury, 4-door hardtop.
Vehicle #2 - 1960 Ford, 4-door sedan.

B. AMBIENCE:

Weather: Clear and dry; daylight.

Temperature: Estimated 90 degrees F.

C. HIGHWAY:

Moderately heavy travel - Interstate highway approximately fifty miles west of Memphis, Tennessee. Post speed limit of 70 mph.

D. TYPE OF ACCIDENT:

Vehicle #2 was going wrong way on interstate; was struck head on by Vehicle #1, both vehicles burned.

E. OCCUPANTS: (All occupants fatally burned).

Male : Age 45, driver of vehicle #1, 100% burns.
Female: Age 43, front seat occupant of vehicle #1, 100% burns.
Female: Age 23, front seat occupant of vehicle #1, 100% burns.
Male : Age 24, rear seat occupant of vehicle #1, 100% burns.
Male : Age 04, rear seat occupant of vehicle #1, 100% burns.

Male : Age 87, driver of vehicle #2, 100% burns.
Female: Age 85, front seat occupant vehicle #2, 100% burns.

F. DESCRIPTION OF ACCIDENT:

The driver of vehicle #2 entered the east entrance ramp to Interstate Highway 40 at the Wheatley, Arkansas exit. Instead of proceeding east on the acceleration ramp, the driver turned left after allowing eastbound traffic to clear. He proceeded west at approximately 20 mph in the inside eastbound lane. A westbound driver saw vehicle #2 showing obvious intent to turn the wrong direction and honked his horn and signaled the driver of vehicle #2. When there was no response, he stopped his car and got out with the intention of flagging down vehicle #2. Vehicle #2 proceeded and struck vehicle #1 approximately 7/10 head on as vehicle #1 was passing a semi-trailer truck at approximately 70 mph. This witness ran to the cars along with an unidentified man, and attempted to get the doors open; they were jammed. Vehicle #1 ignited on the underside and the flames spread to vehicle #2 via the gasoline on the pavement. (The fuel tank on vehicle #2 was thrown behind the vehicle on impact and was leaking gasoline.) The flames forced the witnesses away from the vehicles.

G. PRE-CRASH FACTORS:

Vehicle Factors - No evidence of pre-crash mechanical malfunctions of either vehicle was noted.

Environmental Factors - Many entrance ramps on interstate highways have no warning signs to remind drivers not to turn into the oncoming traffic. This was the case of the Wheatley entrance to Interstate Highway 40, the site of this accident. There were numerous signs, warning drivers not to enter the exit ramps, but none on the entrance ramps.

Human Factors - The driver of vehicle #2 had been arrested in December of 1969 for traveling the wrong way on an interstate highway. It was the opinion of the arresting officer that the subject was incapable of safely driving a motor vehicle, since his vision and judgement were impaired. The court refused to revoke the subject's drivers license. According to friends and neighbors of this driver, he should not have been operating a motor vehicle for several years due to his physical and mental condition.

H. CRASH FACTORS:

Vehicle Factors - The two vehicles collided approximately 7/10 head-on in the inside eastbound lane of the highway. Vehicle #1, a 1966 Mercury 4-door hardtop, was traveling at approximately seventy mph. Vehicle #2, a 1960 Ford, 4-door sedan, was traveling at approximately 20 mph. Vehicle #1 left 151'7" of skid marks before point of impact and 38'9" from impact until the vehicles came to rest. Vehicle #2 left no skid marks and was pushed back a corresponding distance. The fuel tank on vehicle #2 was thrown from the vehicle, erupted, and came to rest approximately twenty feet behind vehicle #2, spilling gasoline under both vehicles.

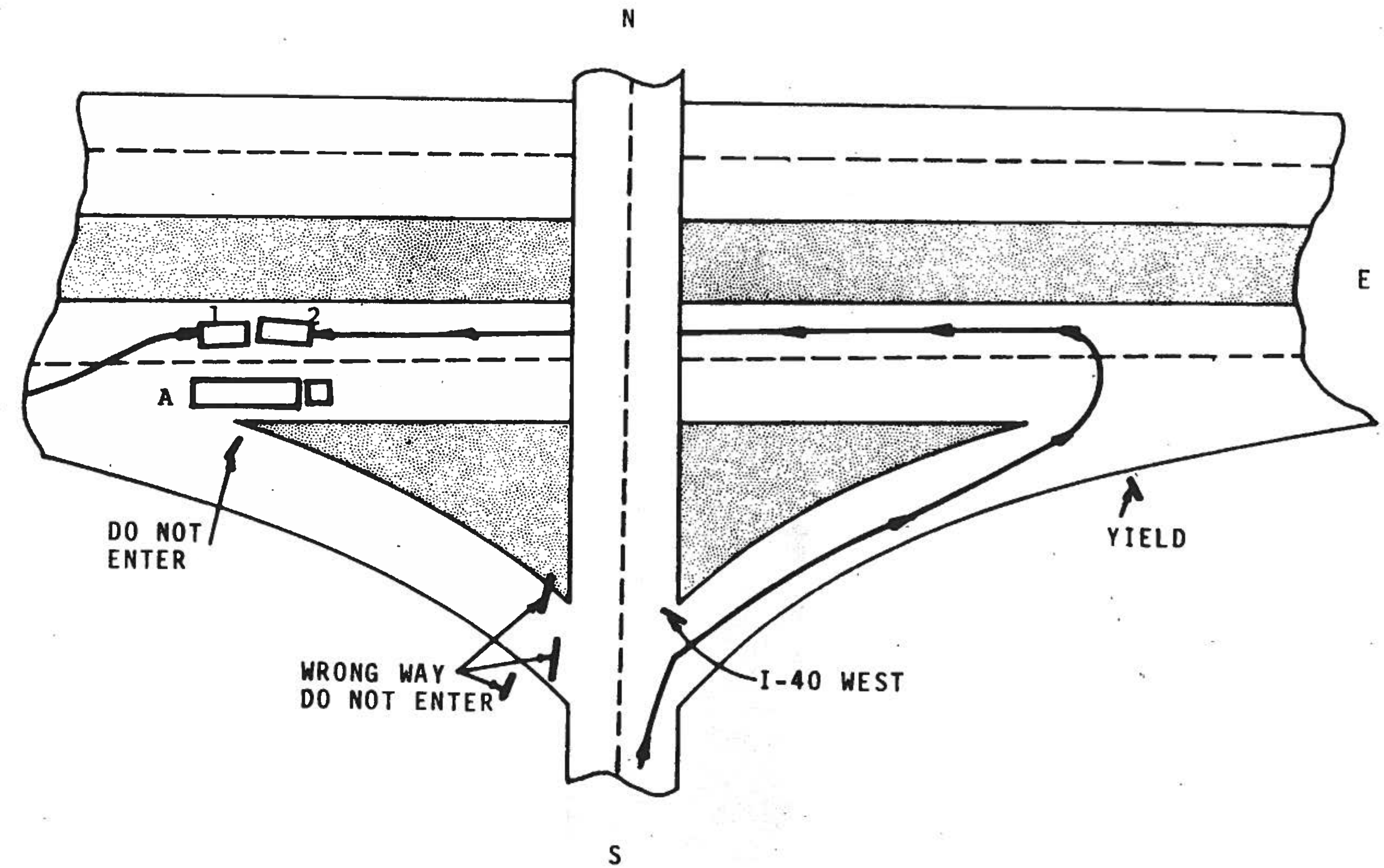


Figure 1. Diagram of collision site.

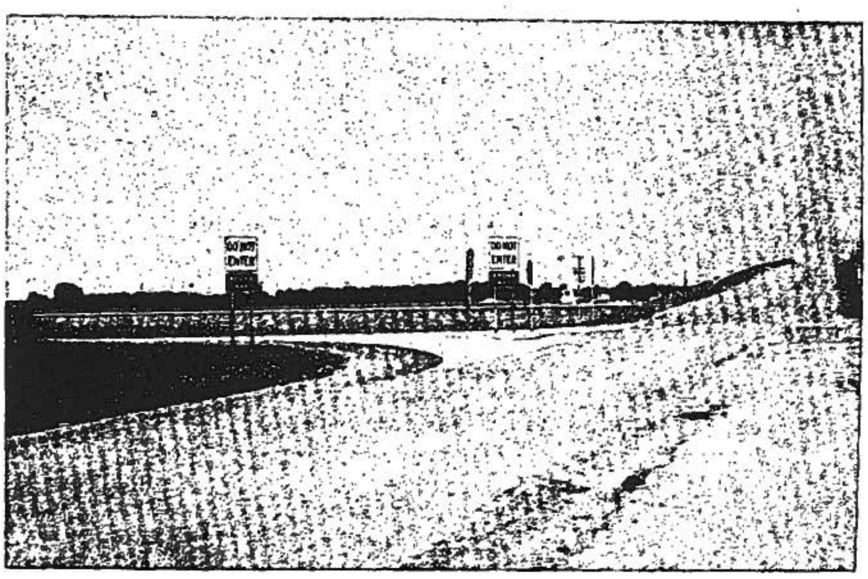


Figure 2. Westbound entrance and exit ramps.

Environmental Factors - The collision occurred on a four lane controlled access highway. The road surface was straight, dry, concrete and the weather was clear and warm. There were no apparent defects in the road at or immediately surrounding the point of impact.

Human Factors - Seat belts were available on vehicle #1 and not present on vehicle #2; none of the occupants were wearing seat belts.

I. POST-CRASH FACTORS

Vehicle Factors - All four doors were jammed on both vehicles and could not be opened by witnesses.

Environmental Factors - Several seconds after impact, flames erupted under vehicle #1 and spread to vehicle #2 via gasoline on the pavement.

Human Factors - All occupants were totally burned. No autopsies were performed on any of the victims, so the relationship between impact injuries and death could not be established from the evidence available. Since screams were heard after the fire penetrated the interior of vehicle #1, it can be assumed that at least one occupant was alive several seconds after impact.

J. OPINIONS AND OBSERVATIONS:

1. There is a vital need for regulations to prohibit persons with chronic illnesses or mental deficiencies from obtaining a driver's license.

2. Entrance ramps to controlled access highways should have clearer instructions, including signs warning drivers that they can only travel in one direction.

3. Fuel tanks on some motor vehicles seem inadequately secured to the vehicles and susceptible to puncture. Fuel tanks should be constructed from a more durable material. Automobile interiors should be constructed to provide an environment for occupants that is not susceptible to fire.

CASE # 1

SOURCES OF DATA FOR: EPIDEMIOLOGICAL ANALYSIS

1. Accident Report [XXX]

Report Number 25428
Date 8-14-70

2. Newspaper Accounts [X]

3. Death Certificates [ ]

Certificate Number(s)__________

---

4. Interviews: [X]

(a) Investigating Officer [X]

(b) Occupant(s) Vehicle #1:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(c) Occupant(s) Vehicle #2:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(d) Occupant(s) Vehicle #3:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

---

5. Hospital Records: [ ]

(e) Special Accident Investigator:

[X] State Police

(f) Eye Witness(es): [X] No. 3

(g) Private Physician(s) [ ] No.___

(h) Newspaper Reporter - or Photographers

[X] No. 1

(i) Ambulance Attendant(s) [ ] No.___

(j) Fireman [ ] No.___

6. Accident Investigation by Staff: [X]

(k) Embalmer [ ]

(l) Family or Friends of Victim(s):

[X] No. 4

(m) Wrecker Operator(s) [ ] No.___

(n) Other(s) [ ] Specify__________

ARKANSAS REPORT OF MOTOR VEHICLE TRAFFIC ACCIDENT

PLACE WHERE ACCIDENT OCCURRED County St. Francis City, town or township

If accident was outside city limits, indicate distance from nearest town ___ miles ☐ ☐ ☐ ☐ North S E W of ___ City or Town

ROAD ON WHICH ACCIDENT OCCURRED Interstate - 40 Give name of street or highway number (U.S. or State). If no highway number, identify by name.

AT ITS INTERSECTION WITH ___ Name of intersecting street or highway number

IF NOT AT INTERSECTION 2046'6" feet ☐ ☐ ☐ ☒ North S E W of Wheatley Overpass Show nearest intersecting street or highway, house no., bridge RR crossing, milepost, underpass, or other landmark.

Interstate-40 ROUTE | 51 SECTION NUMBER | 240.72 LOG MILE

FATAL ☒ INJURY ☐
PROPERTY DAMAGE ☐
PHOTOS-YES ☒ NO ☐
NUMBER OF VEHICLES INVOLVED 2
DATE OF ACCIDENT 8/14/70 19 70
DAY Friday
HOUR 3:20 AM PM

25128

VEHICLE 66 Mercury 4 Dr. H.T. Year Make Type (sedan, truck, taxi, bus, etc.) License Plate 70 Miss. [redacted] Year State Number

Vehicle defects (Before Accident) none apparent Estimate of damage $ 2000.00

Parts of vehicle damaged Complete (BURNED) Vehicle removed to [redacted] Texaco

Were seat belts present in vehicle — yes ☒ no ☐ Does vehicle have a current inspection sticker — yes ☐ no ☐ unknown

OWNER [redacted] Print or type FULL name Address New Albany, Mississippi Street or R F D City and State

DRIVER [redacted] Print or type FULL name Address same as above Street or R F D. City and State

Condition of the driver or physical handicaps noted none noted

Driver's License Miss. State Number Regular ☐ Other ☐ Race Caucasian Date of Birth Month, Day, Year

	Name	Address	AGE	SEX	INJURY CODE	IF SEAT BELT WAS IN USE INDICATE WITH YES
Driver	[redacted]	same as above	45	M	K	no
OCCUPANTS Front Center	[redacted]	New Albany, Mississippi	43	F	K	no
Front Right	[redacted]	same as above	23	F	K	no
Rear Left	[redacted]	same asdabove	24	M	K	no
Rear Center						
Rear Right	[redacted]	same as above	4	M	K	no

VEHICLE 60 Ford 4 Dr. Sedan Year Make Type (sedan, truck, taxi, bus, etc.) License Plate 70 Ark. [redacted] Year State Number

Vehicle defects (Before Accident) none apparent Estimate of damage $ 600.00

Parts of vehicle damaged Complete (BURNED) Vehicle removed to: [redacted] Wrecker Brinkley, Ark.

Were seat belts present in vehicle — yes ☐ no ☒ Does vehicle have a current inspection sticker — yes ☐ no ☐ unknown

OWNER [redacted] Print or type FULL name Address [redacted] Brinkley, Arkansas Street or R.F.D. City and State

DRIVER (or Pedestrian) [redacted] Print or type FULL name Address same as above Street or R F D. City and State

Condition of the driver or physical handicaps noted none noted

Driver's License [redacted] State Number Regular ☒ Other ☐ Race Caucasian Date of Birth 10-07-[illegible] Month, Day, Year

	Name	Address	AGE	SEX	INJURY CODE	IF SEAT BELT WAS IN USE INDICATE WITH YES
Driver	[redacted]	same as above	[illegible]	M	[illegible]	[illegible]
OCCUPANTS Front Center						
Front Right	[redacted]	same as above	65	F	[illegible]	[illegible]
Rear Left						
Rear Center						
Rear Right						

FIRST AID GIVEN BY none INJURED Taken to [redacted] Funeral Home

DAMAGE TO PROPERTY OTHER THAN VEHICLES none Name object and state nature of damage $ Estimate

Name and address of owner of object struck

CODE OF INJURY (Use only the most serious one in each space) K—Dead before report made A—Visible signs of injury, as bleeding wound, or distorted member, or had to be carried from scene B—Other visible injury, as bruises, abrasions, swelling, limping, etc. C—No visible injury but complaint of pain or momentary unconsciousness O—No indication of injury

WITNESSES [redacted] [redacted]
and [redacted] Address [redacted]
and [redacted] Address [redacted]

TURN THE PAGE — COMPLETE BOTH SIDES

WEATHER CONDITION
1 [x] Clear
2 [ ] Raining
3 [ ] Snowing
4 [ ] Fog
5 [ ] Dust
6 [ ] High Wind
7 [ ] Other

ROAD SURFACE CONDITION
1 [x] Dry
2 [ ] Wet
3 [ ] Snowy Icy
4 [ ] Other
5 [ ] Unknown

ROAD SURFACE
1 [x] Concrete
2 [ ] Asphalt
3 [ ] Oil
4 [ ] Gravel
5 [ ] Dirt
6 [ ] Other

ROAD ALIGNMENT
1 [x] Straight Road, Level
2 [ ] Straight Road, Hill Crest
3 [ ] Straight Road, On Grade
4 [ ] Sharp Curve or Turn, Level
5 [ ] Sharp Curve or Turn, Hill Crest
6 [ ] Sharp Curve or Turn, On Grade
7 [ ] Other Curves, Level
8 [ ] Other Curves, Hill Crest
9 [ ] Other Curves, On Grade

ROAD CONDITION
1 [ ] Under Construction or Repair
2 [ ] Obstruction—Unlighted at Night
3 [ ] Obstruction—No Warning in Day
4 [ ] Obstruction—Previous Accident
5 [ ] Loose Material on Surface
6 [ ] Holes—Ruts—Bumps
7 [ ] Defective Shoulder
8 [ ] Reduced Road Width
9 [x] No Defects Apparent

ROAD SYSTEM
[ ] Controlled (4 lanes)
[ ] State or U.S.
3 [ ] County Road
4 [ ] City Street
5 [ ] Other & Private

TYPE OF ACCIDENT
Collision of Motor Vehicle With:
1 [ ] Pedestrian
2 [x] Motor Vehicle in Traffic
3 [ ] Parked Motor Vehicle
4 [ ] Railroad Train
5 [ ] Animal-Drawn Vehicle
6 [ ] Bicycle
7 [ ] Animal
8 [ ] Fixed Object
9 [ ] Other Object
Non-Collision Motor Vehicle:
10 [ ] Overturned in Road
11 [ ] Ran Off Road
12 [ ] Occupant Fell From Vehicle
13 [ ] Other Non-Collision

ACCIDENT LOCALE
1 [x] Built-up
2 [ ] Not Built-up
3 [ ] Not stated

RESIDENCE OF DRIVER
If Military Also Indicate Residence

1	2	
[ ]	[x]	1 Local Resident
[ ]	[ ]	2 Resides Elsewhere in State
[x]	[ ]	3 Non-Resident
[ ]	[ ]	4 Unknown

MILITARY (crossed out)

	1	2
A	[ ]	[ ]
N	[ ]	[ ]
AF	[ ]	[ ]

DIRECTION OF TRAVEL

1	2	Vehicle was Going
[ ]	[ ]	1 North
[ ]	[ ]	2 South
[x]	[ ]	3 East
[ ]	[x]	4 West

PEDESTRIAN ACTION (crossed out)
1 [ ] Crossing Road at Intersection
2 [ ] Crossing Road—No Intersection
3 [ ] Walking in Road With Traffic
4 [ ] Walking in Road Against Traffic
5 [ ] Standing in Road
6 [ ] Getting On or Off Vehicle
7 [ ] Working On or Pushing Vehicle
8 [ ] Working On or In Road
9 [ ] Playing in Road
10 [ ] In Road—Other Reason
11 [ ] Not In Road

VISION OBSCUREMENT

1	2	
[ ]	[ ]	1 Rain, Snow, Fog on Windshield
[ ]	[ ]	2 Windshield Obscured—Other
[ ]	[ ]	3 Vision Blocked by Load on Vehicle
[ ]	[ ]	4 " " " Trees, Bushes
[ ]	[ ]	5 " " " Building
[ ]	[ ]	6 " " " Embankment
[ ]	[ ]	7 " " " Signboards
[ ]	[ ]	8 " " " Hillcrest
[ ]	[ ]	9 " " " Parked Vehicle
[x]	[ ]	10 " " " Moving Vehicle
[ ]	[ ]	11 Driver Blinded by Headlights
[ ]	[ ]	12 " " " Sun
[ ]	[x]	12 Vision Not Obscured

TRAFFIC CONTROL
1 [ ] Stop Sign
2 [ ] Yield Sign
3 [ ] Stop-and-Go Signal
4 [ ] Officer or Flagman
5 [ ] Warning Sign
6 [ ] Railroad Sign
7 [ ] Flashing Signal
8 [ ] Signal Not Functioning
9 [x] No Traffic Control Present

LIGHT CONDITION
1 [x] Daylight
2 [ ] Dawn or Dusk
3 [ ] Darkness, No Street Lights
4 [ ] Darkness, Street Lighted

TYPE OF MOTOR VEHICLE

1	2	
[x]	[x]	1 Passenger Car—Regular
[ ]	[ ]	2 Passenger Car—Compact
[ ]	[ ]	3 Passenger Car and Trailer
[ ]	[ ]	4 Truck, Truck Tractor, or Pickup
[ ]	[ ]	5 Truck Tractor and Semi-Trailer
[ ]	[ ]	6 Other Truck Combination
[ ]	[ ]	7 Farm Tractor or Farm Equipment
[ ]	[ ]	8 Taxicab
[ ]	[ ]	9 Bus
[ ]	[ ]	10 School Bus
[ ]	[ ]	11 Motorcycle
[ ]	[ ]	12 Other Vehicle

VEHICLE ACTION

1	2	
[ ]	[x]	1 Going Straight Ahead
[ ]	[ ]	2 Making Right Turn
[ ]	[ ]	3 Making Left Turn
[ ]	[ ]	4 Making U Turn
[ ]	[ ]	5 Slowing Stopping in Trafficway
[ ]	[ ]	6 Entering Parking Position
[ ]	[ ]	7 Parked
[ ]	[ ]	8 Leaving Parking Position
[ ]	[ ]	9 Backing
[x]	[ ]	10 Overtaking, Passing
[ ]	[ ]	11 Avoiding Vehicle, Object, Pedestrian
[ ]	[ ]	12 Unknown

CONTRIBUTING CIRCUMSTANCES

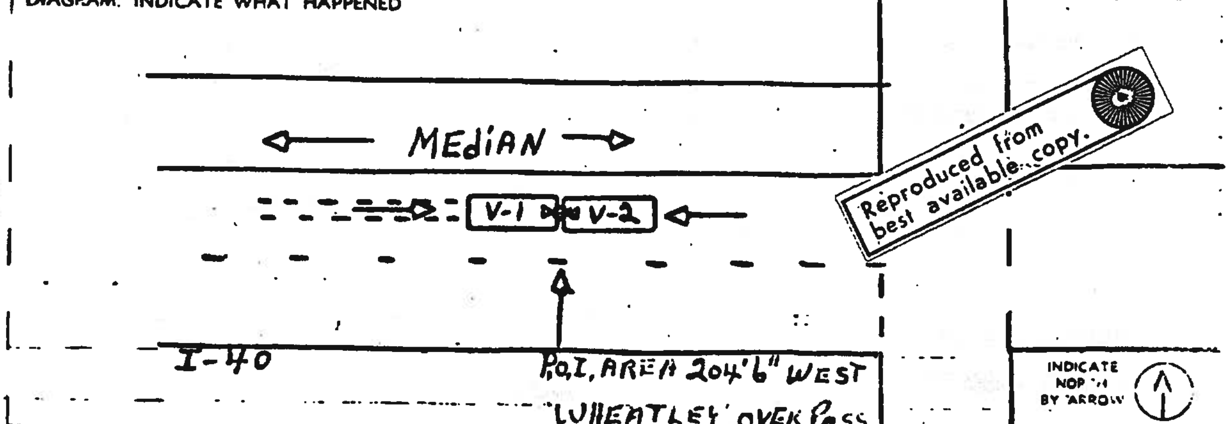
1	2	
[x]	[ ]	0 No Improper Driving
[ ]	[ ]	1 Speed Too Fast For Conditions
[ ]	[ ]	2 Failed To Yield Right-of-Way
[ ]	[ ]	3 Drove On Wrong Side of Road
[ ]	[ ]	4 Improper Passing/Overtaking
[ ]	[ ]	5 Disregarded Stop Sign
[ ]	[ ]	6 " Yield Sign
[ ]	[ ]	7 " Traffic Signal
[ ]	[ ]	8 Followed Too Closely
[ ]	[ ]	9 Made Improper Turn
[ ]	[ ]	10 Inattention
[ ]	[ ]	11 Inadequate Brakes
[ ]	[ ]	12 Improper Lights
[ ]	[ ]	13 Had Been Drinking
[ ]	[x]	14 Other (Explain Below)

DRIVER — OCCUPATION

1	2	
[ ]	[ ]	1 Professional
[ ]	[ ]	2 Business
[ ]	[ ]	3 [illegible]
[ ]	[ ]	4 Skilled Worker
[ ]	[ ]	5 Laborer
[ ]	[ ]	6 Farmer
[ ]	[ ]	7 Housewife
[ ]	[ ]	8 Student
[ ]	[ ]	9 Military
[ ]	[ ]	10 Other
[ ]	[x]	11 Retired
[x]	[ ]	12 Unknown

Explain other improper driving:

DIAGRAM. INDICATE WHAT HAPPENED



POINT OF IMPACT (Check one or more for each vehicle)

1	2		1	2	
[x]	[x]	1. Front	[ ]	[ ]	5. Left side
[ ]	[ ]	2. Right front	[ ]	[ ]	6. Rear
[ ]	[ ]	3. Left front	[ ]	[ ]	7. Right rear
[ ]	[ ]	4. Right side	[ ]	[ ]	8. Left rear

DESCRIBE WHAT HAPPENED: (Refer to vehicles by number) V-1 was traveling East on I-40. V-2 was traveling West on I-40 in East bound lane of Traffic. V-1 was overtaking and passing when hit head-on with V-2.

V-1 left 151'7'' skid marks, before point of impact, and 38'[illegible]'' after point of Impact. V-2 left no skid marks. Point of Impact Area 204'6'' West of Wheatley Overpass. Both Vehicles Burned.

3'4'' Right front of V-2 to North Curb of I-40.

5'5'' Right Rear of V-2 to North Curb of I-40. 4' ~~Rt.~~ Lt. Front of V-1 N. curb I-40

4'2'' ~~Rt.~~ Lt. Rear of V-1 to North curb of I-40. V-1 = 5 killed. V-2 = 2 killed.

ARREST. NAME none CHARGE ______ SUMMONS NO ______

ARREST NAME ______ CHARGE ______ SUMMONS NO ______

INVESTIGATED AT SCENE [x] YES [ ] NO DATE INVESTIGATED 2/14/70 TIME 3:45 [ ] A.M. [x] P.M.

INVESTIGATOR [redacted] # [redacted] ASP DATE 2/14/70
SIGNATURE BADGE NO DEPARTMENT

STATEMENT OF WITNESSES TO POLICE

XXXXX stated he was traveling east on Interstate 40 and observed a 1960 Ford traveling west on Interstate 40 in eastbound lane of traffic. XXXXX said he waved to the driver of 60' Ford trying to get him to pull off road. XXXXX advised he saw the two cars hit head-on. Advised he pulled to right of road and ran back to scene. Advised he heard small child scream. XXXXX said the cars were already in flames and were too hot for him to be of help to passengers of either vehicle.

XXXXX stated he was following the 66' Mercury with Mississippi license. Advised he saw the Mercury pull out to pass the tractor and trailer and hit head-on with the 60' Ford. Advised both cars burst into flames immediately. XXXXX said there was nothing anyone could do to help passengers of either vehicle.

XXXXX stated he was driving tractor and trailer and saw the 60' Ford in eastbound lane traveling west. Advised he tried to signal driver of Ford off road. XXXXX advised 66' Mercury pulled out to pass and accident happened right beside his tractor and trailer. Advised both vehicles burst into flames. XXXXX said the speed of the Ford was approximately 20 miles per hour at point of contact, and estimated the speed of the Mercury when vehicle pulled out to pass 70 mph.

These statements were taken by this writer at scene.

(Signed) XXXXX

This accident report is without the D.O.B. and driver's license number of XXXXX, driver of vehicle #1. Tried to get this information from Batesville, Mississippi and was unable to do so.

151st Year—No. 269

Fiery Collision Leaves 7 Dead Near Brinkley

Motorist Arrested Going Wrong Way In 1969 Is Blamed

Gazette State News Service

BRINKLEY — Seven persons died Friday afternoon in a fiery head-on collision on Interstate Route 40 east of here when an elderly man who was arrested in 1969 for driving the wrong way on the interstate turned into the wrong lane again, State Police said.

The police said [redacted]7, a former mayor of Brinkley, and his wife, [redacted] and five unidentified persons were killed in the wreck near an exit at Wheatley.

[redacted], State Trooper [redacted] said, was arrested January 28, 1969, for driving the wrong way on the interstate. He was fined $10 and $8 in costs, [redacted] said.

State Police said the car driven by [redacted] turned west after entering the eastbound side of the interstate and ran head-on into the car headed east.

The seven were killed instantly or died from the fire that erupted on impact, authorities said.

Authorities said the bodies were burned beyond recognition, but that three adults had been in the front seat of the east-bound car and an adult and a child about four-years old were in the back.

Witnesses at the scene said they heard a child screaming immediately after the wreck occurred. Authorities said the cars could not be approached until 45 minutes after the flames went out.

They said the car with the unidentified victims was registered to [redacted] of New Albany, Miss. State Police said it had been passing a tractor-trailer rig driven by [redacted] of Birmingham, Ala., when the wreck occured.

Firesquads from Brinkley and Wheatley brought the fire under control. The accident was investigated by Troopers [redacted] and [redacted] and [redacted].

NOT REPRODUCIBLE

Seven Dead

A GRINDING, FIERY crash on Interstate 40 at the Wheatley exit meant death for a Brinkley couple and five persons in a New Albany, Miss., family Friday afternoon. Pronounced dead at the scene were [redacted], 87, former Mayor of Brinkley, and his wife, [redacted], 85; [redacted], 45, his wife, [redacted], 43, a son, [redacted], 24, his wife, [redacted], and their child, [redacted]. State Police said the [redacted] vehicle was evidently traveling west in the eastbound side of the highway when the head-on occurred. The wreck blocked traffic on the Interstate for several hours while firemen battled the resulting blaze and then drug the cars to the side of the road to pry them apart to remove the bodies of the seven victims. The accident occurred around 3:30 p.m. Friday. Top photo, a state trooper surveys the wreckage of the [redacted] vehicle, a 1966 Mercury. The [redacted] vehicle, a 1960 Ford, is in the background. Bottom photo, workmen pry apart the wreckage of the [redacted] vehicle to remove the charred bodies of the Brinkley couple. State Trooper [redacted] investigated the accident. (T-H PHOTOS)

INTERVIEW: XXXXX and Trooper XXXXX
Arkansas State Police

Forrest City, Arkansas
Friday, August 21, 1970

I received a call about 3:29 or 3:30. When I arrived out there I found a 1960 Ford and a 1966 Mercury in the eastbound lane of Interstate 40. There was quite a bit of smoke still coming from the cars and there were two fire departments there at the time. They had put the blaze out when I parked my car in the westbound lane and went over to the scene, looked into the car and saw that there were five in the Mercury and two in the '60 model Ford. All of the bodies were charred real bad so at this time I started trying to contact the witnesses that saw it and I did contact three eye witnesses. An ambulance was called out of Brinkly and the bodies were still too hot to move out of the cars, so we had taken wreckers and pulled cars to the south side of the interstate. The 1966 Mercury was traveling east on I-40 on the inside lane, next to the median. The '60 Ford was also in the inside lane, traveling west in the eastbound lane of traffic and about forty-five minutes after I got to the scene, the bodies were moved, were taken out of the car and carried to Metcalf Funeral Home in Brinkly. I talked to the three witnesses that saw it. A Major from the Columbia Military Academy, Columbia, Tennessee, advised that he was the first one to the scene and heard a small child scream one time, and then everything was quiet. He advised that the wreckage was so hot at the time that flames were all around both cars and they were unable to get the doors open; there was nothing they could do to get the bodies out. It was just too hot for them to do anything. Another witness driving a tractor and trailer rig said that the accident occurred right beside his truck. The '66 Mercury from Mississippi pulled out to pass him and just hit head-on right beside his trailer. The Mercury laid down approximately 158 feet of skid marks and the '60 model laid down none, but from the witnesses' statements, they stated that the '60 model Ford that was going the wrong way on the interstate was traveling approximately twenty miles per hour. That's about it.

Q. Was the pavement dry that particular day? A. The pavement was dry.

Q. It was dry, and about what time of day? A. We got the call on the accident--I believe it was logged about 3:29. I got to the scene approximately, I suppose, around twelve minutes after that.

Q. In the afternoon? A. In the afternoon. I got to the scene approximately twelve minutes after we got the call because I was sitting here at headquarters when the call came in, and I went straight to the scene.

Q. You interviewed two or three people? A. Three people.

Q. Are the witnesses in the accident report? A. Yes, sir. Their names, addresses and ages.

Q. Does the accident report also have the names, addresses and ages of all the occupants in the cars? A. Right.

Q. Were the seatbelts in use by the occupants of the cars?
A. Apparently they were not.

Q. Did you see any seatbelts on anybody in that car? A. You couldn't tell. There were no seatbelts on anyone then. They were burned so bad if they had had them they would have been burned off.

Q. Were any of the doors open on any of the cars before they were pried open? A. None of them. All of them had to be pried open. I don't guess whether you could cause any condition that you could tell, have any idea what condition they were in before the wreck--I mean, what kind of condition the cars were in before they collided [Unintelligible on tape].

Q. Can you tell anything about the tires? A. All the tires were burned off the cars.

Q. Was there gasoline spilled, leaked onto the pavement and burned? A. I couldn't tell. When I got to the scene the gas tank of the '60 model Ford was lying approximately three feet behind it on the ground, torn off the car, and it was in flames at the time and it burned for 30-40 minutes after I got there and the tank was burst. I don't know whether the impact burst it or the explosion burst it, but the witnesses stated that immediately upon impact the cars burst into flames.

Q. Could you get any idea on where the flames had started on either vehicle, from the witnesses or from what you saw?
A. No, sir. From the witnesses--they stated that when they hit that flames just went straight up on both vehicles. They were just engulfed in flames. One witness stated that upon the impact of the 1968 Mercury driven by the people from Mississippi, it was started from the rear end, and then on the 1960 Ford it started on the front after the impact or after they had collided on impact.

Q. The vehicles didn't roll or anything; were they still in an upright position? A. That's right--they didn't turn over. They were both still in the same lane when the point of impact occurred.

Q. I assume that the Ford was pushed backwards by the Mercury.
A. It was. The Ford was pushed back several feet. I don't know for sure just how many; it's on the accident report.

Q. Is this the one that had the gas tank lying behind it?
A. That's right. The gas tank was lying behind it.

The following are interviews and letters pertaining to the accident that have been filed with Col. XXXX, Director of the Arkansas State Police.

Letter from Investigator XXXX

Sir:

Sgt. XXXX has advised me that you have requested that I report to you information on the driver of the vehicle traveling the wrong way on I-40.

XXXXX, white male, XXXXX, Brinkly, Arkansas: On January 28, 1969, I summoned XXXXX to municipal court in Brinkly, Arkansas after observing a white 1961 Ford 4-door traveling west in the eastbound lane, traffic lane, of I-40 between Brinkly and Brisco, of which he was the driver and having his wife, XXXXX, as passenger. Mr. XXXXX was obviously not in physical condition to drive an automobile. He was very feeble and wore thick eyeglasses. I was advised by members of the Brinkly Police Force that he was a problem, and I talked with Municipal Judge XXXXX, asking him to revoke his driver's license, pending his taking and passing a driver's test. At the time, Judge XXXXX seemed agreeable to my suggestion, but when his case, State Docket No. 6824 was called, Judge XXXXX allowed a written plea of guilty, without his being in court, and fined him $10.00 and $8.00 costs.

Mr. XXXXX and his wife were old and senile. He was a past mayor of Brinkly and a retired railroad man. Their family doctor is XXXXX, who is himself ninety years old, residing in the nursing home of the Mercy Hospital in Brinkly, Arkansas. Mr. XXXXX, because of his age and condition, should not have been operating a motor vehicle, and with the help of the court, this horrible accident could have been avoided.

Yours truly,

XXXXX
Arkansas State Police
Brinkly, Arkansas

Interview: XXXXX

Background Information

XXXXXXXXXXXXXX
XXXXXXXXXXX Street
Brinkly, Arkansas

I have another document, background information on XXXXX, from the interview of the witness, XXXXX, XXXXX Street, Brinkly, Arkansas; telephone, XXXXX. On Saturday, August 15, 1970, this investigator interviewed XXXXX at the Brinkly City Hall in Brinkly, Arkansas, in reference to an accident that he witnessed on I-40 Friday, August 14, 1970.

XXXXX states:

Yesterday at approximately 3:30 p.m. I was traveling west on I-40 just east of the Wheatly overpass. I saw a car driven by an elderly white man, and an elderly white woman in the right front; the vehicle was in the eastbound entrance to I-40 just east of the overpass. It stopped and waited for the eastbound traffic, then when the traffic cleared, it turned west in the eastbound lane. I slowed and blew my horn trying to get the driver's attention. He was driving very slowly and seemed to be confused. I thought that he was going to pull onto or across the median, but he continued to drive slowly west into the eastbound lane. I pulled over to the right shoulder and stopped, got out, ran across the median, intending to flag him down. I saw an eastbound vehicle and the vehicle going the wrong way hit head-on. I ran to the vehicles that came to rest on pavement of the eastbound traffic lanes, and I and an unknown colored man tried to get the doors open but they were either locked or jammed. The vehicle that was going the right way caught fire underneath and there was a loud pop and it burst into flames. The vehicle that was going the wrong way then caught fire from the fire in the other vehicle. I didn't see anyone in either vehicle more or make a sound. The colored man and myself kept trying to get the doors open to get the people out until the fire drove us away. It was horrible. They burned up and there wasn't anything we could do. I didn't recognize the driver of the vehicle who was going the wrong way before the accident, but I have been advised that he was XXXXX, who lived in Brinkly. I didn't know him personally but knew of him and had observed him driving in Brinkly at various different times and knew as almost everyone did in Brinkly that he should not have been driving.

Interview: Mrs. XXXXX, Neighbor

This is a background investigation interview with neighbor, XXXXX, XXXXX Street, Brinkly, Arkansas; telephone, XXXXX On Saturday, August 15, this investigator interviewed XXXXX at her residence in Brinkly in reference to Mr. XXXXX and his wife, Mrs. XXXXX, who were fatalities in a motor vehicle accident, along with five others, on Friday, August 14, 1970. XXXXX stated that she is a retired telephone operator and has been a friend and neighbor to the XXXXX for over fifteen years. Yesterday after dinner time, XXXXX brought her some fish and told her that "Dad and I are going for a little drive," and asked her to go with them. She advised Mrs. XXXXX that she wasn't dressed, which was an excuse as she wasn't about to get in a car with Mr. XXXXX driving. He was old, his mind was failing, couldn't walk without the aid of a cane and was not capable of driving a car safely. Mrs. XXXXX was a nice old lady about 82 or 83 years old. Mr. XXXXX was old and senile and wouldn't listen to anyone and had told me recently that he was 88 years old his last birthday. Everyone around here knew that Mr. XXXXX was a dangerous driver.

Interview: Mrs. XXXXX, Neighbor

This is another interview document, background investigation, also by XXXXX. On Saturday, August 15, 1970, this investigator interviewed Mrs. XXXXX (Mrs. XXXXX) at her residence, XXXXX Street, Brinkly, Arkansas. In reference to the driving ability of her deceased next-door neighbor, Mr. XXXXX, who was killed along with six others in a motor vehicle accident yesterday, August 14, 1970, XXXXX states:

I and my family have lived next to the XXXXX since 1953. I have observed Mr. XXXXX driving his car, and in my opinion he was a very unsafe driver. He would back his vehicle from his driveway out into the path of oncoming vehicles and they would have to stop abruptly to keep from having a wreck. He would race his engine and let out his clutch. I have said many times in the past that he was going to have a bad accident or cause a bad accident. His mind was bad and he has had back trouble this summer and used two sticks to walk. For the past two years he has become more and more senile and cantankerous as an old goat. Everyone that knew him knew that he shouldn't be driving an automobile. I can't see why the state doesn't take such people's driver's licenses.

Interview: Mr. XXXXX, Neighbor

On Saturday, August 15, 1970, the investigator, XXXXX, interviewed Mr. XXXXX in reference to his knowledge of the driving ability of his deceased next-door neighbor, XXXXX. Mr. XXXXX states:

I have lived next-door to Mr. and Mrs. XXXXX since 1953. I have observed Mr. XXXXX drive a car, and in my opinion he should not have been allowed to drive a car at any time since I have lived next-door to him. He was a very bad driver, and lately he was physically and mentally not able to operate his car with any manner of safety. Just last Thursday I was driving the highway, No. 39, in Fargo, Arkansas and had to stop for Mr. XXXXX when he pulled his vehicle across the highway and blocked traffic for several minutes while he made up his mind which way to go. He was just a little old senile person that no one could reason with, and his son was contacted last year and asked to have his father stop driving because of his condition, and his son refused, saying that his father was still a good driver.

Report: Investigator XXXXX

On January 28, 1969, this investigator summoned Mr. XXXXX to the Brinkly Municipal Court after observing a vehicle that he was operating traveling west in an eastbound lane between Brinkly and Brisco on I-40. It was obvious that Mr. XXXXX, at age 87, was not mentally or physically competent to operate a motor vehicle. He couldn't see where he had done things bad enough to get a ticket for, and advised that he was a past mayor of Brinkly and personal friend of Municipal Judge XXXXX, besides being his family lawyer. I talked with Judge XXXXX about Mr. XXXXX and asked him to suspend Mr. XXXXX's driver's license pending his taking and passing a driver's test, which we both agreed he could never pass, thus taking him off the highway as a driver. Judge XXXXX seemed to agree to my suggestion, but on February 11, 1969, after hearing my testimony, he allowed a written plea of guilty from the subject and fined him $10.00 and $8.00 costs, but did not suspend his driver's license. Judge XXXXX did not suspend the license because of his close personal friendship with the XXXXX family, even though he, along with other responsible citizens, knew long before I did that he was in no condition to operate a motor vehicle. I was given to believe after his case was heard in court that he was not going to operate a motor vehicle in the future, and I have not observed him driving since.

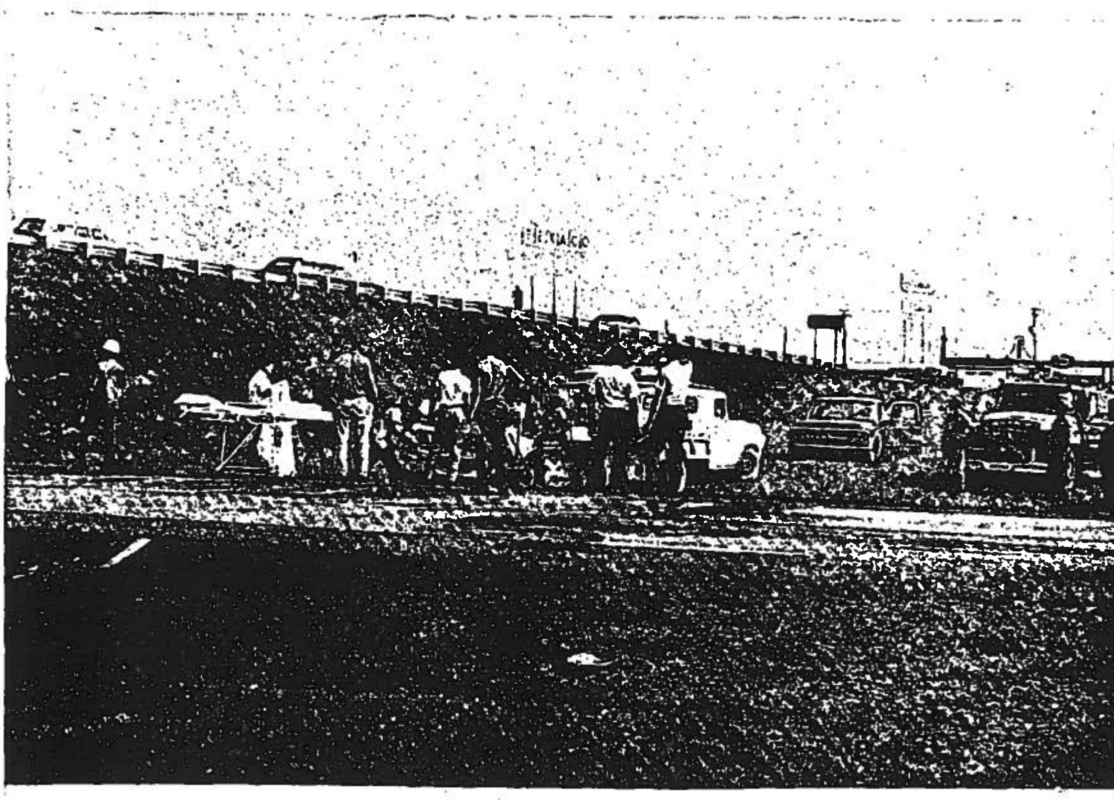


Figure 3. General view of post-collision resting points of vehicles (scorched areas in roadway).

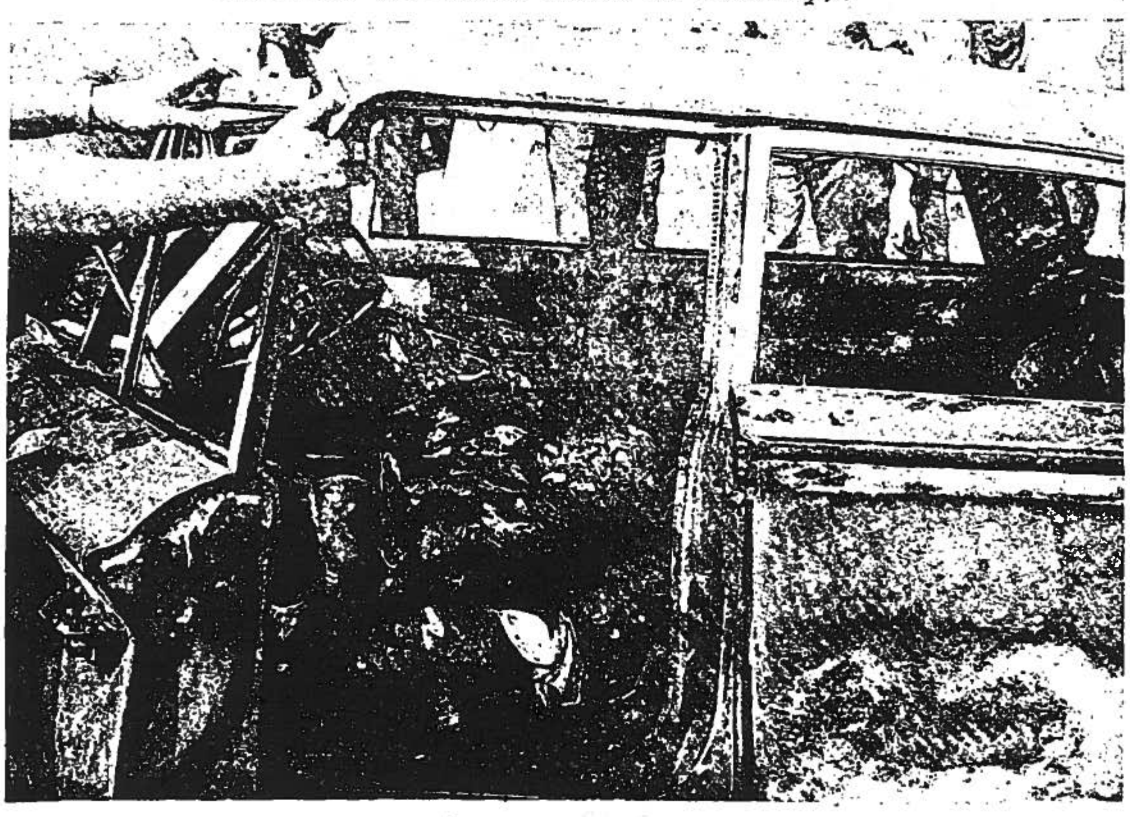


Figure 4. Fire damage, Vehicle #2, as door is pulled open after fire.

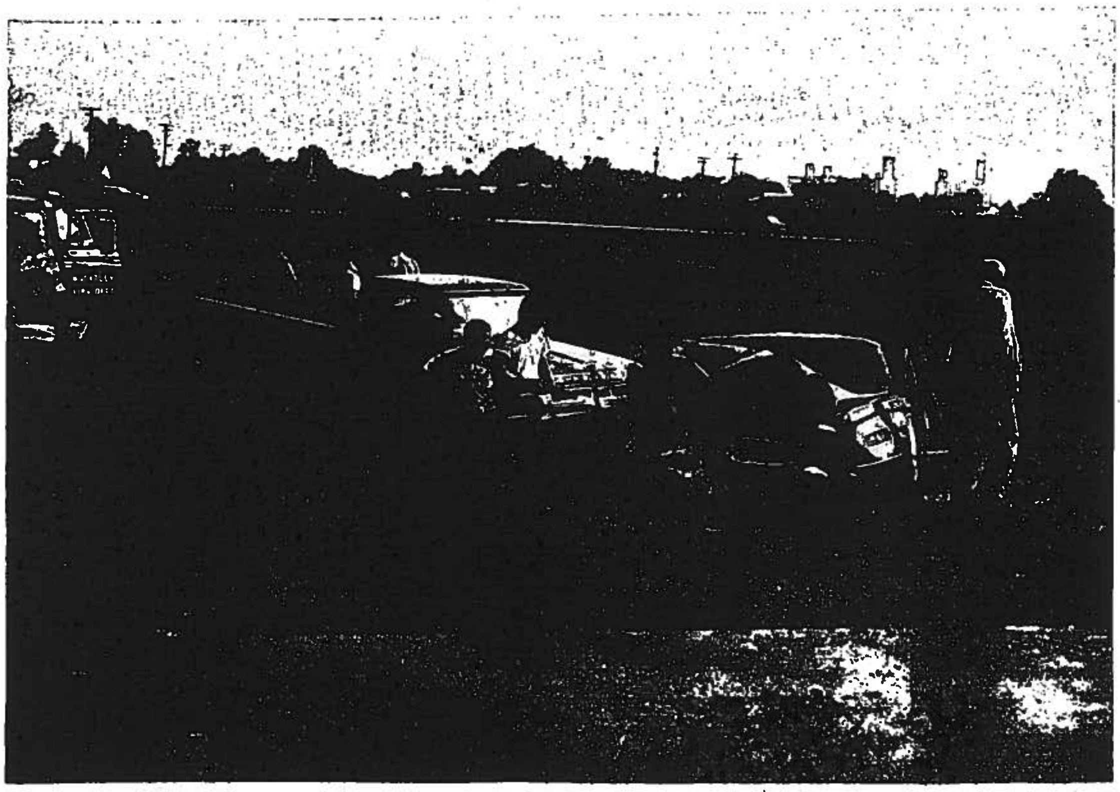


Figure 5. Vehicle #1 before doors were pulled open.

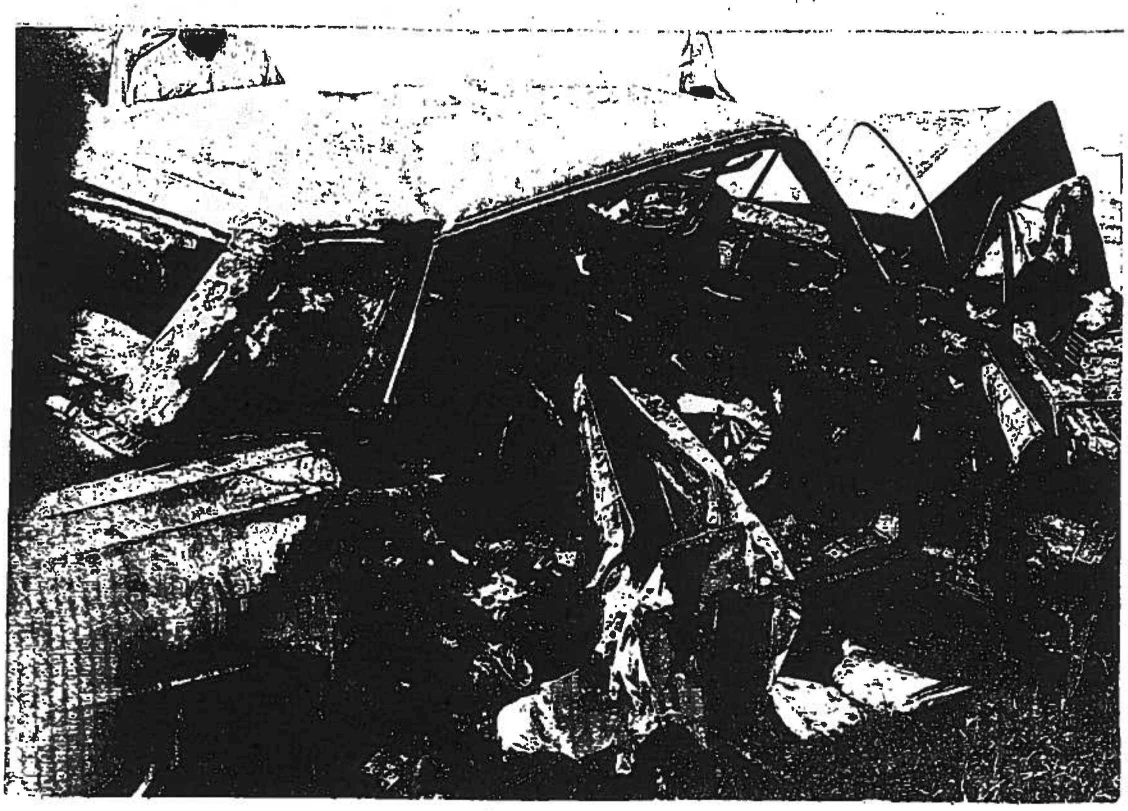


Figure 6. Vehicle #1, fire damage, immediately after doors were pulled open.

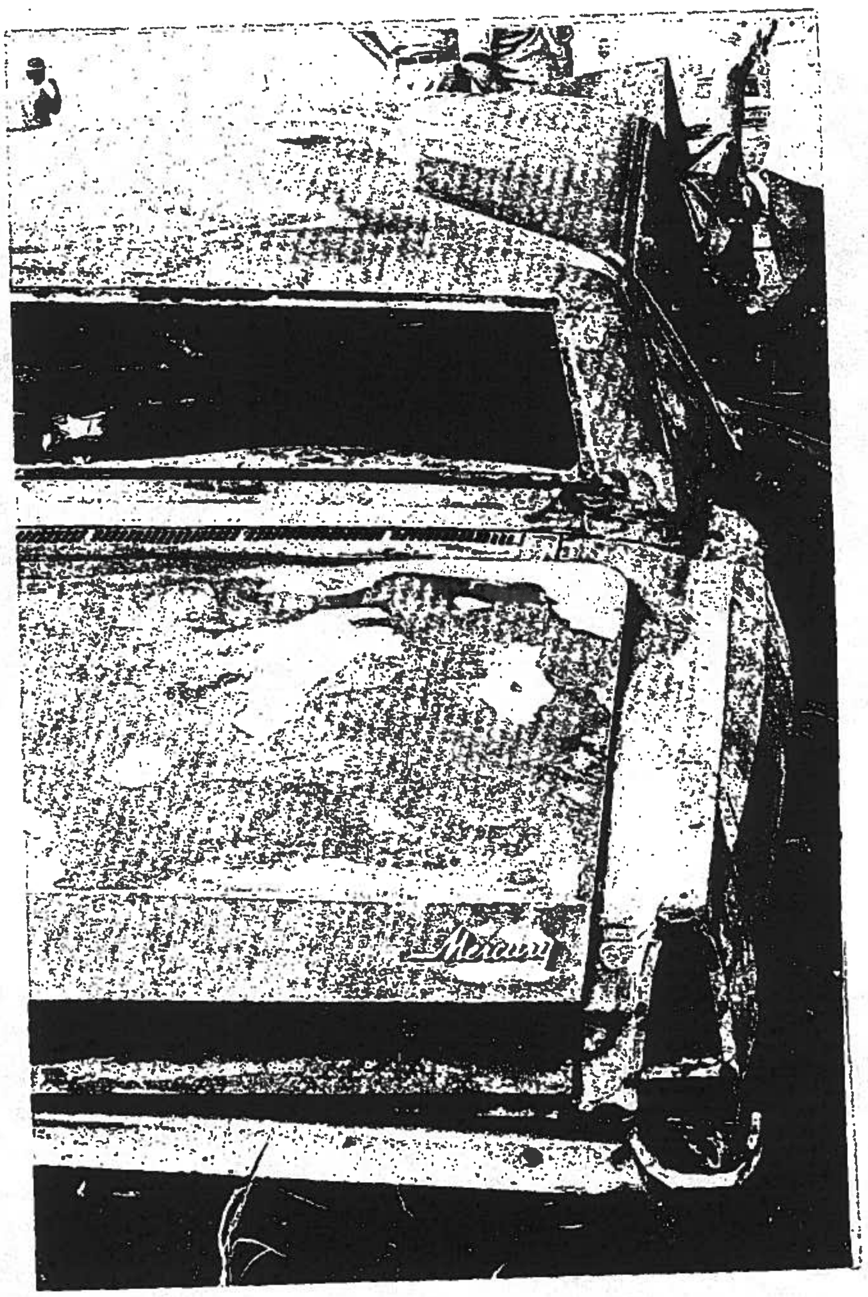


Figure 9. Rear view, vehicle #1.

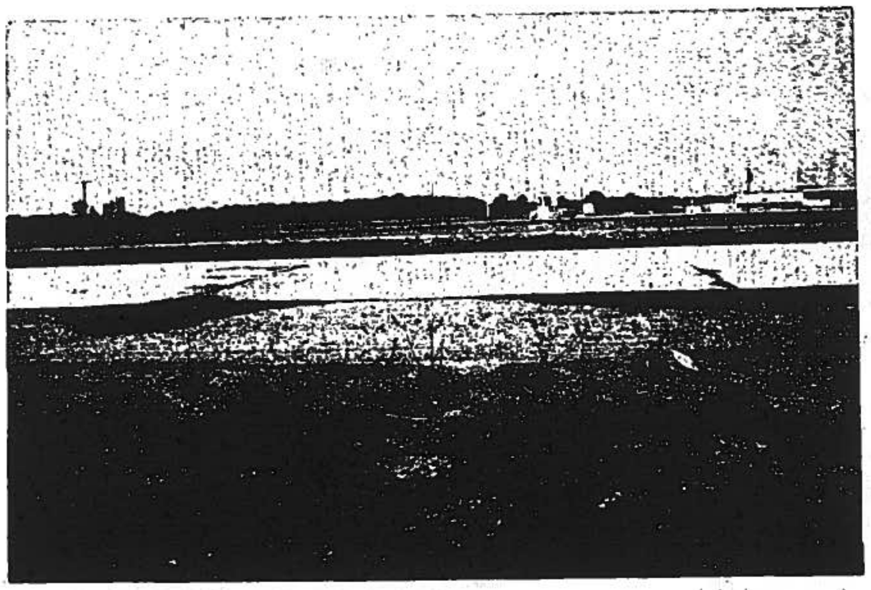


Figure 8. Site of collision.

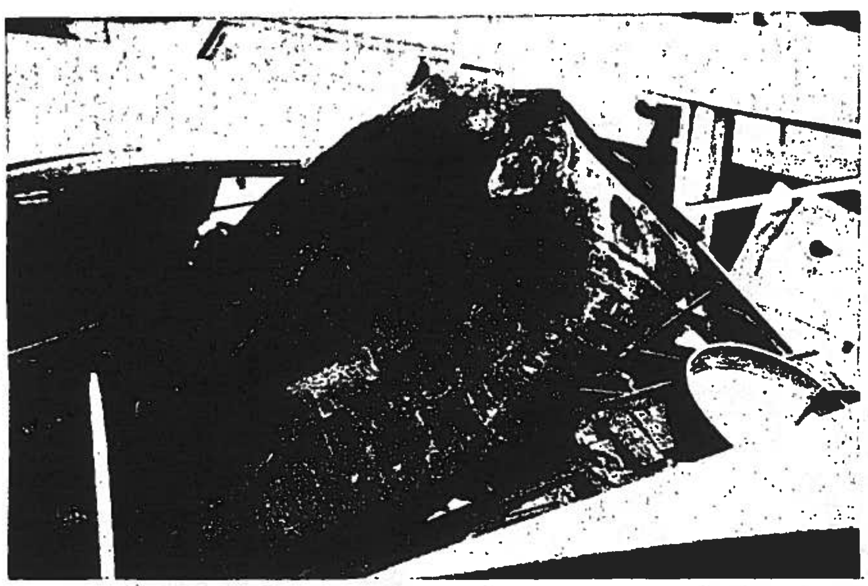


Figure 9. Ruptured gas tank, 1960 Ford. Large tear is approximately under white pointer at left.

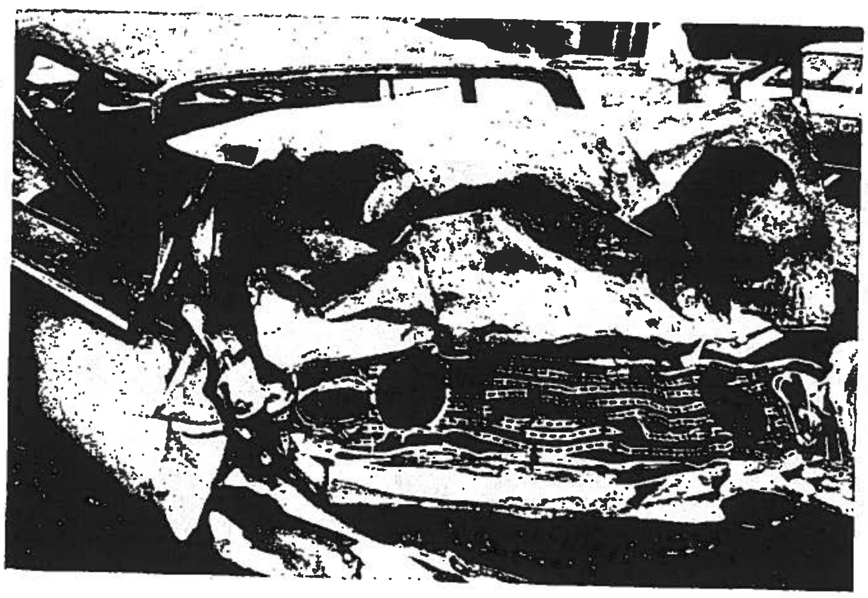


Figure 10. Vehicle #2, 1960 Ford, front view.

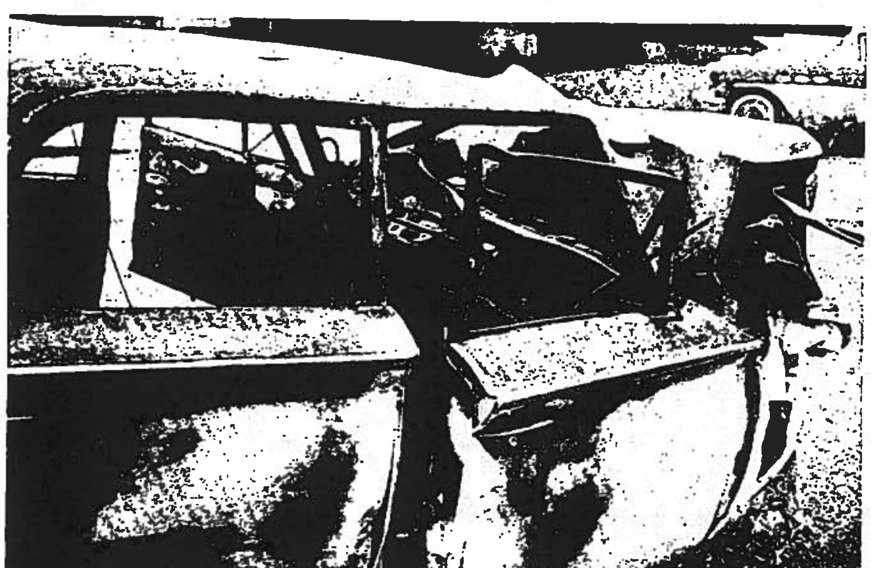


Figure 11. Vehicle #2, side view.

Figure 12. Interior of vehicle #2, 1960 Ford.

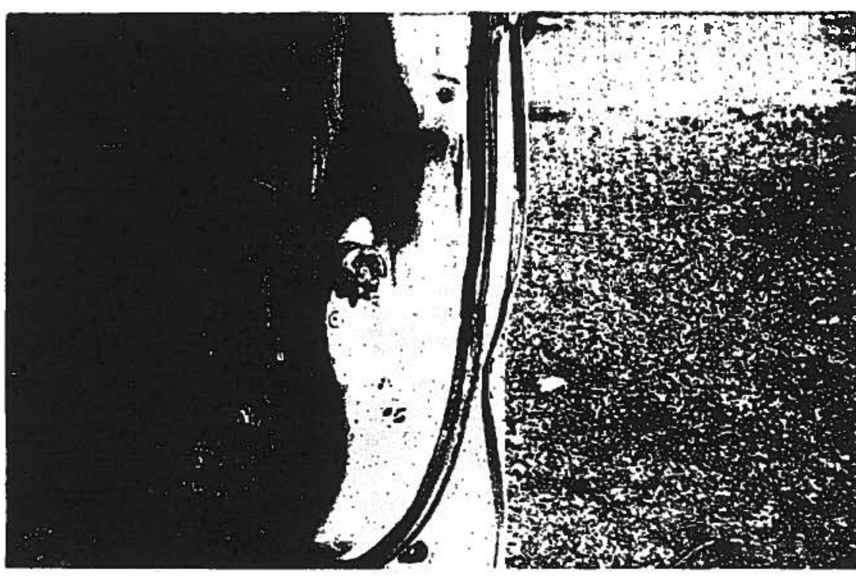


Figure 13. Right front door latch, vehicle #2.

Figure 14. Vehicle #1, 1966 Mercury, front view.

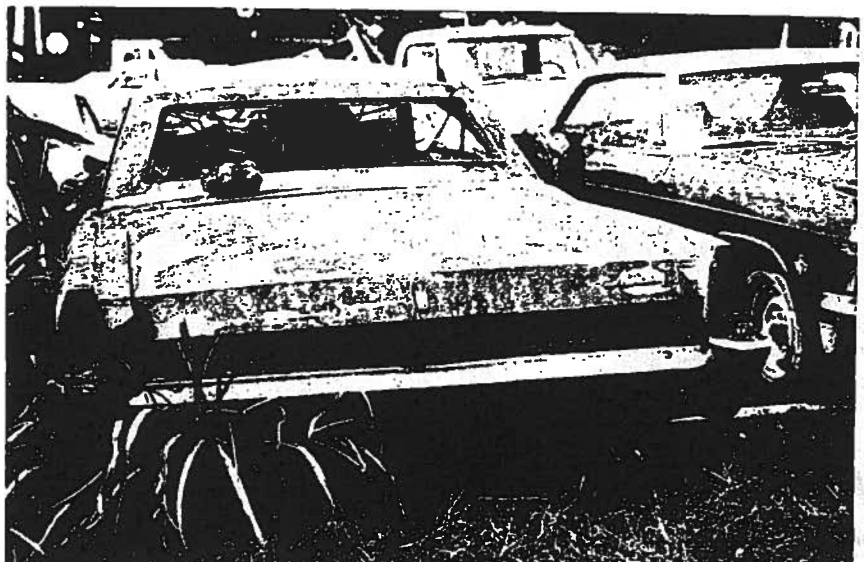


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Figure 15. Vehicle #1, rear view.

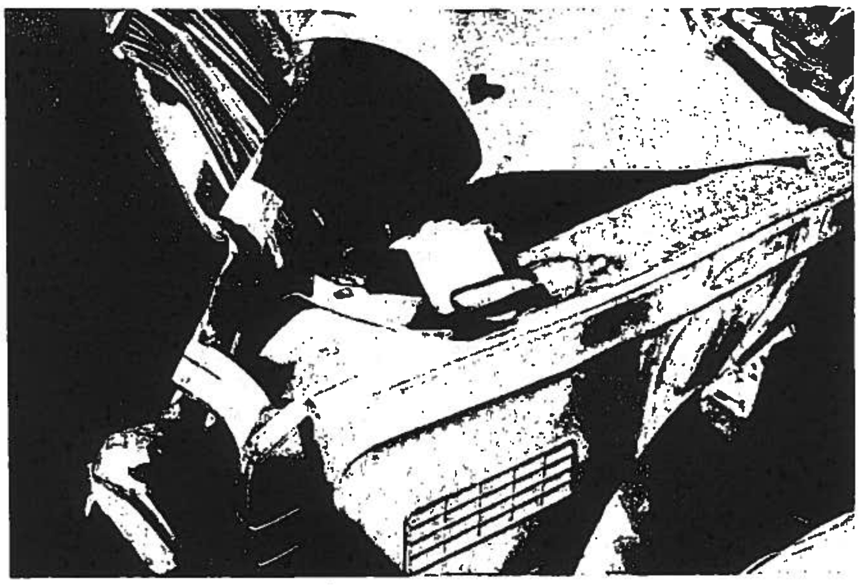


Figure 16. Front of vehicle #1 showing 18 in. crush, folded hood.

Figure 17. Fire destruction to vehicle #1, 1966 Mercury, right front seat area.

SUMMARY OF SCHOOL BUS-AUTOMOBILE COLLISION

Case Number 2

A. IDENTIFYING DATA:

Location: On Northeast 23rd Street, Oklahoma City, OK in the 3600 block. September 1, 1970 at 6:50 a.m.

Vehicles: Vehicle #1 - 1968 Chevrolet school bus with Wayne body, forty-five passenger capacity. Vehicle #2 - 1968 Chevelle, 4-door sedan.

B. AMBIENCE:

Weather: Clear and dry; darkness.

Temperature: Approximately 60 degrees.

C. HIGHWAY:

Heavily traveled two-lane street in the northeast section of Oklahoma City, Oklahoma. Posted speed at 55 mph.

D. TYPE OF ACCIDENT:

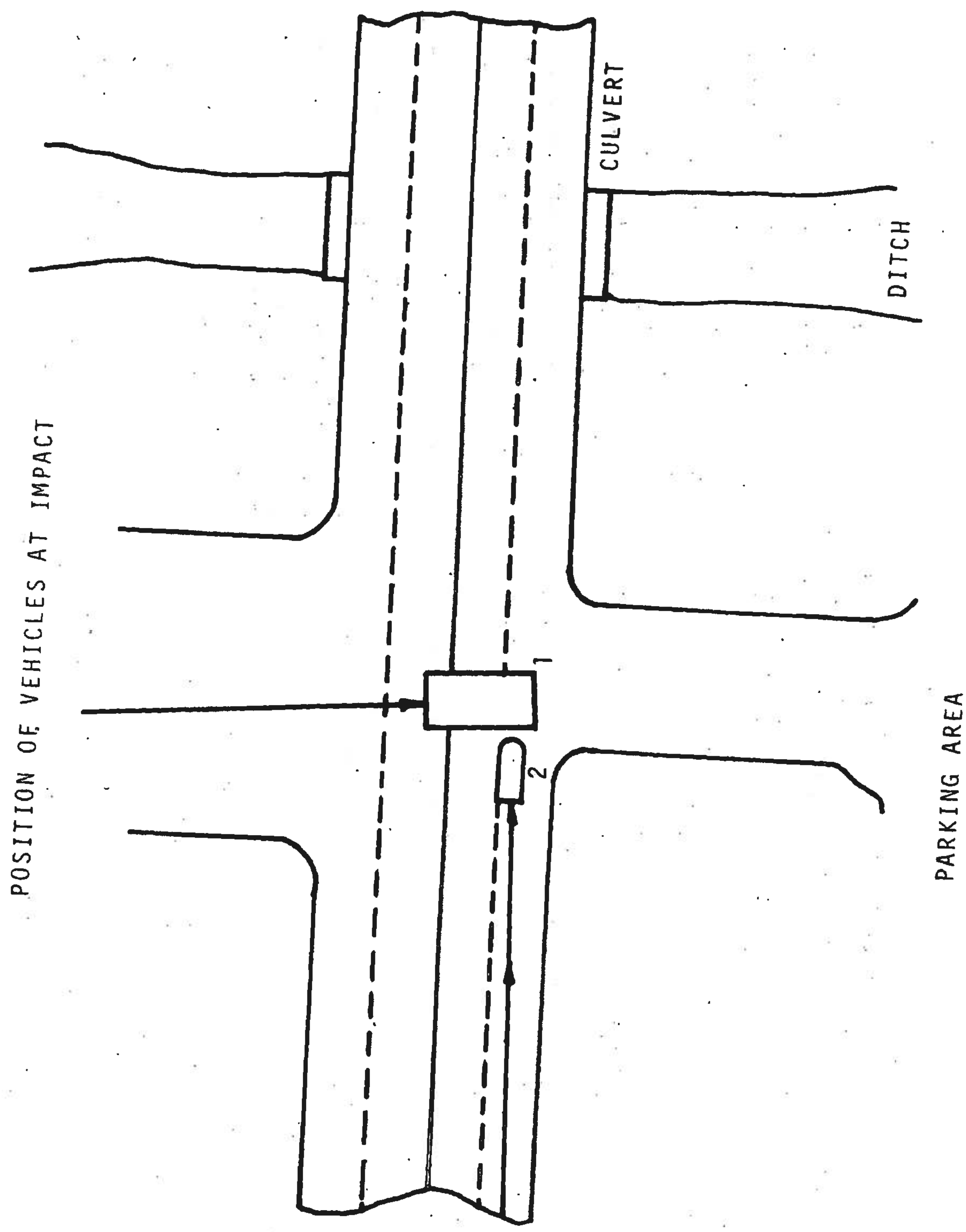
Vehicle #1 was crossing the street from a driveway to enter another driveway, located directly across the street when it was struck by vehicle #2, as it proceeded east on 23rd street; vehicle #1 caught fire upon impact and burned.

E. OCCUPANTS:

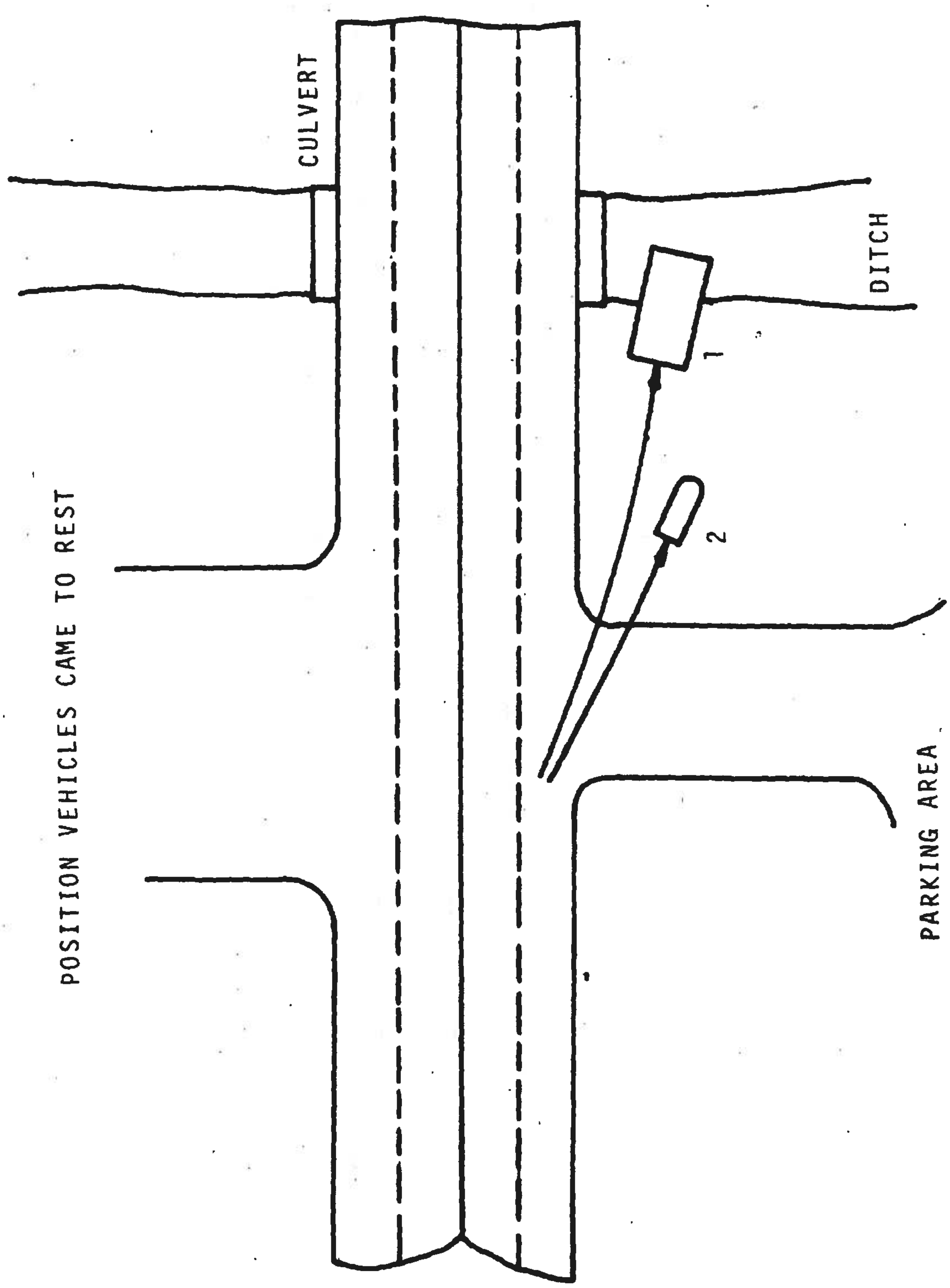
Male: Age 25, driver of vehicle #1, had no injuries at impact but received lacerations on both hands, also singed hair on head and arms during escape.
Female: Age 65, driver of vehicle #2, received lacerations to head at impact.

F. ACCIDENT DESCRIPTION:

Vehicle #1 (the bus) was being moved across the street in order that the driver would not have to turn left during the heavy rush-hour traffic. This vehicle along with five others is moved each morning in this manner for convenience and safety. As the front of the bus entered the eastbound lane, it was struck in the right side, on and directly behind the front door, by vehicle #2. Vehicle #2 ran under the bus, striking the gasoline tank.


POSITION OF VEHICLES AT IMPACT
CULVERT
DITCH
1
2
PARKING AREA

POSITION VEHICLES CAME TO REST



G. PRE-CRASH FACTORS:

Vehicle Factors - The fuel tank on vehicle #1 (the bus) had just been filled with gasoline. There were no identifiable mechanical deficiencies on vehicle #1. All four doors were locked on vehicle #2. There were no mechanical deficiencies on vehicle #2.

Environmental Factors - It was totally dark at the time of the collision and no street lights were present. The accident occurred at the base on a small hill in a 55 mph zone. At legal speed, the time required to reach the point of impact from the crest of the hill is 4.5 to 5 seconds.

Human Factors - Neither of the drivers had completed a driver's training course. Seat belts were present on both vehicles, but were not in use by either driver.

H. CRASH FACTORS:

Vehicle Factors - Vehicle #1 was traveling at approximately 10 mph and was struck at right angles by vehicle #2, which was traveling at approximately 40 mph at impact. Gasoline sprayed into the doorway of the bus and over the hood of the car and ignited upon impact. The left rear corner of the hood on vehicle #2 penetrated the windshield causing a laceration to the head of the driver.

Environmental Factors - The collision occurred on a four-lane, undivided city street. The street was constructed of asphalt and was dry.

Human Factors - The driver of vehicle #1 received no injuries at impact while the driver of vehicle #2 was thrown forward, striking the corner of the hood as it penetrated the windshield. The subject was dazed by this blow to the head.

I. POST-CRASH FACTORS:

Vehicle Factors - The bus (vehicle #1) was knocked upon the left wheels and swerved to the left along the shoulder of the road. It came to rest, front first, in a ditch. The ditch was located seventy-five feet from the point of impact. Vehicle #2 followed approximately the same path and was resting fifty feet from the point of impact. The gasoline on the hood of vehicle #2 burned for several minutes, scorching the paint, but the vehicle did not burn. Vehicle #1 was burned throughout the interior with some burning on the left side exterior. The right front door of vehicle #2 was jammed by the impact and could not be opened.

Environmental Factors - The bus came to a rest in the ditch approximately four to five seconds after the initial impact. At that time flames had surrounded the driver and were traveling toward the back of the bus.

Human Factors - The bus driver chose the front door as an escape exit. He gave the door a kick (it was difficult to open) and jumped through a wall of flames into the ditch. Seats were burning behind the driver when he jumped out, approximately five seconds after impact. There were no other occupants on the bus. He received minor injuries from escaping, including scorched hair. The driver of vehicle #2 had been dazed by the blow on the head and was unable to unlock the front door on the passenger side of the vehicle. The driver of vehicle #1 broke out the right rear window glazing with a hammer furnished by a witness and removed the subject through the front right door after unlocking the door. The gasoline on the hood was still burning when the subject was removed.

J. OPINIONS AND OBSERVATIONS:

1. The interior of the bus was totally engulfed with flames in less than ten seconds.

2. The rubber coupling on the gas tank filler tube of vehicle #1 was jarred off and the compression of the gasoline tank sprayed the fuel over the side of the bus, the hood of vehicle #2 and into the doorway of vehicle #1.

3. A possible source of ignition was the flash of the left front head lamp of vehicle #2 at impact.

4. The gasoline tank on vehicle #1 has no protection from penetration or compression except the thin sheet metal of the body extended below the floor beam.

5. Many school buses have a beam extending along the lower edge of the body.

Figure 1. Scene of accident.

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FATALITY

OFFICIAL POLICE TRAFFIC COLLISION REPORT

Reporting Agency: Okla City Police Dept.

Date: 9-1-70 Day of Week: Tuesday Hour: 650 AM County: Okla

Location: In Ok. City; On NE 23; At 3600

Total number veh. involved: 2 No. Injured: 6 No. Killed: 0

Time Notified: Date 9-1-70 Hour 650 AM; Arrived At Scene: Date 9-1-70 Hour 7 AM

Vehicle 1 — Driver: [redacted] Address: [redacted] N. Midwest Blvd. License: [redacted] Age: 26 Race: W Sex: M Date of Birth: 3-29-44 Vehicle: Chev. School Bus 45 pass. License Plate: [redacted] Owner's Name: [redacted] Legal speed MPH: 10 Vehicle Operable: No Estimated damage: $600 Veh. removed to: owner

Vehicle 2 — Driver: [redacted] Address: [redacted] Normandy Ok. City License: [redacted] Age: 65 Race: C Sex: F Date of Birth: 1-9-06 Vehicle: 1960 Chev. Chevel License Plate: [redacted] Owner's Name: Same Legal speed: 55 MPH, 40 MPH Vehicle Operable: No Estimated damage: $80 Veh. removed to: NE Wreck

Injured/Witness: [redacted] 65 F C [redacted]

Injured/Witness: [redacted] [redacted] 58 F W

Injured/Witness: [redacted] [redacted] 99 [redacted]

Injured Taken To: 1. [illegible] By: [illegible]

Investigation made at scene? Yes. Investigation completed? Yes. Operator's report given to driver: Veh. 1

Officer: [redacted] Fail to Y/Rwy [illegible] Citation No.: [redacted]

District or Division: Traff. Date of report: 9-1-70

B-32

Unit 1 2	What vehicles were going to do
✓ ✓	1. Go ahead
	2. Turn left
	3. Turn right
	4. Make "U" turn
	5. Stop
	6. Slow for cause
	7. Start from park
	8. Change lanes
	9. Overtake or pass
	10. Back
	11. Start in traffic lane
	12. Remain stopped / parked

Unit 1 2	What vehicles did
✓ ✓	1. Went ahead
	2. Turned left
	3. Turned right
	4. Entered "U" turn
	5. Stopped
	6. Slowed
	7. Started from park
	8. Entered other lane
	9. Overtaking
	10. Backed
	11. Started forward
	12. Remained parked / parked

Unit 1 2	Type of road
	1. One-way road
	2. Alley
	3. Two lanes
	4. Three lanes
	5. Four or more divided
✓	6. Four or more not divided
✓	7. Driveway
	8. Turn bay
	9. On ramp
	10. Off ramp

Unit 1 2	Traffic control
	1. Stop sign
	2. Traffic signal
	3. Flashing signal
	4. Yield sign
	5. Warning sign
	6. RR gates, signals
	7. No-passing zone
	8. Officer
✓ ✓	9. No control

Unit 1 2	Road character
✓	1. Straight-level
	2. Straight-upgrade
✓	3. Straight-downgrade
	4. Straight-hillcrest
	5. Curve-level
	6. Curve-upgrade
	7. Curve-downgrade
	8. Curve-hillcrest
	9. Sharp curve (add to above if applicable)

Unit 1 2	Condition of drivers and pedestrians
✓ ✓	1. Apparently normal
	2. Driving ability impaired
	3. Odor of alcoholic beverage
	4. Very tired
	5. Sleepy
	6. Sick
	7. Condition not known
	Body defects (arm, leg, eyes, etc.)

Unit 1 2	Object struck by vehicle or load at first contact
	1. Street light pole
	2. Comm. or utility pole
	3. Guard rail
	4. Guard post
	5. Culvert
	6. Traffic signal
	7. Tunnel
	8. Curb
	9. Island
	10. Traffic control sign
	11. Ditch
	12. Embankment
	13. Tree
	14. Dividing strip
	15. Retaining wall
	Bridge
	Over highway object

Unit 1	Point of first contact on vehicles	Unit 2	
✓	1. Front-center		7. Right-side-center
	2. Front-right	✓	8. Right-side-forward
	3. Front-left		9. Right-side-aft
	4. Rear-center		10. Left-side-center
	5. Rear-right		11. Left-side-forward
	6. Rear-left		12. Left-side-aft

Light		Weather	
✓	1. Daylight	✓	1. Clear
	2. Darkness		2. Partly cloudy
	3. Lighted		3. Overcast
	4. Dawn		4. Raining
	5. Dusk		5. Snowing

What pedestrian was doing
1. Crossing at intersection
2. Crossing not at intersection
3. Crossing at other crosswalk
4. Getting on or off vehicle
5. Walking in traffic
6. Walking against traffic
7. Push/work on vehicle
8. Playing
9. Door working

Unit 1 2	Road condition
✓ ✓	1. Dry
	2. Wet
	3. Ice/Snow
	4. Muddy

Unit 1 2	Road surface
	1. Concrete
✓ ✓	2. Asphalt
	3. Gravel
	4. Dirt

Locality
1. Residential
✓ 2. Business
3. Industrial
4. School
5. Not built-up

Unit 1 2	Vehicle condition
✓ ✓	1. Apparently normal
	2. Brakes
	3. Steering
	4. Headlights
	5. Rearlights
	6. Tires

Tire check

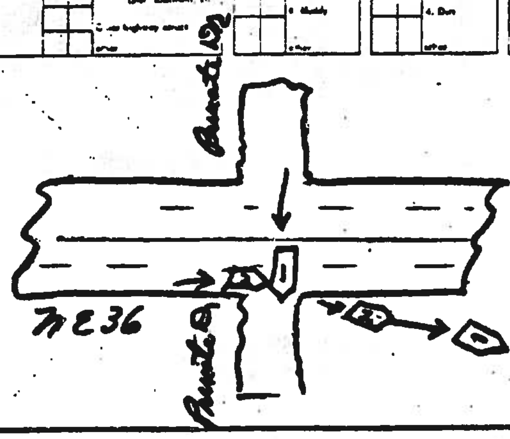
Indicate North by Arrow

Direction of travel

Veh. 1 N S E W

Veh. 2 N S E W

Collision Diagram



Remarks: (refer to vehicles by number)

V1 Traveling South from Prewitt Dr. to Prewitt Dr.
V2 headed East on NE 23. The front of
V2 collided with the LF front side of V1
V1 traveled 75 ft S.E. after impact, V2 50 ft S.E.
after impact. V2 60 ft. before impact
[illegible] 6 ft. north of South edge of 23 [illegible] 3605

Improper, unlawful, or other action (this section is primarily for general statistics and administrative purposes)

Unit 1 2		Describe
✓	1. Failed to Yield	While crossing
	2. Followed too Closely	three traffic lanes
	3. Unsafe Speed	
	4. Made Improper Turn	
	5. Changed Lanes Unsafely	
	6. Stopped in Traffic Lane	
	7. Failed to Stop	
	8. Unsafe Vehicle	
	9. Left of Center	

Unit 1 2		Describe
	10. Improper Overtaking	
	11. Improper Parking	
	12. Inattention	
	13. Wrong way on	
	14. Improper Start from	
	15. Other Improper Act or Movement	
	16. Not Known — or — No Improper Action	
	17. Other Action — not directly related to collision	
	18. Pedestrian Action	

Bus came to rest nose down in ditch. (Times Staff Photo by [redacted])

No Students on Board

School Bus Burns

An Oklahoma City school bus carrying no passengers plunged into a ditch and caught fire this morning after colliding with a car in the 3900 block of NE 23.

The bus was being moved to an assembly area across NE 23 from its parking area at [redacted] Garage and Service, [redacted] NE 23.

The bus driver, [redacted] of Midwest City, escaped with only singed facial hair.

[redacted], 64, of [redacted] Drive, driver of the car, was reported in good condition at St. Anthony Hospital.

[redacted] said the east-bound car topped a hill on NE 23 and slammed into the bus near the loading door.

The impact ruptured the gasoline tank, and the bus caught fire.

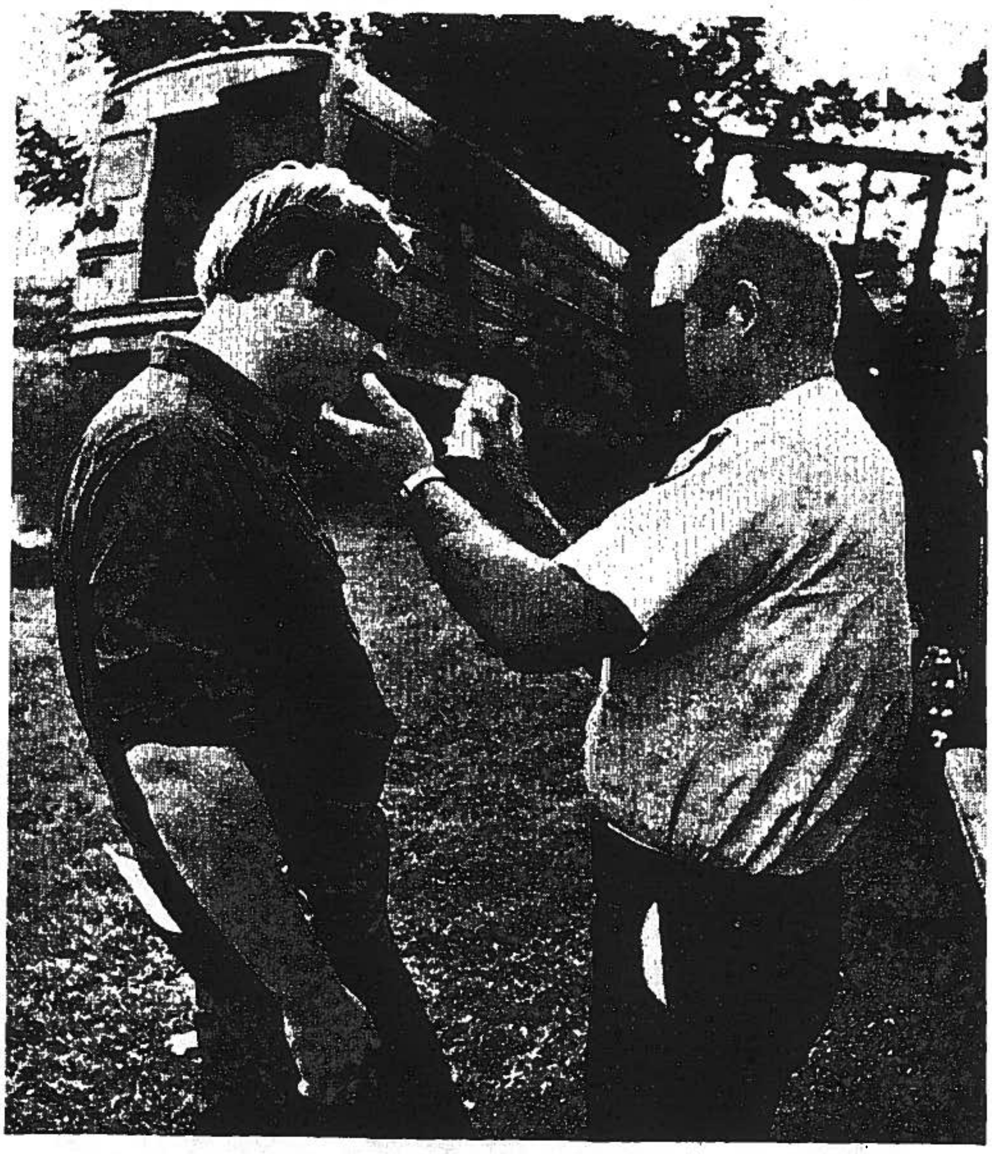
Firemen quickly extinguished the blaze, but the interior of the bus suffered heavy smoke damage.

Firemen had to snuff the fire from the seeping gas tank by shoveling dirt around the tank as the bus lay nose-down in the ditch.

[redacted], owner of the bus and a contract carrier for the city, said the bus was the second wrecked in the same spot within a year.

He said city ordinance forbids his buses from making left turns from the parking lot, so six of his 26 buses must be moved directly across the street to start east-bound on their routes.

[redacted] said the hills on NE 23 at that spot do not allow his drivers to see oncoming traffic, so the buses are moved beginning about 6:30 a.m.



Bus Driver Treated For Burns

An Oklahoma City Fireman gives first aid to the driver of a bus that crashed Tuesday morning. [redacted] received slight facial burns following the accident. He was the only person in the bus which caught fire following a crash with a car in the 3900 block of NE 23. The wreck was the second bus accident in the location in the past year. (Staff photo

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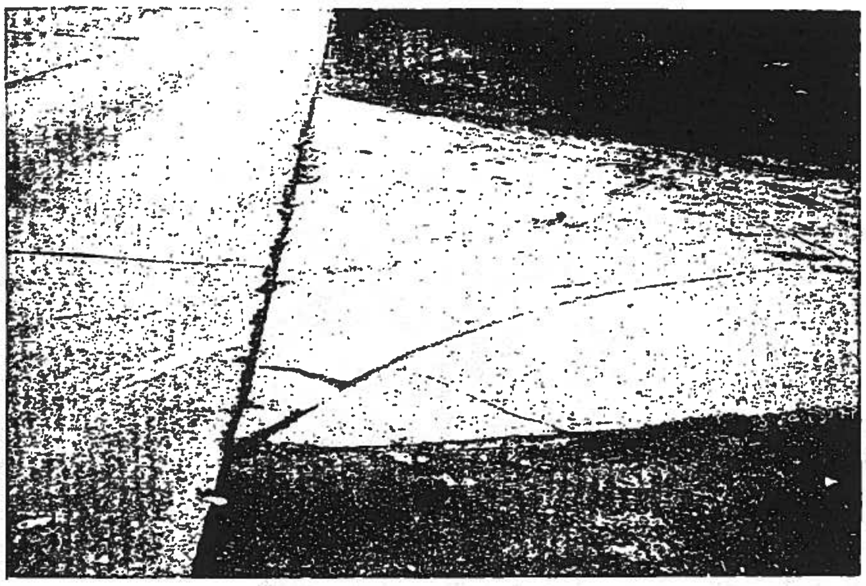

Figure 2. Point of impact.

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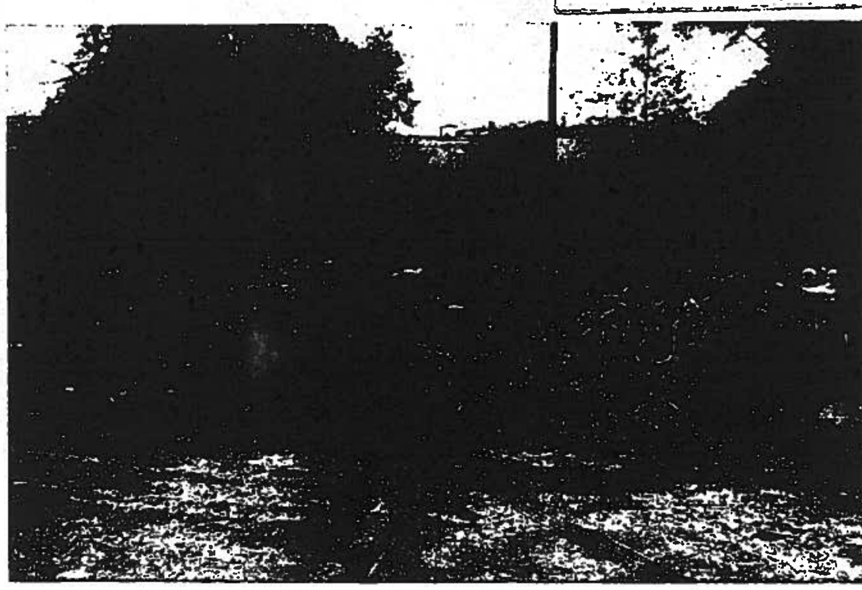


Figure 3. Locations where vehicles came to rest. Vehicle #1 stopped in creek at pole in background; vehicle #2 (car) stopped in grass near pole in right foreground.

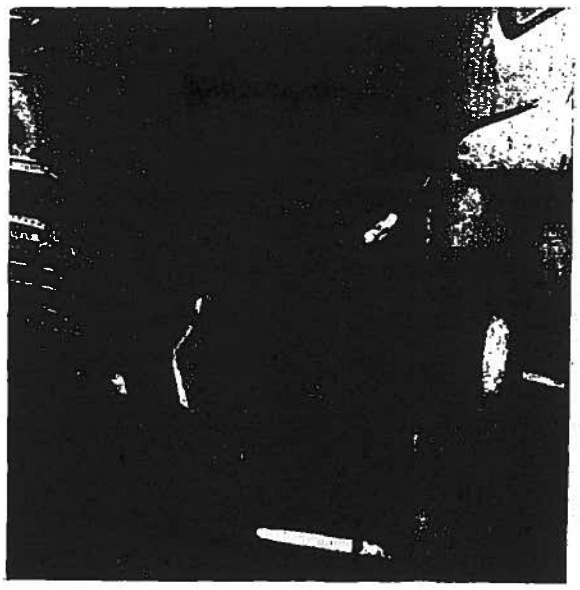


Figure 4. Damage to door of vehicle #1. Folding of step allowed fuel to be expelled from tank into vehicle.

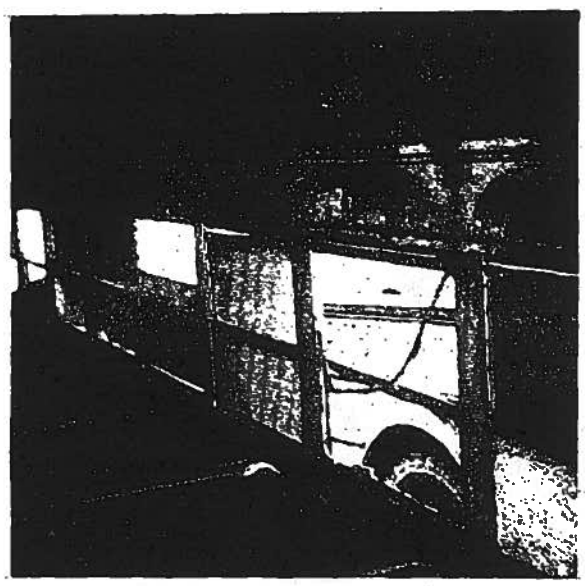


Figure 5. Fire destruction to vehicle #1. Note melted interior light fixtures.

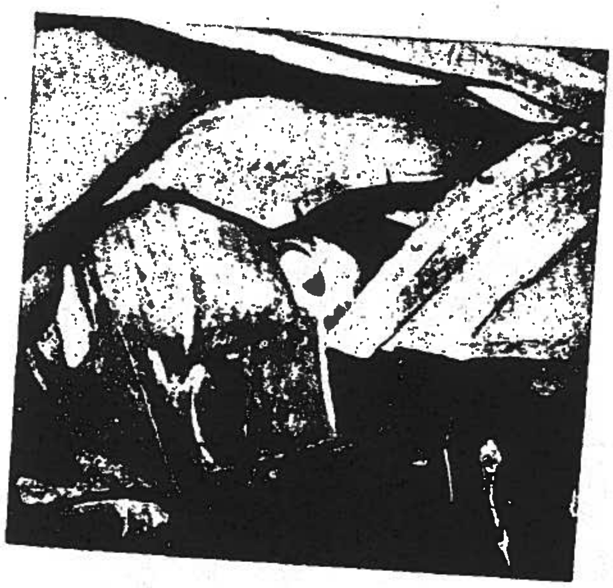


Figure 6. Gas tank of vehicle #1. Note filler neck opening aligned with hole at step well, bent skirt which directed fuel into bus interior.

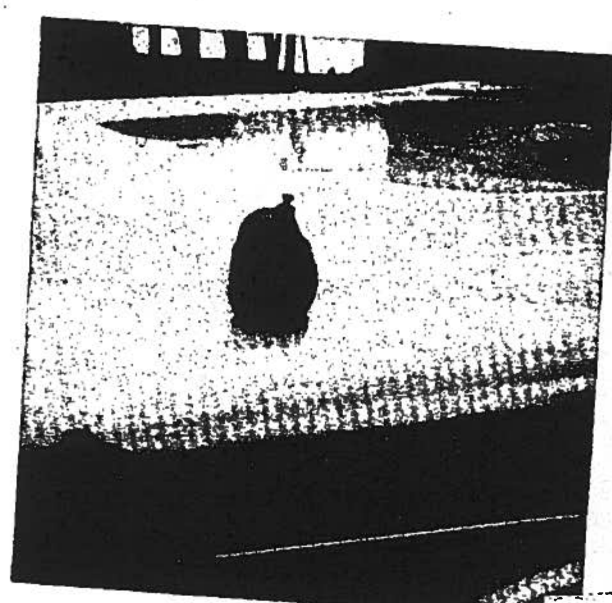


Figure 7. Deformed gas tank filler neck, vehicle #1.

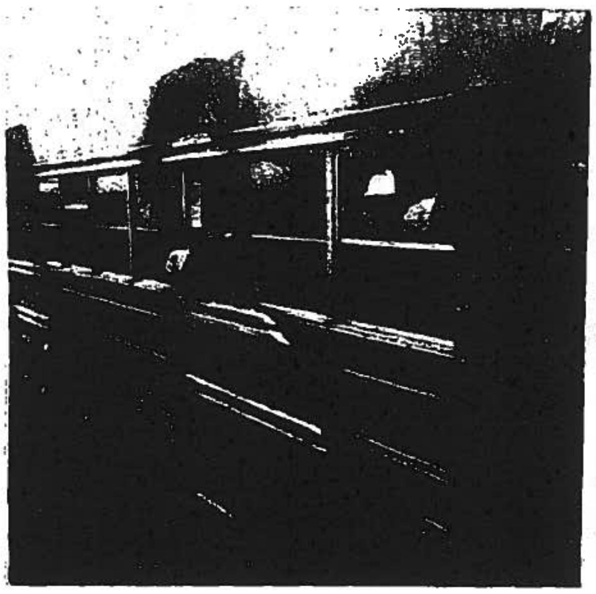


Figure 8. Right side of vehicle #1.

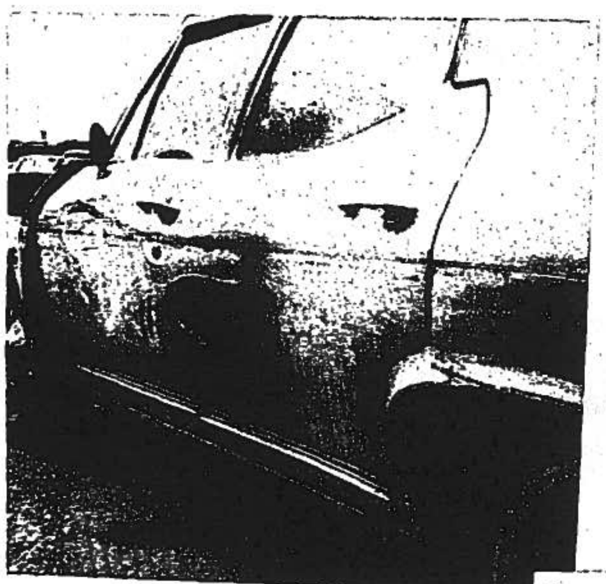


Figure 9. Left side of vehicle #2.

Figure 10. Front view of vehicle #2.

Figure 11. Front end damage, vehicle #2. Note slight scorching of paint, no other fire damage.

Figure 12. Hood penetration of window glazing, vehicle #2.

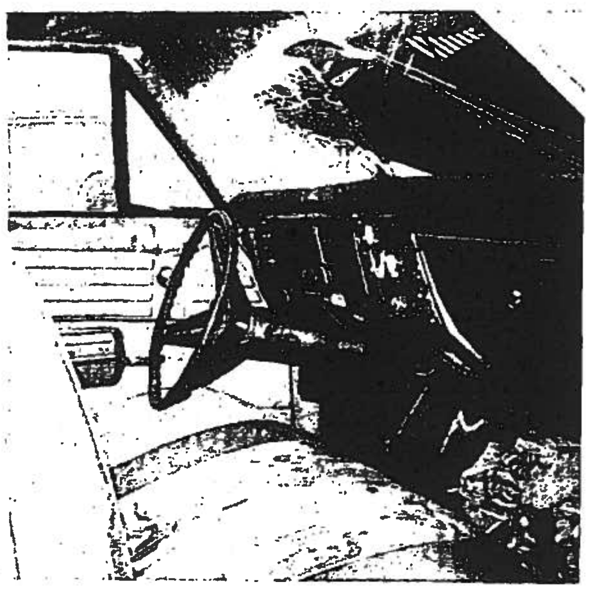


Figure 13. Interior view of energy-absorbing steering column and windshield penetration by hood.

SUMMARY OF POST-CRASH FIRE, PICKUP

Case Number 3

A. IDENTIFYING DATA:

Location: 3.2 miles west of Stonewall, Oklahoma, on a country road, September 13, 1970, at 10:00 p.m.

Vehicle: Vehicle #1, 1965 Ford, 3/4 ton pickup.

B. AMBIENCE:

Weather: Dark, heavy rain, visibility of fifty feet.

C. HIGHWAY:

Location: On a country road, two lane, asphalt.

D. TYPE OF ACCIDENT:

Vehicle #1 ran off road, struck end of bridge, overturned into a creek and burned.

E. OCCUPANT:

Male: Age 59, driver of vehicle. Burns to 95% of body, complete destruction of both feet, one hand, and all hair. Fatally burned.

F. DESCRIPTION OF ACCIDENT:

The driver was proceeding along country road at approximately 30 mph in heavy rain and darkness. Visibility was less than fifty feet. The vehicle approached a bridge located on a sharp turn in the roadway. Instead of turning to the right and remaining on the roadway, the vehicle proceeded straight ahead, striking the end of the bridge, which consisted of a raised concrete section of twelve inches with a three inch pipe for a rail. The vehicle ran down the steep embankment, throwing the driver from the vehicle into a creek. The truck over-turned and came to rest upside down. The driver was trapped under the bed of the pickup. The truck ignited and burned. The interior was completely burned as was the bed and undercarriage of the truck. Witnesses approximately one hundred yards from the scene, at their residence, described a bright flash at 10:00 p.m., but did not investigate. The engine compartment showed no evidence of fire nor did the exterior paint of the vehicle with the exception of sections around the cab and interior of the pickup bed. There was evidence of intense heat at two points:

(1) the instrument cluster; (2) the fuel tank filler neck. The fuel tank was intact and the only damage was to the filler neck.

Crash destruction of the vehicle was so great that it was unlikely that the occupant could have escaped had he not been ejected.

Statements by the investigating officers would indicate that the occupant of this vehicle was alive and possibly attempting to free himself from the bed when he was incinerated. The occupant had protected his face from the flames and appeared to have been trying to lift the bed of the truck (out-stretched hands under the side). The occupant's face and bib of his overalls were not burned.

The accident was not discovered until 8:00 a.m. the following morning and at that time the water was twelve to fifteen inches deep. The rain had possibly destroyed fire evidence since water had run off from the scene.

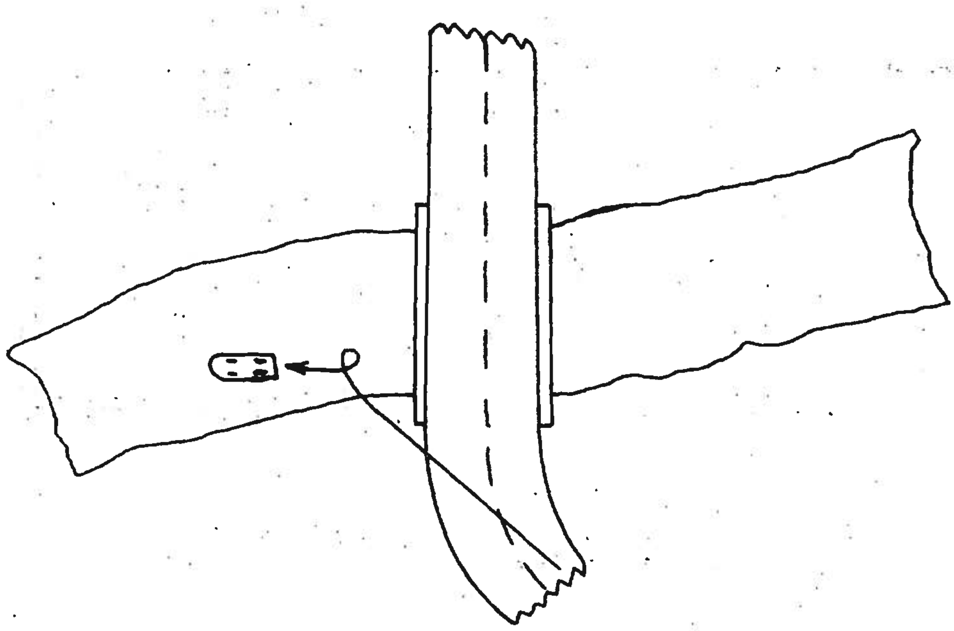


Figure 1. Collision diagram.

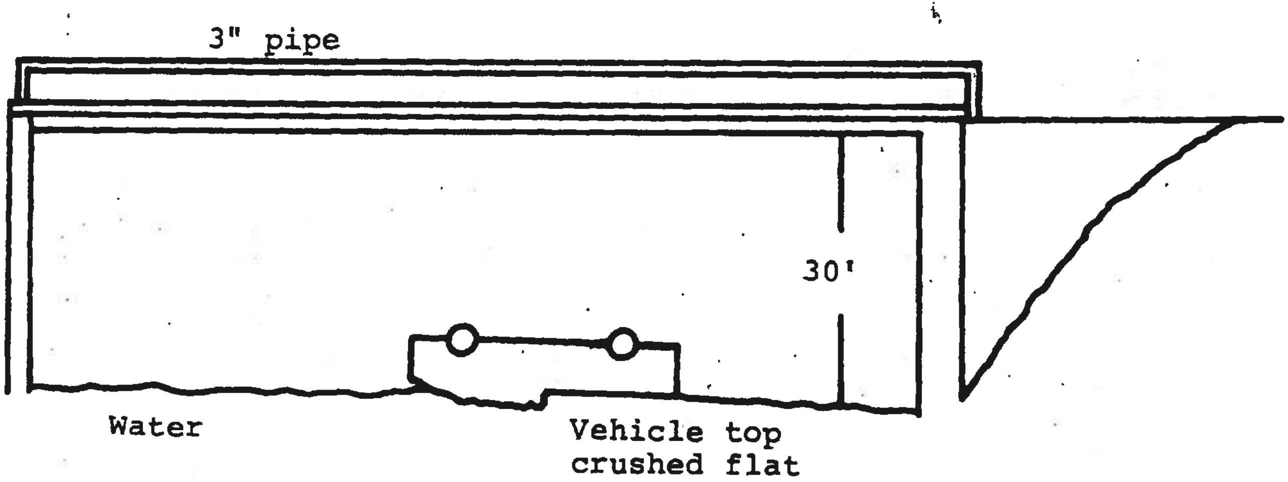


Figure 2. Final position of vehicle.

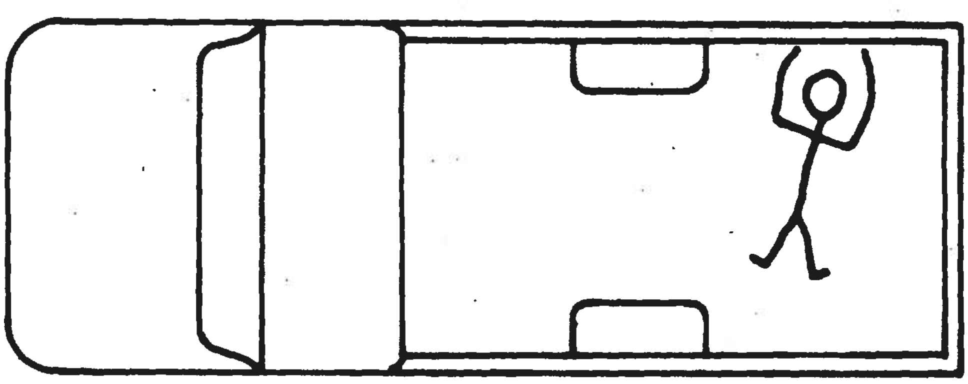


Figure 3. Final position of driver looking from below overturned pickup.

G. OPINIONS AND OBSERVATIONS:

1. The driver had extremely poor vision and had been arrested twice in the past few months for traffic violations. These violations were the result of poor vision and/or judgement.

2. This vehicle was not equipped with seat belts and the driver was ejected.

3. When approaching this bridge from the west, the driver must make a sharp turn to the right to enter the bridge, making it a dangerous manuever, especially driving in darkness. The retarding structure, constructed of three inch pipe, is inadequate to stop a vehicle even at low speed. Many similar accidents have occurred at this site.

4. It is probable that gasoline leaked from the fuel tank when the vehicle overturned and spread the flames to the underside of the pickup bed.

5. Although there was no evidence of fire in the engine compartment, the battery was crushed by the impact.

6. The cab of the vehicle was crushed and extended below the steering wheel. If the driver had been wearing seat belts, he would certainly have been trapped between the seat, steering wheel and cab.

7. The spare tire, which was mounted on the side near the gas tank cap, was totally burned and this area was exposed to a substantial amount of heat.

8. The wooden bed was 95% destroyed by fire and the paint was completely burned on the interior of the bed; however, the outside of the bed was not burned.

9. All four tires were still inflated and showed no evidence of fire damage.

CASE #______

SOURCES OF DATA FOR: EPIDEMIOLOGICAL ANALYSIS

1. Accident Report [X]

Report Number 0256 0473
Date Sept. 13, 1970

2. Newspaper Accounts [X]

3. Death Certificates [X]

Certificate Number(s) 18480

---

4. Interviews: [X]

(a) Investigating Officer [X]

(b) Occupant(s) Vehicle #1:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(c) Occupant(s) Vehicle #2:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(d) Occupant(s) Vehicle #3:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(e) Special Accident Investigator: [ ]

(f) Eye Witness(es): [ ] No.______

(g) Private Physician(s) [ ] No.____

(h) Newspaper Reporter - or Photographers [X] No. 1

(i) Ambulance Attendant(s) [ ] No.__

(j) Fireman [ ] No.______

(k) Embalmer [ ]

(l) Family or Friends of Victim(s): [ ] No.______

(m) Wrecker Operator(s) [X] No. 1

(n) Other(s) [ ] Specify______

---

5. Hospital Records: [ ]

---

6. Accident Investigation by Staff: [X]

NOT REPRODUCIBLE

Sheet 1 of 1 Sheets FATALITY: yes

OFFICIAL POLICE TRAFFIC COLLISION REPORT

Reporting Agency: Oklahoma Highway Patrol

Date: Sunday · Day of week: Sunday · Hour: 10:00 AM · County: [illegible]

If collision was outside city limits: 2 1/2 Miles

On: County Road

Distance from intersection: 2/10 Mi. West

Time Notified: Date: 9/1/70 Hour: 2:00

Arrived At Scene: Date: 9/1/70 Hour: 2:15

Unit 1

Driver: [redacted]

Address: [redacted] Oklahoma [redacted]

License: [redacted] [redacted]

Age: 59 · Date of Birth: 10/20/10

Vehicle: 65 Ford Pickup

License Plate: [redacted]

Owner's Name: Driver

Address: Driver

Speed: 55 · Before contact: 30 MPH · At contact: 30 MPH · Estimated damage: $1000.00

Vehicle removed to: [illegible] · by: Smith Wrecker

Unit 2

(blank)

Injured / Killed

1. [redacted] · Address: Rt. #1 [illegible] · Age 59

Injured taken to: 1. Smith Funeral Home · by: Smith Ambulance

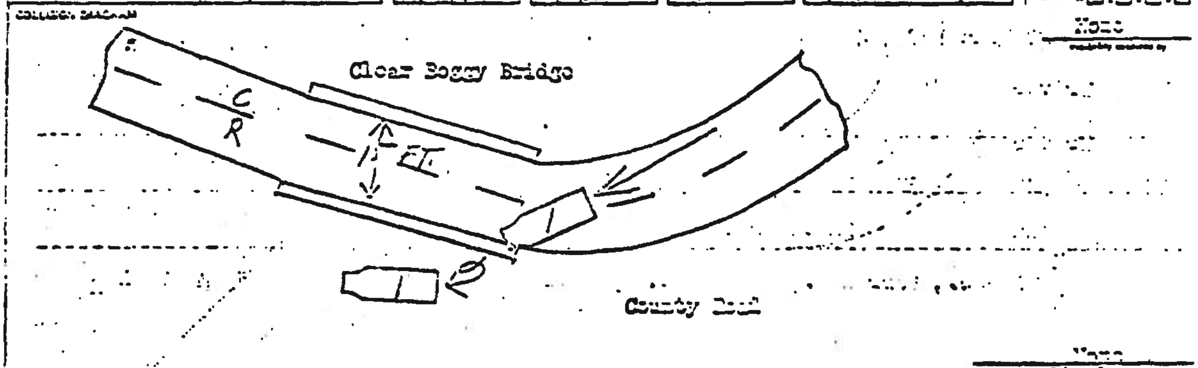
Witnesses: 1. None

Officer: [redacted] · Badge No.: [redacted] · District or Division: 3 · [redacted]

B-47

NOT REPRODUCIBLE

Collision Diagram



None

Defect in Road

Vehicle # 1 traveling West on county road failed to negotiate a curve to the right and through the bridge bannister on the South East end. Vehicle # 1 traveled over the bridge overturning 1/2 time coming to rest upside down in the creek bed. Vehicle # 1 then caught fire and burned. Driver of Vehicle # 1 was thrown from the Vehicle and was trapped under the pickup bed.

Vehicle # 1 - Weather Conditions

[redacted]s partially burned body was found this morning pinned beneath the wreckage of his pickup truck which missed a bridge and plunged into Boggy Creek on a Pontotoc County road 3½ miles west of Stonewall.

Residents in the area said they saw a fire about 10 p.m. Sunday but thought it was a campfire. Trooper [redacted] Ada, said the blaze apparently was [redacted] pickup truck, however.

[redacted] said a wrecker had to be used to free the body after the wreck was discovered by a passing resident of the area about 8 a.m. today.

Roff Resident Dies In Fiery Crash At Boggy Creek Bridge

A county resident lost his life Sunday about 10 p.m. in a fiery crash at the Boggy Creek bridge at Frisco.

He was identified as [redacted], 59, Roff.

The charred and smashed pick-up the man was driving was found today about 8 a.m. in Boggy Creek. The vehicle apparently crashed through the guard-rail and caught fire upon impact. It came to rest bottom-side-up.

A Frisco resident noticed a fire near the bridge about 10 p.m. Sunday but dismissed it as another resident burning brush or trash and did not investigate.

The victim's badly burned body was recovered from the wreck about 9:30 a.m. today after rescue workers moved the pick-up.

Approaching the Boggy Creek bridge from the west a driver has to manage a sharp turn before he enters the bridge, making it a dangerous maneuver, especially at night. Other accidents of this kind have occurred at the bridge.

Two double fatality car wrecks led a bloody series of Sunday crashes that left eight persons dead. Six deaths were blamed partially on Oklahoma's rain slick streets.

The deaths brought Oklahoma's traffic toll for the year to 544, compared with 600 for the same time a year ago.

The victims:

[redacted], 21, Oklahoma City.

[redacted], 20, Norman.

[redacted], 81, Enid.

[redacted], 25, Calvin.

[redacted], 21, [redacted], 58, Custer City.

[redacted], 44, Oklahoma City.

[redacted], 22, Kinta.

The Highway Patrol said Mrs. [redacted] and [redacted] were killed when the car in which they were riding collided with a truck on U.S. 77 South of Wynnewood in Murray County. The patrol said the car driven by [redacted], was hurtled 135 feet backward after the collision. The driver was listed in critical condition. Troopers said the car skidded out of control on wet pavement while attempting to pass another vehicle and struck the front of the approaching truck.

The elderly [redacted] was struck by a car and killed while crossing an Enid street late Sunday night during the rain. The driver said he did not see the man because of bad weather and street light reflections.

[redacted] and [redacted] were riding in a car that skidded on rain-slick U.S. 270 one mile north of Holdenville and collided with another car.

[redacted] was killed and her husband, 69-year-old [redacted], 69, was injured critically when their car ran off the road west of Thomas in Custer County and crashed in a dry creek bed.

[redacted] car skidded out of control during a heavy rain on Interstate 40 at the east edge of Oklahoma City.

The Highway Patrol said [redacted] car ran off the highway two miles west of Kinta and crashed into an embankment.

Rescue workers remove the body of a Pontotoc County resident from the water of Clear Boggy Creek. His wrecked pickup is visible in the background. **(Staff Photo by [redacted]**

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Figure 4. Front of submerged 1965 Ford pickup. Note damage to cab.

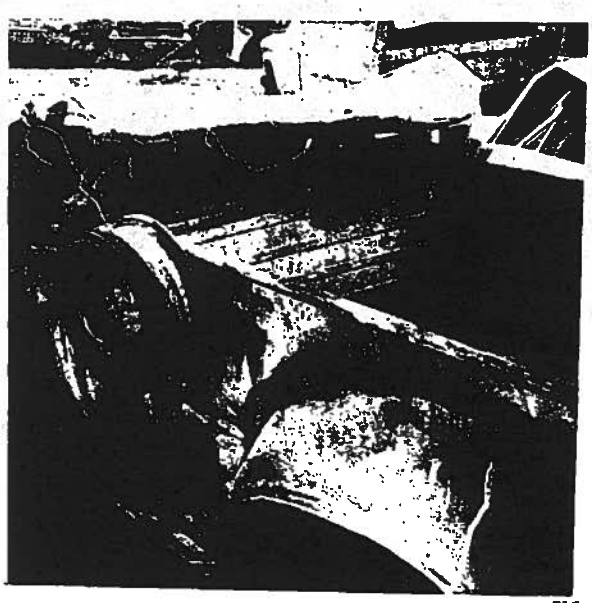

Figure 5. Bed of pickup.

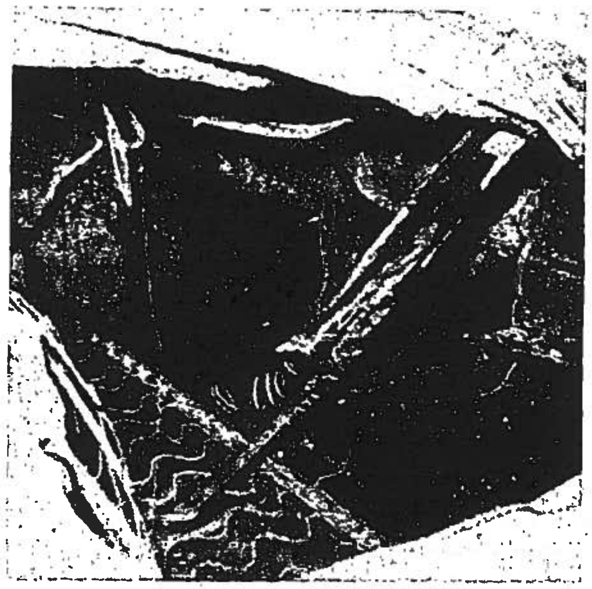

Figure 6. Interior of pickup cab.

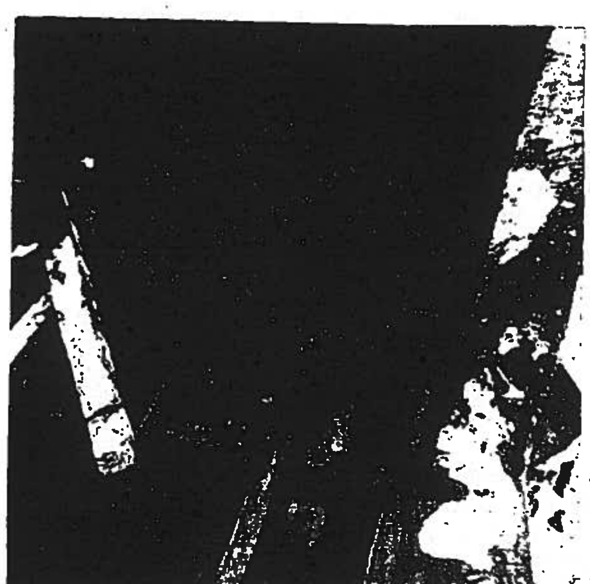

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Figure 7. Inside bed of pickup.

Figure 8. Left side of pickup.

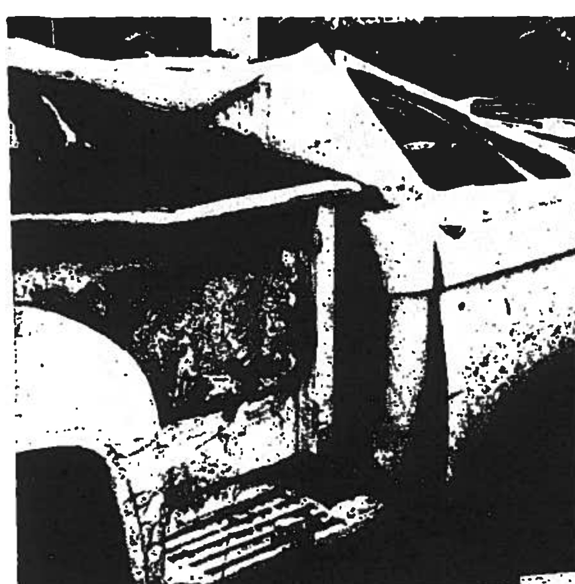


Figure 9. Right side of pickup.

SUMMARY OF LITTLE BAD CREEK SUBMERGENCE

Case Number 4

A. IDENTIFYING DATA:

Location: 1.5 miles west of Bryan, Oklahoma, on old Highway 62 (county road), November 1, 1970, 12:30 a.m.

Vehicle: Vehicle #1 - 1953 Mercury, 2 door sedan.

B. AMBIENCE:

Weather: Clear; darkness.

C. HIGHWAY:

Location: On a county road, two lanes asphalt.

D. TYPE OF ACCIDENT:

Vehicle ran off road, struck bridge guard rail and overturned into creek in three and a half (3½) feet of water.

E. OCCUPANTS:

One fatal; one escaped.

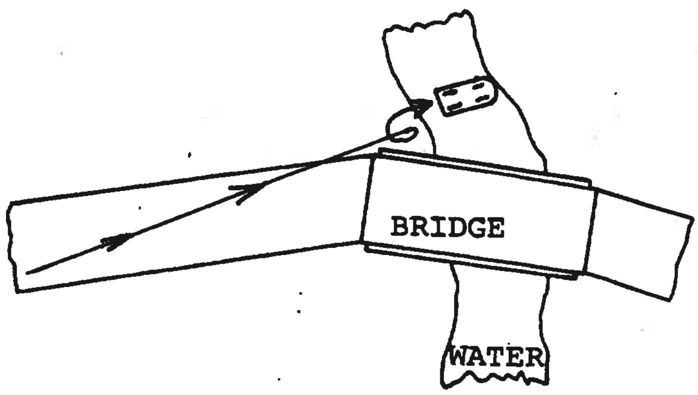
Male: Age 20, driver of vehicle. Suffered no significant injuries, but was trapped and drowned.

Male: Age 22, passenger in vehicle. Suffered bruised thighs, laceration requiring eleven stitches in left hand, bruises to face, sprained back. Escaped.

F. ACCIDENT DESCRIPTION:

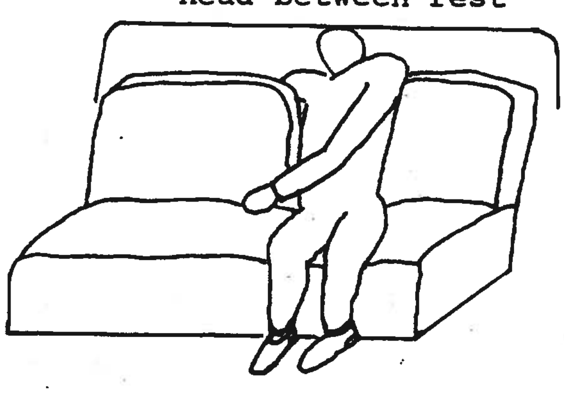
This vehicle was proceeding east on old highway 62 (now county road), when it approached a one lane bridge which required a sharp turn to the right for entry. (Drawing on page B-56).

The driver of the vehicle was not aware of the presence of the bridge or the sharp turn and proceeded directly into the rail. There was little or no lessening of the vehicle's velocity since the bridge rail was constructed of rusted angle iron. The vehicle rotated to the left and came to rest on its top facing forward.



The vehicle traveled fifty feet in the air before striking the opposite bank and coming to rest in 3½ feet of water. The top of the vehicle was compressed and rested on the top of the front seat back. The location of the passenger in the vehicle at the time the vehicle came to rest is not known. The driver's head was trapped between the seat back and the roof of the vehicle. He was bent over the seat with his head facing the roof area.

Face looking up with head between rest



Roof of car

The passenger was able to free his left leg and pull his head above the water; however, he was unable to remove the driver. The driver was pronounced dead from drowning by an attending physician. No autopsy was performed. The deceased had no fractures or lacerations.

G. PRE-CRASH FACTORS:

Vehicle Factors: No evidence of mechanical malfunctions was noted.

Environmental Factors: The site of this accident is extremely hazardous. The two lane road has no signs of any type to inform motorists of hazardous situations. The bridge is narrow and accepts only one lane of traffic and the approach on both sides requires manipulating a sharp curve in the road approximately one hundred yards before entering the bridge. The bridge was constructed perpendicular to the creek and requires a turning maneuver of approximately fifty (50) degrees for entry. The rails on the approaches and along the bridge are of small angle iron and were broken off with no apparent retaining ability. Darkness contributed to this accident, particularly since no warning signs were present.

Human Factors: The driver of the vehicle had been drinking heavily and had not slept in approximately forty hours. He had fallen asleep in two bars prior to the accident. The driver did not apply his brakes and made no attempt to turn. He proceeded straight ahead in the direction of travel. Neither of the occupants were wearing seat belts since the vehicle was not equipped. The survivor estimates a speed of fifty miles per hour at impact. This was certainly an overestimate.

H. OPINIONS AND OBSERVATIONS:

1. The vehicle was traveling no more than 28-30 mph when it struck the bridge rail. This estimated speed was derived from mathematical computations.

2. The victim would have escaped if he had not been trapped in the vehicle.

3. This type of bridge has been observed throughout Oklahoma and is extremely hazardous. All single lane bridges and bridges requiring difficult maneuvers should be eliminated or at least equipped with appropriate danger signs.

4. Guard or retaining rails on many older bridges should be improved.

5. Methods utilized by law enforcement officials for speed estimates should be evaluated and perhaps improved.

INTERVIEW: Surviving Passenger of Vehicle
November 7, 1970

Q. Mr. XXX, could you review the series of events relating to your automobile accident on November 1, 1970? A. Well, XXX and I were driving to Henryetta and he decided to take a short-cut on the old highway. We had been to a basketball game and it was around midnight when we had the wreck. I guess we were going about fifty to sixty miles per hour when we came onto the bridge. I didn't know it was there and didn't know what was going on. I didn't feel anything until we landed on our top. When I woke up my head was under water and I was coughing water out. I got my head above the water and I remember the horn was blowing. My left leg was caught but I don't know where. It must have been between the seat and the top of the car. It took me about ten minutes to get my leg loose and get out. I hollered at XXX but never did hear a sound. I found his arm hanging out the door and tried to pull him loose. I saw the lights of a house and so I ran up there to get help. They didn't have a phone, but the man went into Bryan to call and his son took me back to the creek.

Q. How did you get out of the car? A. I don't know, it must have been through the door.

Q. On your side? A. Yes. You know I don't even know whether I was in the front or back seat when we landed.

Q. Where were you riding just before the car ran off the bridge? A. I was in the front seat on the right side.

Q. Were either of you wearing seat belts? A. No, the car didn't have any.

Q. Exactly how were you trapped in the car? A. This leg was caught (left) somewhere. I scratched up my thigh pretty bad getting loose. I think I got loose a little bit just before I got my head above the water, then it took me a while to get it the rest of the way loose.

Q. Do you remember trying to open the door? A. No, I don't; I don't know whether I went out the window or what. Neither one of the front doors had a window; I remember that because it was pretty cold driving!

Q. Do you mean they had been broken out? A. Yes.

Q. When did this accident occur? A. Oh, it was about 12:30 a.m. Saturday night.

Q. Could you tell me what all had happened before the accident? A. Well, we had been to a ball game at Weleetka and when we left there we went to a beer joint in Henryetta and stayed a while; I don't remember the name of the place.

Q. What time were you at the beer joint? A. About nine o'clock. After we left there we went over to Weleetka again to another place. I guess we stayed there till eleven thirty or eleven forty-five. XXX was awful tired; he went to sleep both places. I don't think he had been to bed since Thursday night. He just got off work Friday and started drinking.

Q. What time did he get off? A. At five, I'm pretty sure.

Q. When did you start drinking with him? A. Saturday morning. There was another guy with him but I never did know what his name was. He left us during the ball game. He had bought some gas for us to take him home to Okmulgee, then he changed his mind. He said XXX was driving too crazy.

Q. What did he mean by that? A. I don't know - I guess too fast.

Q. Did you think he was driving too fast? A. No, I think he was more tired and sleepy than drunk.

Q. So you were driving back from Weleetka to Henryetta, is that right? A. Yeah, we started back and took the back road. I don't know why we pulled off the main road - XXX said it was a short-cut.

Q. Did you see a bridge when you rounded the curve? A. No, I didn't see a thing. It was awful dark and there were no signs or anything. The first thing I knew we hit the rail.

Q. Were you thrown forward when you hit the rail? A. No, I don't think so. It just barely bumped when we hit it. We just crashed on through. I knew when I woke up that we'd had a wreck but I couldn't figure out why we were in the water.

Q. Did you talk to XXX anytime after you hit the rail?

A. No, XXX never did move; his arm was limp when I got to him.

Q. Could you tell me about your injuries? A. Well, both thighs are scratched and I've got eleven stitches in my left hand. My back is awful sore. The doctor said my shoulder blades were jammed into my back bone. My forehead was bruised pretty bad here on the left side and you can see the scratches (left side of face). I did have two black eyes.

Q. Did you know XXX very well? A. No, not very well; I'd seen him a few times.

Q. What do you know about his personal life and his drinking habits? A. I don't know anything about his drinking. He lived in Okmulgee. He was married and had one little girl about two or three years old. He worked over at XXX Mills as a "piece painter." He had lived in Okmulgee a long time.

Q. How long had he been working at XXX Mills? A. About two weeks.

Q. Whose car was he driving? Was it his? A. No, it belonged to his sister and she was letting him use it. He had just put a battery in it and had done some painting on the inside. It had been setting for a long time.

INTERVIEW: XXX
Wrecker Operator
Henryetta, Okla.

Tuesday, November 3, 1970

Q. XXX, could you tell me what you have observed about this particular crash and about your part in the removal of the victim? A. I got the call from the highway patrol and rushed to the scene. This was the second time I've had to pull a car out of that creek in the last few months. I got there at the same time the ambulance showed up. We waded into the water and tried to turn the car over but we couldn't do it. We looked in the car and could see the man's arm but we couldn't get him loose. I brought a cable down and hooked it and we turned her over. We still couldn't get him out. He was pinned in.

Q. What was the position of the victim in the vehicle? A. He was bent over backwards with his face against the roof.

Q. How far back did he extend? A. Oh, I'd say the top of his head was five or six inches from the back edge of the seat. His right arm was over the seat too. His left arm was the one we saw when we got there; it was hanging out the door.

Q. What did you do next? A. After we got the car over on its wheels, I chopped a little hole in the top and hooked on my little "come along" winch. We winched up the top a little bit and then lifted him out and took him in the ambulance.

Q. Has anything been changed on the vehicle since you first saw it? A. No, we didn't bang it up or anything. When I took the winch loose the top went back like it was.

Q. Can you tell if the automobile had been altered? A. It's stock just like it came from the factory as far as I can tell.

Q. Can you tell where the vehicle was located and in what position when you got there? A. It was on its top and the front bumper was against the bank on the other side of the creek.

Q. Do you think it hit the bank very hard? A. No, because there's not much damage to the front end at all.

Q. How fast do you think they were traveling? A. I'd say they were going seventy or eighty; these old flat-heads run pretty fast.

Q. Did you have any trouble getting into the car? A. No, the doors were both open and mashed clear around against the front fenders just like this one is now (pointing to the left side.) We pulled the other one shut and tied it.

Q. Do you have any other observations about the accident? A. No, I don't guess so; they had had quite a bit to drink. A friend of mine saw them at the basketball game over in Weleetka and they were both loaded. I found a lot of beer in the car and there was a broken half pint bottle and a pint with about a drink left in it.

Q. How do you think the other fellow got out? A. He claims he was inside and it took ten minutes to get out but I think he would have been killed if he was still in the car. I think he was probably thrown out. It was awful dark out there.

INTERVIEW: Trooper XXX
(Investigating Officer)
Oklahoma Highway Patrol

Tuesday, November 3, 1970

Q. Would you describe the circumstances of the submergence near Bryan, Saturday night? A. The accident occurred 1½ miles from Bryan on old highway 62 at the Little Bad Creek Bridge. I arrived at the scene approximately forty-five minutes after Trooper XXX. He was assisting in the removal of the victim so I took a statement from the survivor. His name was XXX. Mr. XXX was obviously suffering from shock and still showed signs of intoxication. The subject stated that he and XXX had been drinking heavily, that they were driving fifty-sixty miles per hour and that he had been trying to get him to slow down. He felt that XXX might have gone to sleep. He remembered hitting the bridge; then the next thing he remembers was waking up and looking for XXX. He called for him but he was way under the car upside down. He escaped from the car and ran to a farm house about ¼ mile up the road. There was no phone but the man there went into Bryan and called the patrol and an ambulance. Another member of the household took XXX back to the scene, but they did not enter the water.

Q. What was the approximate depth of the water? A. The water was three to four feet deep and the car was upside down. The victim was pinned between the seat and the top of the car.

INTERVIEW: XXX
Ambulance Attendant;
Embalmer of Deceased

Tuesday, November 3, 1970

Q. Would you please describe your observations and activities immediately following the accident near Bryan? A. We arrived at the scene approximately five minutes after the call was received. The highway patrolman and wrecker operator both arrived at about the same time. This was about thirty to forty minutes after the crash occurred. It was an hour before we could get him out. The car was turned upside down in the creek and the top was mashed flat.

Q. How deep was the water at the point where the front seat was located? A. It was about two and a half feet deep I would say.

Q. Could you tell me the location of the victim in the vehicle? A. His head was trapped between the front seat backs. He was facing the top and his left arm was hanging out of the driver's side. The top of the car was flat on the dash and seats and his head was caught between the seats and the top. The left door was open when we got there and his arm was hanging out the door.

Q. How did you get him out of the vehicle? A. We couldn't pull him out so we chopped a hole in the roof after we turned the car over with the wrecker and winched the top up; then I went in through the door on the driver's side and lifted him out.

Q. How long had he been underwater at that time? A. I would say about an hour and a half.

Q. What did you do next? A. We brought him into town and took him to the hospital where Doctor XXX diagnosed him as drowning.

Q. Were there any noticeable injuries? A. No, he just had a small strawberry on his right leg. The doctor said he didn't have any broken bones. I think he could have gotten out if his head hadn't been trapped.

Q. Do you feel that drowning was the cause of death? A. Yes, I do. When I embalmed him I was able to purge a lot of water out of his lungs and he didn't have any other injuries that I could see.

Q. Was an autopsy performed? A. No, I called the coroner but he wasn't interested in doing an autopsy.

Submersion

FATAL

Unit 1 of 1 units FATALITY: yes [X]

OKLAHOMA /O OFFICIAL POLICE TRAFFIC COLLISION REPORT

Reporting Agency: Oklahoma Highway Patrol

No. 0304 1250

Date: 10-31-70 Day of Week: Saturday Hour: AM 11:40 PM County: Okfuskee

If collision was outside city limits: 2.4 miles N [ ] S [X]; Pharoah (of nearest city) 2.0 miles E [X] W [ ]

Total number veh involved: 1 No. Injured: 1 No. Killed: 1

In city or town: ; On: County Road; At:

NOT AT INTERSECTION: 0.4mi South [X] of County Road (Bryant Road)

STATE HIGHWAY CODE: County Number 54; County Section Loca Grid: East 01 26, North 06 10

Time Notified: Date: 11-1-70 Hour: 12:42 AM; Arrived At Scene: Date: 11-1-70 Hour: 1:13 AM

Unit 1

Driver: [redacted]

Address: [redacted]

License: [redacted] Operator [ ] Chauffeur [X]

Age: 20 Race: I Sex: M Date of Birth: 1-19-50

Highschool Driver Training: No [X]

Veh. ID No.: [redacted]

Vehicle: 53 Merc. 2dr.

License Plate: [redacted]

Owner's Name: [redacted]

Address: [redacted] Okmulgee, Okla.

Is Veh Operable? No [X]

65 MPH legal speed; 55 MPH before contact; 70 MPH estimated speed at contact; $250.00 estimated damage

Veh. removed to: Henryetta by: [redacted]

Unit 2

(blank)

Injured / Witnesses

No.	Name	Address	Age	Sex	Race	Veh.
1	[redacted]	Above	20	M	I	1
2	[redacted]	[redacted] Tulsa, Okla	22	M	I	1

Injured Taken To:
1. Henryetta Memorial By: [redacted] Time left scene: 12:50 AM Time arrived hospital: 1:00 AM
2. Henryetta Memorial By: [redacted] Time left scene: 12:50 AM Time arrived hospital: 1:45 AM

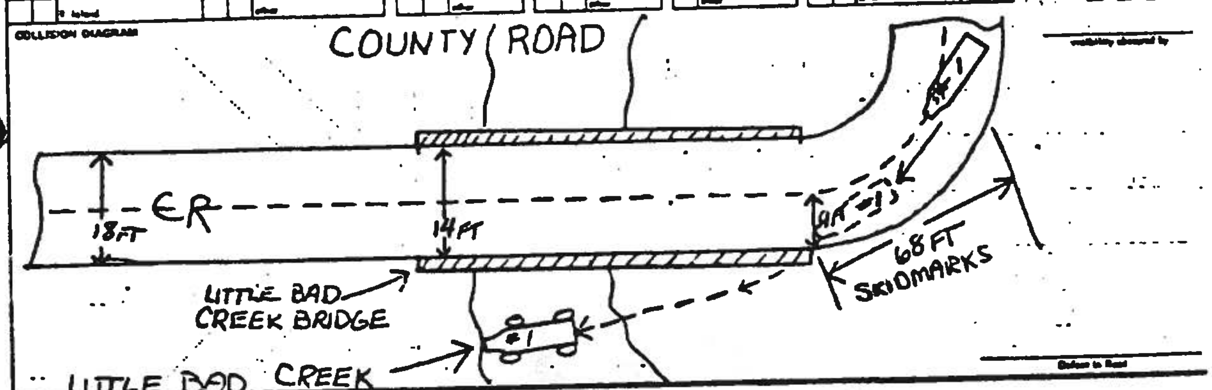
Damage to property other than vehicles: Bridge $35.00 Okfuskee County Address: Court House Okemah

Investigation made at scene: Yes [X]; Investigation completed: Yes [X]; Photos taken: No [X]

Sign here: [redacted] Badge No.: [redacted] District or Division: #2 Approved by: [redacted] Date of report: 11-1-70

B-64

COLLISION DIAGRAM



REMARKS:

Passenger stated he and driver had been drinking. Veh.#1 left 68ft. skidmarks before impact. Veh.#1 left the ground for 85ft. coming to rest on its top in the creek. Veh.#1 was in 3-4ft. of water. Driver pinned in Veh.#1. Approximately 25ft. of bridge rail was torn loose by Veh.#1.

UNSAFE, UNLAWFUL, OR OTHER ACTION

Describe: Driving while under the influence of alcohol

80

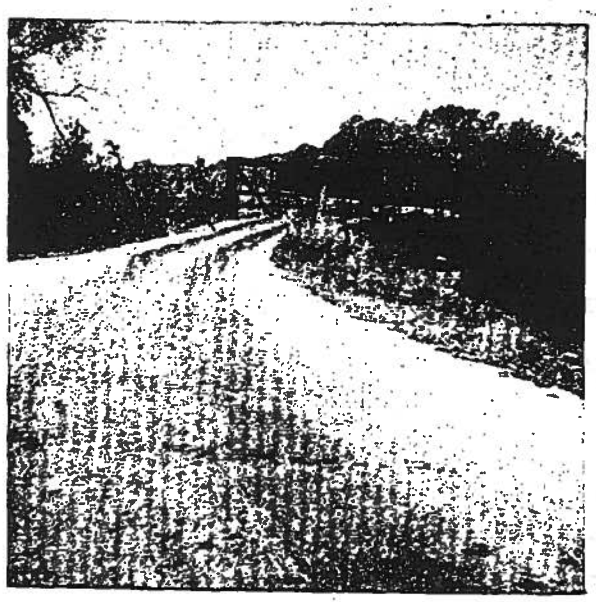


Figure 1. Approach to bridge.

Figure 2. Note missing bridge railing at left.

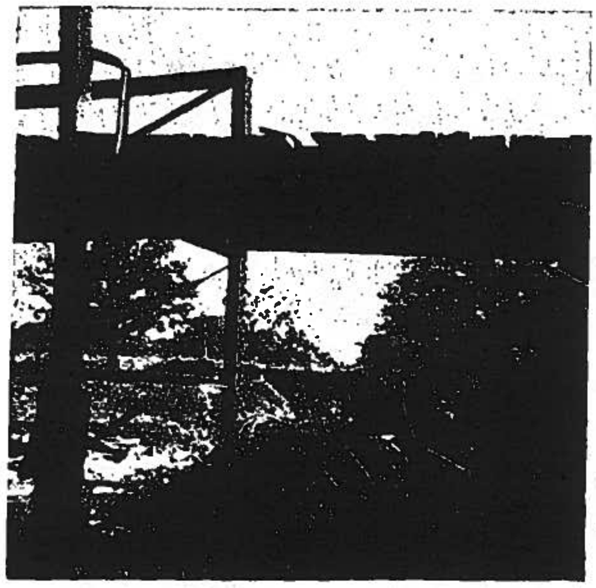


Figure 3. Above and below bridge.

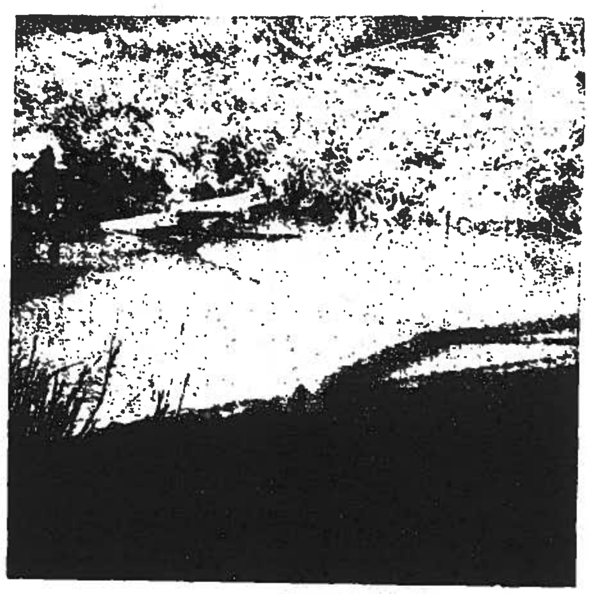


Figure 4. Creek bed where vehicle came to rest on far bank.

Figure 5. Damage to front of vehicle, 1953 Mercury.

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Figure 6. Imprint of impact on radio grille.

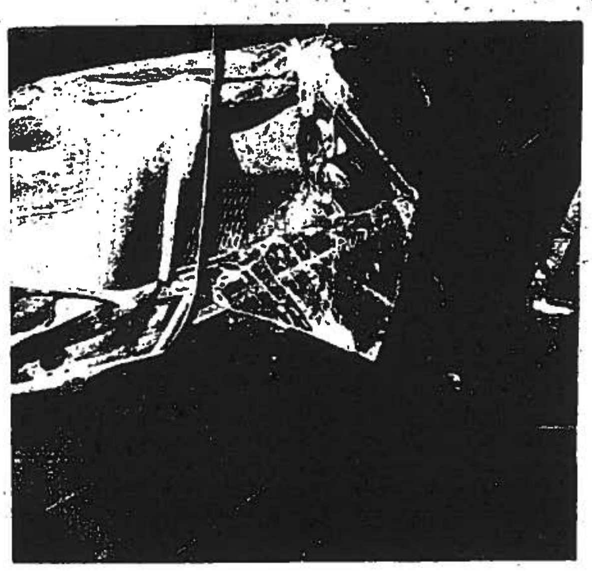
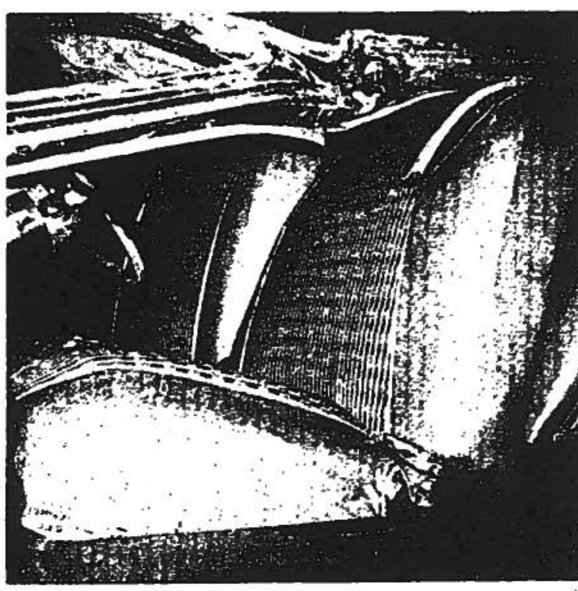


Figure 7. Right side of vehicle.



This page is reproduced at the back of the report by a different reproduction method to provide better detail.

Figure 8. Driver's head and right arm were trapped by collapsed roof.

MOTOR VEHICLE SUBMERGENCE: SUCCESSFUL SURFACE ESCAPE BY SEVEN OCCUPANTS

Case Number 5

A. IDENTIFYING DATA

Location: On private road, 2-1/2 miles east of Konawa, Oklahoma, at boat ramp on Lake Konawa. November 19, 1970 at 7:15 p.m.

Vehicle: 1970 Oldsmobile, Delta 88, 4-door sedan.

B. AMBIENCE

Weather: Clear and dry; darkness, artificial lighting.
Temperature: Air temperature: 60°; water temperature: 45°F
Wind: North, 15 mph.

C. HIGHWAY:

Two-lane road that was formerly country road, ran directly into a lake and a concrete slab had been poured for a boat ramp.

D. TYPE OF ACCIDENT:

Vehicle was traveling down highway at legal speed limit. When driver saw that the road was a dead end into lake, he applied brakes and skidded sixty-three (63) feet. The vehicle planed on the water for 130 feet and sank in ten feet of water.

E. OCCUPANTS:

Male : Age 32, driver, 5'11", 170 pounds.
Male: : Age 16, position 2, 5'9", 145 pounds.
Female: Age 14, position 3, 5'3", 110 pounds.
Female: Age 14, position 4, 5'5", 110 pounds.
Female: Age 14, left position 5, 5'1", 120 pounds.
Male : Age 15, right position 5, 5'7", 120 pounds.
Male : Age 17, position 6, 6'1", 175 pounds.

F. ACCIDENT DESCRIPTION:

The vehicle was proceeding west at 55 mph on a two-lane highway when the driver noted something on the road that first looked like sand. He immediately recognized that the road was covered with water and slammed on the brakes and skidded sixty-three (63) feet where the vehicle entered a lake. The vehicle planed across the water for approximately

130 feet and stopped. The front of the vehicle dropped and began to sink. The four door-windows were rolled down and all seven occupants left the vehicle and swam to shore. The vehicle sank in ten (10) feet of water and came to rest on the roadway, which was covered by the lake.

G. PRE-CRASH FACTORS:

Vehicle Factors - No evidence of pre-crash mechanical malfunction was noted. The vehicle was a 1970 Oldsmobile, Delta 88, 4-door sedan. The gasoline tank was slightly less than half full. There had been no alterations to the factory delivered vehicle and there was nothing which contributed to the normal weight of the vehicle, except the occupants.

Environmental Factors - The accident occurred on a two-lane highway that had formerly been the most desirable route between two rural towns. A creek had been dammed by a private corporation and the lake covered a one mile section of the road. Local residents now take other routes for traveling between the two towns. Where the highway enters the lake, a concrete slab has been poured that enters the water at a 30% angle and this slab is utilized as a boat launching area. There were no signs to indicate that the highway was impassable and no barricades were present. The immediate area of water entry is lighted. The road was dry and there was clear visibility. The temperature was approximately 60 degrees and the water temperature was 45 degrees F. when the accident occurred.

Human Factors - The vehicle contained an adult driver (age 32) and six teenage passengers. The driver had driven this highway prior to the construction of the lake and did not know that the lake had been built.

H. CRASH FACTORS:

Vehicle Factors - The vehicle struck the water at right angles at approximately 40 mph. The vehicle planed across the water for 130 feet, spraying water over the windshield. Water entered through the ventilation system into the front floor board. There were 63 feet of skid marks on the road that extended to the edge of the lake. There was no impact damage to the vehicle. The time from the water's edge until the vehicle stopped was 2-4 seconds.

Human Factors - The occupants were all braced as they entered the water due to the braking procedure. There was a mass confusion and hysteria among all passengers. The driver was calm and took control of the group by the time the vehicle stopped.

I. POST-CRASH FACTORS:

Vehicle Factors - The vehicle came to rest with the front at approximately 30° below horizontal. Water was rushing in through the heater outlet. All four windows were rolled up and three of the four doors were locked. The entire vehicle submerged approximately five minutes after entry into the water. Fifteen minutes post-crash, the headlights and taillights were still visible. Upon recovery, the vehicle was still on the roadway. An air bubble was present that was 2-1/2 feet in diameter and 2" in total depth.

Human Factors - The driver instructed the passengers to roll down the windows and to swim toward the shore. They began to exit approximately eight seconds after the vehicle stopped. They all swam to shore.

J. OPINIONS AND OBSERVATIONS:

1. Warning of the impending danger was not provided and would have prevented this accident.

2. The most expedient escape can be performed prior to submergence of the vehicle (through the side windows).

3. Heavy winter clothing can increase the escape hazard if such clothing is not removed.

4. If vehicle damage is negligible, there is adequate time available for a "surface" escape.

ESCAPE ROUTES UTILIZED BY THE SEVEN OCCUPANTS
(windows)

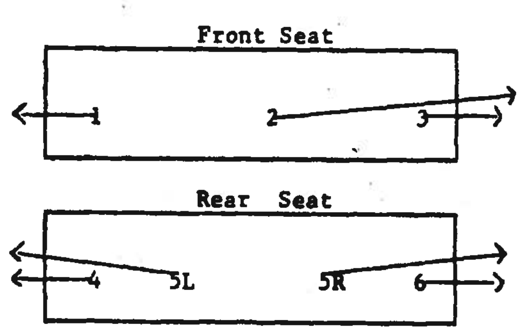


Figure 1. Diagram of escape routes.

OKLAHOMA PRESS
CLIPPING BUREAU
Oklahoma City, Oklahoma

Daily Oklahoman
Oklahoma City, Okla.
184,792

112:-73

DATE:

Group Unhurt After Dunking

KONAWA — Six Holdenville teen-agers and an adult have only sniffles and a bone-chilling experience to recall Friday after getting a sudden dunking when the car in which they were riding plunged into Konawa Lake Thursday.

The teens, all members of the First Baptist Church, were going to Konawa for a church singing session Thursday night and [redacted], 31, a Holdenville plumber, was taking them in his 1970 four-door hardtop. [redacted] traveled along SH-99, then turned onto a county road which had been the road to Konawa, but now ends in the lake.

Around The State

"He thought that was the right road," said [redacted], 16, one of the passengers and son of Highway Patrol Trooper [redacted].

[redacted] said the windows were rolled up on the car when it hit and went under and someone yelled, "Oh my gosh — water." He said the car immediately came to the surface and they rolled down the windows, crawled out and began to swim to shore.

He said all were able to swim and only were in the water about five minutes.

The group was only on shore about three to four minutes when Trooper [redacted] happened to drive up during a routine check for beer drinkers at the lake.

Trooper [redacted] took the chilly group to the Konawa police station where they began trying to dry their clothes. The dunking occurred about 7:30 p.m. and most of the youths were home by 10 p.m.

NOT REPRODUCIBLE

Submission PRIVATE PROPERTY PRIVATE PROPERTY FATALITY · yes ☐

OKLAHOMA

OFFICIAL POLICE TRAFFIC COLLISION REPORT

Reporting Agency: OKLAHOMA HIGHWAY PATROL

No. 0323 0908

Date: 11-19-70 Day of Week: THURSDAY Hour: 7:15 PM County: SEMINOLE

If collision was outside city limits: 2 miles N ☒ S ☐ / 2.5 miles E ☒ W ☐ of nearest city: KONAWA

Total number units involved: 1 No. Injured: No. Killed:

On: PRIVATE ROAD (name or number of street or highway)

At: (name of intersecting road or landmark)

NOT AT INTERSECTION: 1740 ft. West ☒ of COUNTY ROAD (show nearest intersecting street or highway)

STATE HIGHWAY CODE — County Number: 67; County Section Line Grid: East 0038, North 0116

Time Notified: Date 11-19-70 Hour 7:18 PM

Arrived At Scene: Date 11-19-70 Hour 7:18 PM

Unit 1

Driver: [redacted]

Address: [redacted] HOLDENVILLE, OKLA [redacted]

License: [redacted] Chauffeur ☒

Age: 32 Race: W Sex: M Date of Birth: 10-12-38

Highschool Driver Training: No ☒

Veh. ID No: [redacted]

Vehicle: 70 OLDS DELTA 88 4D S.{

License Plate: [redacted]

Lap belt: Yes ☒ Shoulder belt: Yes ☒

Owner's Name: SAME

Is Veh. Operable? No ☒

Legal speed: 55 MPH; Before contact: 50-55 MPH; At contact: 45-50 MPH; Estimated damage: $ 4500.00

Veh. removed to: OKLA CITY by: BROWNS WRECKER

Unit 2

(blank)

Injured / Witnesses

(blank)

Pedestrians / Injured Taken To

(blank)

Investigation made at scene? Yes ☒

Investigation completed? Yes ☒

Operator's report given to driver: Veh 1 ☒

Photos taken? No ☒

Chemical test: Driver #1 — ☒

Hit & Run: ☒

Sign Here: Trooper [redacted] (officer's name & number)

Badge No.: [redacted] District or Division: 2 Approved by: [redacted] Date of report: 11-22-70

B-74

NOT REPRODUCIBLE

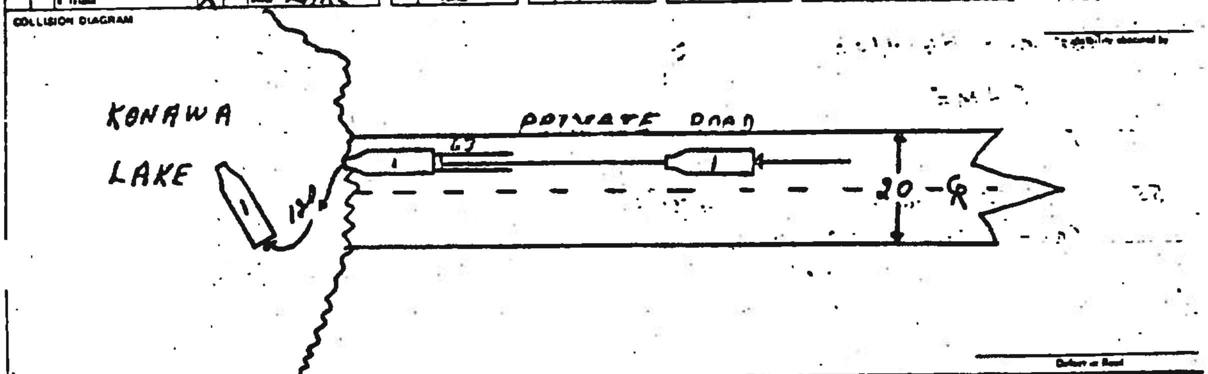
WHAT VEHICLES WERE GOING TO DO | WHAT VEHICLES DID | TYPE OF ROAD | TRAFFIC CONTROL | ROAD CHARACTER | CONDITION OF DRIVERS AND PEDESTRIANS

POINT OF FIRST CONTACT ON VEHICLES | LIGHT | WEATHER | WHAT PEDESTRIAN WAS DOING

OBJECT STRUCK BY VEHICLE OR LOAD ON FIRST CONTACT — Other highway object: LAKE

ROAD CONDITION | ROAD SURFACE | LOCALITY | VEHICLE CONDITION

COLLISION DIAGRAM



REMARKS

THE DRIVER, UNAWARE THAT THE ROADWAY CAME TO A DEAD END AT THE LAKE EDGE, SAW THE WATER TOOLATE TO STOP. VEHICLE TRAVELED APPROXIMATELY 120 FEET INTO THE LAKE BEFORE STOPPING AND SINKING. VEHICLE SETTLED IN APPROXIMATELY 12 TO 15 FEET OF WATER. LAKE AND ROAD OWNED BY OKLA GAS AND ELECTRIC COMPANY. LAKE EDGE APPROXIMATELY 1740 FEET WEST OF COUNTY ROAD

UNSAFE, UNLAWFUL, OR OTHER ACTION

Unit 1	Unit 2	Describe	Unit 1	Unit 2	Describe
		1 Failed to Yield			10 Improper Overtaking
		2 Followed too Closely			11 Improper Parking
		3 Unsafe Speed			12 Inattention
		4 Made Improper Turn			13 Wrong way on –
		5 Changed Lanes Unsafely			14 Improper Start from –
		6 Stopped in Traffic Lane			15 Other Improper Act or Movement
		7 Failed to Stop	X		16 Not Known – or – No Improper Action
		8 Unsafe Vehicle			17 Other Action – not directly related to –
		9 Left of Center			18 Pedestrian Action

INTERVIEW WITH FIVE VEHICLE OCCUPANTS

ONE WEEK FOLLOWING THE ACCIDENT

Driver's account

We were traveling from Holdenville to Konawa. We were east of Konawa on what was State Highway 99. As we crested the hill there was a slight incline, I should say decline, and after we crested the hill some 1000 feet or so at the end of this slight decline there was another break and on making this break it was evident that there was something on the roadway. The first impression to me was it was sandy because you could see the ripples and waves and as it turned out, waves weren't apparently sand on the road. This was on the reservoir for, I would estimate, approximately 150 feet away; of course, when I observed this, I immediately began to brake the automobile. We did skid 63 feet before we made contact with the water. The decline was very slight as we approached the water so we actually made contact with the water almost on a level path. Upon contact there was no change in the deceleration of the vehicle, no impressive change, and it did seem to plane out on top of the water for a good part of the distance we traveled, which was approximately 130 to 140 feet. Of course at the end of the travel the automobile as it decreased in speed, of course, the planing action also decreased. It went down and settled in the water. At this point the water level on the automobile was approximately 8-10 inches below the front corner of the windows. The attitude of the car I would estimate to be around 10-15 degrees lower in the front that it was in the rear. It was on the same alignment that we came to rest in the water that it was during this travel. It remained straight throughout the travel; so there was no particular change here that was evident. As the car settled in the water, of course, there was some confusion among my passengers as to just exactly what happened. It only took a moment when water started coming in through the fire wall or through the vents, holes in the fire wall at our feet and I could hear rushing water, of course, coming in. What we had to do was quite evident. Observing the fact the water was low on the automobile, as it was, it seemed to me best to evacuate it at that time. I told the people with me that we were going to have to swim and that we would leave the car through the windows. They all rolled the windows down which were all operable at this time; of course, we immediately left the automobile. I did have six passengers with me, myself and two in the front seat and four in the rear seat. The car was a four-door sedan, so the windows were fairly large, or nearly as large as any vehicle on the market, I suppose. There wasn't any difficulty getting out of these windows as far as I observed. When I left the automobile, of course, on the driver's side, front window, I stayed at that position holding to the car on the outside until all the passengers had gotten out. As soon as they were all out of the automobile I began to swim back in the exact same path the car had traveled. I very shortly overtook one of my passengers, who was sitting in the front seat. She had gone to the rear of the car and then somehow she had swum across behind the car and was directly in my path. She was the furtherest behind at this point so I took her by the collar (back of the collar) and together we swam where she could stand. We passed another one of the youngsters, (5a), I believe. We passed her and tried to hold up for her but she began to swim more slowly as the time elapsed and I had to return for her and I did return. She was still up and keeping her head out of the water. I returned approximately, I guess, 50 feet and helped her swim to safety. Throughout this time the automobile was still afloat; however, I noticed the automobile had gone down a good deal. I would guess that it was approximately three to four minutes by the time we got completely out of the water and at this time the automobile was still afloat. The tail lights were visible above the water line as well as the entire back window. The attitude of the car at this time I would estimate was approximately 30-45 degrees, somewhere in this vicinity. Now, I believe that the front of the automobile at this time was resting on the bottom due to the knowledge that I have now learned as of the exact depth of the water. The water was very cold. There was a north wind blowing I would estimate somewhere around 15 miles per hour; rather gusty north wind or rather northwest wind. After we left the water, of course, there was some hysteria that tried to develop but we settled that rather quickly through some loud words. They listened real good and settled down. At this time we started back up the highway because there was a house approximately less than a quarter of a mile back up the road. We met a highway patrolman when we were a couple hundred feet up the highway. At this time the car was still afloat, the rear of it was like it had gone down very little from the time we left the car, approximately the same position. However, the rear end of the car was swinging to the south at the time the patrolman arrived which would have been estimated five to six minutes, I suppose, when he arrived. But the rear end was still afloat, floating south. It continued to float throughout the conversation. As we were talking to the highway patrolman, which lasted approximately five minutes, the automobile was (the rear of it) still afloat. It was sinking very slowly. After I completed my conversation with the highway patrolman and he was rather slow to invite us in the automobile, consequently I was rather short tempered; I went to the first house back up the road to make a phone call and to see if I could find a dry warm coat. I was glad at the time that I had on a long sleeve shirt, a rather snug fitting shirt; and a pair of trousers that were also rather snug fitting. I don't believe any of the passengers removed any of their clothing until after they left the automobile. One girl at that time swam out of her coat and the two girls that I assisted still have their coats on. Perhaps I let them all down, not instructing them to remove some of these heavier garments but I failed to do so. This is about all I can think of, off hand, other than it took about approximately fifteen minutes when I went to the house and returned. When I returned the automobile was going out of sight. It was approximately fifteen minutes before it was completely submerged.

Q. You said that you had come back and checked the depth of the water. Do you know what the depth of the water was?

A. It was right at ten feet. I did make the recovery of the automobile myself. I've done some diving, a considerable amount, so it was approximately ten feet; this would be within inches of the correct depth. I didn't measure it as such but I do know that it was very close to ten feet.

Q. Some people did lose their coats in the water, but were all the people wearing them when they escaped from the car?

A. No, (6) was not wearing a coat and I wasn't wearing a coat. The rest of the people were wearing a coat. (2), wearing a sports coat, a light sports coat, I believe, it was cotton. The girls were all wearing, rather, two of them were wearing heavy coats. They were heavy pile coats. (4), however, was wearing a suede, cotton suede coat.

Q. The other two were wearing heavy coats?

A. Yes, they were wearing heavy long coats.

Q. (4), you were wearing a skirt, I suppose?

A. No.

Q. Describe your clothing for us.

A. It was a dress, with heels, with a cotton suede coat.

Q. (5a), what did you have on?

A. I had on a dress, with heels and my coat was furry topped. It had long hair and was long in length.

Q. Was the coat to knee length or shorter than this?

A. It was about knee length; with a short skirt.

Q. How long was your coat, (4)?

A Knee length.

Q. Were either of you wearing a scarf or anything like this?

A. No.

Q. Did you have handbags?

A. Yes, they were left in the car.

Q. (2), what were you wearing?

A. I just had on a sports coat, turtle neck shirt, slacks and dress shoes.

Q. (6)?

A. I had on a pair of slacks, short sleeve shirt, tie, dress shoes; that's about it.

Q. Can anybody remember what the other two had on, approximately?

A. (5b) had on a pair of bell bottoms, I believe, with a short sleeve shirt, with a pair of dress shoes, rather, tennis shoes.

Q. Was he wearing a coat?

A. No. (3) was wearing a shirt which was short; her coat was knee length and this was a long hair coat.

Q. Is she the one that was swimming out of her coat?

A. Yes and she also had on heels. She swam out of it almost immediately after she left the automobile within fifteen feet.

Q. Do you know if she removed her coat purposely?

A. No, she said she actually just swam out of it. It just came off, actually, as she made a natural stroke around her arms slipped out of the coat.

Q. Let's get the order in which you left the car. According to XXX's estimation in the first interview here, (1), you went out the left front window. Were you the first one out?

A. At the time I went out, there were three others going out upon the order to leave the car. It took place then; everyone began to leave at once. The first three seconds there was a person in each window.

Q. (1), would be going out; (4) you were next to a window, were you the first one out the other window on the left side?

A. Yes.

Q. (5b) followed (4) out?

A. (4) was on the back seat of the driver's side, then (5a) went out behind her.

Q. (5a), you followed (4) out?

A. Yes.

Q. The other side, (3) went out before (2).

A. Yes.

Q. (6), you were next to the right rear?

A. Yes, I went out first.

Q. Then (5b)? Did anybody assist anybody else that you can recall, other than (1) assisting?

A. No.

Q. Who in here considers themselves to be a good swimmer?

A. I can swim pretty good, but it sure seemed like a long ways to the bank! (6 stated this).

Q. Were you feeling any particular muscle cramp by the time you got to the shore? Tell me again, how far you think the car was from the shore?

A. It was approximately 130 to 140 feet. There was a preliminary guess on this which was a few feet closer than this.

I guessed it to have been around 120-125 feet. Upon recovery, of course at daylight, it was made a more accurate guess.

Q. Did you say the water temperature was about forty degrees, (1)?

A. I believe the temperature we took the following week was around 45 degrees but I'm not certain. Maybe I said 40, I don't have that figure with me.

Q. Was that based on the light?

A. Yes, I think I saw 47 degrees at one time. I don't think in a week the temperature would change that much. The weather was approximately the same as it had been.

Q. (5a), do you consider yourself a good swimmer or just getting by?

A. I can swim but I'm not a very good one at that.

Q. Did you feel you had any cramps?

A. No.

Q. (4), do you consider yourself a good swimmer?

A. No.

Q. How about you, (6)? Do you participate in any competition or anything like this?

A. No, no competition.

Q. Do you have your life saving certificate?

A. Scout life guard.

Q. Had any of you reached your limit of capability in swimming back to shore? Were you at the point of physical exhaustion? Would you have been able to continue another thirty to forty feet?

A. It was cold out! I don't think so.

Q. Did anyone know how well (5b) swims?

A. He can swim.

Q. Nobody was about to sink? Was the bank such an inclination that you could stand up some time before you reached the shore?

A. It drops gradually for about ten feet and then drops off fairly rapidly. You could get your head out of the water, I would say around fifteen to twenty feet from the shore where you could stand up.

Q. So you swam over 150 feet?

A. Yes.

Q. Was it (5a) you had to go back and assist?

A. Yes, the best I recall, she had almost ceased to travel but was keeping her head up. She was traveling slightly at this point. She was decreasing her travel.

Q. How much light did you have that night? Was it reasonable?

A. It was cloudy that evening the best I recall, at least partly cloudy. There was a recreation area which had picnic tables and things of this nature that was south of the roadway. As this was being used as a boat mark area. There were some bright lights. The lighting was--

Q. Could you spot all the people?

A. Oh yes, I could see all of them throughout the entire procedure.

Q. You had no trouble seeing the shore?

A. No, no trouble.

Q. When you started swimming, did you swim as fast as you could?

A. Yes.

Q. You skidded sixty-three feet. Can you make an estimate of how fast you were going into the water?

A. I estimated approximately forty miles per hour. I was traveling the speed limit when I applied the brakes, after sixty-three feet of skid on.

Q. You skidded sixty-three feet. Speed limit was 55 mph? He said where you skidded, where your skid marks were, was some gravel.

A. There was gravel where the boat launches were. The vehicle carried some gravel from the shoulder out on the pavement.

Q. You said you didn't go into a lock brake skid?

A. No, I don't believe they were completely locked because the car didn't give any indication of skidding sideways, so I figured it was maximum braking.

Q. You said you started to brake at 150 feet?

A. No. I said somewhere between 100-150 feet. This was the point which was evident that there was something on the roadway.

Q. You had some previous familiarity with this road didn't you?

A. In years past I have traveled this road frequently, years past, before the lake was built.

Q. How long ago was this?

A. This has been about ten years when I did some lease work in this area.

Q. Was anybody wearing seat belts?

A. Not to my knowledge.

Q. Do any of you feel that the impact of the water seemed like the car must have planed across the water? Do any of you feel like you were pitched forward at any time?

A. A little bit. We didn't hit the dash or anything like that.

Q. You were sort of braced?

A. Yes, guess so. I didn't realize what it was until I got out.

Q. What kind of car was this again?

A. 1970 model Delta 88, four-door sedan.

Q. You have never had any experience or trouble with the door or windows sealing? What I mean is wind noise or water leaks?

A. The car I would say was reasonably tight.

Q. Did it have power windows?

A. No, it did not. It was manually operated.

Q. Did any of you sustain any bruises or scrapes?

A (4). I had one little bitty bruise.

Q. Do you think you rolled the windows all the way down or part way?

A (1). All the way.

Q. Did anybody try the door?

A (1). No.

Q. You were riding with the doors locked?

A (6). Back doors were locked because we were fighting and cutting up.

Q. All three doors were locked except for the driver's side?

A. I suppose this is correct.

Q. Do the front doors open locked from the inside of your car?

A. No.

Q. Have any of you passengers ridden in this car before this time?

A. No.

Q. Did it take you some time to locate the window cranks?

A. No.

Q. Did it feel hard to crank the windows open?

A. No.

Q. Do any of you remember the sensation of the whole car as it plunged into the water?

A. I did at first. I thought it went under. I guess because the water went over the windshield. There was a great amount of spray of course and without the windshield wipers on your vision is completely obscured. You can't tell if there is a quarter of inch on the windshield or just how much.

Q. Were your air vents open?

A. I believe I had the ventilation system and fresh air vent on, however, it hadn't passed through the heater in this position. It did not have the ventilation as I determined later. They were not present.

Q. Did you remember turning on the interior lights?

A. No, I did not because the dash lights were still on.

Q. How about the horn, did it start to blow. Does anybody remember?

A. It did not. The lights were on in the automobile and the switch was still on in this position when I recovered it. I left the lights on and I didn't think about the lights being in any position particularly because we did have enough illumination to see. It just didn't seem to be any point in thinking about the lights being on off since we didn't need the lights.

Q. In the testing, we did have four men who knew what they were supposed to do. We lowered the car into the water and waited for it to start to float and then gave them the signal to escape, a siren that we used. It still took them about fifteen seconds to get out.. Mr. XXX who was down the other day talking with you reported that you stated everybody got out of the car in ten seconds. Do you still think that if I put your car out there today and had a set way to get out and you could dive out anyway you wanted to go, do you still think you could get out in ten seconds?

A. I believe they could get out in less than fifteen seconds. I believe it would be around ten seconds. Of course if something like that happens you are more scared. We didn't know if we were going to get out or not!

Q. Do any of you remember getting confused or tangled or anything of this sort?

A. We didn't have any trouble.

Q. Let's take this one at a time. (3) you went out the right front window first. Does anybody remember how she went out?

A (1). She went out kind of sideways.

Q. (2)?

A (2). I dived out.

Q. Then you dived out more or less, just straight into it. What I am trying to figure out is if you pulled yourself through the windows or pushed off?

A (2). I pushed off.

Q. (4)?

A (4). I went out the left window and pushed myself out with my hands.

Q. (5a)?

A (5a). I went out head first. I don't remember keeping a hold of the door handle or what.

Q. Did any of you notice any particular urgency behind you in getting out?

A. Yes, there was some.

Q. How many have had driver's training or are now in it?

A. Two.

Q. Had you had any discussion or instruction or talk in the driver's training classes about possible need to ever get out of the car?

A. Not like that.

Q. I know sometimes they give literature which tells you about things like this.

A (2). Our coach told us about two weeks before how to get out in this type of situation.

Q. How did he tell you to go about it?

A (2). To go through the windows.

A (1). Yes, I've seen something like that too.

Q. (1) you might want to tell us where you picked this up.

A. Well, I saw a film on water except I believe this was around ten years ago. This piece of film I saw was where it was completely submerged and rested under water. It showed people getting out where they used the air bubble on top, of course, and then made their exit.

Q. What is your opinion of their advice?

A. In my opinion it was very poor advice because probably it would have been fatal for some people. The number of people in my car, I am sure that if we had gone completely under it would have been bad. Of course the person's natural reaction is to fight for all the air he can get. I can see perhaps where this would be conceivable had you been involved in a wreck, disoriented. This would have allowed you a few minutes where you could get yourself together and size up the situation.

Q. We were guessing maybe what had happened, that after that first plunge, water filled up the vents and then it just ran out quickly or something; then maybe it slowed down and stopped.

A. I don't believe so, because you could hear--it's what--as you say--a gravity flow. It was pressurized, of course, due to the fact that the water was entering below the water level.

Q. Of course the thing to me, I suspect this car could have an inspection plate over this, I don't know, the transmission or some other opening other than the vent.

A. I don't believe it was coming in--is it impossible now and you probably examined this, I don't know, this type of vehicle, but is it not possible for water to come through this ventilation system?

Q. It's suppose to be around the top of the cowl.

A. How about the joints?

Q. They aren't that type. It could have come around the front corner of the door and you thought it was coming from the fire wall. You didn't notice one way or the other whether it was coming around the door?

A. The sound of the water, I don't remember feeling the water but I recall hearing it distinctly. It sounded to me like it was coming through this ventilation system which dumps its air in the floor, near the floor; near the center of the car. I believe this is the way the water was entering.

Q. On the rear doors there is a vent on the backside where the door sets, in other words, in the door frame itself, there is a kind of plastic vent, so big. Had you happened to have noticed that?

A. When the door is opened, is it visible in the jam?

Q. Yes, it is.

A. I didn't know this was a vent. I thought it was a noise insulator between the door.

Q. I didn't see the car. Describing it as it appeared to be a vent of some sort. I just thought it had a flow-through ventilation or something like that.

A. Was this vent you are talking about visible from the inside?

Q. When you open the door, which is on the latch side of the door.

A. I remember seeing just a rubber pad.

Q. Yeah, it's just a rubber pad. Some of the cars have their ventilation discharged along the side of the car. And there's nothing, no little grill or anything along the side?

A. There is along the dash. One on the extreme right and one on the extreme left. All ventilation must come through your heating-air conditioning system.

Q. Then it is very hard for you to imagine that it came from somewhere else other than the center of your fire wall?

A. It was coming straight in. It wasn't an extremely large amount of water. I don't know, from what I heard, of course, it was more something you hear. It couldn't have been over a gallon a second. I'm sure it couldn't have been any greater quantity than that. It wasn't a large flow of water.

Q. You do believe that the front end of the car had already gone below the water by the time everybody got to the bank?

A. Oh, yes. I guess, of course, I was primarily watching the passengers as we were progressing to the shore, observing them. I would venture to say that the car went down to the point that the water entered the windows somewhere around probably a minute after we left the car--forty-five seconds to a minute, after it came to rest.

Q. Do any of you recall a lot of air bubbles being driven out of the car, from the trunk, or the exhaust? Could you see a bit of air coming out after you looked at it from the shore?

A. You couldn't hardly see anything! You could tell that there was not; had there been air coming out, there would have been something there you could see.

Q. No turbulence or anything like that?

A. There was no turbulence.

Q. It must have been a very tight trunk!

A. I believe the water that entered the trunk originally, probably entered through the interior of the car until it reached the attitude of water.

Q. When you returned or recovered the car, there was nothing wrong with the trunk seal, lights; it didn't pop the tail lights or anything like this?

A. No, they were all still intact.

Q. Was there any deformation of the body of the car?

A. None that was visible.

Q. Have you opened the trunk of your car since?

A. Yes I did. It opened and closed with normal ease immediately upon recovery. I opened it and removed my personal things out of it for the insurance company. I had little or no weight at all in it. I had a couple of stadium seats and two blankets, I think.

Q. What would you estimate on how much gas you had in your tank?

A. I had slightly less than half a tank of fuel left.

Q. What are the weights and heights of the passengers?

A. The driver is 5'11" and 170 pounds; (2), 145 pounds, 5'9"; (6) 5'11" and 170 pounds; (5a), 5'1" at 105 pounds; (4), 5'5" and 110 pounds; (4), 5'3" and 110 pounds; (5b), 5'7" at 140 pounds; and (3) 6'1" at 175 pounds.

Q. Were you all frightened or were you starting to the point of panic?

A. We were all scared.

Q. (1) said you were pretty excited and noisy when you first went in.

A. I think we were fighting when we first went in.

A. When we first went in we were fighting and trying to get everybody's girlfriend.

Q. How much had you all been drinking when you went in?

A. Point zero!!

Q. No drugs of any kind?

A. No.

Q. Anybody on medication of any kind?

A. I was. I went to the doctor for my hayfever.

Q. Do you know what it was he gave you?

A. It was just a prescription for my hayfever.

Q. Nobody was asleep?

A. No.

Q. Do you have the ages of each of you?

A. (5a), 14; (4), 14: (2), 16; (6), 17; (3), 14; (5b), 15; (1), 32.

Q. You might mention to the group what you found when you dived in terms of the position of the car as well as the air bubble you observed on the inside and about how long after the submergence it was.

A. Let's see, we submerged the car that night before, it was a little after seven and I recovered the automobile around 3:30 the following evening. The car was in the water for approximately or a little less than eight hours. The automobile was almost parallel with the shore line. It turned approximately eighty degrees. The rear of the automobile, I feel, was to the wind upon it and swung to the south. Apparently had settled straight down and hadn't moved, I don't believe. I felt that this water being approximately ten feet deep, the front end of the automobile came to rest. Pretty shortly after, it went into the water and sank. It didn't make a descent in the water.

I know it was. All windows were still open. Attaching the line onto it, I observed the wheels of course, due to the fact that we were towing the rear end of it back toward the shore and straightened it up. This was my choice, at least before; however, I did notice a bubble in the top of the car but it was still there, but it was very small, probably not over, I would say, two and a half feet in diameter, which was a very small thin air bubble on top of the car. There was very little of it visible.

Q. Can you give us an estimate of the elapsed time between coming to rest in the water--the sequence of the events and what the passengers of the automobile went through until the time you could no longer see it in the water?

A. The time we entered the water until the time the car contacted the water until it stopped its travel, I would say it was around two seconds approximately. Perhaps a little bit longer than this. After the whole body was stopped, the car approximately standing still, until the time we started to evacuate the car I would say approximately eight seconds. We weren't on bottom because we could feel a slight bobbing action of the car as it came back up to a balanced point. As we already discussed, I would say we left the car within ten seconds period before we looked over the situation.

Q. Then the time the car actually started in the water to the edge of the lake, until you were all out of the car, it was twenty seconds?

A. Yes, somewhere around this. We were talking earlier about this ten seconds time and the time you had the divers to get out, I actually feel if we should go through this again, I feel it would actually be less than ten seconds.

Q. They were two hundred pounders, of course, and they were coming out of a hard top. Our divers, that is.

A. As soon as we left the vehicle, of course, I stayed around the car approximately three to five seconds after they all evacuated the car.

Q. The clock in the car was apparently stopped at 7:20, although it didn't look like that to me on the film. It looked like 7:40 to me. I thought if we had a stop watch or a stop clock, we could find out. We had a very vague notion.

Q. The clock in the car may not have stopped immediately. Was it electrically operated or electrically wound?

A. I don't know. The clock had a sweep hand on it I believe. If it did then its action would have been slowed so greatly in the water as well as the device that is in it to cause it to keep correct time. It acts on wind resistance. I would venture to say it probably ran for three or four hours and would not keep proper time in the water due to the motor-action in the water.

Q. I guess those things are kept pretty well closed up to keep dust out of it so it may not have gotten any water in it and stopped when the battery ran down.

A. You said it was setting on 7:40?

Q. Yes, that's what it looked like.

A. I don't believe the battery would have operated after twelve hours with the lights on.

Q. That was one thing. After this thing was completely under water could you see the lights on?

A. You would see it below in the water. You would see the tail lights because I remember the car was setting parallel to the bank at this time. You could see a glow from the headlights.

Q. When you went back to recover the car, what kind of underwater surface did it have? Was it soft or muddy?

A. We were still on the highway.

Q. You never drifted off onto the ground?

A. No.

Q. What I am trying to discover is, if the car hit very hard on bottom on the front of the car, or did it sink slowly?

A. I believe it sunk very slowly because we were present during this time and had it struck the bottom with more force, you can clearly hear this type of sound. You would have heard it since we were present during this time, and had been present in the water proceeding to get out.

Q. Is that lake fairly clear compared to Tenkiller?

A. No. It is very muddy compared to other lakes.

Q. Probably like Texoma?

A. Less visibility than Texoma.

Q. How much underwater visibility did you have?

A. Well of course, this is directly related to how deep you are. We could see a little bit, due to the headlights, of course if we had illuminated an area to the north. This is where you could see the illumination. And I passed the first pass I made for the car and had a little bit of difficulty.

Q. If you had not known where the car went down, you would have had more difficulty?

A. No, because I made several passes feeling for the car in the lake as I went into the water and traveled back and forth several times and then of course at one point, I thought I had found it but it was an old bridge underneath. It was a hard object and not attaching mud. I went down and made some sweeps; I used a line with knots tied into it. It is around six feet when you drop the weight and with the line attached, it makes this line taunt either afloat or below. I can put a loop around that line so you can use it as a central point and keep searching at six foot intervals so you can pick the whole thing up and move it to another location. I did this three or four times.

Q. So you didn't immediately locate it.

A. No, but I actually knew it had to be in the area. It was too flat and no slopes in the area. No other slopes on the bottom and very flat. I tried to locate the automobile simply by dropping the rope with the weight attached and tried a weight to the other end of the line, stretching it out and rode the boat in a circle. We set the boat right straight above it.

Q. But you could not see from the surface?

A. No.

Q. You said you were close on the first pass?

A. Yes. I was within three or four feet from the end of the vehicle, because it was still on the roadway and the roadway was visible.

Q. Both sides of the way?

A. Close to the sides of course.

Q. Could we go back for the last time; the last indication you gave use was the complete evaluation of being too close. Could you tell us at that point the attitude of the vehicle and the position inthe water?

A. Everybody was out of the car. It was still approximately the same attitude; however, the front end had lowered some but during this brief time period, it would have been very slight, because at this point, the water had not started going through the windows.

Q. You happened maybe to notice you were holding the window at this time; you did not happen noticing how far down the water was at that time?

A. After I had gotten out?

Q. Yes.

A. Some several inches. There were several inches of space between the water and the window but in the back there were a couple of feet maybe.

Q. Do any of you, particularly the girls, feel that the coats were a hindrance to you in getting out?

A. Not getting out but I think we could have swum better if we didn't have them on.

Q. Did you attempt to take off the coats?

A. Didn't really think about it.

Q. The other girl, (3), I am very interested in. You say she had on a heavy coat and two or three inches of fur. I believe you said you went back and helped her at one time or another?

A. No. These two girls were the only two that I aided. This girl swam out of her coat and I would say she reached the shore probably as soon as any.

Q. You indicated the other day that some of the girl's coats weighed the same, which with the water absorbed would weigh 30 to 35 pounds.

A. I would venture to say that (5a)'s coat would weigh close to 25 pounds. I know this seems like a lot of water, three gallons, somewhere in this vicinity, but her coat was extremely heavy.

Q. (6), did your tie give you any trouble?

A. No.

Q. Nobody had any problems with the shoulder harness falling down into the window?

A. It stayed intact.

Q. Did anything on the automobile get in your way?

A. No.

Q. How much work does the car need before you can drive it again?

A. I don't know. I have never seen it since I recovered it and as far as I am concerned, that's well and good.

Q. A fellow and I went to look at it in Oklahoma City and it was damaged on the inside by the water.

Q. How many of you are enrolled in gymnastics of some kind? Maybe I should say, do any of you get very much physical activity?

A. We all get some type of physical activity.

Q. (1), do you drive frequently?

A. No, not too frequently, especially in this type of weather.

Q. Let me ask you a nonsense question. Say you crashed, not in the water, this time in fire around the automobile and under it. How would you go about escaping?

A. You would have to get out! I guess go through the door as fast as you could before it blows up!

Q. Have any of you been in any serious accidents before?

A. No.

Q. We thank you for coming and appreciate your cooperation here.

Figure 2. Signs installed after the accident.

Figure 3. Submerged vehicle - 1970 Oldsmobile.

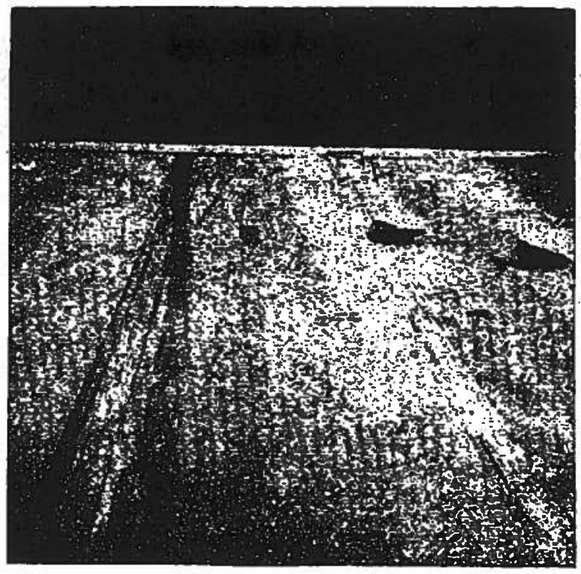


Figure 4. End of road.

Figure 5. View looking toward point of entry showing gentle slope.

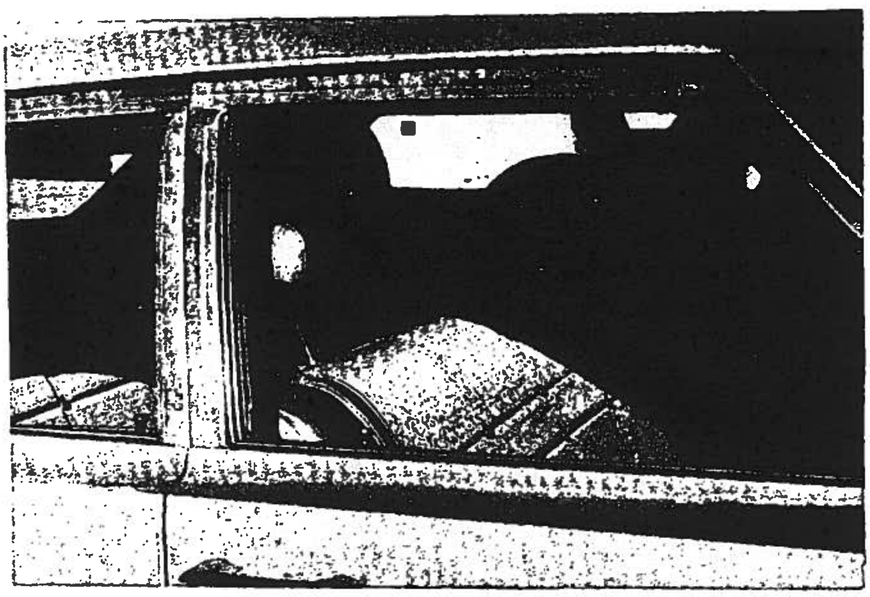


Figure 6. Interior of submerged vehicle.

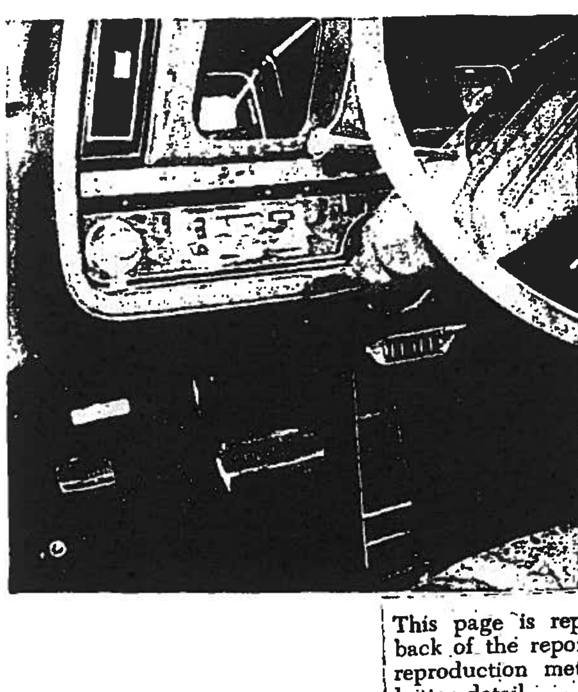


Figure 7. Air vent controls

SUMMARY OF REAR END COLLISION

Case Number 6

A. IDENTIFYING DATA:

Location: Accident occurred on a county road (old U.S. 66), 1.5 miles west of Oklahoma State Highway 58, near Hydro, Oklahoma on February 20, 1971, 12:15 a.m., Saturday, involving two cars.

Vehicles: #1 - 1969 Chevrolet Impala Custom, two-door hardtop, lap belts and shoulder harness present, extensive damage to front. Estimated $2,000 damage.

#2 - 1964 Chevrolet Impala, two-door hardtop, no belts, extensive damage to rear and total fire destruction to interior. Estimated $500.00 damage.

B. AMBIENCE:

Darkness, clear, no precipitation; temperature 30 degrees F., road surface dry.

C. HIGHWAY:

County road, two lane, concrete, no shoulder, lightly traveled rural area, speed limit: 65 mph, day and 55 mph at night.

D. TYPE OF ACCIDENT:

Vehicle #2 was stopped on the highway in the right lane, facing west when vehicle #1 struck #2 in the rear. Vehicle #2 burst into flames and burned. Both vehicles were actually totaled and sold for salvage.

E. OCCUPANTS:

#1 - Driver, 28, male, driver's training, current operator's license, received visable lacerations to the head. No restraints in use.

#2 - Driver, 21, male, driver's training, current operator's license, received second degree burns to face and back of right hand. No restraints available.

#2 - Right front passenger, 24, male, fatally injured. One hundred percent (100%) burns to body. No restraints available.

#2 - Center front passenger, 21, female, fatally injured. 100% burns to body. No restraints available.

F. ACCIDENT DESCRIPTION:

Pre-Crash - Vehicle #1 was proceeding west on this two-lane road at approximately 65 mph when it overtook #2 which was stopped (apparently stalled) on the highway. Vehicle #1 skidded twenty-seven feet before striking #2 directly in the rear. Speed at impact was approximately 50 mph.

Crash - The driver of vehicle #1 impacted the steering wheel, instrument cluster and windshield. The steering wheel column collapsed and center section (horn area) was broken. The instrument cluster was broken and the air conditioner ducts and ash tray were broken loose. This individual's head impacted the windshield causing a visible laceration to the head, which was his only injury except for minor scratches and bruises.

The rear of vehicle #2 was crushed forward and pushed up. The gas tank was forced down where it contacted the pavement and was ruptured. Gasoline was forced through the seat back and saturated the rear seat of the vehicle. The gasoline ignited at or near the time of impact. The front seat back was broken down and came to rest on the rear seat bench.

The driver of vehicle #2 held on to the steering wheel bending it back four inches on each side. He remained in the front seat after impact.

The two passengers of vehicle #2 were forced into the rear seat along with the front seat back at impact. These two passengers were engulfed with flames at or near the time of impact.

Post-crash - Vehicle #2 came to rest on the highway 37 feet from the point of impact. Vehicle #1 traveled approximately 35 feet and came to rest in the ditch parallel to vehicle #2.

The driver of vehicle #1 escaped from his vehicle suffering from minor shock.

All three occupants of vehicle #2 remained conscious after the crash. They suffered no injuries at impact. The two passengers were burning before the vehicle came to rest, at which time the driver burned his hand reaching across the front seat to open the right door. Flames were reaching into the front seat at this time. The driver escaped with second degree burns. The two passengers were unable to move from their positions at impact.

G. OPINIONS AND OBSERVATIONS:

1. The driver of vehicle #1 had been drinking all evening and was extremely intoxicated.

2. The three occupants of vehicle #2 had been drinking and had beer in the vehicle.

CASE # 6

SOURCES OF DATA FOR: EPIDEMIOLOGICAL ANALYSIS

1. Accident Report [X]

Report Number 10510475
Date 2-20-71

2. Newspaper Accounts [X]

3. Death Certificates [X]

Certificate Number(s)________

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4. Interviews: [X]

(a) Investigating Officer [X]

(b) Occupant(s) Vehicle #1:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(c) Occupant(s) Vehicle #2:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(d) Occupant(s) Vehicle #3:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

---

5. Hospital Records: [ ]

(e) Special Accident Investigator: [ ]

(f) Eye Witness(es): [ ] No.____

(g) Private Physician(s) [X] No. 2

(h) Newspaper Reporter - or Photographers [ ] No.____

(i) Ambulance Attendant(s) [X] No. 2

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6. Accident Investigation by Staff: [ ]

(j) Fireman [X] No. 3

(k) Embalmer [X]

(l) Family or Friends of Victim(s): [ ] No.____

(m) Wrecker Operator(s) [X] No. 1

(n) Other(s) [ ] Specify____

Burned

FATAL

Sheet 1 of 1 sheets FATALITY • yes ☒

OKLAHOMA 04 OFFICIAL POLICE TRAFFIC COLLISION REPORT

Reporting Agency: HIGHWAY PATROL

1051 0175

Date: FEBRUARY 20, 1971 Day of Week: SATURDAY Hour: 12:15 AM County: CADDO

If collision was outside city limits: HYDRO 1.5 miles W ☒

Total number veh. involved: 2 No. Injured: 2 No. Killed: 2

On: COUNTY ROAD (OLD U.S. #66)

Not at intersection: 1.5 MILE West ☒ of STATE HIGHWAY #58

STATE HIGHWAY CODE — County Number: 08 — County Section Line Grid: 001-0 East, 094-0 North

Time Notified: Date: 2-20-71 Hour: 12:40 AM

Arrival At Scene: Date: 2-20-71 Hour: 1:42 AM

	Unit 1	Unit 2
Driver	[redacted]	Driver ☒ [redacted]
Address	[redacted], WEATHERFORD, OKLAHOMA	[redacted] WEATHERFORD, OKLAHOMA
License	TEXAS [redacted] ☒ Operator	OKLAHOMA RECEIPT [redacted] ☒ Operator
Age / Race / Sex / Date of Birth	28 W M 12-29-42	21 W M 4-23-49
Highschool Driver Training	☒ Yes	☒ Yes
Veh ID No	[redacted]	[redacted]
Vehicle	1968 CHEVROLET 2DR. S.	1964 CHEVROLET 2 DR. S.
License Plate	[redacted]	[redacted]
Owner's Name	DRIVER	DRIVER
Address	SAME	SAME
Legal speed / before contact / at contact	55 MPH / 65 MPH / 50 MPH	55 MPH / 0 MPH / 0 MPH
Is Veh Operable?	No ☒	
Estimated damage	$2000.00	$560.00
Veh removed to / by	WEATHERFORD by SKEETER WRECKER	WEATHERFORD by BUD'S WRECKER

INJURED / WITNESSES

No.	Name	Address	Age	Sex	Race	Position in vehicle
1	[redacted] (KILLED)	BLAKWELL OKLA. [redacted]	1	F	W 2	
2	[redacted] (KILLED)	[redacted] WEATHERFORD OKLA.	24	M	W 2	
3	[redacted]	DRIVER - VEHICLE #2	21	M	W 2	
4	[redacted]	DRIVER - VEHICLE #1	22	M	W 1	

Injured Taken To: 1. #1 AND #2 LOCKSTONE FUNERAL HOME by WEATHERFORD AMBULANCE

2. #3 AND #4 WEATHERFORD HOSPITAL by WEATHERFORD AMBULANCE

Time left scene: UNKNOWN — Time arrived: UNKNOWN

Breathalyzer made at scene? Yes ☒ — Breathalyzer completed? Yes ☒ — Operator's report given to driver: Veh 1 ☒ — Photos taken? No ☒

Chemical test: Driver of 1 — X; Driver #2 — X; Hit & Run — No X

Name: 1. [redacted] — Citation: CARELESS DRIVING 11-901 — Citation No: A623485

Sign here: [redacted] (officer's name & rank) — Badge No. [redacted] — Number of Division: 4 — Approved by: [redacted] — Date of report: 2-20-71

B-107

WHAT VEHICLE WAS DOING: 1 Go ahead (X)

WHAT VEHICLE DID: 1 Went ahead (X, Unit 1); 5 Stopped (X, Unit 2)

TYPE OF ROAD: Two lanes (X X)

TRAFFIC CONTROL: No control (X X)

ROAD CHARACTER: 1 Straight-level (X X)

CONDITION OF DRIVERS AND PEDESTRIANS: 3 Odor of alcoholic beverage (X); 7 Condition not known (X)

POINT OF FIRST CONTACT ON VEHICLES: 1 Front-center (X); 4 Rear-center (X)

LIGHT: 2 Darkness (X)

WEATHER: 1 Clear (X)

WHAT PEDESTRIAN WAS DOING

OBJECT STRUCK BY VEHICLE OR LOAD ON FIRST CONTACT

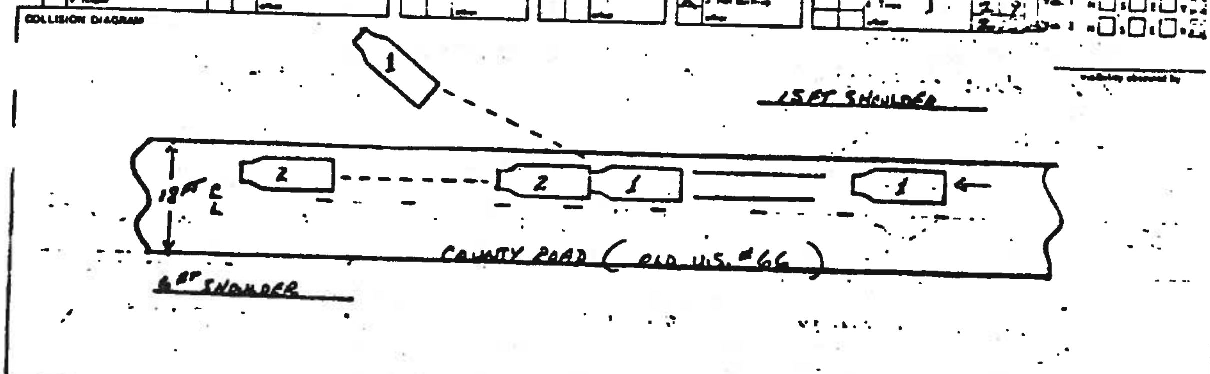
ROAD CONDITION: 1 Dry (X X)

ROAD SURFACE: 1 Concrete (X X)

LOCALITY: 5 Not built-up (X)

VEHICLE CONDITION: 1 Apparently normal (X X)

COLLISION DIAGRAM



REMARKS (Refer to vehicles by number)

VEHICLE #2 STALLED IN THE WESTBOUND LANE OF THE ROAD. VEHICLE #1 APPROACHED FROM THE REAR, SKIDDED APPROXIMATELY 22 FEET AND STRUCK VEHICLE #2 FOUR FEET NORTH OF THE CENTER LINE.

UNSAFE, UNLAWFUL, OR OTHER ACTION

3 Unsafe Speed (X) — OVER SPEED LIMIT

15 Not Known — or — No Improper Action (X)

18

TWO WRECKER drivers try to extinguish flames in this burning auto near Hydro early Saturday morning after the car was struck from the rear by another car, causing it to burst into flames. Two Southwestern State College students burned to death in the car and another was severely burned. (Photo by [redacted])

Two students burn to death

By [redacted]

A car carrying three Southwestern State College students stalled on old U.S. 66 a mile and a half west of Hydro early Saturday morning and minutes later was rammed from the rear by an auto driven by a Weatherford man.

The impact ruptured the stalled auto's gas tank and the car burst into flames burning two of the students to death and severely burning the third.

The dead were identified as [redacted], 21, of Blackwell, and [redacted], 24, of Weatherford. They were both riding in the front seat of the stalled auto, which was driven by [redacted], 21, of Weatherford.

[redacted] was burned on his face and neck, but was reported in good condition in a Weatherford hospital later Saturday.

The driver of the auto which rammed [redacted]' car, [redacted], 28, of Weatherford, suffered head lacerations and possible chest injuries. He was reported in satisfactory condition in the Weatherford hospital.

Highway Patrolman [redacted], who investigated the accident, cited [redacted] for careless driving.

The two deaths raised the 1971 traffic death toll for Caddo County to five. The death count stood only at one Thursday, but two women were killed in separate accidents Thursday night followed by the two deaths Saturday morning.

In a minor mishap Friday, a car driven by [redacted], 29, of [redacted] Fort Cobb, struck a cow about six miles northwest of Anadarko.

There were no injuries in that accident.

City Coed Killed in Fiery Crash on US 66 Near Hydro

A 1967 graduate of Blackwell high school, [redacted], 21, a student in her senior year at Southwestern State at Weatherford, was fatally injured at 12:15 a.m. Saturday in a two car auto crash, west of Hydro on US 66. She was the daughter of Mr. and Mrs. [redacted], east of Blackwell.

Day, time and place of funeral will be announced by Barr Funeral home.

Also dead in the crash was [redacted] 24, also a student at Southwestern State College, from the Republic of Singapore.

Miss [redacted] and [redacted] were passengers in a 1964 Chevrolet driven by [redacted], 21, of Weatherford, which had apparently stalled on the west bound lane of the highway.

A 1969 Chevrolet driven by [redacted] 28, Weatherford, struck the [redacted] vehicle from behind and the [redacted] Chevrolet burst into flames on impact from a ruptured fuel tank.

Both Miss [redacted] and [redacted] were dead on arrival at Weatherford hospital. [redacted] was taken to Weatherford hospital with head injuries and possible injuries to the chest. [redacted] was also taken to the Weatherford hospital with burns to the face and neck.

The dead were taken to Lockstone Funeral Home at Weatherford.

[redacted] was born April 11, 1949, at Grove City, Pa. and came to Blackwell with her parents about eight years ago. An active student at Blackwell high school, she was a member of the Maroon Highlights staff and was listed on the state and national honor societies.

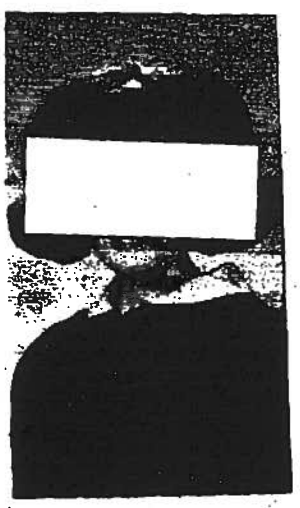
In her senior year, Miss [redacted] was named the [redacted] Homemaker of Tomorrow.

She attended Northwestern State College at Alva, for two years before enrolling in the school of pharmancy at Weatherford. At the beginning of the spring semester there, [redacted] had been initated into Kappa Epsilon, a national professional pharmacy fraternity.

She was a member of the Lutheran Church at Boynton Beach, Fla.

In addition to her parents, she is survived by three sisters, Mrs. [redacted] of Arkansas City, Kans.; Mrs. [redacted], East

(Continued On Page 3)



Quogue, N.Y.; Miss [redacted], a student at Oklahoma State University at Stillwater; an aunt and uncle living in Pennsylvania and four nieces.

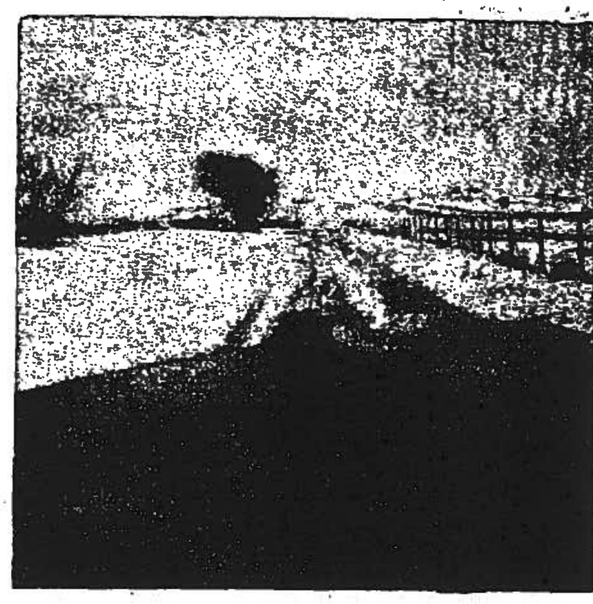


Figure 1. Scene of accident.

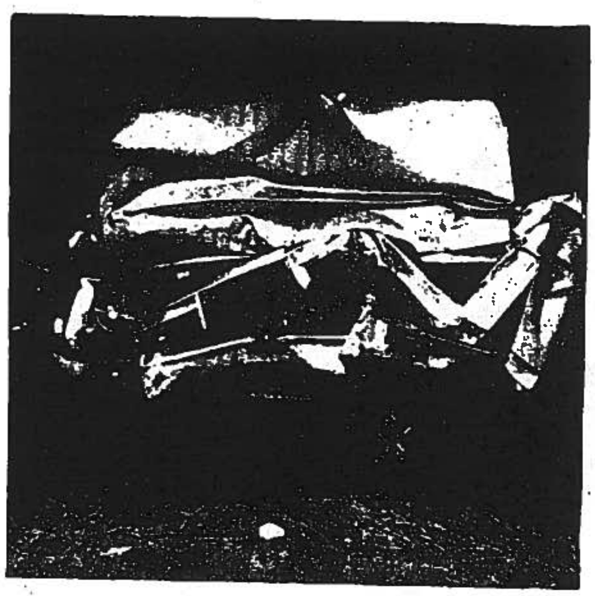


Figure 2. Vehicle #1, 1969 Chevrolet.

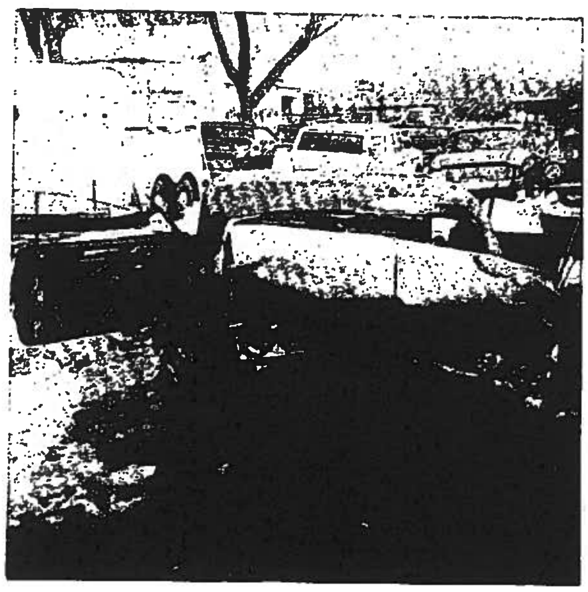


Figure 3. Vehicle #2, 1964 Chevrolet.

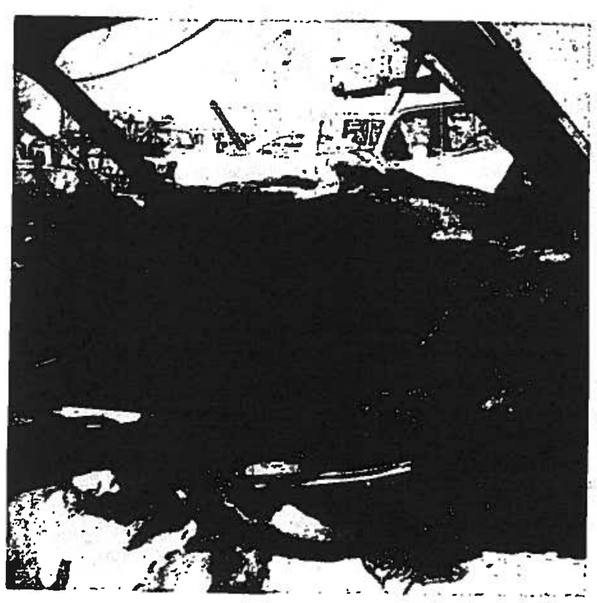


Figure 4. Vehicle #2, interior.

SEMI-TRAILER CRASH AND FIRE

Case Number 7

A. IDENTIFYING DATA:

Location: Intersection of Interstate Highway 35 (southbound) and Interstate 40 (eastbound), November 6, 1970, 3:57 p.m.

Vehicle: 1965 Kenworth Trailer with aluminum closed tractor (refrigerated).

B. AMBIENCE:

Weather: Clear, dry; daylight.

C. HIGHWAY:

On curve of interstate exchange, 2 lanes (one way), asphalt. Posted speed limit 65 mph. Suggested speed 45 mph.

D. TYPE OF ACCIDENT:

Vehicle skidded out of control on a curve, impacted a bridge rail and burst into flames.

E. OCCUPANTS:

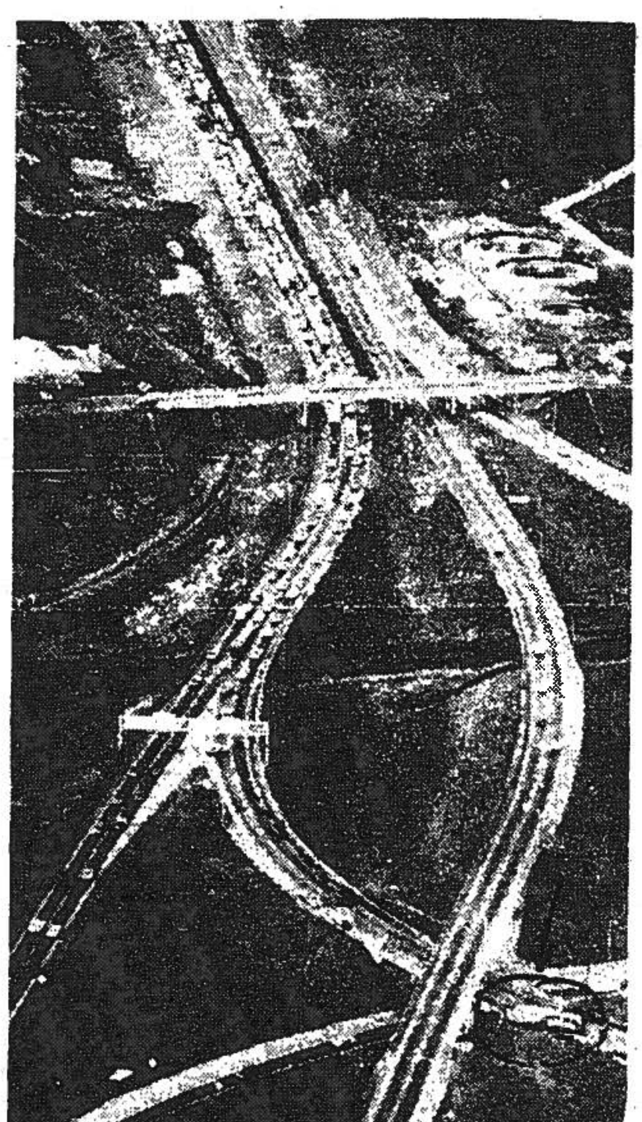
Male: Age 30, driver of vehicle. Suffered lacerations to right hand, numerous bruises, three fractures of right leg and was treated for shock. Subject was released after three days hospitalization.

F. ACCIDENT DESCRIPTION:

Vehicle was proceeding south of Interstate Highway 35 in the left lane and entered a two lane exchange which merges with Interstate Highway 40 (eastbound). The legal speed for this section of road is 65 mph; however, suggested speed is 45 mph for this curve. The subject entered the curve at 55 mph. The driver lost control of the rig and the vehicle skidded across the right lane and tore out 38 feet of guard rail and came to rest with the tractor wedged between the overturned trailed and a light pole.

G. PRE-CRASH FACTORS:

Vehicle Factors - No evidence of mechanical malfunction was noted.



BACKED UP TRAFFIC, accumulated when a semi tractor-trailer truck crashed and burned on I-40 at the Tinker Diagonal during the rush hour Friday afternoon, is seen from an aerial view. Traffic was re-routed from southbound lanes of I-35 that cut into I-40 west. (Aerial Staff Photo by [redacted])

Environmental Factors - The roadway is extremely complicated and confusing to motorists at this particular exchange. There are no signs to point out the existence of a potentially hazardous curve and the curve is not banked.

Human Factors - There was an apparent odor of alcohol in the cab of the truck. No chemical investigation was done of blood-alcohol level. There were no seat belts in the vehicle.

H. CRASH FACTORS:

The truck was loaded with sides of beef that were suspended from rails in the roof of the trailer. When the vehicle entered the curve at an excessive rate of speed, the beef swung to the right causing the driver to lose control of the rig. The vehicle skidded 272 feet before striking the guard rail. The rig struck the guard rail; the cab was knocked from its undercarriage and was pinned between the trailer (on its side) and a pole. The trailer was also between the cab and its undercarriage.

I. POST-CRASH FACTORS:

The undercarriage struck the rails and one of the aluminum saddle tanks erupted and broke into flames. The diesel fuel ignited the trailer and the contents and trailer burned. The driver was removed before the flames reached the cab. (Flames were extinguished by the fire department.) The driver was pinned in the vehicle by two components: the steering wheel and the brake pedal.

J. OPINIONS AND OBSERVATIONS:

1. Neither the fire department or ambulance operators had adequate equipment to remove the driver. (The brake pedal had to be winched by a wrecker operator.)

2. Saddle tanks (particularly aluminum) present an enormous fire hazard.

3. The weight trade-offs practiced by owners and manufacturers of tractor-trailers are at the expense of the driver's safety, i.e., weight regulators are based on maximum gross weight, therefore, more payload can be carried if the rig is constructed of light materials.

CASE # 7

SOURCES OF DATA FOR: EPIDEMIOLOGICAL ANALYSIS

1. Accident Report [X]

Report Number 03100220
Date 11-6-70

2. Newspaper Accounts [X]

3. Death Certificates [ ]

Certificate Number(s)________

---

4. Interviews: [X]

(a) Investigating Officer [X]

(b) Occupant(s) Vehicle #1:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(c) Occupant(s) Vehicle #2:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(d) Occupant(s) Vehicle #3:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(e) Special Accident Investigator: [ ]

(f) Eye Witness(es): [ ] No.____

(g) Private Physician(s) [ ] No.____

(h) Newspaper Reporter - or Photographers [ ] No.____

(i) Ambulance Attendant(s) [X] No. 2

(j) Fireman [X] No. 2.

(k) Embalmer [ ]

(l) Family or Friends of Victim(s): [ ] No.____

(m) Wrecker Operator(s) [X] No. 1

(n) Other(s) [ ] Specify____

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5. Hospital Records: [ ]

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6. Accident Investigation by Staff: [ ]

Sheet 1 of 1 Sheets FATALITY - yes ☐

55

OFFICIAL POLICE TRAFFIC COLLISION REPORT

OKLAHOMA 10 Reporting Agency: OKLA. HIGHWAY PATROL

No. 0210 0229

Date: 11-6-70 Day of Week: FRIDAY Hour: 3:57 PM County: OKLA.

Location: In OKLA. CITY (City or Town)
On INTERSTATE HIGHWAY 35 (SOUTHBOUND)
At INTERSTATE HIGHWAY 40 (EASTBOUND)

Total number veh. involved: 1 No. Injured: 1 No. Killed: 0

State Highway Code — Control No.: 6807 Location: CC 13
County Number: 55

Time Notified — Date: 11-6-70 Hour: 4:00 PM
Arrived At Scene — Date: 11-6-70 Hour: 4:05 PM

Unit 1

Driver: [redacted]
Address: [redacted] ENID, OKLA. 73701
License: 11/70 OKLA. 9189754 ☒ Chauffeur
Age: 30 Race: W Sex: M Date of Birth: 7-30-40
Highschool Driver Training: ☒ Yes
Vehicle: 65 KENWORTH TRUCK
License Plate: [redacted]
Owner's name: [redacted]
Address: [redacted] ENID, OKLA.
Is Veh. Operable? Yes ☐ No ☒
65 legal speed — 50-55 MPH before contact — 50-55 MPH at contact — Burned? ☐ Yes — $15,000.00 estimated damage
Veh removed to: CROWN WRECKER by: Wr. DRIVER

Unit 2

(blank)

Injured / Witnesses

Injured/Witness	Address	Age	Sex	Race
[redacted]	[redacted] ENID, OKLA.	30	M	W

Injured Taken To: 1 MERCY HOSPITAL By GOLD CROSS AMBULANCE — Time left scene: 4:33 P — Time arrived hospital: 4:38 P

Damage to property other than vehicles: BRIDGE $500.00 Owner: OKLA. HIGHWAY DEPT. Address: OKLA. CITY, OKLA.

Investigation made at scene? Yes ☒ Investigation completed? Yes ☒ Operator's report given to driver — Veh 1 ☒ Photos taken? No ☒

Name 1: [redacted] Citation: CARELESS DRIVING 11-801 Citation No. A644777

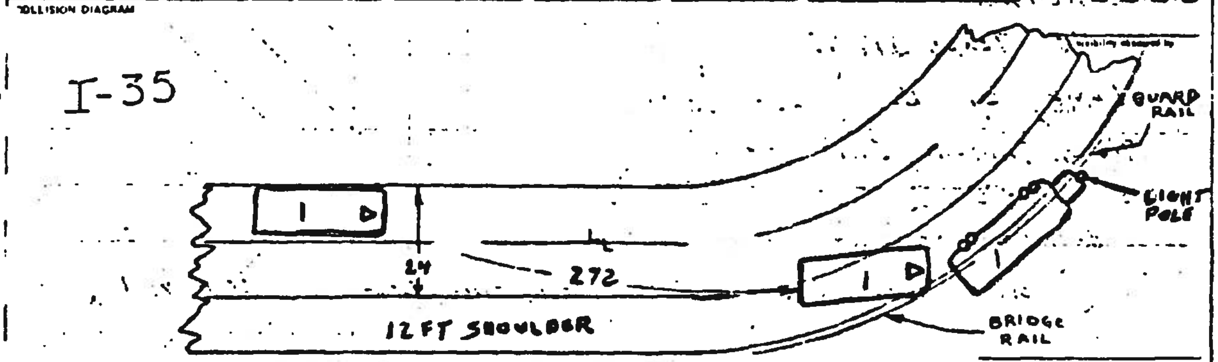
Sign Here: TROOPER [redacted] Badge No. [redacted] District & Division: 1 Approved: [redacted] Date of report: 11-11-70

B-117

NOT REPRODUCIBLE

Section	Marked
WHAT VEHICLES WERE DOING	
WHAT VEHICLES DID	X (8)
TYPE OF ROAD	X (5)
TRAFFIC CONTROL	X (9)
ROAD CHARACTER	X (6)
CONDITION OF DRIVERS AND PEDESTRIANS	X (3)
POINT OF FIRST CONTACT ON VEHICLES	X (1)
LIGHT	X (1 Daylight)
WEATHER	X (1 Clear)
OBJECT STRUCK BY VEHICLE OR LOAD ON FIRST CONTACT	
ROAD CONDITION	X (1 Dry)
ROAD SURFACE	X (2)
LOCALITY	X (3)
VEHICLE CONDITION	X — UNKNOWN

COLLISION DIAGRAM



REMARKS

Vehicle #1 was Southbound on Interstate 35 in the left lane and attempting to make the turn onto Interstate 40 to go East. Vehicle #1 skidded out of control, across the right lane, struck the curb, jumped the curb, struck the bridge rail, knocked down 38 ft. of rail and six posts. Veh. #1 then turned over on its right side, knocked down 50 ft. of guard rail and came to rest with the tractor crushed between the trailer and a light post, then the trailer partly burned. Veh. #1 left a total of 272 ft. of skids before impact. Condition of vehicle unknown due to damage and fire; demolished from impact and fire.

UNSAFE, UNLAWFUL, OR OTHER ACTION

Unit 1	Action	Describe	Unit 1	Action	Describe
	1 Failed to Yield			10 Improper Overtaking	
	2 Followed too Closely	Sharp Curve; Shifting		11 Improper Parking	
X	3 Unsafe Speed	Load In Trailer		12 Inattention	
	4 Made Improper Turn			13 Wrong way on –	
	5 Changed Lanes Unsafely			14 Improper Start from –	
	6 Stopped in Traffic Lane			15 Other Improper Act or Movement	
	7 Failed to Stop	27		16 Not Known – or – No Improper Action	
	8 Unsafe Vehicle			17 Other Action – not directly related to collision	
	9 Left of Center			18 Pedestrian Action	

Traffic's Snarled

A semi trailer-truck caused one of the worst traffic jams in Oklahoma City history Friday when it jacknifed at the junction of Interstates 35 and 40.

The accident, which occurred during the 4 p.m. rush hour, brought traffic to a standstill for nearly 3 hours and the road way was still partially blocked at 10 p.m. Friday.

The truck, eastbound on Interstate 40, attempted to make an east turn at the fork in the road when the driver, [redacted], 30, of Enid, apparently lost control of the vehicle.

After overturning across the road, the truck, loaded with sides of beef, caught fire. [redacted] was pinned in the truck for about 30 minutes, but was not seriously injured.

He was taken to Mercy Hospital where he was listed in good condition with a broken leg, lacerations and minor burns.

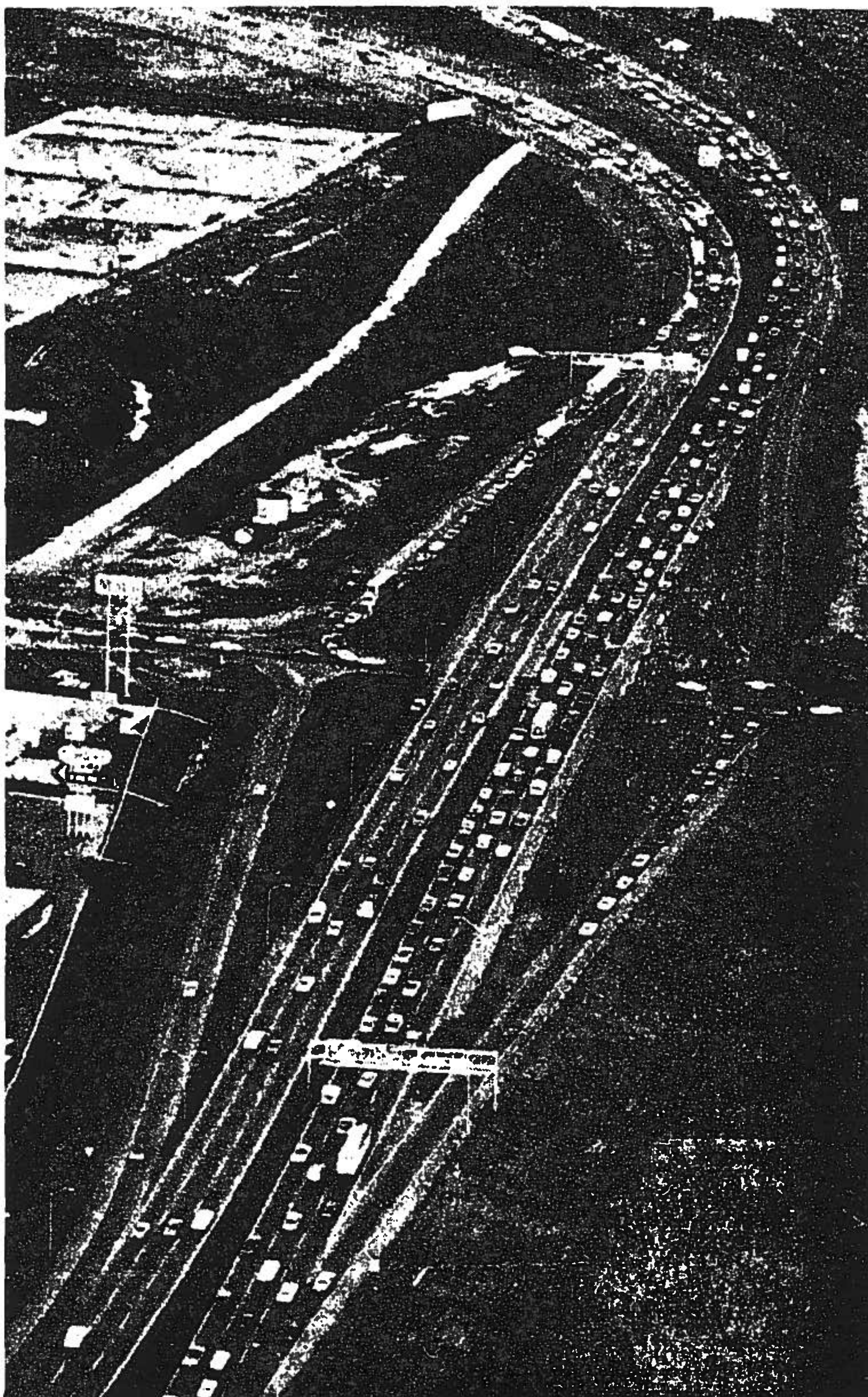
Oklahoma City police and the sheriff's office, alerted by the highway patrol when rush hour traffic began to stack up along the busy interstate, quickly blocked all downtown entrances to the expressway.

Officers said cars were stalled along the interstate's east-bound lane from the point of the accident to the May Ave. exit ramp for nearly three hours. The intersection was closed off.

"That was the nastiest traffic jam I've ever seen," one officer said. "We just didn't know what to do with all those cars."

Officials said the traffic tie-up ranks as one of the worst in the city's history.

"They couldn't have picked a worse time of day to do that," an officer said. "And on a Friday, yet."



Frustrating Friday

Friday afternoon's rush hour traffic ran smack into frustration when a semi-trailer truck jacknifed at the intersection of Interstates 35 and 40, closing the freeways for hours. Hundreds of Tinker Air Force Base workers hit the tieup shortly after the 4 p.m. shift change, and they were joined by the downtown rush an hour later. Six hours later, the loaded trailer still blocked one lane of traffic. Traffic is shown here backed up on northbound I.H. 35, at exits and on frontage roads.

TRUCK JACKKNIFES

Crash Creates Jam

By Tom Mundy

A semi-tractor-trailer truck laden with sides of beef jackknifed, overturned and burned on I-40 at the Tinker Diagonal during rush hour traffic Friday afternoon, injuring the driver and causing a massive traffic jam that lasted for several hours.

The overturned truck backed traffic up several miles before emergency units could arrive, slowing the arrival of firefighting units to extinguish the blaze and an ambulance to evacuate the injured truck driver.

Oklahoma City police were called in to assist the Oklahoma Highway Patrol by blocking all I-40 entrances to the eastbound lanes and re-routing rush-hour traffic in the area.

Traffic in all three of the eastbound I-40 lanes was brought to a standstill for nearly three hours and was backed up as far as downtown Oklahoma City.

Streets and access roads surrounding the interstate were overflowing with the detoured motorists as police re-routed the traffic.

The massive traffic jam forced the highway patrol to completely close I-40 and I-35 at that location for several hours in order to try to clear the lanes blocked by the overturned truck.

By late Friday night, only one lane of the sweeping curve where the truck overturned was open to traffic, and troopers were expected to stay at the scene several hours longer.

Although the truck was removed from the roadway, the loaded trailer was still blocking one lane about 10 p.m.

The trailer could not be removed until the beef was unloaded, to lighten the trailer enough to allow wreckers to put it back on its wheels and pull it away.

The truck apparently struck a concrete guardrail as it attempted to negotiate the sweeping turn, jackknifed and overturned, spilling fuel across all three traffic lanes and dumping fresh cut beef

Continued on Page 2, Col. 4

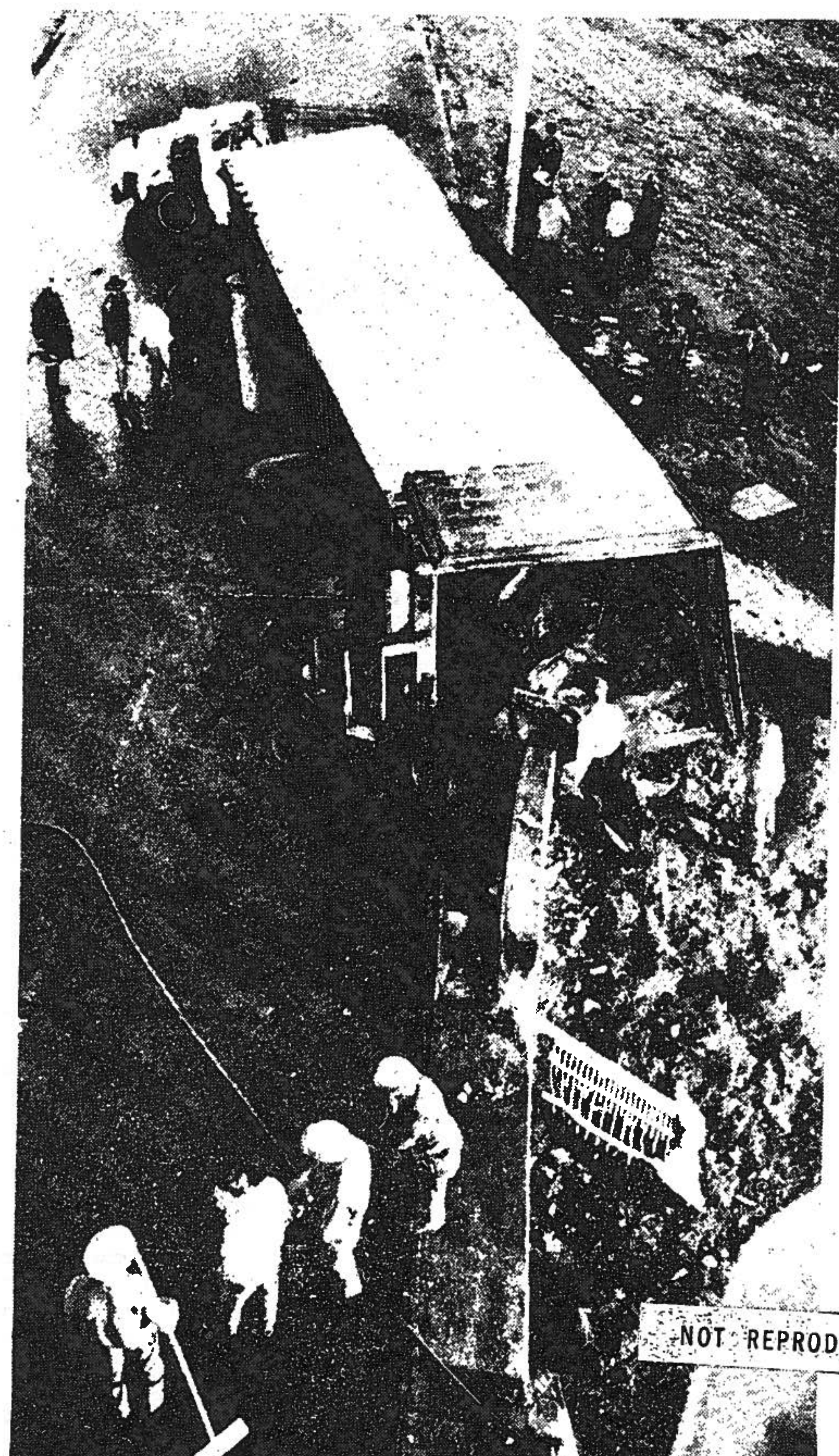
Continued From Page One

along the roadside.

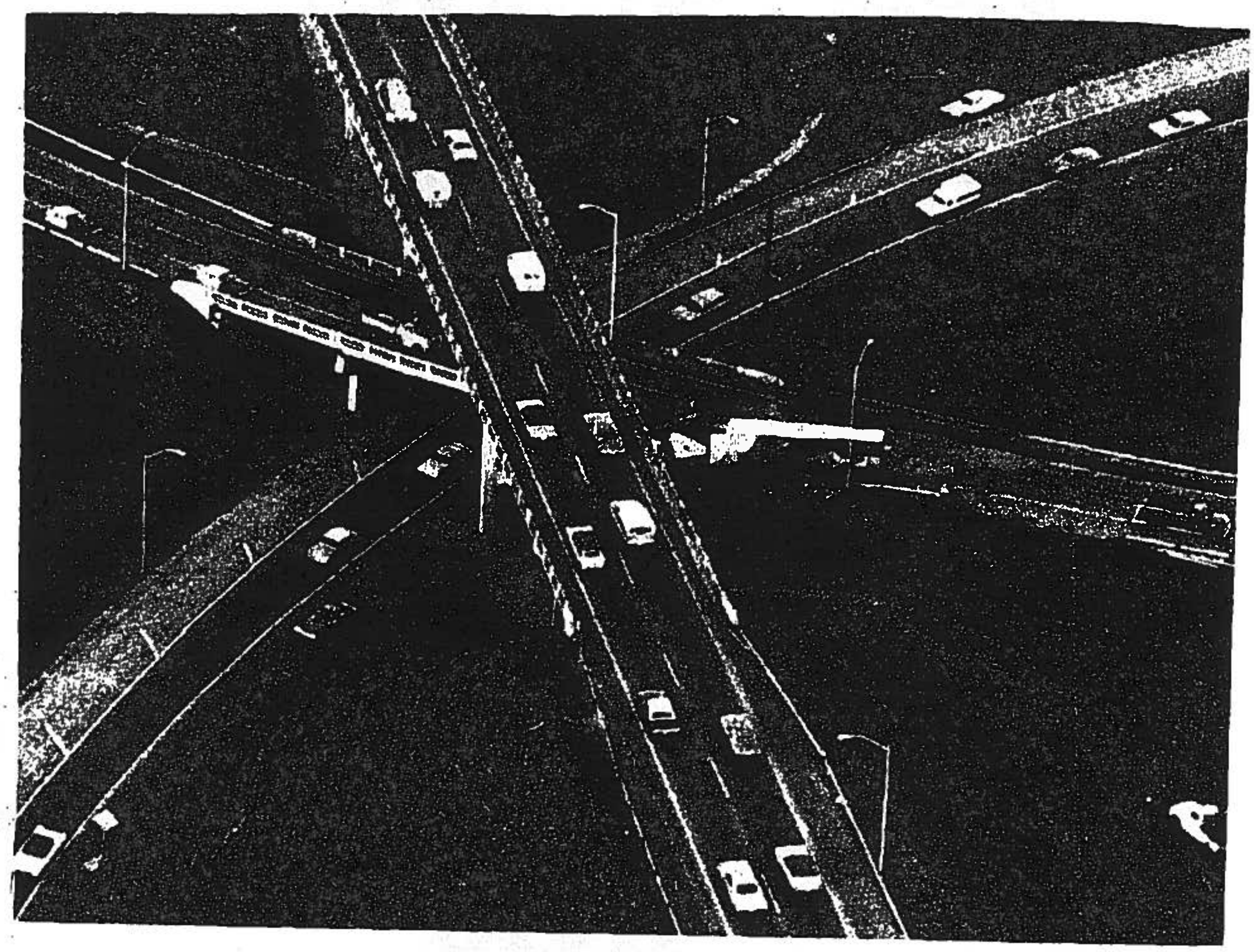
[redacted], 30, Enid, driver of the beef truck, was taken to Mercy Hospital with a fractured leg, lacerations and minor burns.

A hospital spokesman said [redacted] was in "good" condition late Friday.

First reports said several private vehicles were involved in the accident and that several persons were injured, but a highway patrol spokesman later said that only the truck was involved and [redacted] was the only injury.

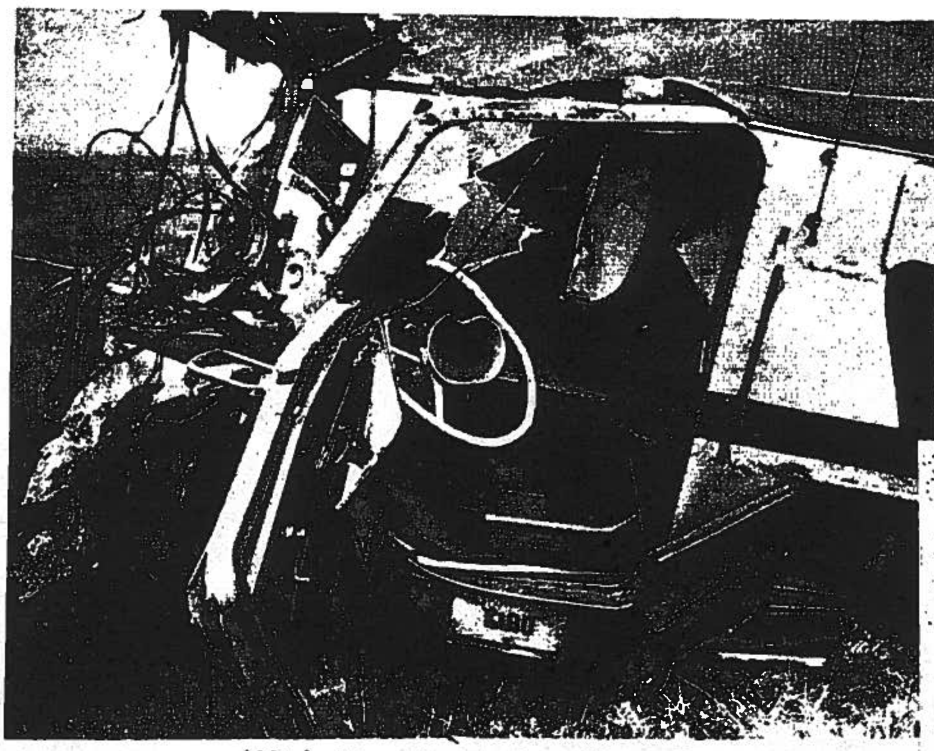


Workmen begin task of removing mangled tractor-trailer from the roadway Friday after it overturned on the Tinker Diagonal. (Staff Photo,



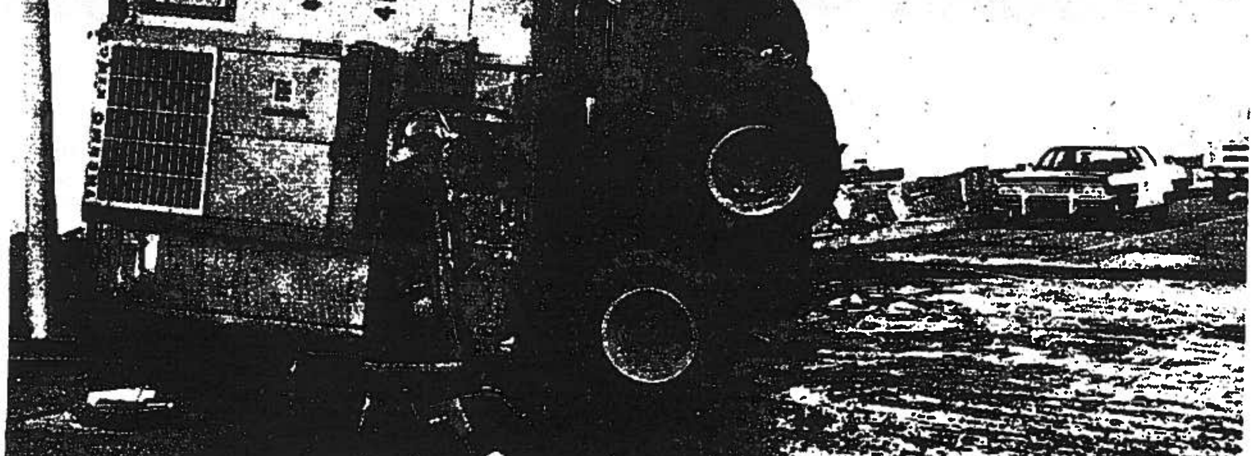
The Traffic Jam Started Here

The blackened remains of a semi-trailer truck hauling frozen beef carcasses can be seen just to the right of the three-level interchange at Interstates 35 and 40, where a massive traffic tie-up began Friday afternoon. It was perhaps the worst in Oklahoma City's history. A relatively few cars are in the intersection, since traffic was stopped and re-routed away from the scene of the crash. More photos on Page 2. (Aerial Staff Photos by [redacted])



'Kido' Lucky To Be Alive-O

[redacted] was trapped inside this crumpled cab of his semi-trailer truck Friday afternoon when the vehicle overturned at the intersection of Interstates 35 and 40. [redacted], 30, of Enid, was rescued after about 30 minutes and taken to Mercy Hospital, where he was listed in fair condition Friday night. The "KIDO" was on a plate attached to the truck's running board. (Staff Photo by [redacted])



Scene Of Truck Crash

Firemen and law enforcement officers surround burned-out semi-trailer truck Friday afternoon, following crash at three-level intersection at Interstates 35 and 40. The refrigeration unit, carrying beef carcasses, flipped over and caught fire. The driver was rescued, but traffic was tied up for hours. At right can be seen guard rails smashed by the jacknifing truck. (Staff Photo by [redacted])

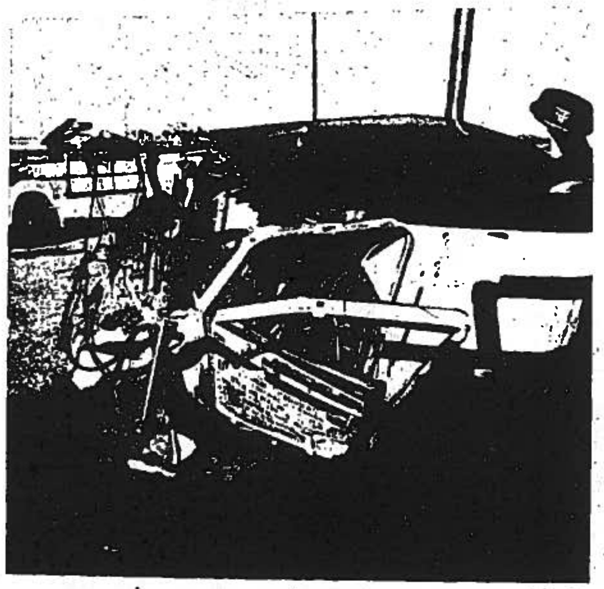


Figure 1. Cab of 1965 Kenworth truck.

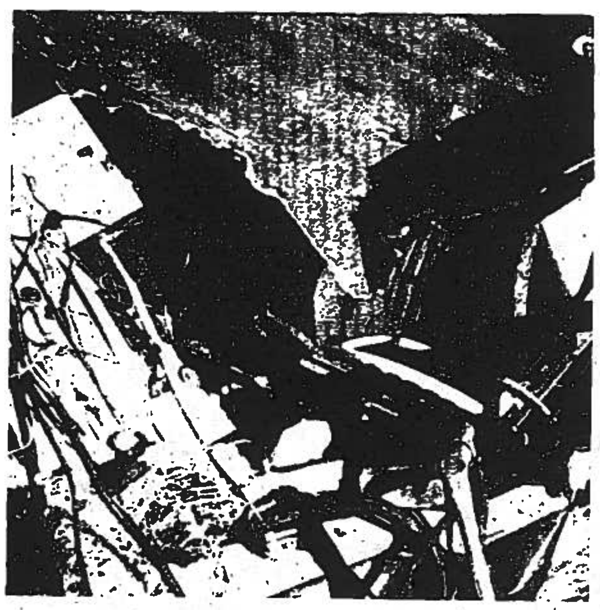


Figure 2. Note condition of fiberglas roof.

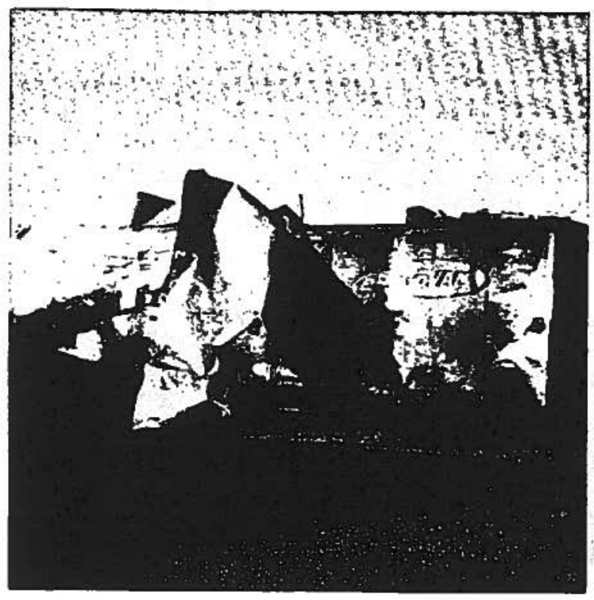


Figure 3. Trailer.

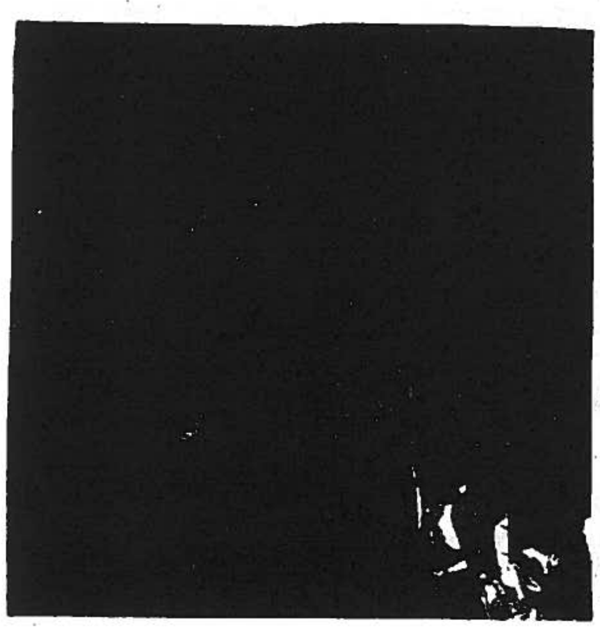


Figure 4. Trailer interior.

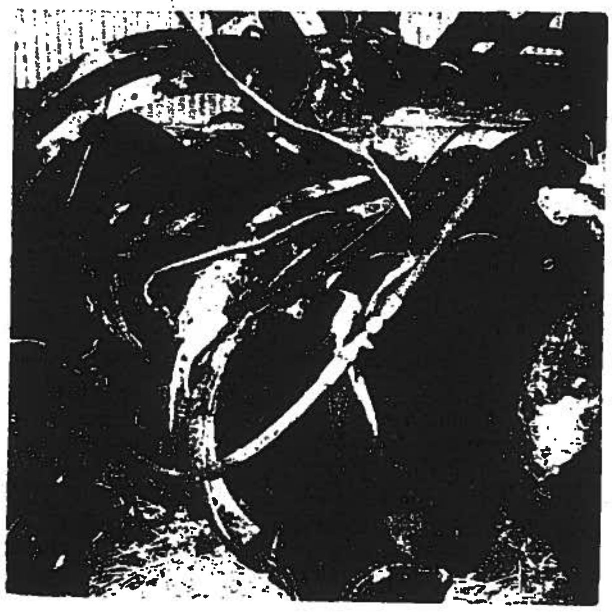


Figure 5. Ruptured saddle tank.

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AUTOMOBILE SUBMERGENCE, NON-FATAL

Case Number 8

A. IDENTIFYING DATA:

Location: Rural area on Oklahoma State Highway 123, February 11, 1971, at 6:20 a.m.

Vehicle: 1960 Ford, 4-door.

B. AMBIENCE:

Weather: Overcast and wet; darkness.

Temperature: Approximately 28 degrees F.

C. HIGHWAY:

Lightly traveled two-lane asphalt highway, curve with downgrade. Posted speed limit is 55 mph.

D. TYPE OF ACCIDENT:

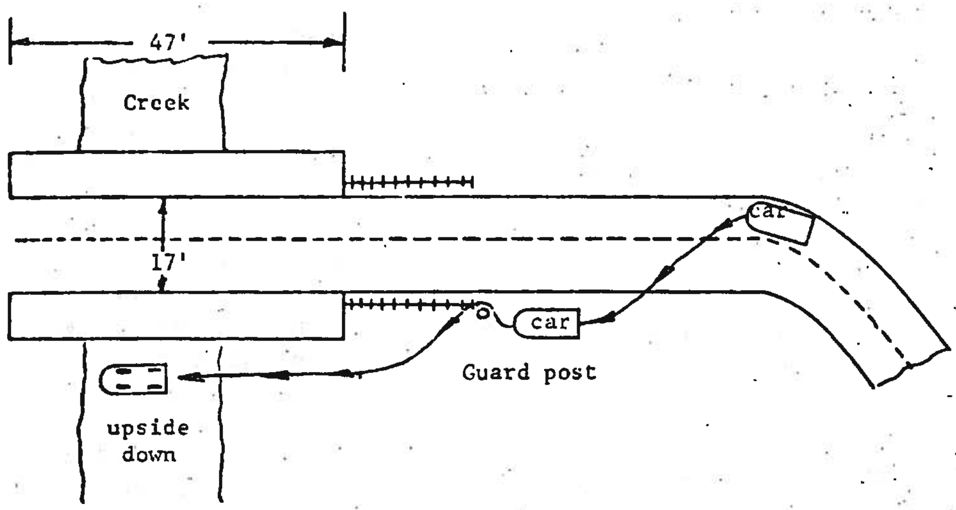
Vehicle was traveling on wet asphalt when the driver lost control on a curve with downgrade; vehicle ran off road and overturned in water.

E. OCCUPANTS:

Female: Age 28, driver of vehicle; no injuries at impact but suffered from exposure in cold water.

F. ACCIDENT DESCRIPTION:

Subject was driving the car to work just before dawn on wet roads. A fine mist was falling at the time of the crash. Subject entered curve at approximately 50-60 mph and vehicle skidded out of control on wet asphalt. Vehicle knocked down retaining post and rolled one-half times into creek of four feet of depth. The water was frozen with two inches of ice on the surface. The subject was not injured but was unable to escape from the vehicle. There was approximately three inches of air space and the subject remained in the vehicle until she was removed by a passing motorist, twenty minutes post-crash. Seat belts were not in use.



G. PRE-CRASH FACTORS:

Vehicle Factors - There were apparently no deficiencies of the vehicle except for the tires. The rear tires were practically bald; the front tires had some tread.

Environmental Factors - It was totally dark at the time of the accident and the asphalt was extremely slippery due to a fine mist in the air.

Human Factors - The driver had not received driver's training but was apparently a good driver. The subject was unfamiliar with the vehicle and was pre-occupied with the gas gauge which was on empty.

H. CRASH FACTORS:

Vehicle Factors - The rear tires slipped on the road, and the front right struck a retaining post. The vehicle came to rest on its top with no compression of the vehicle roof.

Environmental Factors - The combination of wet asphalt, a curve, darkness and minimal guard rails contributed to the dynamics of this crash and the exodus from the roadway into the creek.

Human Factors - The subject was unfamiliar with the vehicle and was accustomed to power steering and brakes, which this vehicle did not have. The subject probably over compensated during the initial skid causing the vehicle to go to the left side of the highway and into the creek.

I. POST-CRASH FACTORS:

Vehicle Factors - The vehicle came to rest on its top in four feet of water with two inches of ice on the surface. The left rear window was knocked out as the vehicle impacted the rocks on the side of the creek and water rushed in as the car came to rest. The left front door was jammed. The vehicle was filled with water with a three inch air space at the top (floor board). No interior lights were in working order and the left headlights remained on for about one hour post-crash on the submerged vehicle. The right side headlights were knocked out when the vehicle impacted the guard post.

Environmental Factors - The water was at the freezing point and contributed to the problems encountered by the individual.

Human Factors - The combination of panic, an unfamiliar environment (darkness, overturned vehicle, cold water, small air space), could easily have taken the life of this individual. The subject was too frightened to effect her own escape and would have eventually died of exposure had she not been rescued.

J. OPINIONS AND OBSERVATIONS:

The fact that headlights remained on after the vehicle was submerged was a critical component in the subject's survival.

Interview with Occupant XXXXX

Case Number 8

The car was different than what I was used to. The car I drive has power steering and power brakes on it. The car I was driving was my husband's old car that he usually drives. This car was harder and too, I was low on gas that morning and I had that on my mind. There was some girls in front of me that was going the same place I was; so I thought, well now, if I could catch up with them, if I ran out of gas, I could maybe signal them to stop. I just didn't have my mind on what I was doing. Coming down that hill, I must have been going fifty-five miles per hour and for a slick wet pavement, that was too fast really. But the minute I put the brakes on, I had forgotten that they weren't power brakes and didn't push on them like I should have. The steering was so much more difficult and too, being a woman, I just panicked! As soon as it started skidding around and swirling on the highway, it must have turned around two or three times, I just stopped and lost complete control of it them. It started skidding sideways down the embankment dropping about ten to fifteen feet down in the water.

Question: What do you remember next?

Answer: The first thing that I remember after beginning to roll over, was the water. The car was completely filled up with water and I must have already hit bottom at that time because it was, I don't know, it seemed several minutes, but I know it must just have been a few seconds; I was completely submerged in water with no breathing space at all. But the car did settle and there was about three inches left between what was the floor board. I didn't realize at the time, when I could breathe but the more moving I done, the further I went under water. So I then was so panicky, I just kept fighting, trying to find the doors. But, I didn't realize it was upside down at the time. I had no idea that the car was upside down! I know that I couldn't locate anything that was familiar. I was feeling for a steering wheel or door handles so I could get out of it, but I couldn't find anything familiar and the more moving I done the further I went under water so I just finally quit moving and fighting and just started yelling and hollering. The back window was completely broken out and anybody that wasn't afraid of water and could have kept from getting so panicky, could have went under water and held their breath long enough to get out. One door now, in the front, I guess that's where I was, was jammed shut. The other one was to a certain extent, but the man managed to pull it open and I probably could have if I would have kept my cool long enough to have gotten under water and found a door handle. But I can't swim and not used to water at all and the thought of going under water just terrified me! So I didn't.

Question: You never found anything that was familiar to you?

Answer: No. If I just could have realized; something was pressing hard on my head, so I know there couldn't have been more than two or three inches and I couldn't budge,it, I was trying to move it. I don't know what it might have been. It might have been a seat or something. It wasn't. It must have evidently been the floor board of the car. It was almost level in the water completely submerged except the wheels and the bottom of the car.

Question: This man opened the door?

Answer: He must have opened the door opposite from the driver's side. Yeah, I know it was because the other one was jammed when we went to where they had the car parked.

Question: Was that the closest door to you or the furtherest?

Answer: It must have been the closest one to me because the minute he opened the door, I was almost out of the car. I don't know, if I just had stayed calm, I really think I could have gotten out but at the state I was in, I couldn't have possibly gotten out without help!

Question: Were you numb?

Answer: Yes. By the time he had gotten there, which was about twenty-five minutes, the water was icy.

Question: Could you move your arms or anything?

Answer: I could move my arms a little, not much, but I could move my feet freely. I still can't understand just exactly how I was in the car!

Question: Do you think you were in the car about twenty-five minutes?

Answer: About, as near as we could figure from the time I left the house and the time he left for work; the time we arrived at the hospital, it amounted to about twenty minutes. What I didn't realize at the time and I suppose he didn't either, was the fact that there wasn't much air left in the car. If it had been another thirty minutes it would have been too late!

Question: You think you were in the water for actually around twenty-five minutes?

Answer: Yes I'm quite sure. It was about twenty-five minutes.

Question: About how cold was it that day?

Answer: It wasn't as cold as it had been for the few days before, but it was cold enough that it was freezing. I'm sure at least thirty-two degrees.

Question: The paper said and I also talked to the trooper; they said there was some ice on the water.

Answer: Yes, there was about two inches of ice, I guess, something like that. I didn't realize the water at that point was that deep. It really doesn't look that deep. It looks like a little creek.

Question: How deep do you figure it was?

Answer: Oh, it must have been in the neighborhood of five to six feet deep. I'm not very good at judging distance. But judging the size of the car and how deep it was in the water, probably five feet.

Question: Was this a Ford?

Answer: It was a '59 or '60 Ford.

Question: Two or four door sedan?

Answer: Four door.

Question: One of the windows was broken out?

Answer: The back window was completely broken out. The one back window, where the damage was done was broken.

Question: Was that on the driver's side?

Answer: No, opposite the driver's side.

Question: You actually went out the passenger side when he opened the door?

Answer: I think so. I couldn't swear to it.

Question: You feel the other door was jammed?

Answer: Yeah, when we went to look at the car afterwards, the door opposite the driver's side was completely jammed; we couldn't pry it open.

Question: Was this after it had been towed out of the water?

Answer: Yes it was after it was towed out of the water. He must have gotten me out on the driver's side, because, I guess, that door was jammed on the opposite side.

Question: Was it raining when this happened?

Answer: It was just beginning to mist a little--a fine mist, just enough to wet the pavement barely.

Question: Was there frost on your windows at all that morning as you were going to work?

Answer: No there wasn't.

Question: So your visibility was good?

Answer: Visibility was good that morning.

Question: The pavement was wet or icy?

Answer: It wasn't icy, just wet. It was kind of misty out. But that was so early. That was about twenty after six o'clock.

Question: Do you feel that you were conscious throughout this whole thing?

Answer: Yes I think my hands were froze but I thought so at first, trying to find my way out, that I had scratched them up pretty bad, but they are just beginning to numb out good but I still can't take pulse with my fingers because the end of my fingers are numb. I didn't have any serious injuries that I can speak of. I just had a bad bruise on my leg but outside of my cold, I like to never got warmed up enough! I stayed in the hospital till about, I believe, eleven o'clock that day.

Question: The paper just said that you were blue. Is that true?

Answer: That's what that man told me when he got me out. I had on a heavy big fur type coat and it just absorbed water like a sponge. He said when he pulled me out that my lips were purple and that my whole face was blue; but I remember shaking violently; my hands especially!

Question: How long was the coat?

Answer: Three quarters length.

Question: Three quarters length and it had a thick pile?

Answer: Yes. He pulled it off of me the minute he got me out of the water. Before we ever got up the embankment. The car was a distance of maybe about three feet from the water; so he had to jump over on the bottom of the car and pull me out. And then to get both of us back up the embankment, which was about ten feet straight up, almost, over rocks and how he got both of us up there, I don't know, because I wasn't helping any! I was too panicky at that time and I don't know, too grateful to be out of the water to think of anything else I guess, but he was a big man. He must have been over six feet tall but he managed to get both of us up there without any help from me, and over about three feet of water from the car to the embankment! I was so grateful to him. I hope he gets a good reward someday for that!

Question: How were you dressed other than the coat?
Answer: A uniform and my hose. No heels on my shoes. My glasses were lost and I couldn't find them. We even went back afterwards. I looked through the water but it was a little muddy; but you could see some through it.
Question: Would you need your glasses to find your way out?
Answer: Well, I can see right close to me but no distance at all.
Question: Was it dark?
Answer: Yes. Getting lighter now at the time really, but at that time it was completely dark!
Question: You had your lights on?
Answer: Yes. When the two head lights opposite the driver's side was still burning; that's what caused him to see me in the water. At first it was the dirt on the road he said, because he noticed it wasn't there when he went to work and the dirt attracted his attention at first and then when he looked toward the water he saw the lights.
Question: Was it still dark when he saw the lights?
Answer: Yes. He said he thought maybe there was some fishermen down there because they usually will have on lights like that but as soon as he stopped to investigate he saw that it was me.
Question: The other lights were out?
Answer: Yes.
Question: Had it been knocked out?
Answer: Yes. It was broken out completely. We had a new battery but still under the water that long, I don't know how the lights were still burning, but even after they took me to the hospital and went back out to the car, the lights were still burning at that time!
Question: Were there any interior lights burning that you could see?
Answer: No.

__Question__: What could you see?

__Answer__: Just nothing, it was completely black. At that time it was so terribly black, I couldn't see anything in that water!

__Question__: You say you couldn't find anything?

__Answer__: I kept feeling, you know, all around me but I couldn't find a single thing that felt familiar to me, but I didn't have much space. Not much overspace. Just space that I was in and maybe a foot around me if that much. I was so boxed in. I still can't imagine what position I was in! I was too panicky to think of anything! That's a bad thing to do, is to panic. It's the worst thing you can do! I suppose I could have gotten out if it wasn't for that, but I never will believe it in my heart. I don't really believe I would have gotten out if it wasn't for that man.

__Question__: Had he speculated on whether he would have seen you or not if it hadn't been for the lights?

__Answer__: He said if it hadn't been for the lights he didn't think he would have. I know, we found out since then, there maybe had been one, possibly two, cars that went by before he did, after I had went into the water.

__Question__: Was he going the same direction you were or the opposite, or did you know?

__Answer__: I don't know now, he was going to Ocheleta from Bartlesville.

__Question__: He would have been coming the other way then I guess.

__Answer__: He worked at the smelter and had gotten off and was headed towards Ocheleta and I was going to Bartlesville. He must have been rather observant to notice the dirt on the highway but he is a deputy sheriff in Ocheleta. I suppose they notice things that most people wouldn't notice the dirt on the highway or wouldn't think anything of it if they did! But really that's about all there is to it. Just a nightmare I'll tell you!

Question: Did he see the lights from the road or did he have to stop to see them?

Answer: No. He said he slowed down when he noticed the dirt but he said he hadn't stopped at that time he saw the lights. He said he thought about just going on cause he thought well, it's just some fishermen. But he slowed down just enough to see that it wasn't.

Question: Have you thought about how long it might have been that you tried to find some way out before you finally quit?

Answer: You know, it seemed like an eternity to me because I remember moving my arms at first and when I didn't find anything there, I thought maybe I could kick my feet and maybe bust out a window. I couldn't find one. I thought maybe I could have. I kept kicking my feet for a long time but it couldn't have been much over twenty after six when I arrived at that point and we were at the hospital before seven o'clock. So really, I couldn't have been there as long as I thought I was. It really seemed like an eternity to me and then after I did stop fighting it, it felt like a long time to me before he did come and then he couldn't imagine where I was in the car. I kept hollering until he did locate me and after he did get me out, I remember him asking me several times if there was anybody else in the car. He wasn't sure. I was so incoherent, he wasn't sure I was alone or not!

Question: Did you hear him come up or something?

Answer: I heard his car. As soon as I hollered, he kept asking me where I was and I hollered. It seemed like quite a little while before he located me. He didn't have to get in the water to get me out. Just his arm is all he got wet and of course, what he got off of me coming up the embankment.

Question: Had you been taking any medication or anything?

Answer: No.

Question: No sedatives that might have effected your ability to reason or anything for colds or sinus?

Answer: I do take medicine for my sinus.
Question: Had you taken any shortly before going to work?
Answer: I may have taken some that morning. I couldn't honestly say.
Question: What do you take?
Answer: It's a medicine that the Drug of Bartlesville puts up. Sinusule. They could probably tell you what it is but I know it helps them a great deal. What it has in it, I don't know.
Question: Is there anything else that you would have taken prior to twenty-four hours?
Answer: No not anything else other than my birth control pills and I don't think that has anything that would effect anything. I had been taking them a long time and never had any trouble before.
Question: How often do you take this sinus medication?
Answer: Just occasionally. When it bothers me. I never average more than twice a day because it doesn't really bother me too much; not enough to be a nuisance. I can't really remember if I took any that morning or not. I don't really think I did, cause I hadn't had them too long and I don't remember if I had them at that time or not. Gosh, I wouldn't think they would have anything in them that would bother! They are put up like a prescription but you don't have to have a prescription for them. He puts them in a prescription bottle.
Question: I can go by the label. I can find out what they are. I'm just interested if they could have affected your ability to reason.
Answer: I would be anxious to know myself! I know I had taken them a good deal since then and they never bothered me. Really, it's my own fault for not paying attention to what I was doing. I didn't have my mind on it at all. And driving a different car like that. I should have paid double attention, because it was so much harder to drive. To me it was like driving a

cattle truck after getting used to power steering and brakes.

<u>Question</u>: What kind of car were you normally driving?

<u>Answer</u>: A Rambler. It has power steering and power brakes; a light car where this car was so much more heavier and more difficult with the brakes and the steering.

<u>Question</u>: Were you going any faster than you would have normally gone around that curve?

<u>Answer</u>: Not really.

<u>Question</u>: Would you think you would have made it around the curve if you were driving your own car?

<u>Answer</u>: Yes.

<u>Question</u>: You think so?

<u>Answer</u>: Yes. With that power steering it would made a whole lot of difference. That car gives, I know, I've made different steps at different times and with that power steering and brakes I have complete control when the car does swerve a little or I go a little too fast around curves. With this other car, it didn't have power steering and power brakes. The first little didoo that you make your control is gone! Especially if you need to apply your brakes in a hurry. They simply wouldn't stop you like power brakes will. Power brakes when you touch them will grab that minute and with these brakes you askew all along the highway and slide around two or three times before you finally get to a stop. This is much more difficult.

<u>Question</u>: Do you think that there was any way now that you could have possibly gotten out, say if this would happen again. Do you think you would be able to get out?

<u>Answer</u>: I think so now because anybody can hold their breath that long. Long enough to go a distance of a car even if you did have to go from the front seat to the back. I don't know. I probably wouldn't! I probably would do the same thing. Just panic! Because it was so black. Now daylight, that would make it entirely different! In daylight I probably

would and could get out easily but as black as it was, I wouldn't see anything. It was like being blind!

Question: You say you can't swim? Are you accustomed to holding your breath in going under water at all?

Answer: A person like that wouldn't have panicked like that if he had been around water. I'm not accustomed to it. Probably would have gotten out easily but I couldn't. I don't believe and I don't believe I could again if the same identical thing was to happen again! I really thought when I first felt the water and it was several seconds under water when I was swallowing water that I thought that that was really it! I thought that was going to be the end of me right there.

Question: Did you then cough some water out of your lungs?

Answer: After the car had finally settled down and I managed to get my head above water, then it was back tilting my head backwards. The full length of my head so much in the top would have stayed out of water without tilting my head backwards. But I don't know how much longer that amount of air would have lasted. Not much longer I would think!

Question: Was that air actually trapped under there?

Answer: The way the car was situated there was no way for any more air to get in there upside down in the water; right side up it would have. Really, I don't suppose another twenty minutes would have been too late. That didn't occur to me at all at the time. The only thing I knew was that my head was out of the water. What I thought was I would freeze to death cause the cold was so terrible. I have never been that cold. I have always been cold blooded but that was something else.

Question: Can you think of any other items about this?

Answer: No.

Question: Any thoughts you might have had?

Answer: Not really except that I really, don't get my wrong, I don't normally speed any more than anybody else does; I drive around sixty on a good highway and before the accident, I usually go seventy on a freeway or a good road. But around those curves, I always slow down to around fifty to sixty. That's all you could do on a hill. Coming down that hill about fifty like I was doing that day. But I have slowed down a good deal since then, believe me, and I would advise it for everybody driving after night or during the dark like that.

Question: That car wouldn't have had seat belts would it? The Ford rather.

Answer: I believe there was seat belts in that car.

Question: Do you ever wear seat belts?

Answer: No. That's something I never have on hardly. Really, the whole mess is keeping my mind on what you're doing. If I had been paying more attention to what I was doing, it wouldn't have happened.

Question: Had you had driver's education?

Answer: No.

Question: What sort of driver do you feel you are?

Answer: Just about average, really. This is the second accident I've been involved in. The other was a very minor accident but really, I'm a lot slower driver than I was before. I've noticed a lot of times that I have my mind on too many things. Especially if I had the children in the car. That's going to be the death of me yet, if I don't quit it. I've tried to and have!

Question: Do you feel you had your mind on other things when this happened?

Answer: Yes. Too many other things and too strongly. My mind was too much on running out of gas and the car being different and getting to work on time. Just about everything I shouldn't have been thinking about but just driving.

Question: You told me earlier that you have heard since then that there has been several accidents there?

Answer: And more serious than my own! I don't know anybody by name or anything, but what I have been told since then, being a small community like that people remember you know, really quickly. I understand that some people have died in that exact same place. In one, I believe, yeah, some of my mother-in-law's relatives. Nobody was killed in that accident but seriously injured. There were three men I believe that time. In the exact same spot in fact. I think more of the accidents, I understand it, have happened in that direction. Because coming the other way, there is a curve but nothing like the one I was coming from. I understand I knocked a guard rail down too. It looks like that would have slowed me down but it didn't. It obviously wasn't set very deep. It was one of those real thick posts, you know, and you would think it would have stopped me but it didn't.

Question: Did you feel it when you hit the post?

Answer: No.

Question: Did you feel any slowing of the car when you went?

Answer: No I didn't. I sure didn't feel anything. I might have been mistaken about that. That might have been a metal guard rail. You know, the long silver type thing. Somebody mentioned that we would have to pay for that guard rail from the post. I must not have hit the post cause there wasn't any slowing down or no bumps at all. Just the sudden flying through the air!

Question: I believe you said you sold your car?

Answer: Yes. I sold it to a man in Tulsa that he works with.

Question: I wondered if they fixed it yet?

Answer: No. I don't imagine that they have. They may have taken the motor out but the body was too badly damaged to be of much use.

Question: Do you remember what sort of damage it had on it?

Answer: The driver's side of the car was heavily damaged and about the end of the trunk was damaged to an extent we couldn't even open the trunk on it. The front tires were blown out. The back ones weren't.

<u>Question</u>: How were the tires on the car?

<u>Answer</u>: Just fair. They weren't real good tires and it was just his old car he drove back and forth from work. Really, the top of it wasn't a great deal of damage to it. It wasn't as bad as I thought it would have been, you know, being upside down. I think the most damage was coming down the embankment because it was completely rocky. There wasn't any dirt to it. Just all rocks.

<u>Question</u>: How do you think you went off?

<u>Answer</u>: Really I think I went sort of in the air for a time. I really felt I was just before I hit the water.

<u>Question</u>: Do you think it rotated over to the left?

<u>Answer</u>: Yes and I think, it seems to me, that coming down the embankment there was a time between when I hit the water and coming off the rocks that I must have been in the air for a short time. I must have bounced from those rocks into the water.

<u>Question</u>: One thing I was going to ask you about sinus prescription or sinus medicine: does it ever make you sleepy?

<u>Answer</u>: No. Not at all. It has no effect on me at all. There's several different kinds and I know that I asked them if this was the kind to just keep from having a headache because if that's what it was I didn't want it. I needed something to drain them. That's its primary purpose I understand. Strictly for draining.

CASE #______

SOURCES OF DATA FOR: EPIDEMIOLOGICAL ANALYSIS

1. Accident Report [X]

Report Number 10420262
Date Feb. 11, 1971

2. Newspaper Accounts [X]

3. Death Certificates [ ]

Certificate Number(s)______________

4. Interviews: [X]

(a) Investigating Officer [X]

(b) Occupant(s) Vehicle #1:

[X] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(c) Occupant(s) Vehicle #2:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(d) Occupant(s) Vehicle #3:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(e) Special Accident Investigator: [ ]

5. Hospital Records: [ ]

(f) Eye Witness(es): [ ] No:______

(g) Private Physician(s) [ ] No.___

(h) Newspaper Reporter - or Photographers [ ] No.______

(i) Ambulance Attendant(s) [ ] No.___

(j) Fireman [ ] No.______

6. Accident Investigation by Staff: [ ]

(k) Embalmer [ ]

(l) Family or Friends of Victim(s): [ ] No.______

(m) Wrecker Operator(s) [ ] No.___

(n) Other(s) [ ] Specify______

NOT REPRODUCIBLE

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Sheet 1 of 1 Sheets — FATALITY: yes [ ]

OFFICIAL POLICE TRAFFIC COLLISION REPORT

OKLAHOMA 2 / — No. 021042 0262 2

Reporting Agency: OKLAHOMA HIGHWAY PATROL

Date: 2-11-71 — Day of Week: THURSDAY — Hour: 6:20 AM — County: OSAGE

If outside city limits: 2.4 miles, S [X] of nearest city: BARTLESVILLE

Total number veh involved: 1 — No. Injured: 1 — No. Killed: 0

LOCATION — ON: STATE HIGHWAY 123 (name or number of street or highway)

NOT AT INTERSECTION: 2 ? ft, South [X] OF COUNTY ROAD (show nearest intersecting street or highway)

STATE HIGHWAY CODE — County Number: 57 — Control No / Sel / Location — County Section Line Grid (East / North)

Time Notified: Date 2-11-71, Hour 6:55 AM

Arrived At Scene: Date 2-11-71, Hour 7:25 AM

Unit 1

Driver: [redacted] — phone no: NONE

Address: [redacted] OKLA. [redacted]

License: OKLA. [redacted] — Operator [X]

Race: W — Sex: F — Age: 28 — Date of Birth: 4 16 42

Highschool Driver Training: No [X]

Veh ID No: [redacted]

Vehicle: 66 FORD 2DS

License Plate: [redacted]

Owner's Name: DRIVER

Address: SAME AS DRIVER

Is Veh Operable? No [X]

Legal speed: 65 MPH — Estimated speed before contact: 60 MPH — at contact: 40 MPH — Estimated damage: $350.00

Veh removed to: BARTLESVILLE by: WILSON MOTOR CO.

Unit 2

(blank)

Injured / Witnesses

1. Injured [X] — [redacted] — address: [redacted] OKLA. [redacted] — age 28, sex F, race W

Damage / Investigation

Damage to property other than vehicles: GUARD POST — $132.00 — Owner: STATE OF OKLA. HIGHWAY DEPT. — Address: 129 E. MAIN PAWHUSKA OKLA.

Investigation made at scene: Yes [X] — Investigation completed: Yes [X] — Operator's report given to driver: Veh 1 [X] — Photos taken: No [X]

Chemical Test — Driver of: No [X]

Charges

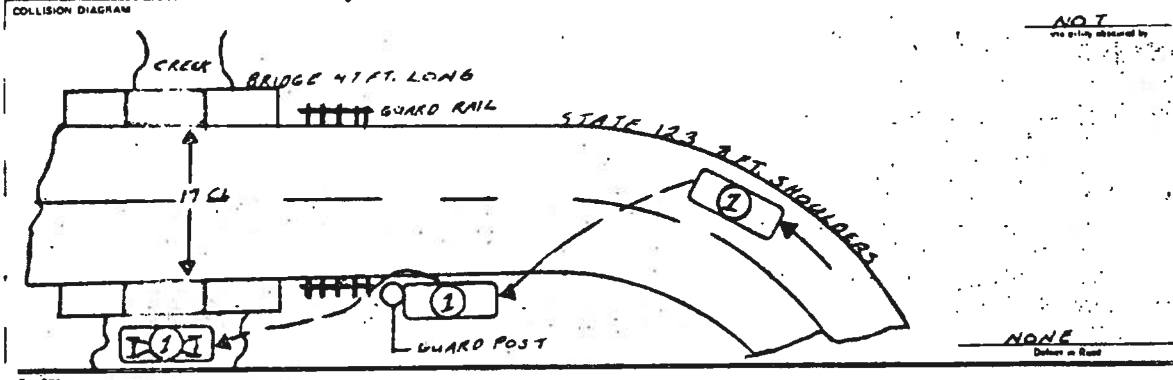
Name 1: [redacted]

Charge: OPERATING A M.V. IN A MANNER NOT REASONABLE AND PROPER — Citation No: A57-093?

Sign Here: [redacted] — Badge No: [redacted] — District & Division: 7 — Approved by: [redacted] — Date of report: 2-15-71

Section	Marked (Unit 1)
What vehicles were going to do	1 Go ahead
What vehicles did	1 Went ahead
Type of road	3 Two lanes
Traffic control	9 No control
Road character	7 Curve downgrade
Condition of drivers and pedestrians	1 Apparently normal
Object struck by vehicle or load on first contact	4 Guard post
Point of first contact on vehicles	2 Front right
Road condition	2 Wet
Road surface	2 Asphalt
Locality	5 Not built up
Light	4 Dawn
Weather	3 Overcast
Vehicle condition	6 Tires
What pedestrian was doing	(crossed out)

COLLISION DIAGRAM



NOT
(Visibility obscured by)

NONE
(Defects in Road)

REMARKS
(Refer to vehicles by number)

OPERATOR OF VEH. #1 THOUGHT THAT SHE LOST CONTROL BECAUSE SHE WAS NOT USED TO THE VEH. IT DID NOT HAVE POWER STEERING. OFFICER FEELS THAT THE VEH. WENT OUT OF CONTROL BECAUSE THE ROADWAY WAS WET AT THE CURVE. IT APPEARED THAT AFTER LOOSING CONTROL THE DRIVER FROZE UP. THE VEH. TRAVLED APPROX. 203 FT. ON THE WEST SHOULDER WITHOUT THE BRAKES BEING APPLIED. IT THEN HIT A GUARDPOST, THEN CLIPPED THE END OF A GUARDRAIL. IT THEN WENT INTO A CREEK TURNING OVER 1½ TIMES LANDING ON ITS TOP. POINT OF IMPACT WAS 9 FT. EAST OF THE CENTERLINE OF STATE 123.

UNSAFE, UNLAWFUL, OR OTHER ACTION (This section – primarily for general statistics and administrative purposes)

Unit 1	Unit 2	Action	Describe	Unit 1	Unit 2	Action	Describe
		1 Failed to Yield				10 Improper Overtaking	
		2 Followed too Closely	DUE TO THE CONDITION			11 Improper Parking	
X		3 Unsafe Speed	OF ROADWAY AND VEH.			12 Inattention	
		4 Made Improper Turn				13 Wrong way on –	
		5 Changed Lanes Unsafely				14 Improper Start from –	
		6 Stopped in Traffic Lane				15 Other Improper Act or Movement	
		7 Failed to Stop				16 Not Known – or – No Improper Action	
		8 Unsafe Vehicle	22			17 Other Action – not directly related to violation	
		9 Lack of Control				18 Pedestrian Action	

Sooner Scene

Woman Survives Icy Plunge

BARTLESVILLE (UPI) — A 28-year-old Barnsdall woman spent about 20 minutes in icy water Thursday after her car ran off SH 123 south of Bartlesville and landed upside down in a creek. The highway patrol said a passing motorist saw the car in the creek and rescued [redacted] who was taken to a Bartlesville hospital suffering from exposure. The woman had only about three inches of air space left in the vehicle when she was rescued. Officials said the creek was covered with an inch-thick layer of ice.

MRS. [redacted] HAD NARROW ESCAPE FROM ICY WATER

[redacted], 28, of Barnsdall, was treated for shock and possible frost-bite and released from a Bartlesville hospital a few hours after being rescued from her overturned car from a creek at the foot of "44 Hill," this side of Bartlesville early last Thursday morning.

Mrs. [redacted] lost control of her car on the rain-slick highway as she was enroute to a Bartlesville nursing home where she is employed, about 6:20 a. m. The car skidded about 200 feet, ripped out a section of guard rail, flipped in the air and landed on its top in a creek in three feet of water. She was pinned in the car with only a few inches of breathing space between the floor of the car and the icy water.

[redacted], Washington County deputy sheriff from Ochelata, discovered Mrs. [redacted] trapped in the car, and forced a door open and released her after she had been in the icy water for about 20 minutes. [redacted] said he noticed the car because the lights were on and submerged in the water.

The 1960 Ford Mrs. [redacted] was driving was a total loss. She said it was not the car she usually drives, and did not have power steering. which she had become accustom to.

Woman, 28, Saved From Icy Stream

A 28-year-old Barnsdall woman spent 20 minutes trapped in icy water with just three inches of air space inside her overturned car this morning, before she was rescued apparently unharmed.

The highway patrol reported Mrs. [redacted] emerged from the perilous episode with no effect except exposure. She is under observation in the Washington County Hospital.

Trooper [redacted] said a Washington County deputy sheriff, [redacted], happened to drive by the scene, saw car lights gleaming in a creek bed and rescued Mrs. [redacted].

[redacted] said Mrs. [redacted] had lost control of the car on rain-slick SH 123 south of Bartlesville about 6:30 a.m. It bounced against a guard post and the end of a bridge before flipping upside down into a creek.

The car lay in three feet of water topped by about an inch of ice. [redacted] said. [redacted] estimated breathing space inside at 3 inches.

Figure 1. Highway 123 approaching bridge.

Figure 2. Where vehicle #1 entered the water.

CAR-PICKUP COLLISION AND FIRE

Case Number 9

A. IDENTIFYING DATA:

Location: At intersection of two county roads, near Altus, Oklahoma, March 21, 1971, at 6:20 p.m.

Vehicles: Vehicle #1 - 1968 Chevrolet Bel Air, 4-door sedan.
Vehicle #2 - 1971 International Harvester, 1/2-ton pickup with "goose neck" horse trailer.

B. AMBIENCE:

Weather: Clear and dry; daylight.

C. HIGHWAY:

Accident occurred at intersection of two two-lane county roads, asphalt (no shoulders), posted speed limit 65 mph (both roads), no traffic control.

D. TYPE OF ACCIDENT:

Intersection - collision - fire.

E. OCCUPANTS:

Vehicle #1: Male, age 54, fatal resulting from massive head injuries.

Vehicle #2: Male, age 18, driver of vehicle, suffered minor bruises.
Male, age 18, passenger of vehicle, suffered minor bruises.

F. ACCIDENT DESCRIPTION:

Vehicle #1 was northbound at approximately 60 mph; vehicle #2, westbound at 45 mph. Neither vehicle slowed for the intersection; vehicle #2 struck vehicle #1 in the right front door; Vehicle #1 overturned and vehicle #2 burst into flames.

G. PRE-CRASH FACTORS:

Vehicle Factors - Vehicle #2 had been converted to a propane fuel system. Utilizing a Beam 400A regulator mounted on the right wheel well and rubber hose extending beneath the vehicle to a tank in the forward section of the pickup bed.

Environmental Factors - The intersection is not equipped with stop signs or any other means of traffic control.

Human Factors - There was no evidence of alcohol or drug involvement. Both vehicles were equipped with seat belts but none were in use. The driver of vehicle #2 had received high school driver's training.

H. CRASH FACTORS:

Vehicle #1 either swerved to the left or was in the wrong lane at time of impact. Vehicle #2 did not alter its speed or course. Neither vehicle left any skid marks prior to impact. Point of impact was nine feet east of the west edge and ten feet south of the north edge of the intersection; vehicle #1 traveled 105 feet rolling one time after impact. Vehicle #2 traveled 90 feet after impact. The tractor broke away and traveled an additional 75 feet. The driver of vehicle #1 was ejected and the vehicle rolled over the subject causing head injuries and death.

I. POST-CRASH FACTORS:

Vehicle #2 suffered damage to the front fenders at impact and the propane regulator was broken. The front of the vehicle burst into flames at impact. The occupants were forced to escape on the left side since the right door was jammed at impact. The flames engulfed the interior in 1-2 minutes post-crash.

J. OPINIONS AND OBSERVATIONS:

1. Propane conversions should be examined as a possible hazardous situation.

CASE #______

SOURCES OF DATA FOR: EPIDEMIOLOGICAL ANALYSIS

1. Accident Report [X]

Report Number 1080 06 23
Date 3-21-71

2. Newspaper Accounts [X]

3. Death Certificates [ ]

Certificate Number(s) ______

---

4. Interviews: [X]

(a) Investigating Officer [X]

(b) Occupant(s) Vehicle #1:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(c) Occupant(s) Vehicle #2:

[X] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(d) Occupant(s) Vehicle #3:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(e) Special Accident Investigator: [ ]

(f) Eye Witness(es): [ ] No.______

(g) Private Physician(s) [ ] No.___

(h) Newspaper Reporter - or Photographers [ ] No.______

(i) Ambulance Attendant(s) [ ] No.___

(j) Fireman [ ] No.______

(k) Embalmer [ ]

(l) Family or Friends of Victim(s): [ ] No.______

(m) Wrecker Operator(s) [ ] No.___

(n) Other(s) [ ] Specify______

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5. Hospital Records: [ ]

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6. Accident Investigation by Staff: [ ]

[redacted] FATAL Sheet 1 of 1 Sheets FATALITY: yes

OKLAHOMA 04 OFFICIAL POLICE TRAFFIC COLLISION REPORT

No. 1030 0623

Reporting Agency: [illegible] Highway Patrol

Date: 3-21-71 Day of Week: Sunday Hour: 6:20 PM County: Jackson

If collision was outside city limits: Altus 0.3 miles of nearest city

Total number veh. involved: 2 No. Injured: 3 No. Killed: 1

On: County Road

At: County Road

State Highway Code — County Number: 33; East: 05 3+0; North: 04 6+0

Time Notified: Date: 3-21-71 Hour: 6:33 PM

Arrived At Scene: Date: 3-21-71 Hour: 6:37 PM

	Unit 1	Unit 2
Driver	[redacted] None	[redacted] 482-4021
Address	[redacted] Oklahoma 73521	[redacted] Altus, Oklahoma 73521
License	Oklahoma [redacted] — Operator	Oklahoma [redacted] — Operator
Age / Race / Sex	56 / W / M	18 / W / M
Date of Birth	12-11-16	3-15-53
Highschool Driver Training	No	Yes
Veh ID No.	[redacted]	[redacted]
Vehicle	1968 Chev. Bel Air 4Dr. s.	1971 I-H P.U. ½ ton — Towed: Trailer
License Plate	[redacted]	[redacted]
Owner's Name	Driver	Driver
Address	Same As Driver	Same As Driver
Legal speed	65	60
Estimated speed before contact	60	45
At contact	60	45
Is Veh. Operable?	No	No
Burned?	No	Yes
Estimated damage	$2000.00	$3000.00
Veh. removed to	Altus	Altus
By	Altus Body Shop	Green Motor Co.

Injured or Witnesses

No.	Name	Address	Phone No.	Age	Sex	Race	Veh. #
1	[redacted]	[redacted] Altus, Okla.	None	56	M	W	1
2	[redacted]	[redacted] Altus, Okla.	3227094	19	M	W	2
3	[redacted]	[redacted] Altus, Okla.	482-4021	13	M	W	2

Injured Taken To: 1. Jackson Memorial Hospital By: Tims Ambulance — Time left scene: 6:40P — Time arrived hospital: 6:45P

Damage to property other than vehicles: None $.00

Driver arrested: Yes. Investigation completed: Yes. Operator's report given to driver: Veh 2. Photos taken: No.

Name of officer: Trooper [redacted] Badge No.: [redacted] District or Division: 5 Approved by: [redacted] Date of report: 3-21-71

DPS 67-1

B-153

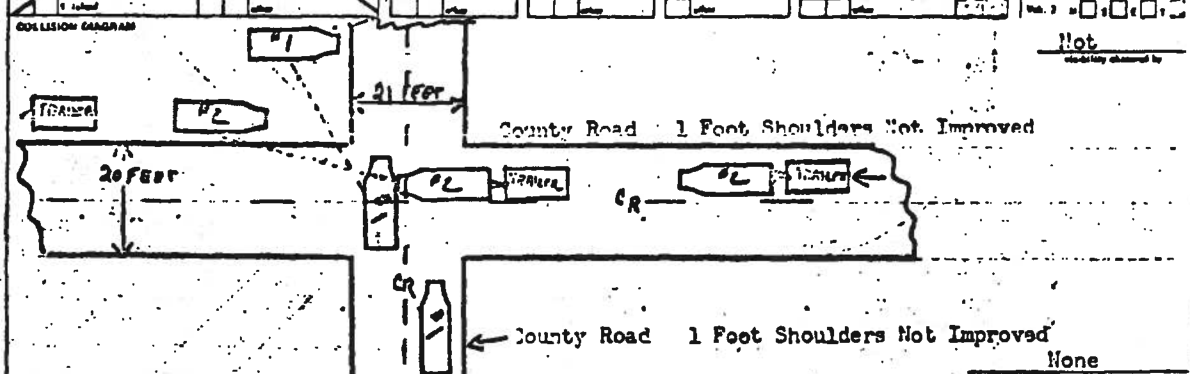
WHAT VEHICLES WERE GOING TO DO | WHAT VEHICLES DID | TYPE OF ROAD | TRAFFIC CONTROL | ROAD CHARACTER | CONDITION OF DRIVERS AND PEDESTRIANS

POINT OF FIRST CONTACT ON VEHICLES | LIGHT | WEATHER | WHAT PEDESTRIAN WAS DOING

OBJECT STRUCK BY VEHICLE | ROAD CONDITION | ROAD SURFACE | LOCALITY | VEHICLE CONDITION | DIRECTION OF TRAVEL

Not

COLLISION DIAGRAM



None

REMARKS:
(Refer to vehicles by number)

Vehicle # 1 was North bound on a county road. Vehicle # 2 was West bound on a county road. Apparently the drivers of both Vehicles did not see each other in time to stop. Neither Vehicle left any skid marks before impact. Point of impact was 9 foot East of the West edge and 10 foot South of the North edge of the intersection. Vehicle # 1 traveled 105 feet rolling 1 time after impact. Vehicle # 2 traveled 90 foot after impact. The trailer broke away and traveled another 75 feet.

UNSAFE, UNLAWFUL, OR OTHER ACTION

Unit 1	Unit 2		Describe	Unit 1	Unit 2		Describe
X		1. Failed to Yield	Failed to yield to the			10. Improper Overtaking	
		2. Followed too Closely	Vehicle on the right.			11. Improper Parking	
		3. Unsafe Speed				12. Inattention	
		4. Made Improper Turn				13. Wrong way on	
		5. Changed Lanes Unsafely				14. Improper Start from	
		6. Stopped in Traffic Lane				15. Other Improper Act or Movement	
		7. Failed to Stop			X	16. Not Known – or – No Improper Action	
		8. Unsafe Vehicle	08			17. Other Action – not directly related to accident	
		9. Left of Center				18. Pedestrian Action	

NOT REPRODUCIBLE

6 Are Killed In Accidents

STATE TRAFFIC TOLL
1971 to date: 144
1970 to date: 120
'71 deaths under 21: 33

Six lives were lost in Oklahoma weekend traffic crashes, including a truck-train collision that pushed the Oklahoma City toll to 16 for 1971 — double the total to date last year.

The dead are:

[redacted], 62, of [redacted] Pioneer.

[redacted] SR., 54, Altus.

[redacted]., 21, Locust Grove.

[redacted]WAY, 35, Checotah.

[redacted] 18, Fort Worth.

[redacted], 69, Fay.

[redacted] was killed late Sunday night when the 2-ton truck he was driving was struck by a Rock Island freight train at the south edge of the state fairgrounds, on Delmar Gardens.

Police said the truck was struck in the bed, hurtled 34 feet and flipped over, throwing [redacted] out.

[redacted] suffered massive head injuries in a car-pickup crash at 6:20 p.m. Sunday, north of Altus on a Jackson County road.

Trooper [redacted] said [redacted] failed to yield at a county road intersection to a pickup with which [redacted], 18, was hauling a trailer. [redacted] escaped with minor injuries although his truck overturned and caught fire.

[redacted] was fatally hurt in a one-car smashup early Sunday near Locust Grove on SH 82 in Mayes County. Trooper [redacted] said he apparently went to sleep and ran the car into a culvert.

Trooper [redacted] said [redacted] was killed early Sunday when his car crossed the center line on U.S. 69 near Muskogee and slammed into a semi-trailer rig driven by [redacted], 23, Lavaca, Ark.

Turn Attempted

The Texas girl was struck and dragged by a truck shortly before midnight Saturday 19 miles north of Atoka on U.S. 69. Trooper [redacted] said she ran into the vehicle' path from in front of the parked truck in which she had been riding.

[redacted]' chest was crushed when his car and another auto collided at U.S. 270 and SH 58A 9 miles west of Watonga about 1 p.m. Saturday. Trooper said [redacted] was attempting a left turn in the other car's path.

E-155

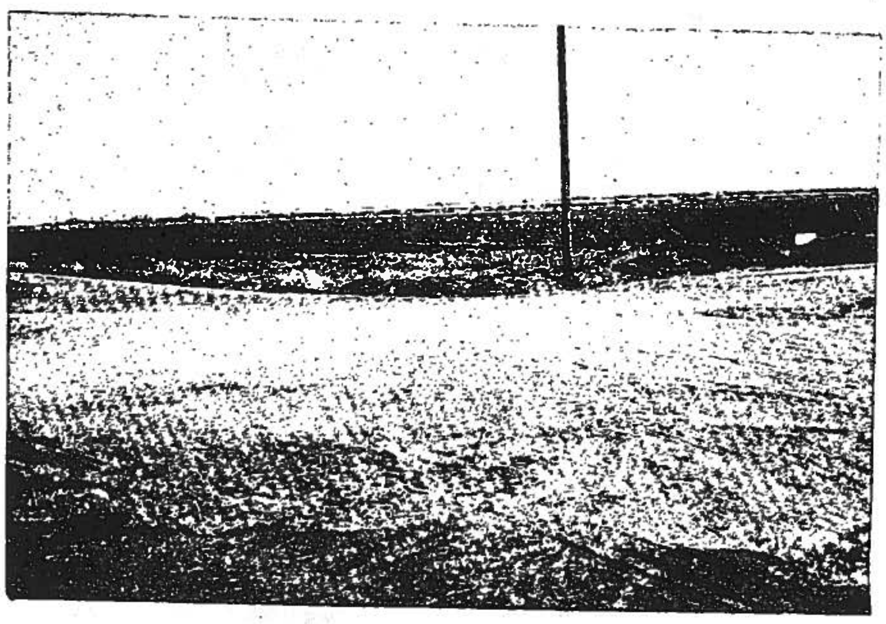


Figure 1. Scene of accident.

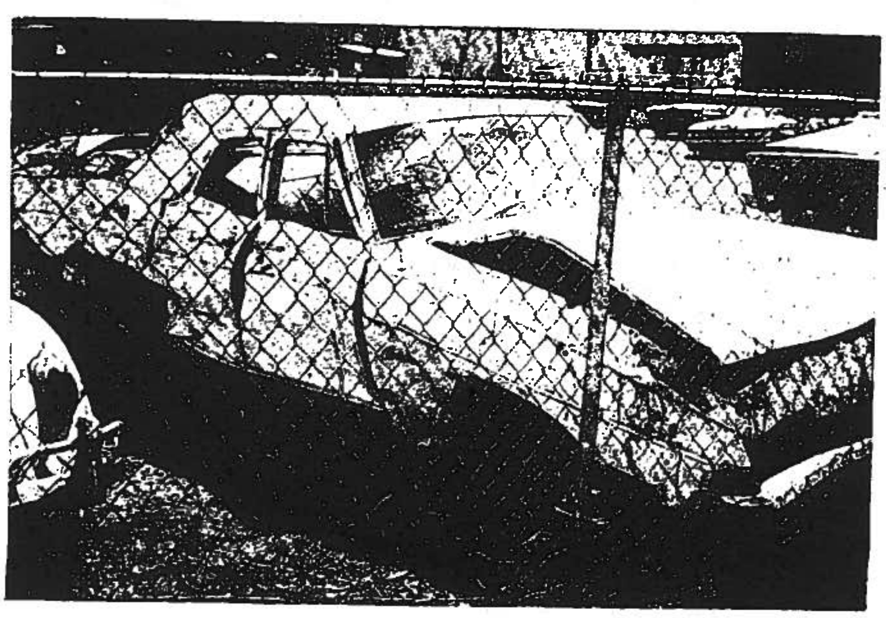


Figure 2. Right side of vehicle #1, 1968 Chevrolet Bel Air.

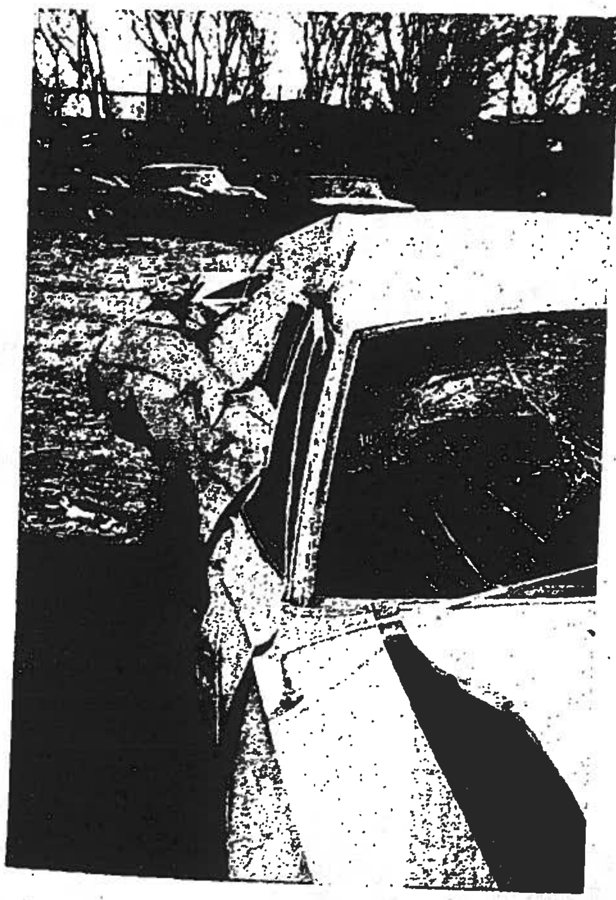


Figure 3. Right front of vehicle #1.

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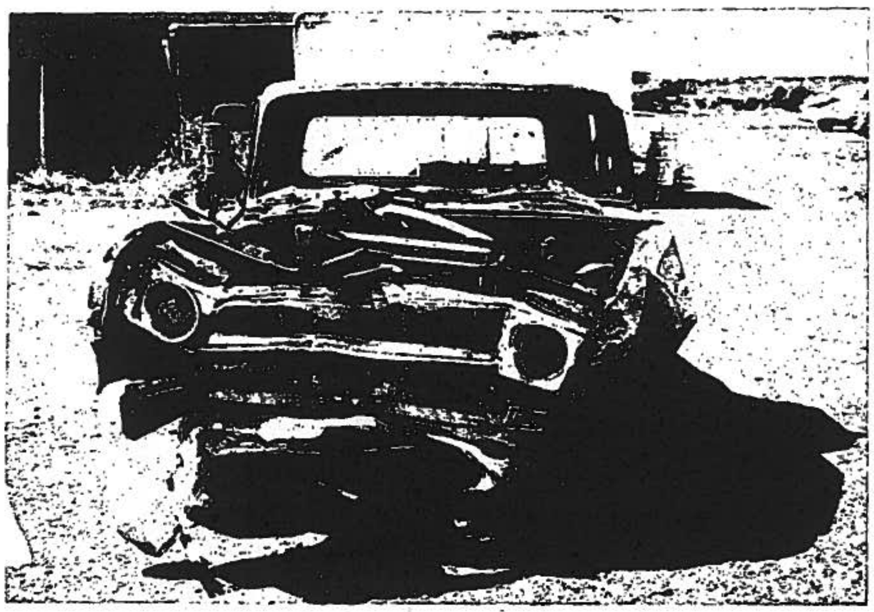

Figure 4. Front of vehicle #2, 1971 International Harvester half-ton pickup.

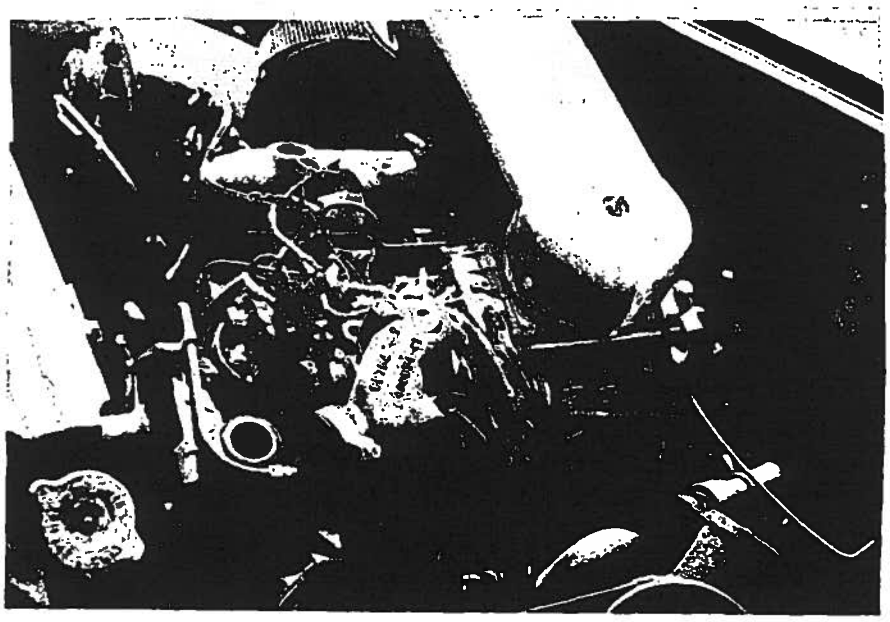

Figure 5. Motor of vehicle #2.

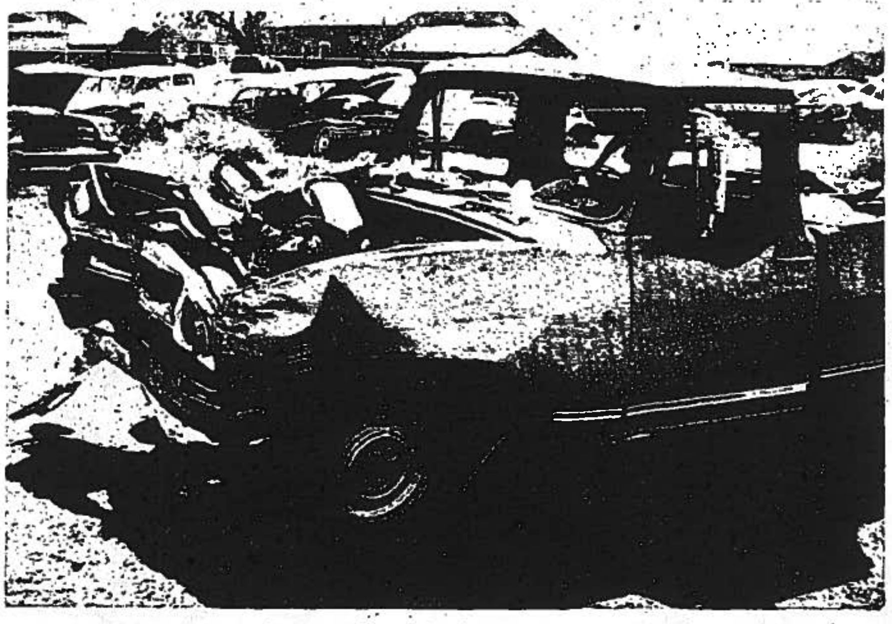

Figure 6. Left side of vehicle #2.

Figure 7. Right side of vehicle #2.

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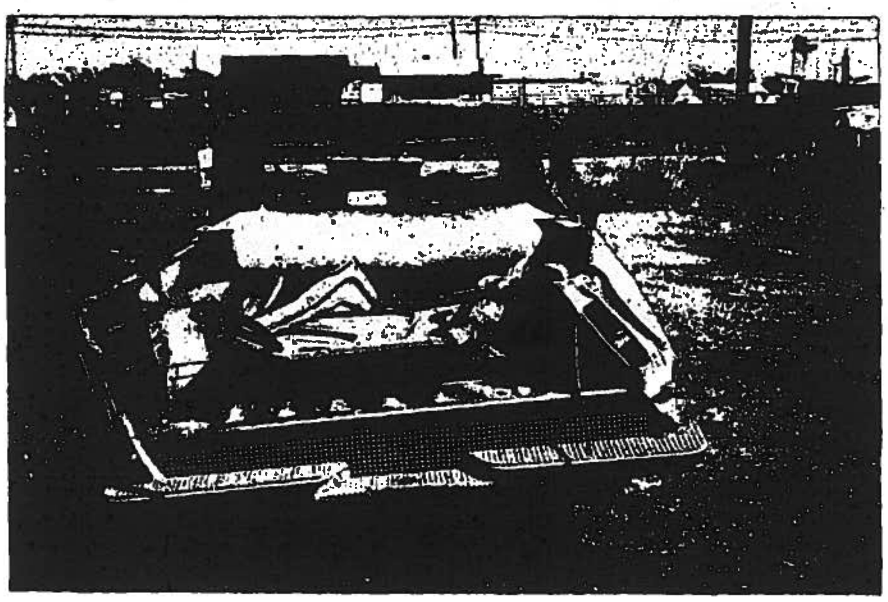


Figure 8. Rear of vehicle #2.

HEAD-ON COLLISION, FIRE

Case Number 10

A. IDENTIFYING DATA:

Location: On State Highway 51, 6 miles west of Wagoner, Oklahoma, on the Verdigris River Bridge. April 13, 1971, at 7:30 p.m.

Vehicles: Vehicle #1 - 1962 Oldsmobile, Starfire, 2-door hardtop, V-8 automatic transmission, air conditioning, odometer reading: 88,083 miles.

Vehicle #2 - 1969 Ford Mustang, 2-door hardtop, 6 cylinder, automatic transmission.

B. AMBIENCE:

Weather: Clear and dry; darkness.

Temperature: Approximately 70 degrees.

C. HIGHWAY:

Two-lane state highway, bridge over river, twenty-two foot road width with three foot width raised walkway on both sides; concrete surface. Posted speed limit of 55 mph.

D. TYPE OF ACCIDENT:

Vehicle #1 was traveling west; crossed to the opposite lane and struck Vehicle #2 on the right front. Vehicle #2 burst into flames at impact.

E. OCCUPANTS:

Vehicle #1 - Male, age 47, driver of vehicle, suffered massive internal injuries, diaphragm was forced up to breast level, leaving four inches of lung tissue. The gastric pattern was 1/2 inch below the diaphragm and even with the aortic knob. Patient survived.

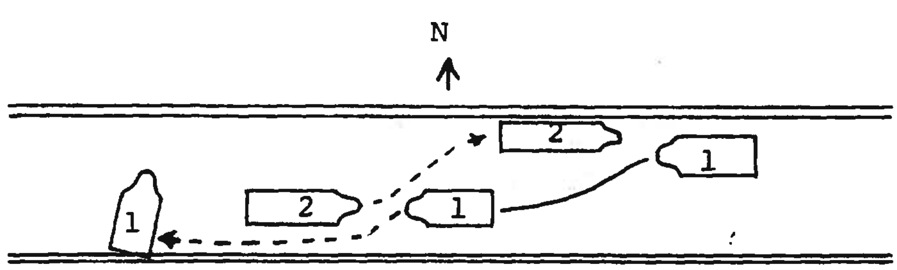
Vehicle #2 - Female, age 20, driver of vehicle, suffered multiple lacerations to head and face, fracture of right orbit, questionable fracture of the spine, hair burned away. Patient survived.

Female, age 20, position 3, suffered fractured right femur, fractured pelvis, fracture of 4th lumbar, singed hair. Patient survived.

Female, age 21, position 5, burned beyond recognition. Fatality.

F. ACCIDENT DESCRIPTION:

Near the middle of the bridge, vehicle #1 veered across into the path of vehicle #2; the right front of vehicle #1 struck the right front portion of vehicle #2. Vehicle #2 burst into flames and burned.



G. PRE-CRASH FACTORS:

Vehicle Factors - There were no apparent mechanical deficiencies on vehicle #2. The tires on vehicle #1 were very poor (rear tires were totally bald).

Environmental Factors - There were no apparent hazards related to the road environment.

Human Factors - No pre-crash information was collected on the occupants of vehicle #2. The driver of vehicle #1 was drunk at the time of the collision and the following records (incomplete) give some indication of his behavior:

1/19/71 - accident, Mayes county
10/20/70 - public disturbance, Wagoner, OK
2/04/70 - reckless driving, Wagoner, OK
12/30/69 - accident, Tulsa, OK
11/18/69 - reckless driving, Wagoner, OK
4/30/69 - order setting aside
4/25/69 - license revoked
11/07/68 - D.W.I., Tahlequah, OK
7/09/63 - accident, Tulsa, OK
8/25/62 - left of center

10/20/46 - reinstated
4/25/46 - suspended
4/19/46 - reckless driving, Bryan county
1941 - convicted of manslaughter (Tulsa)

This individual had been arrested by local police and had his car impounded two weeks prior to this accident for drunken driving.

H. CRASH FACTORS:

Vehicle Factors - Vehicle #1 was traveling at 40-50 mph both prior to the crash and at impact when he veered across the center lane. Vehicle #2 was also traveling at 40-50 mph. Neither vehicle left any skid marks prior to impact. Vehicle #1 struck vehicle #2 on the right front. Vehicle #1 traveled 39 feet after impact. Vehicle #2 traveled 16 feet after impact. The fuel tank on vehicle #2 was knocked from its brackets and came to rest under the rear bumper of the vehicle. The fuel line was broken loose and the tank was penetrated on one end (4" x 1-1/2"). The Mustang (vehicle #2) doors were both jammed and the frame was forced to the ground on the right side. The right windshield corner post was driven back 3 inches. The glove box was forced back 3 feet and the right wheel 3-1/2 feet. The steering wheel was deformed and dropped from the brackets. The interior was totally burned.

The windshield of vehicle #1 was broken. The steering wheel was broken down 5 inches on one side and the turn indicator was broken off. The instrument panel was indented 3 inches below the ignition, the instrument panel was broken completely loose and the floor board was curled up on both sides. The right door was jammed.

Environmental Factors - The pavement beneath vehicle #2 was sprayed with gasoline.

Human Factors - The injuries at impact very severe to all four victims. It was not possible to ascribe injury to specific components of the vehicles.

I. POST-CRASH FACTORS:

Vehicle Factors - Vehicle #2 began burning at impact and continued after the crash until extinguished by the fire department.

Environmental Factors - The gasoline on the pavement contributed to the fire of the vehicle.

Human Factors - The occupants of both vehicles were conscious after the crash but none of the four were able to get out of the vehicles. The driver of Vehicle #2 was removed by two passing motorists immediately after the vehicles came to rest. The driver of vehicle #1 was removed through the left door. The other two individuals were removed through the side windows. The rear seat individual passenger of vehicle #2 was trapped by the front seat back which pinned her legs. Even though she was conscious and was attempting to escape, the flames engulfed the rear seat before the passing motorists could assist her. She burned to death before the witnesses.

J. OPINIONS AND OBSERVATIONS:

1. It is outrageous that persons such as the driver of vehicle #1 are allowed to drive a motor vehicle.

2. If the fuel had been retained in the tank of vehicle #2, the individual killed would have survived.

Burned

FATAL

Sheet 1 of 1 Sheets FATALITY: yes ☒

OFFICIAL POLICE TRAFFIC COLLISION REPORT

1103 0180

OKLAHOMA 04 — Reporting Agency: OKLAHOMA HIGHWAY PATROL

Date: 4-13-71 Day of Week: TUESDAY Hour: 7:30 PM County: WAGONER

Total Number Motor Veh. Involved: 2 No. Injured: 2 No. Killed: 1

WAGONER (Name of Nearest City) Distance From Nearest City Limits: 6 Miles

Location: ON SH51 — NOT AT INTERSECTION: .6 mi East OF COUNTY Rd

State Highway Code: Control No. 141 Location 0920

County Number: 73 County Section Line Grid: 0350 1 0267

Time Notified: Date 4-13-71 Hour 7:40 PM
Arrived At Scene: Date 4-13-71 Hour 7:45 PM

	Unit 1	Unit 2
Name	[redacted]	[redacted]
Address	[redacted]	[redacted]
License	[redacted] OKLA [redacted] ☒ Operator	[redacted] ☒ Operator
Age / Race / Sex	47 W M	20 N F
Date of Birth	5 3 23	9 12 50
Driver Training	☒ No	☒ No
Veh ID No.	[redacted]	BURNED
Vehicle	62 Olds Starfire 2 DRS	69 FORD MUSTANG 2 DR
License Plate	[redacted]	[redacted]
Owner's Name	DRIVER	DRIVER
Address	SAME AS DRIVER	SAME AS DRIVER
Is Veh Operable?	No ☒	No ☒
Legal speed / before contact / at contact	55 MPH / 40-50 MPH / 40-50 MPH	55 MPH / 40-50 MPH / 0-0 MPH
Estimated damage	$1000.00	$2200.00
Veh. removed to / by	WAGONER / HEFNER	WAGONER / FREEMAN

	Name	Address	Age	Sex	Race	Veh	Position
1	[redacted]	SAME AS DRIVER VEH 2	21	F	N	2	
2	[redacted]	2829 E 36th N TULSA OKLA	20	F	N	2	
3	[redacted]	SAME AS DRIVER VEH 1	47	M	W	1	
4	[redacted]	SAME AS DRIVER VEH 2	20	F	N	2	

Injured Taken To: 1 WAGONER HOSP By: MALLETT FUNERAL HOME — Time left scene: 7:50 Time arrived hospital: 7:55

Investigation made at scene? Yes ☒ Investigation completed? Yes ☒

Arrest: [redacted] Citation: MANSLAUGHTER 1st 721-5711 Citation No. 1127E113

Signature: [redacted] District or Division: 9 Date of report: 4-13-71

B-165

NOT REPRODUCIBLE

WHAT VEHICLES WERE GOING TO DO: 1 Go ahead (Unit 1 X, Unit 2 X)

WHAT VEHICLES DID: 1 Went ahead (Unit 1 X, Unit 2 X)

TYPE OF ROAD: 3 Two lanes (Unit 1 X, Unit 2 X)

TRAFFIC CONTROL: 9 No control (Unit 1 X, Unit 2 X)

ROAD CHARACTER: 1 Straight-level (Unit 1 X, Unit 2 X)

CONDITION OF DRIVERS AND PEDESTRIANS: X marked for Unit 1 and Unit 2

POINT OF FIRST CONTACT ON VEHICLES: 1 Front center (Unit 1 X, Unit 2 X)

LIGHT: 2 Darkness (X)

WEATHER: 1 Clear (X)

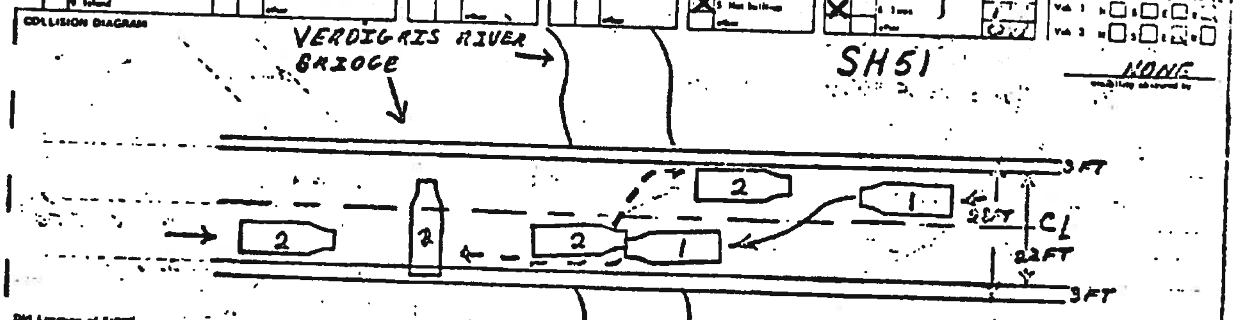
ROAD CONDITION: 1 Dry (Unit 1 X, Unit 2 X)

ROAD SURFACE: 1 Concrete (Unit 1 X, Unit 2 X)

LOCALITY: 5 Not building (X)

VEHICLE CONDITION: 6 Tires (X)

COLLISION DIAGRAM



Did Location of FIRST Damage or Injury Producing Event Occur on Travel Portion of Trafficway? Yes ☒ No ☐

NONE — Defect in Road

REMARKS: (Comments that will clarify report. Refer to vehicles by number)

NO SKIDMARKS FOR EITHER VEH BEFORE IMPACT. VEH #1 TRAVELED 39FT AFTER IMPACT. VEH #2 TRAVELED 16FT AFTER IMPACT. POI WAS 3.5 FT SOUTH OF CENTER LINE, AND 154FT EAST OF WEST END OF BRIDGE.

GAS TANK OF V#2 RUPTURED.

UNSAFE, UNLAWFUL, OR OTHER ACTION (this section is primarily for general statistics and administrative purposes)

Unit 1	Unit 2	Action	Describe	Unit 1	Unit 2	Action	Describe
		1. Failed to Yield				10. Improper Overtaking	
		2. Followed too Closely				11. Improper Parking	X DWI
		3. Unsafe Speed				12. Inattention	
		4. Made Improper Turn				13. Wrong way on –	
		5. Changed Lanes Unsafely				14. Improper Start from –	
		6. Stopped in Traffic Lane		X		15. Other Improper Act or Movement	
		7. Failed to Stop				16. Not Known – or – No Improper Action	
		8. Unsafe Vehicle	58			17. Other Action – not directly related to accident	
		9. Lapsed Conv.				18. Pedestrian Action	

Passing Motorists Rescue Pair

Flaming Collision Kills Woman

STATE TRAFFIC TOLL
1971 to date: 192
1970 to date: 176
'71 deaths under 21: 50

A young Tulsa woman died in flaming wreckage and two other persons were killed in a separate headon collision Tuesday night in eastern Oklahoma.

Dead are:

[redacted], 22, Tulsa.

[redacted], 27, Parkhill.

[redacted], 19, Siloam Springs, Ark.

Miss [redacted], burned beyond recognition, was trapped in a car from which three passing motorists rescued her sister and another Tulsa girl shortly after a 7:30 p.m. crash at the Verdigris River Bridge on SH 51 near Wagoner.

Troopers [redacted] and [redacted] said a car driven by the victim's sister, [redacted], 18, Tulsa, and an auto driven by [redacted], 48, Tulsa, collided after Miss [redacted] tried to swerve to avoid impact.

The surviving sister and another passenger, [redacted], 20, Tulsa, are in serious condition in Tulsa's Osteopathic Hospital and St. John's Hospital respectively. [redacted] was listed in serious condition in St. Francis Hospital.

The two women were pulled from the car by passing motorists [redacted] and [redacted], Wagoner, and [redacted], Tulsa.

Investigating officers said only the quick action saved the two lives.

[redacted] and Miss [redacted] were killed when [redacted]'s car collided headon with a pickup driven by [redacted], 29, Tahlequah about 11:30 p.m. just south of Tahlequah on U.S. 62.

Trooper [redacted] said the pickup, traveling an estimated 70 miles per hour, crossed the center line. [redacted] was admitted to St. Francis Hospital in fair condition.

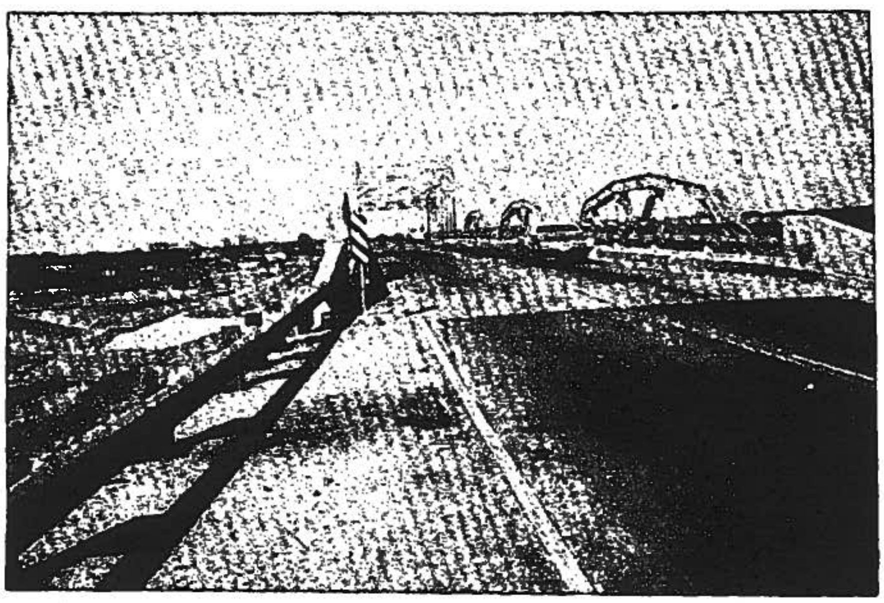


Figure 1. Scene of accident.

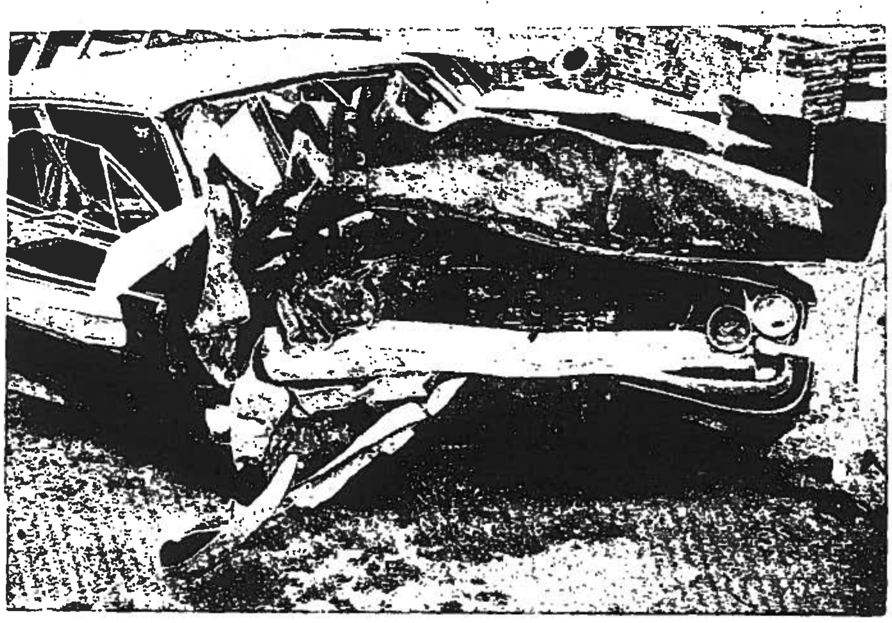


Figure 2. Front of vehicle #1, 1962 Oldsmobile Starfire.

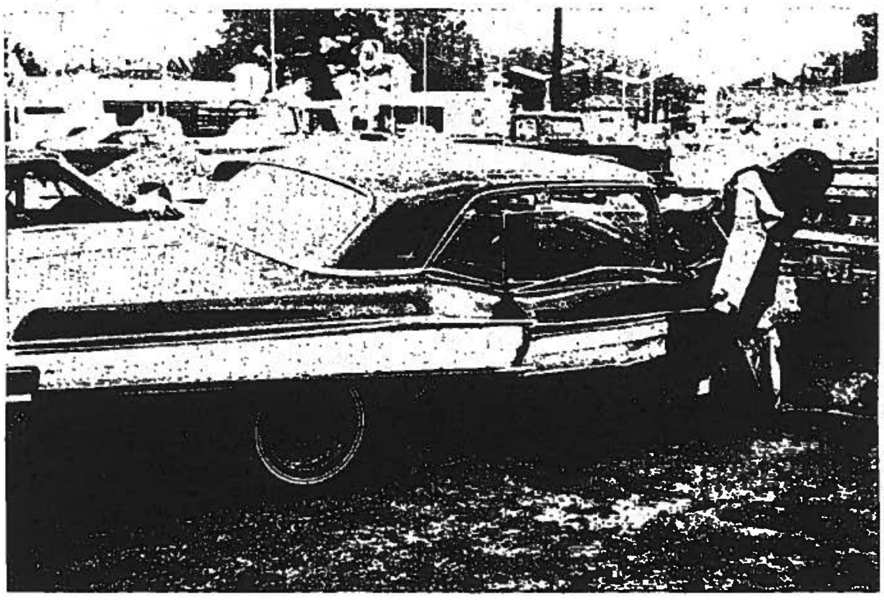


Figure 3. Right side of vehicle #1.

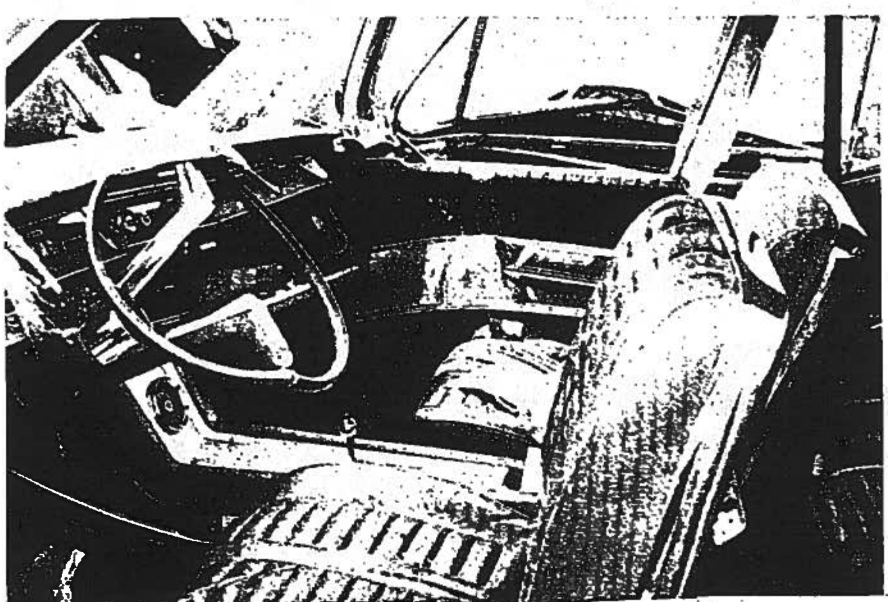


Figure 4. Interior of vehicle #1.

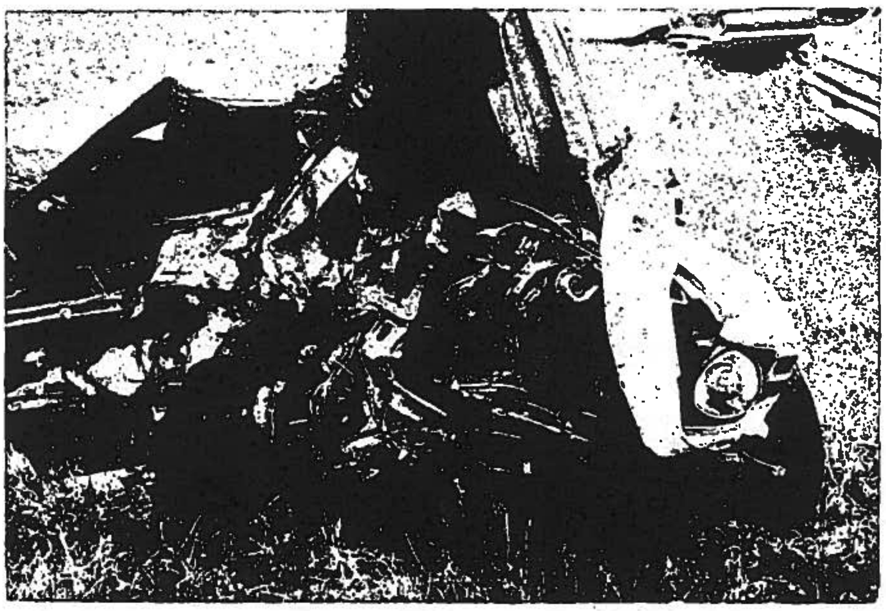


Figure 5. Front of vehicle #2.

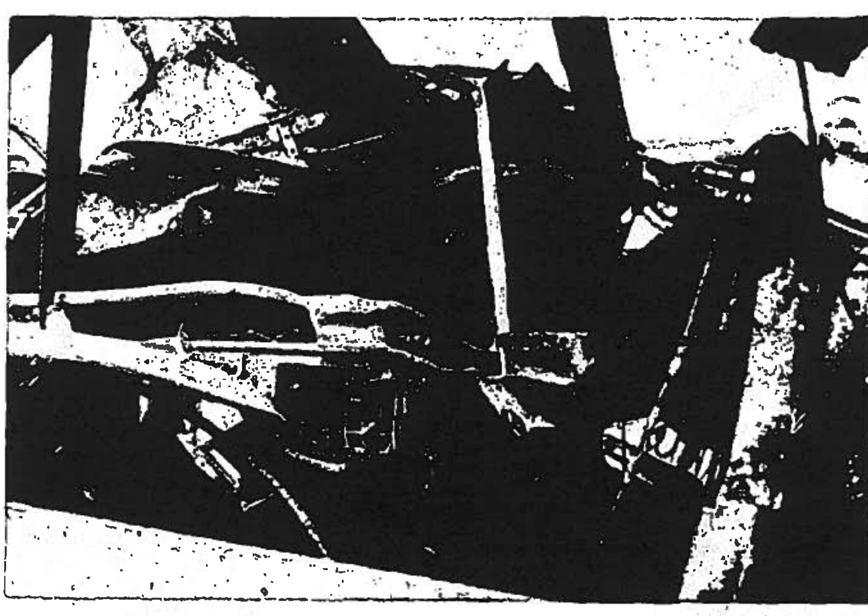


Figure 6. Interior of vehicle #2.

Figure 7. Left side of vehicle #2, 1969 Ford Mustang.

Figure 8. Right side of vehicle #2.

Figure 9. Fuel tank, vehicle #2.

This page is reproduced at the back of the report by a different reproduction method to provide better detail.

TRACTOR-TRAILER CRASH, FIRE

Case Number 11

A. IDENTIFYING DATA:

Location: Interstate Highway 40, eastbound at North Canadian River bridge, April 11, 1971, at 11:20 a.m.

Vehicle: 1966 White Freightliner, refrigerated trailer, loaded with sides of beef suspended from the roof.

B. AMBIENCE:

Weather: Clear and dry; high gusty winds estimated at 35 mph.

C. HIGHWAY:

Heavily traveled, one-lane road at interchange of I-35 and I-40 in Oklahoma City. Lane merged at North Canadian River Bridge. Posted speed limit is 65 mph; suggested speed is 45 mph.

D. TYPE OF ACCIDENT:

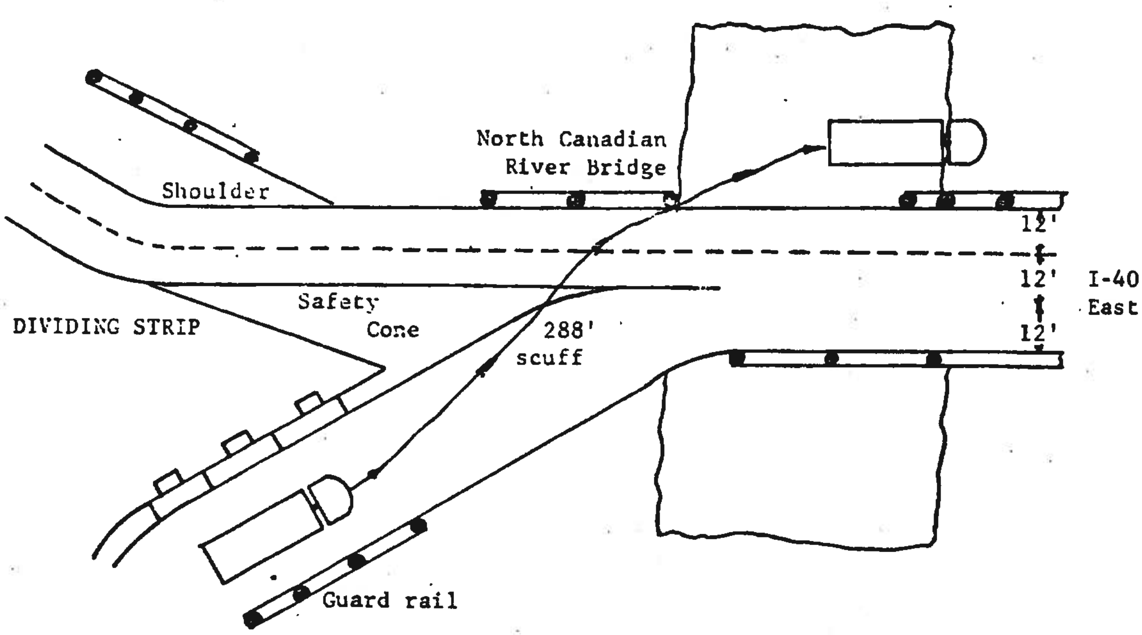
Vehicle struck rough portion of highway, lost control and ran through bridge railing into river. Tractor exploded and burned along with portions of the trailer.

E. OCCUPANTS:

Male: Age 41, driver of vehicle, suffered minor lacerations and shock.

F. ACCIDENT DESCRIPTION:

Vehicle was traveling north of Interstate 35 at approximately 60-65 mph when the I-40 east exit consisting of a single lane was taken. As the vehicle entered the gentle curve, a rough spot in the road caused the load to shift and this coupled with a gust of high wind and excessive speed caused the driver to lose control. The vehicle ran through the guard rail of a bridge and fell forty feet to the river bed. The gas tanks exploded upon impact.



G. PRE-CRASH FACTORS:

Vehicle Factors - There were no identifiable mechanical deficiencies.

Environmental Factors - The "rough spot" in the road causes a sudden dip in the surface which is hazardous when approached at high speed.

Human Factors - Seat belts were not in use.

H. CRASH FACTORS:

Vehicle Factors - The swinging beef shifted the C.G. of the vehicle causing the driver to lose control. The fuel tanks erupted upon impact and flames spread throughout the immediate area. The fiberglass cab of the tractor burst open and the driver was ejected through the broken cab.

Environmental Factors - The incident occurred on concrete that was dry. Even though the speed limit was 65 mph, it is not possible to turn this curve with a rig such as this at that speed. The suggested speed is 45 mph, but is unlikely that many motorists see the small sign suggesting this speed due to the confusion that is probable at this intersection.

Human Factors - The driver fought to gain control of the rig but was unable to do so. He received minor lacerations as a result of the crash.

I. POST-CRASH FACTORS:

Vehicle Factors - The trailer split open upon striking the river bed, and the drag axle was torn loose from the drive axle. The cab split open as it hit the bank. The tail gate also came off at impact. One of the gas tanks was found to be split open and the other could not be found. These saddle tanks were constructed of aluminum and fueled the fire that consumed the tractor and portions of the trailer and load of meat. The fire was extinguished ten minutes post-crash by the fire department.

Human Factors - The subject was ejected from the broken cab and landed in soft sand ten feet from the major portion of the cab and undercarriage.

J. OPINIONS AND OBSERVATIONS:

1. Four tractor-trailer rigs have been involved in similar collisions at this site in less than twelve months.

2. Three of these trucks have been loaded with swinging beef.

CASE #______

SOURCES OF DATA FOR: EPIDEMIOLOGICAL ANALYSIS

1. Accident Report [X]

Report Number 11010381
Date April 11, 1971

2. Newspaper Accounts [X]

3. Death Certificates [ ]

Certificate Number(s)______________

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4. Interviews: [X]

(a) Investigating Officer [X]

(b) Occupant(s) Vehicle #1:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(c) Occupant(s) Vehicle #2:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(d) Occupant(s) Vehicle #3:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(e) Special Accident Investigator: [ ]

(f) Eye Witness(es): [ ] No.______

(g) Private Physician(s) [ ] No.___

(h) Newspaper Reporter - or Photographers [ ] No.______

(i) Ambulance Attendant(s) [ ] No.___

(j) Fireman [x] No. 2

(k) Embalmer [ ]

(l) Family or Friends of Victim(s): [ ] No.______

(m) Wrecker Operator(s) [ ] No.___

(n) Other(s) [ ] Specify______

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5. Hospital Records: [ ]

---

6. Accident Investigation by Staff: [ ]

Burned E-Sutherland (struck through)

Sheet 1 of 1 Sheets FATALITY: yes

OKLAHOMA /0 — OFFICIAL POLICE TRAFFIC COLLISION REPORT — 1101 — CCS1

Reporting Agency: OKLAHOMA HIGHWAY PATROL

Date: 4-11-71 — Day of Week: SUNDAY — Hour: 11:20 AM — County: OKLAHOMA

Total Number Motor Veh. Involved: 1 — No. Injured: 1 — No. Killed: 0

In: OKLAHOMA CITY

On: I-40 EAST BOUND

At: NORTH CANADIAN RIVER BRIDGE (.4)

State Highway Code: Control No. 68 — Location 0040 — County Number 55 — 18 — City Code 701 — 0

Time Notified: Date 4-11-71 Hour 11:25 AM

Arrived At Scene: Date 4-11-71 Hour 11:30 AM

Unit 1

Driver: [redacted]

Address: [redacted]

License: [redacted] — Chauffeur [X]

Age: 41 — Race: W — Sex: M — Date of Birth: 8-6-29

Highschool Driver Training: No [X]

Veh ID No.: [redacted]

Vehicle: 66 WHITE FREIGHT LINER

License Plate: [redacted]

Owner's Name: SAME AS DRIVER

65 MPH legal speed — 60-65 MPH before contact — 45-50 MPH at contact

Is Veh Operable? No [X] — $3500.00 estimated damage

Veh removed to: OKLA. CITY by: CLAUD'S WRECKER

Unit 2

(blank)

Injured / Witnesses

1. Injured [X] — [redacted] — RT #1 HARRISON TENN — Age 41 — Sex M — Race W — Veh 1

Injured Taken To:

1. MERCY HOSPITAL by SYKES AMBULANCE — Time left scene 11:45 AM — Time arrived hospital 12:00 PM

Damage to property other than vehicles: GUARD RAIL $300.00 — Owner: STATE OF OKLAHOMA

Investigation made at scene? Yes [X] — Investigation completed? Yes [X]

1. [redacted] — Citation: OPERATING A MOTOR VEH. IN A MANNER NOT REASONABLE AND PROPER (11-901) — Citation No. A 527719

Sign Here: Trooper [redacted] — Troop: 1 — Reviewed by: [redacted] — Date of report: 4-13-71

WHAT VEHICLES WERE GOING TO DO	WHAT VEHICLES DID	TYPE OF ROAD	TRAFFIC CONTROL	ROAD CHARACTER	CONDITION OF DRIVERS AND PEDESTRIANS
Unit 1: 1 Go ahead (X)	Unit 1: RAN OFF BRIDGE (X)	Unit 1: 5 Four or more divided (X)	Unit 1: 10 No control (X)	Unit 1: 7 Curve downgrade (X)	Unit 1: 1 Apparently normal (X)

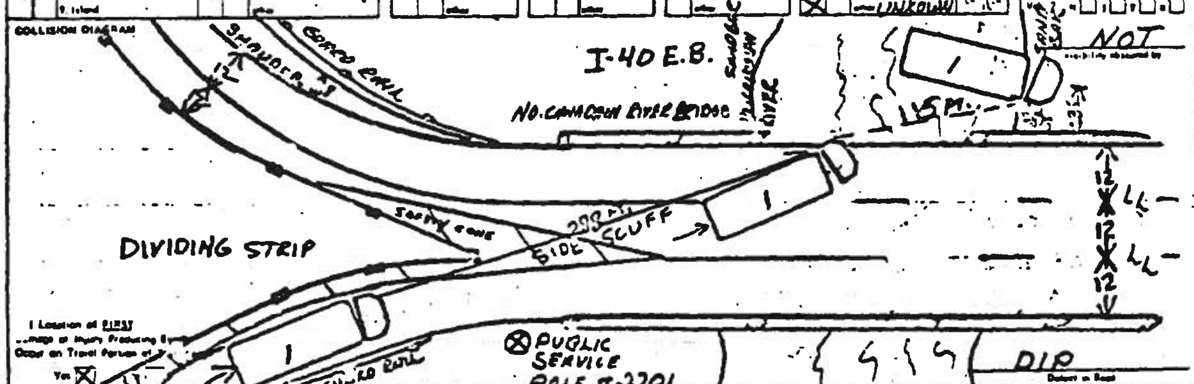
POINT OF FIRST CONTACT ON VEHICLES — Unit 1: 11 Left side forward (X)

LIGHT	WEATHER	ROAD CONDITION	ROAD SURFACE	LOCALITY	VEHICLE CONDITION	TIRE CHECK
1 Daylight (X)	1 Clear (X)	1 Dry (X)	1 Concrete (X)	8 Not built-up (X)	other: UNKNOWN (X)	

DIRECTION OF TRAVEL: Veh 1 — E (X)

VISIBILITY OBSCURED BY: NOT

COLLISION DIAGRAM



REMARKS:

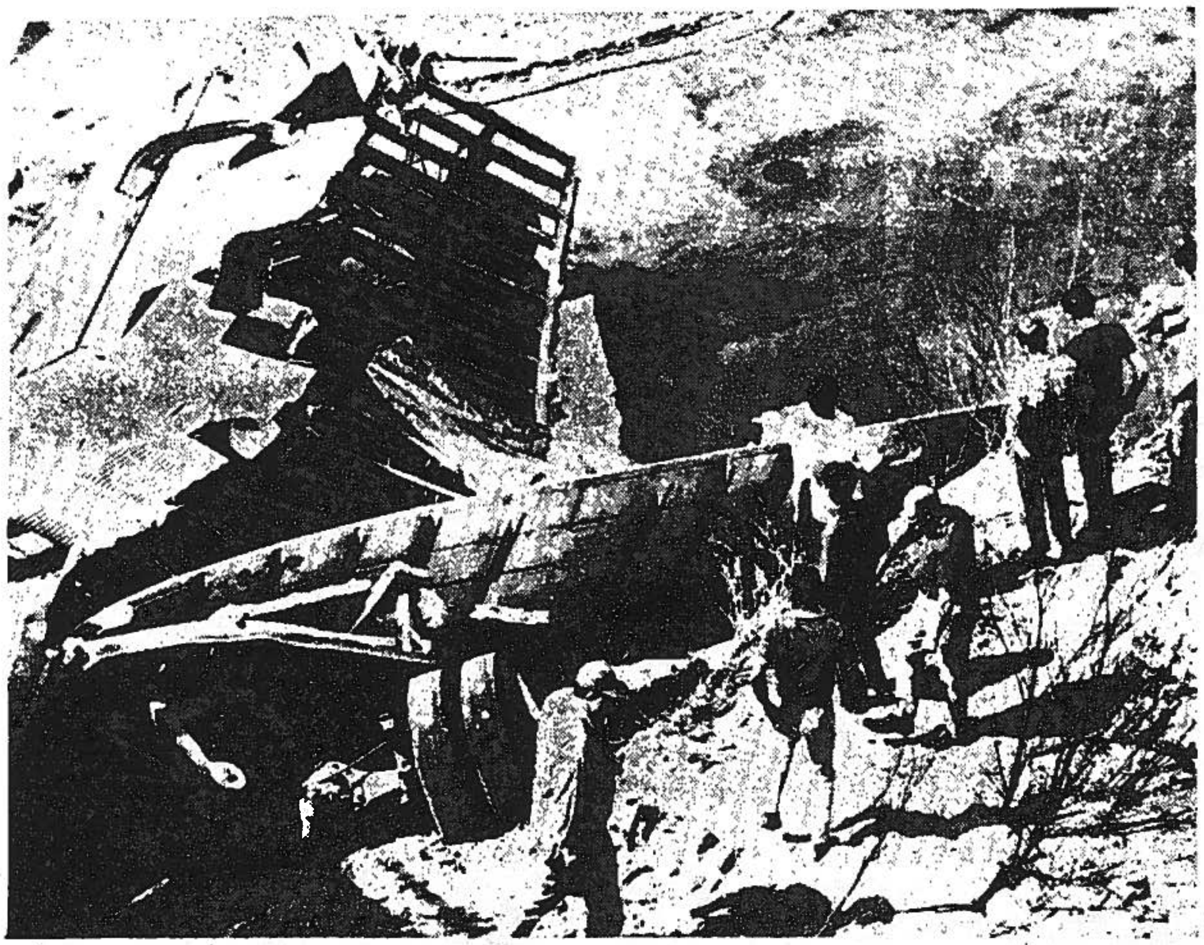
VEH #1 GOING AROUND CURVE LOST CONTROL OF VEH, STRICKING CURB TRAVELLIN' 'NOTHER 15 FT TAKING OUT GUAR RAIL, THEN VEH #1 WENT INTO RIVER, POINT OF IMPACT WAS APPROXIMATELY 93 FT EAST OF PUBLIC SERVICE POLE #2701 AND APPROXIMATELY 38 FT NORTH OF SOUTH EDGE OF ROADWAY.

'TIRE INFORMATION NOT AVAILABLE VEH BURNED") (# NOTE DRIVER STATED THAT WHEN HE FELT HIS LOAD SHIFT HE ACCELERATED)

UNSAFE, UNLAWFUL, OR OTHER ACTION

3 Unsafe Speed → DUE TO SUGGESTED SPEED OF HE MAN AND "WIND"

27



Smashed refrigerated trailer and $20,000 worth of beef lie in the North Canadian River. (Staff Photo by Dave Pate)

Trucker Survives Fiery Crash; Cargo, Tractor Total Loss

By Mike Burger

A tractor-trailer truck crashed through a guard rail on an I-40 bridge Sunday at nearly 50 miles an hour and plunged 50 feet into the North Canadian river where it burned and exploded.

The driver received only minor injuries.

"I remember someone brushing sand out of my face and dragging me," driver [redacted], 41, of Harrison, Tenn., said afterward.

Investigating highway patrol Trooper [redacted] said [redacted] apparently lost control of his truck which was loaded with 39,000 pounds of hanging beef just before he turned onto the eastbound I-40 bridge over the river in Oklahoma City.

[redacted] said the truck left 288 feet of skid marks, tore out 60 feet of guard rail and flew 50 feet forward and 50 feet down before landing in the river bed.

He said the refrigerated trailer crashed into the water, spilling its cargo. The tractor crashed into the sand on the far side of the water and burst into flames.

The driver of a second truck behind [redacted]'s and two passing motorists rushed to [redacted] aid. They told [redacted] was sitting in the sand 15 feet away from his burning tractor.

They said he did not appear hurt, but was dazed. They pulled him to safety just before a large gas tank on the truck exploded, [redacted] said. The tractor was a total loss.

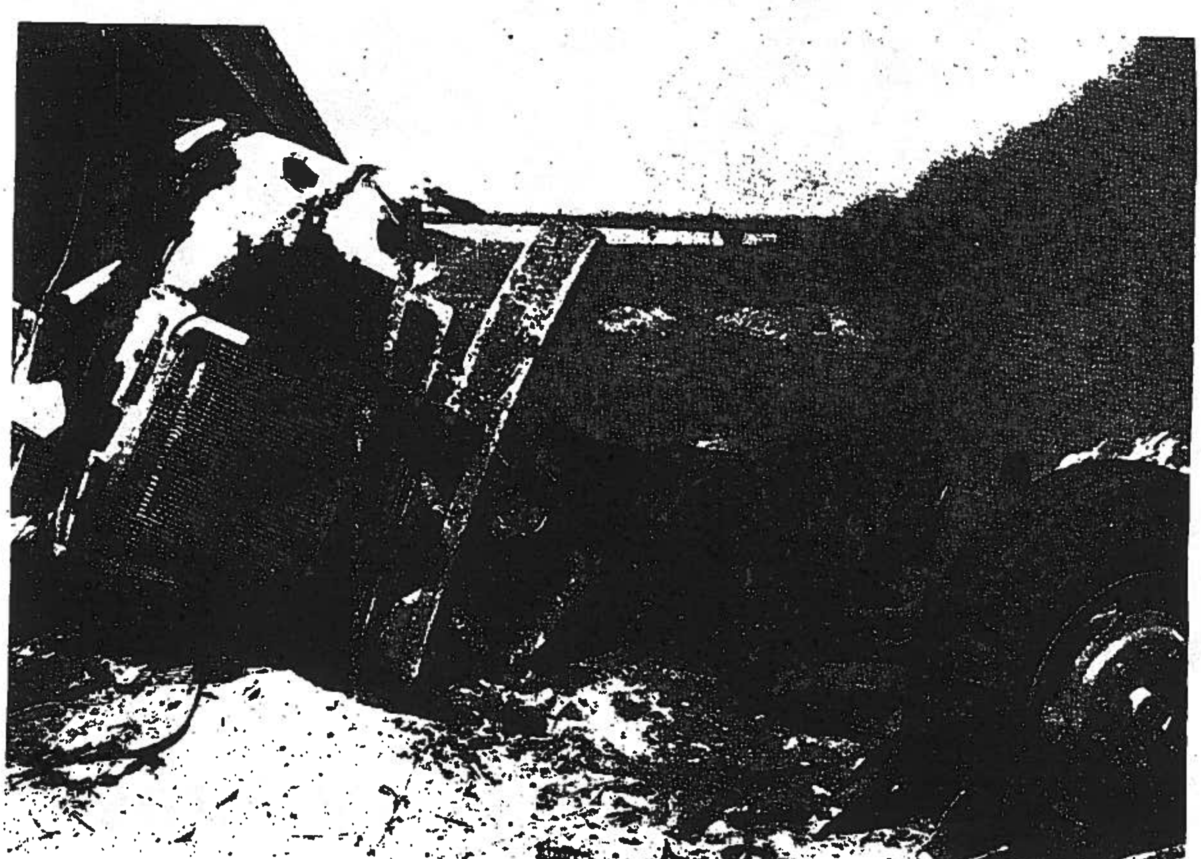
[redacted] was enroute from Guymon to Pennsylvania.

[redacted] said a state meat inspector at the scene told him the cargo, valued at $20,000, also would be a total loss.

In his Mercy Hospital room where he is awaiting results of an x-ray examination for possible injury, [redacted] said he lost control of the truck when he hit a dip just before the bridge.

The dip caused the load to shift, [redacted] said, and tipped the trailer over causing the tires on one side to rub. When the tires rubbed, it pulled the rig off the road, he said.

He told [redacted] he almost got the rig under control once, then a heavy gust of wind sent it out of control and off the bridge.



After The Fall, There Was Fire

The cab and engine of the semi-truck that plunged into the North Canadian Sunday exploded into flames soon after hitting the ground. [redacted], 41, driver of the rig, escaped death when he was thrown clear of the wreckage. Story on Page 1. (Staff Photo by [redacted])

This page is reproduced at the back of the report by a different reproduction method to provide better detail.

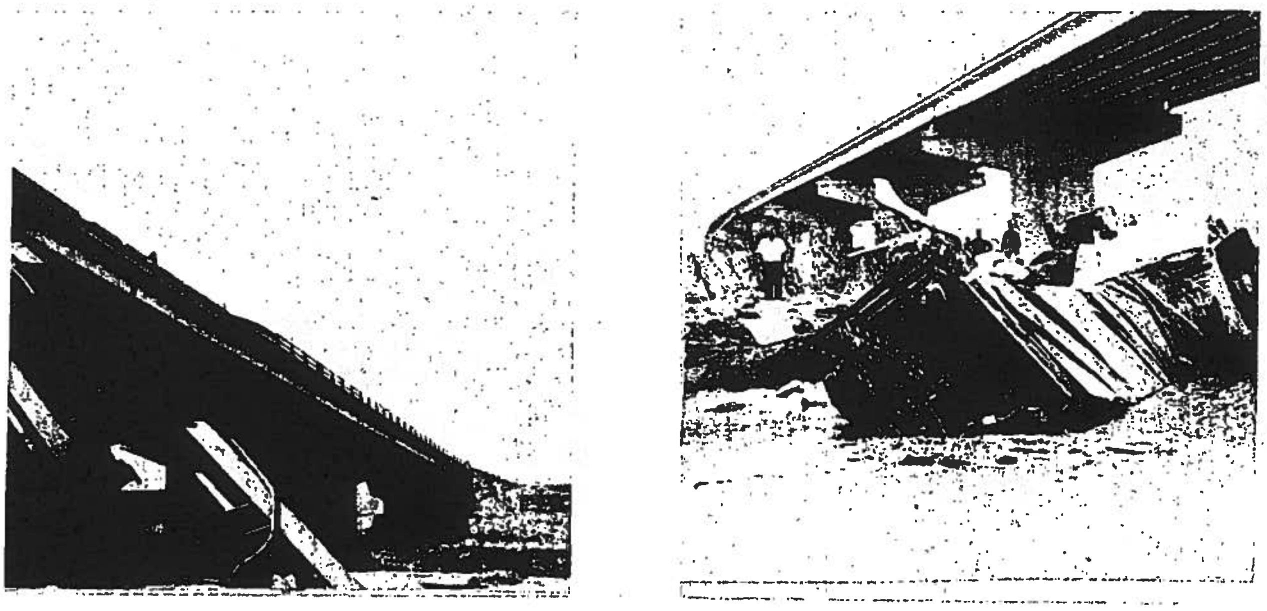
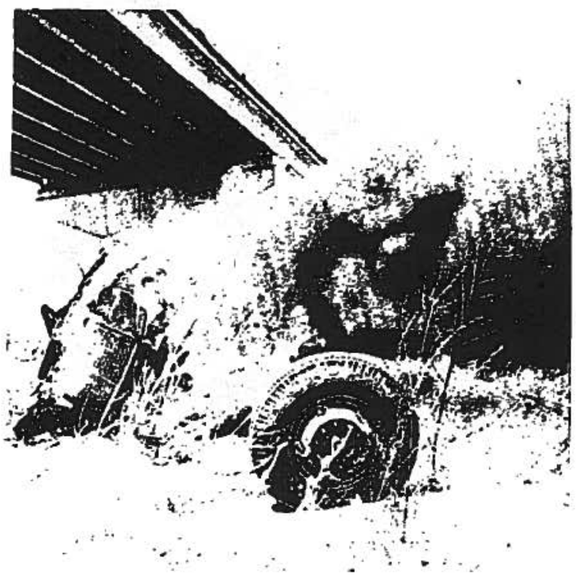


Figure 1. Bridge where truck went off.

Figure 2. Trailer of 1966 White Freightliner.



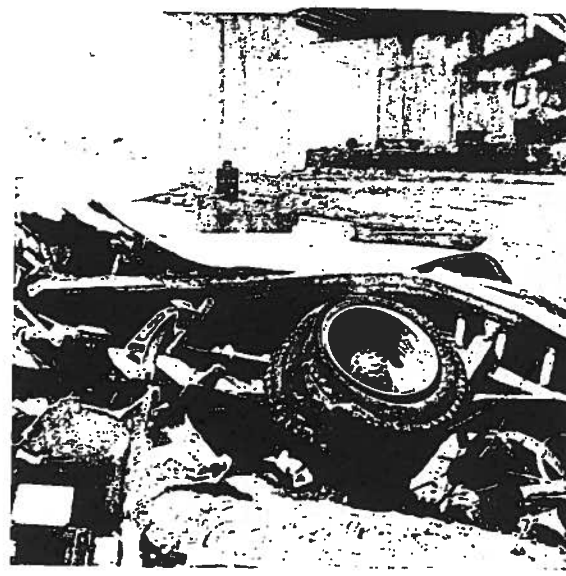


Figure 3. Trailer.

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Figure 4. Trailer and cargo.

SUMMARY OF TWO VEHICLE COLLISION INVOLVING OCCUPANT FATALITY (wearing lap belt and shoulder harness)

Case Number A-1

A. IDENTIFYING DATA:

Location: Accident occurred on U.S. Highway 75 at the intersection of a city street in Lehigh, Oklahoma, on September 7, 1970, 7:45 a.m., Monday, involving two cars, with a right angle collision.

Vehicles: #1 - 1966 Chevrolet Biscayne, 4-door sedan, lap belts present, damage $750.00 to right front quarter panel and door.

#2 - 1969 Volkswagen, (bug) type 1131, 4-speed transmission (floor), lap belts and shoulder harness present, odometer reading: 13,841 miles. Damage $1,000.00 to front and left rear fender.

Both vehicles were actually totaled and sold for salvage.

B. AMBIENCE:

Daytime, partly cloudy, no precipitation; temperature 65°F, road surface dry.

C. HIGHWAY:

U.S. highway at city street, both concrete, light business location. Speed limit 50 mph on both roads. Traffic control: none.

D. TYPE OF ACCIDENT:

Vehicle #1 crossed U.S. highway and was struck in the side by vehicle #2.

E. OCCUPANTS:

#1 - Driver, 71, female, no driver's training, current operator's license, received visible lacerations to head. No restraints in use.

#2 - Driver 26, male, no driver's training, current operator's license, received visible lacerations to head. Lap belt and shoulder harness in use.

#2 - Right front passenger, 25, female, 5'1", 135 pounds, lap belt and shoulder harness in use. Fatality. Injuries: con usion of head, cerebral concussion, ruptured spleen, fracture of liver (left lobe completely loose), trauma to jejunum, contusion extending from right shoulder down across chest involving the lower left ribs with fracture of two lower left ribs. Patient died 33 days post-crash of complications resulting from injuries. Cause of death described as: cardiac failure secondary to hepatic failure, ruptured spleen, fracture of large fragment of liver.

#2 - Child, right front passenger (sitting in mother's lap), 23 months, female, no restraints in use. Injuries: contusion forehead, simple fracture of left femur.

F. ACCIDENT DESCRIPTION:

Pre-Crash - Vehicle #1 (the Chevrolet) was leaving post office parking lot at 10 mph and was cutting diagonally across the intersection and was in the wrong lane at the time of impact. The driver did not stop at highway but proceeded directly east across the highway. There was no evidence of braking action for vehicle #1.

Crash - Vehicle #2, impacted head-on into the right front quarter of vehicle #1. Impact speed was 15-17 mph. The driver of vehicle #2 was thrown forward and to the left impacint the side glass with his head, breaking and bending the steering wheel down 3 inches. One foot deformed the clutch pedal slightly down and to the left. The steering wheel was not collapsed but the tube was slightly deformed at the mounting bracket.

The adult female was thrown forward and to the left. The lap and shoulder harness rode upward above the iliac crest. Her shoulder probably came out of the shoulder harness and her head struck some portion of the instrument panel. The shoulder belt was probably adjusted properly for this size individual (disregarding sitting height). The lap belt was adjusted for a much larger person. The lap belt would have had approximately six inches of free space when stretched out in front of the groin.

The child was thrown forward striking her head (probably on the glove box door leaving a slight indention). The left leg struck some unknown part under the instrument panel on the fire wall.

Post-Crash - While it would normally be expected that these individuals would have been protected by the shoulder harness, in this case, the occupants were subjected to fairly high sideward forces since vehicle #2 rotated clockwise about its C.G., approximately 80 degrees.

Vehicle #1 - Vehicle #1 rolled out at 40 degrees to the left some 33 feet post impact, mounting a curb and ending up off the roadway. Vehicle #2 rotated approximately about its C.G. at the point of impact rotating approximately 80 degrees and ending up in the center of the intersection in the northbound lane of U.S. 75.

G. OPINIONS AND OBSERVATIONS:

1. The drivers of both vehicles were apparently normal.

2. There were no indications of alcohol or drugs.

3. Both vehicles were apparently normal.

4. The couple in vehicle #2 always wore their lap belts and shoulder harness.

5. The ambulance arrived approximately ten minutes after the accident and delivered the victims to the hospital approximately five minutes later.

6. The driver of vehicle #1 was issued a citation for "improper start from a stopped position."

7. Both vehicles were removed by wreckers almost immediately.

8. The lap belt on the passenger side was too loose. Measurements: Passenger side: Shoulder harness, 3'9-1/4" from mounting bolt to end of tongue at latch. Lap belt, 4'11" from mounting bolt to end of tongue at latch. Driver's side: Shoulder harness, 3'10-1/2" from mounting bolt to end of tongue at latch. Lap belt, 4'2-1/2" from mounting bolt to end of tongue at latch.

9. Total crush to the front of vehicle #2 (Volkswagen) was 1'7".

CASE #________

SOURCES OF DATA FOR: EPIDEMIOLOGICAL ANALYSIS

1. Accident Report [X]

Report Number 02500231
Date 9-7-70

2. Newspaper Accounts [ ]

3. Death Certificates [X]

Certificate Number(s)________

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4. Interviews: [X]

(a) Investigating Officer [X]

(b) Occupant(s) Vehicle #1:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(c) Occupant(s) Vehicle #2:

[X] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

(d) Occupant(s) Vehicle #3:

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] 6 [ ] 7 [ ] 8 [ ] 9

---

5. Hospital Records: [X]

(e) Special Accident Investigator: [ ]

(f) Eye Witness(es): [ ] No.____

(g) Private Physician(s) [X] No. 1

(h) Newspaper Reporter - or Photographers [ ] No.________

(i) Ambulance Attendant(s) [ ] No.__

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6. Accident Investigation by Staff: [X]

(j) Fireman [ ] No.________

(k) Embalmer [ ]

(l) Family or Friends of Victim(s): [X] No. 2

(m) Wrecker Operator(s) [X] No. 2

(n) Other(s) [ ] Specify________

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0 ... 07...

FATAL

Sheet 1 of 1 Sheets FATALITY: yes

OFFICIAL POLICE TRAFFIC COLLISION REPORT 02 0250 0231

OKLAHOMA 05 Reporting Agency OKLAHOMA HIGHWAY PATROL

Date 9-7-70 Day of Week MONDAY Hour 7:45 AM County COAL

In LEHIGH Total number veh involved 2 No. Injured 3 No. Killed 1

On UNITED STATES HIGHWAY 75

At CITY STREET

State Highway Code: Control No. 02; County Number 15; City Code 15

Time Notified: Date 9-7-70 Hour 7:50 AM

Arrived At Scene: Date 9-7-70 Hour 7:52 AM

Unit 1

Driver [redacted]

Address [redacted] LEHIGH, OKLA [redacted]

License [redacted] Operator

Age 71 Race W Sex F Date of Birth 2-16-99

Driver Training: No

Veh ID No. [redacted]

Vehicle 66 CHEV ...

License Plate [redacted]

Owner's Name SAME AS DRIVER

Address SAME AS DRIVER

50 legal speed, 10 MPH before contact, 10 MPH at contact. Is Veh Operable? No. $ 150.00 estimated damage

Veh removed to VERN'S SAL. by WRECKER

Unit 2

Driver [redacted]

Address [redacted] DR. LITTLE ROCK, ARK

License [redacted] Operator ARK 7Y2PX

Age 26 Race W Sex M Date of Birth 12-24-43

Veh ID No. [redacted]

Vehicle [redacted]

License Plate [redacted]

Owner's Name SAME AS DRIVER

Address SAME AS DRIVER

50 legal speed, 50 MPH before contact, 15 MPH at contact. Is Veh Operable? No. $ 1000.00 estimated damage

Veh removed to WILSON BROS. WRECKER

Injured – Witnesses

	Name	Address	Age	Sex	Race
1	[redacted]	[redacted] LEHIGH, OKLA	71	F	W
2	[redacted]	F LITTLE ROCK, ARK	26	M	W
3	[redacted]	died 10-10-70 ... LITTLE ROCK, ARK	23	F	W
4	[redacted]	LITTLE ROCK, ARK	23	F	W

Injured Taken To: 1-2-3-4 MARY HURLEY HOSP by AMBULANCE, COALGATE. Time left scene 7:55. Time arrived hospital 8:00

Investigation made at scene? Yes. Investigation completed? Yes. Phones taken? No.

Name 1 [redacted] — FAIL ... START FROM STOPPED POSIT... 11-603

Signed: [redacted] Badge No. [redacted] District 3 Approved by [redacted] Date of report 9-10-70

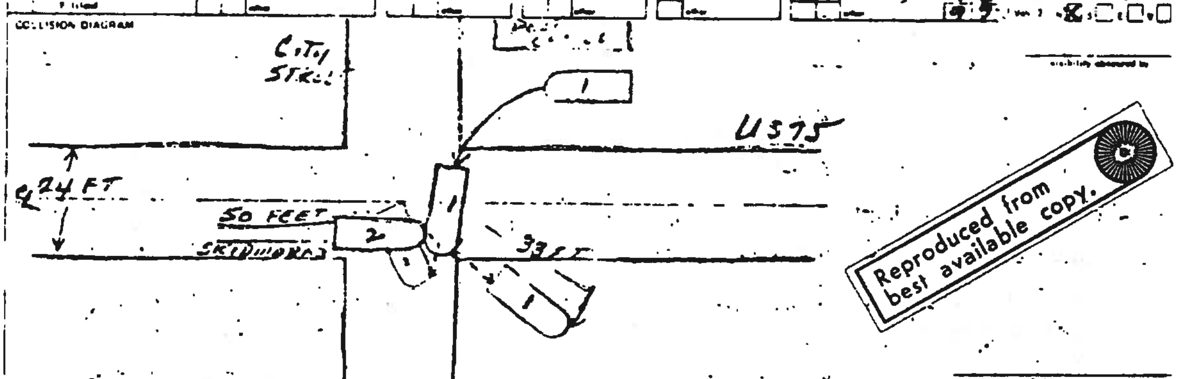
B-187

WHAT VEHICLES WERE GOING TO DO | WHAT VEHICLES DID | TYPE OF ROAD | TRAFFIC CONTROL | ROAD CHARACTER | CONDITION OF DRIVERS AND PEDESTRIANS

OBJECT STRUCK BY VEHICLE OR LOAD ON FIRST CONTACT | POINT OF FIRST CONTACT ON VEHICLES | LIGHT | WEATHER | WHAT PEDESTRIAN WAS DOING

ROAD CONDITION | ROAD SURFACE | LOCALITY | VEHICLE CONDITION

COLLISION DIAGRAM



REMARKS
Refer to vehicles by number

VEH #1 PULLED ACROSS THE ROADWAY FROM THE POST OFFICE, INTO PATH OF VEH #2. NEITHER VEHICLE TURNED OVER.

UNSAFE, UNLAWFUL OR OTHER ACTION

Unit 1	Unit 2	Action	Describe
		1 Failed to Yield	
		2 Followed too Closely	
		3 Unsafe Speed	
		4 Made Improper Turn	
		5 Changed Lanes Unsafely	
		6 Stopped in Traffic Lane	
		7 Failed to Stop	
		8 Unsafe Vehicle	
		9 Lack of Control	
		10 Improper Overtaking	
		11 Improper Parking	#1 STOPPED POSITION
		12 Inattention	
		13 Wrong way on ...	
X		14 Improper Start from ...	
		15 Other Improper Act or Movement	
	X	16 Not Known — or — No Improper Action	
		17 Other Action — not directly related to ...	
		18 Pedestrian Action	

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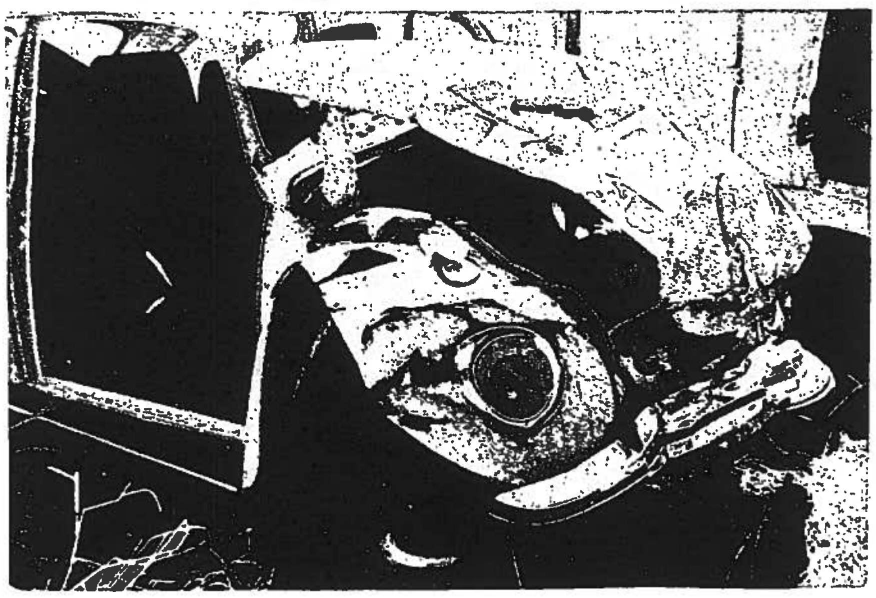

Figure 1. Right front quarter of vehicle.

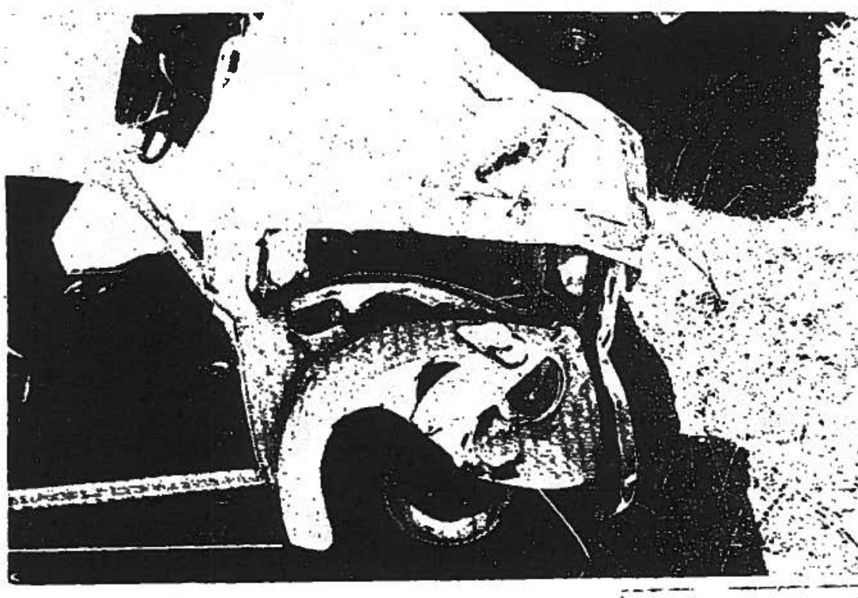

Figure 2. Right side view.

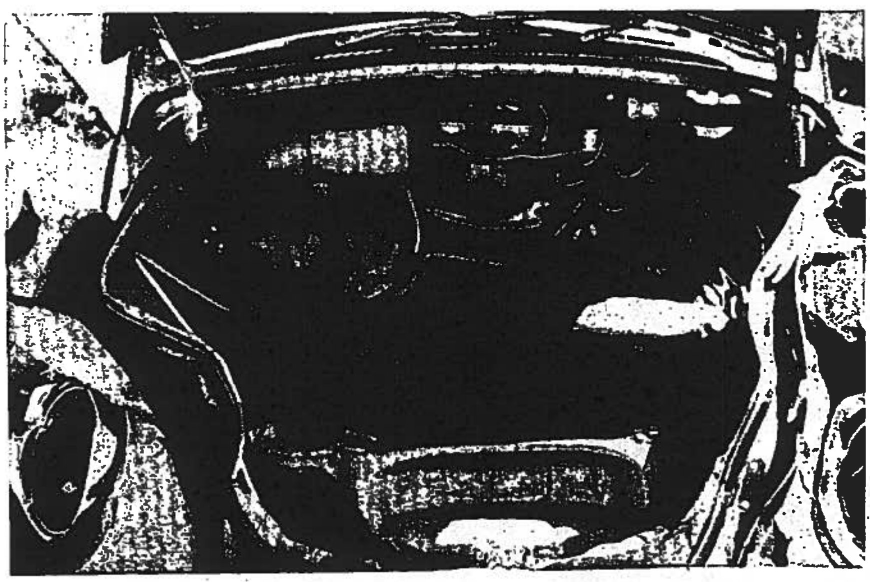

Figure 3. Luggage compartment.

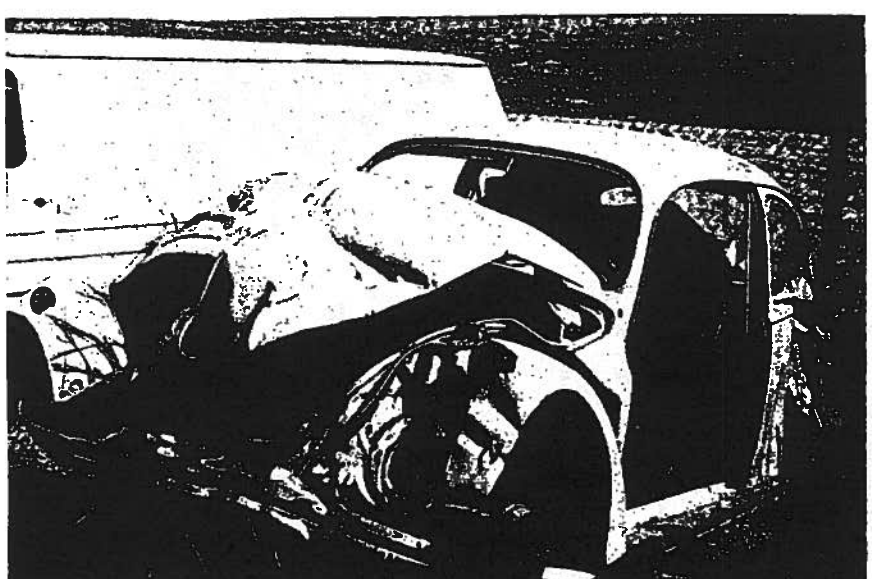

Figure 4. Front and left side view.

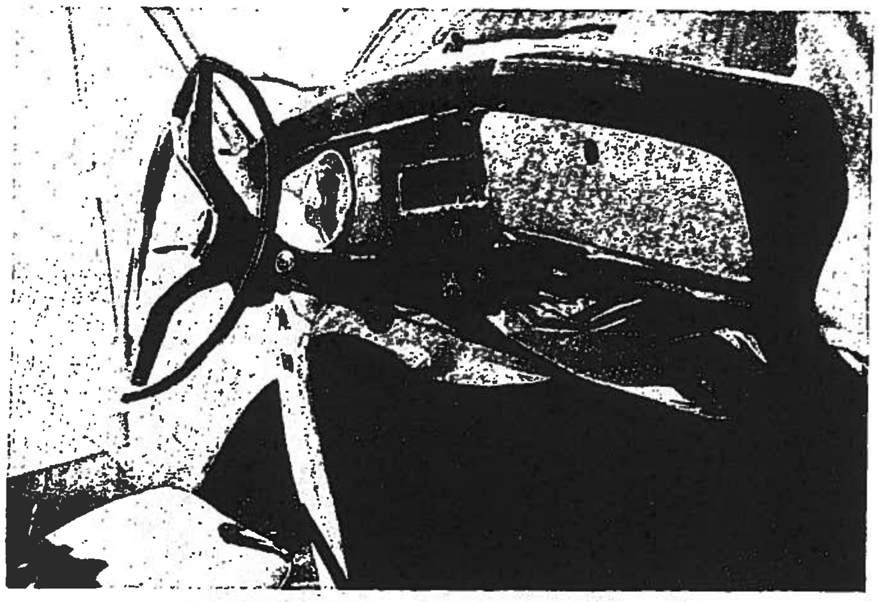

Figure 5. Interior, left side, showing impact area under the glove box and broken steering wheel.

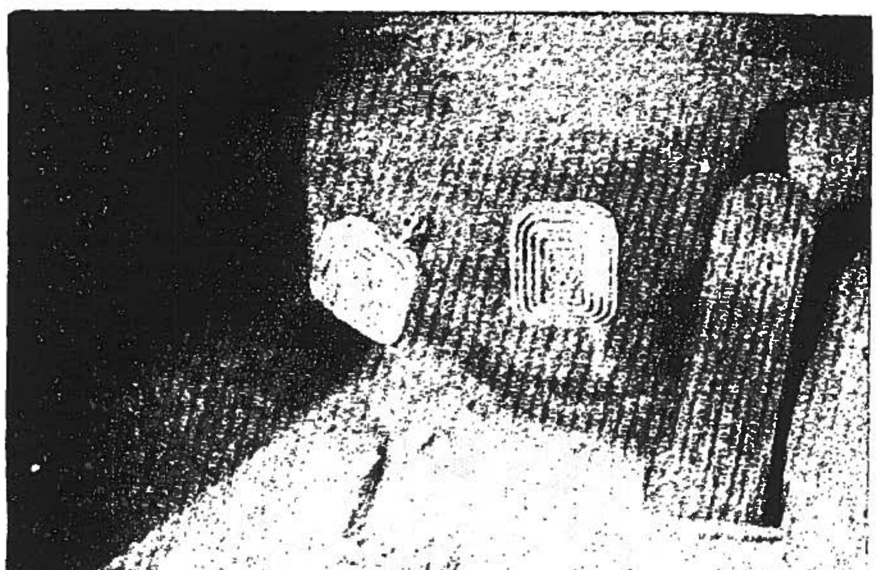

Figure 6. Bent clutch pedal.

Figure 7. Seat belt on passenger side. Note loose adjustment. Subject in seat is 5'4", 140 pounds.

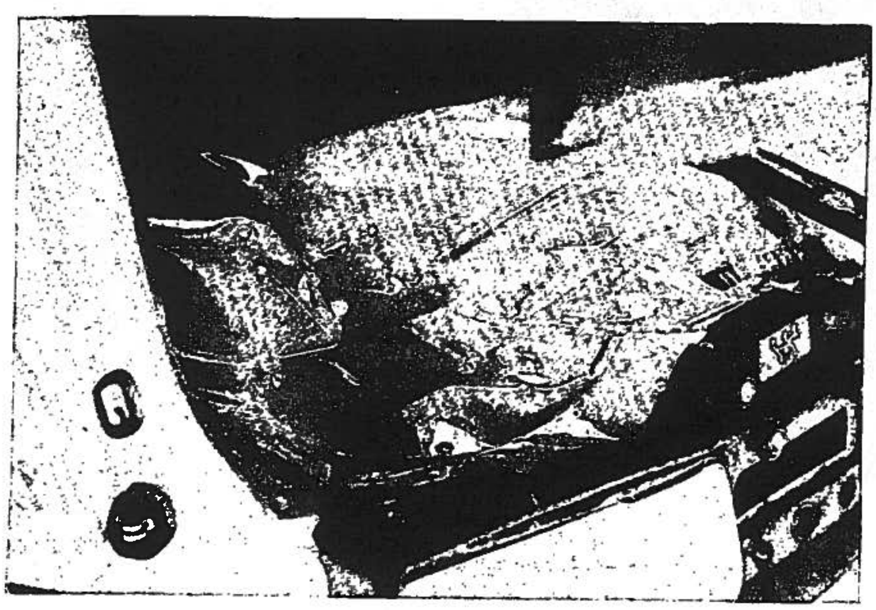

Figure 8. Impact area under glove box.

ACCIDENT SUMMARY

DUAL-FUEL PASSENGER CAR PROPANE EXPLOSION/FIRE

ACCIDENT: Non-crash fire and explosion

DATE: September 8, 1971, 4:30 PM

VEHICLE: 1969 Chevrolet Chevelle 396 SS

- Body: Two-door hardtop sport coupe
- Engine: 396 cid, 325 hp, V8
- Equipment: Air conditioning, power steering, power disc brakes
- Transmission:
- Modifications: Propane-gasoline dual fuel system; two-way radio (transmitter removed); "mag" wheels
- Tires: Reported good
- Prior crash damage: Evidence of some body filling; repainted
- Paint: Blue, white vinyl top
- Interior materials: Vinyl and nylon seats, vinyl headliner, nylon carpet
- VIN: S -36379

LOCATION: Parking lot, college dormitory, college campus

AMBIENCE: Daylight; temperature, 91°; clouds, scattered deck at 25,000 ft covering .1 to .2 of sky, scattered cumulonimbus; humidity, 48 percent; wind speed and direction, 1 to 2 knots from 160°

OTHER VEHICLES: Volkswagen "Beetle" and other unidentified vehicle

EMERGENCY SERVICES: Police, Fire, tow truck

OCCUPANTS: One

- Driver: Male, age 20, 5'10", 170 lbs, physically unimpaired

ACCIDENT DESCRIPTION:

The driver of this 1969 Chevelle routinely commuted to school from another town and on the day of the accident had driven the 36 miles to school. When he had finished his classes for the day, he ran several errands locally for his fraternity. He parked the vehicle in the parking lot and was in the dormitory for approximately 20 minutes. He returned to the vehicle, entered, and turned the ignition switch to the "Start" position. He observed a flash of fire under and at the center of the instrument panel and instantly thereafter heard "an explosion" behind him. He immediately attempted to open the left door and experienced some resistance in the door, so put his shoulder to the door and shoved. The door opened and he had no further difficulty in egressing.

Although the driver was burned by the fire, his clothes were not afire. He moved away from the vehicle, looked back, and saw a small fire between the front and back seats at about the longitudinal centerline of the vehicle. He noticed that the four side windows were missing, although the windshield and rear-facing window were still intact and in place. The fire rapidly progressed to involve the entire interior.

Another student in the parking lot heard the explosion and ran to assist the driver. He subsequently drove the burned driver to the city hospital.

The city fire department received a call at 4:39 PM. Estimated time to the scene was 4 minutes. The fire was extinguished with a 2-inch hand line (water).

OCCUPANT INJURIES:

The driver received first- and second-degree burns to the face, both arms, and right shoulder. Exact extent of skin damage unknown. Medical report not available. Driver denied any burns or sensitivity of nasal passages, mouth and throat. No soreness or tightness of chest; no breathing difficulties.

Because of the obvious overpressure which shattered the four side windows, driver was questioned about temporary partial hearing loss or "ringing" in the ears. He reported that no hearing problems occurred. The driver reported severe pain in the right shoulder and "spots" on the right shoulder. He experienced discomfort in almost any lying position, but particularly when any pressure was on the shoulder. The attending physician is alleged to have attributed the pain and "spots" to "blast injury." The shoulder was alleged to have been "out of joint" from the "blast." As mentioned above, the alleged blast did not result in respiratory distress or hearing loss. The driver was hospitalized for 14 days.

OTHER VEHICLE INVOLVEMENT:

A Volkswagen and an unidentified vehicle were parked on either side of the case vehicle. The Volkswagen is believed by the attending firemen to have had paint and possibly seat covers scorched. The other vehicle had no damage.

POST-ACCIDENT:

The driver was removed to the hospital by private vehicle. The fire department responded in timely fashion (4 minutes) and extinguished the fire without unusual difficulty. The fire department is alleged to have closed the primary valve on the propane tank in the trunk while the fire was in progress. One municipal police car was at the scene but apparently had no responsibility for action.

DISCUSSION:

This investigation was initiated upon special request from NHTSA. The fire occurred in early September; the investigation was conducted in mid-October. In the interim, the propane fuel system had been removed from the vehicle and taken to Louisiana for installation in another vehicle. Consequently, the details of the installation are those reported by the owner, his father, and by firemen who extinguished the fire.

This 1969 Chevrolet Chevelle (Figures 1 through 3) had been modified to a dual-fuel system utilizing either gasoline or propane. This modification was performed by knowledgable employees of a propane sales company. The driver of the case vehicle believes that the company is licensed to perform this modification and believes that the modification conformed to all applicable regulations.

Figure 1. 1969 Chevrolet Chevelle.

The modification consisted of an 18-gallon propane tank mounted at the front of the luggage compartment (trunk). Hold-down was provided by two strap mounts bolted to the floor of the trunk. The tank was fitted with a primary shut-off valve, hose fitting (nipple), and overpressure relief valve (pop-off valve). A high-pressure rubber hose with brass screw-on fittings secured with bands conducted the propane to the engine compartment. The hose was routed through a hole

Figure 2. Rear view. Note rear deck lid has only slight paint blistering.

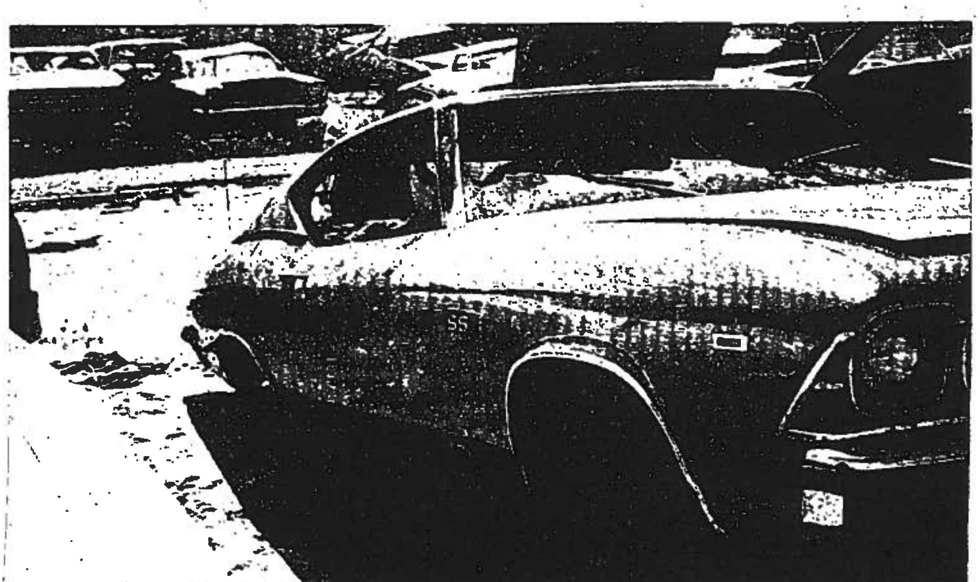

Figure 3. Right front quarter view.

in the trunk floor centered between the two tank mounting holes. All three holes appeared to have been punched--not drilled--through the floor (Figure 4). No grommet appeared to have been installed in the pass-through hole for the hose. The hose was routed underneath the vehicle high on the frame along the passenger side. At various points, the hose was secured with baling wire, and at some points was protected from fretting or chafing by pieces of heater hose split and placed over the high pressure hose. The hose passed along the frame to the rear of the right front fender well, was routed up to the top side of the fender and terminated at a pressure regulator mounted at a position about 1/3 the length of the fender back of the radiator (Figure 5). The regulator was manufactured by Beam Corporation and is in common use in vehicle installations. At one side of the regulator, probably the low-pressure side, a solenoid operated cut-off valve was included in the line to allow switching from one fuel to the other. A "vapor hose" (i.e., hose suitable for low-pressure propane vapor) conducted the propane to an injection fitting on the carburetor.

The switching arrangement for this dual-fuel system was electrical, activated by a three-position switch mounted inside the vehicle on the instrument panel at approximately the driver's right knee impact point. The switch positions provided gasoline, propane, or propane plus primer. The wiring terminated at a solenoid at the regulator and at a solenoid valve in the gasoline line at the carburetor. The driver reported that he used both fuels and that he switched quite often. On the day of the fire, he had begun and continued to use propane and was on propane when the fire occurred.

The driver of the vehicle appeared to be quite knowledgable about the use of propane. He and his father use propane as fuel in "a bunch of combines and farm equipment"

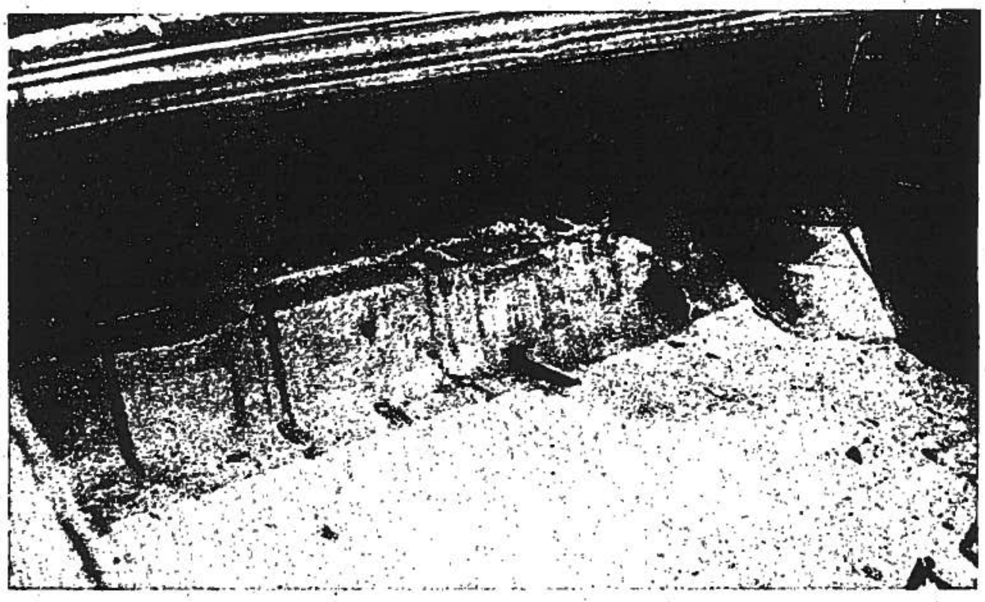

Figure 4. Luggage compartment interior. Note punched holes for mounting and hose pass-through.

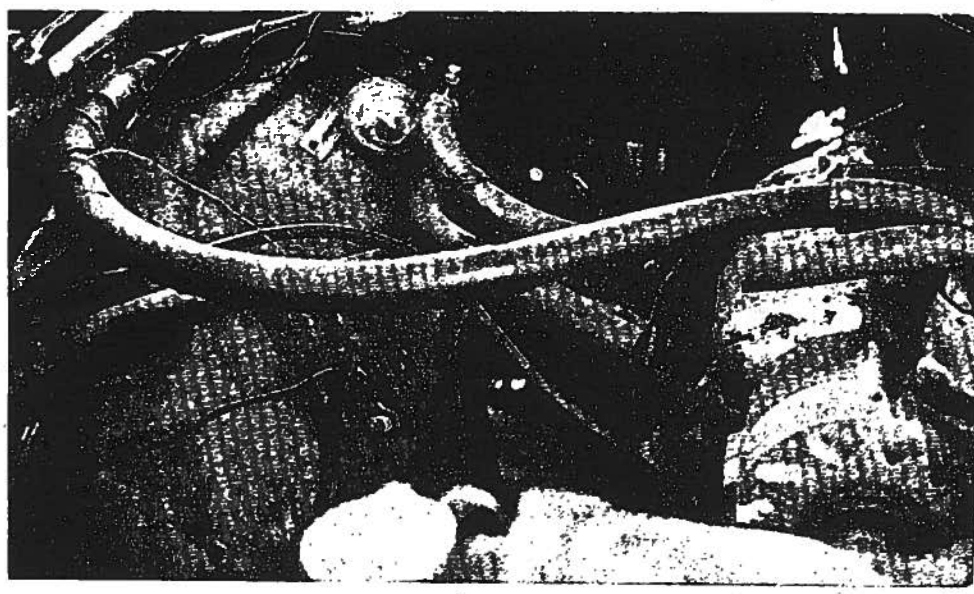

Figure 5. Regulator mounting position below and left of positive battery cable clamp. Note bare wire from clamp running up to hose.

as well as in passenger cars and pickups. His father owned the propane company that made this installation and supplied propane, although he had sold the company a couple of years ago (prior to this installation). The driver's father is alleged to be licensed to perform the fuel system modification. Apparently the father and son are presently farmers and contract harvesters. On alternate weekends, the driver of the case vehicle drove from Oklahoma to Louisiana to assist his father with the harvesting operations. The case vehicle was fitted for a two-way radio, although at the time of the fire, the radio was not installed. During the summer months the radio was removed from the case vehicle and installed in one of the combines. Considering the apparent affluence of the family, the age and use of the vehicle, the driver's familiarity with propane, and the driver's injury, arson is considered to be an extremely unlikely cause of the fire. Similarly, considering both the son's and the father's extensive use of propane, the likelihood of the fuel system modification being slipshod or extremely inferior is rather remote. The system was probably adequate and safe, within the father's judgment as a licensed installer. However, the requirements for this license and the regulations under which and in compliance with which the licensee must operate have not been determined. The regulatory authority is also unknown.

It would seem logical that for a propane-air mixture to attain flammable and explosive concentrations would require that the tell-tale odor added to the propane would also attain sensible concentrations. However, the driver reported that there was no odor in the vehicle. He says he is not sensitized to the odor and readily detects it. "We got a good fright with the stuff. Usually when we get a leak, we don't start the thing or move it until we find where the leak is at. I didn't smell anything."

On the day of the fire, the driver had filled the propane tank (18 gallons). At the time of the fire, he had about 30 percent in the tank. He and his father estimated that this amount was about what should have been left in the tank, considering the driving he had done. They did not believe that very much propane could have been lost through leakage.

VEHICLE DAMAGE:

The vehicle suffered fire damage and what was reported to be blast damage. The fire was essentially confined to the interior of the passenger compartment and apparently involved no fuel other than the vehicle interior materials. However, at inception, the fire was fueled by propane. There was no evidence of progress of the fire into the trunk space (Figure 4). A few wires coming through the front firewall were charred for a short distance. One wire spliced onto the terminal of the positive battery cable was charred for its full length to and through the front firewall (Figure 6). There are three possible explanations for this charring:

1. This circuit shorted and was the ignition source for the fire, which would have required interconnection with the ignition switch.
2. The insulation on this wire was highly combustible--much more than that of other wiring installed in the vehicle, or
3. This wire shorted after its insulation had burned away at the front firewall, which could have occurred whether or not the circuit was routed through the ignition switch (the ignition switch remained in the "on" position).

The remainder of the engine compartment was undamaged (Figure 7).

The majority of the interior materials were reduced to ash in the fire (Figure 8). Some nylon carpeting remained essentially unburned, although this is generally the case when early extinguishment occurs. Temperatures attained were relatively high as evidenced by roof buckling and melting out of body solder at the C-post (rear) roof joint (Figure 9), although they were rather lower than ordinarily occur upon the burning of this quantity of interior materials. The upper temperature limit in this case is characterized by back and windshield glass shattering but not melting to the plastic state (Figures 9 and 10). Ordinarily, while the glass would not have flowed, it would have become plastic enough to conform to curved metal surfaces upon which it lay. Some of the instruments had fallen from the slightly sagging instrument panel (Figure 11). Heavier plastics, such as that on the steering wheel, were entirely consumed. In some places, where protected by the side of the seat, the door panels had only melted and run. The paint was consumed from the roof to about one foor below the lower window sill. Paint on the doors appeared to have melted and sagged (Figure 12). The driver's door (Figures 12 and 13) was open during the fire. From the pattern of scorched paint, any wind would have been blowing from the front to the back of the vehicle. Wind speed and direction, confirmed by Weather Bureau records, was 3-5 mph blowing from front to rear of the vehicle. However, fire damage to the rear seat (Figure 14) was not as extensive as front seat damage. There was no evidence of fire on the underside of the vehicle.

Reports of "blast" damage to the vehicle are undoubtedly reliable, at least with respect to the side windows. Several persons were alleged to have heard an explosion. Glass was scattered for several feet on either side of the vehicle. Furthermore, very few glass particles remained in the lower window channel and none seemed to have fallen inside the car or down into the door. That the windshield and rear-facing window remained substantially intact is attested to by the glass remaining almost complete although shattered on the rear package shelf and some windshield glass on top of the instrument panel. Additionally, the tow truck driver reported that both

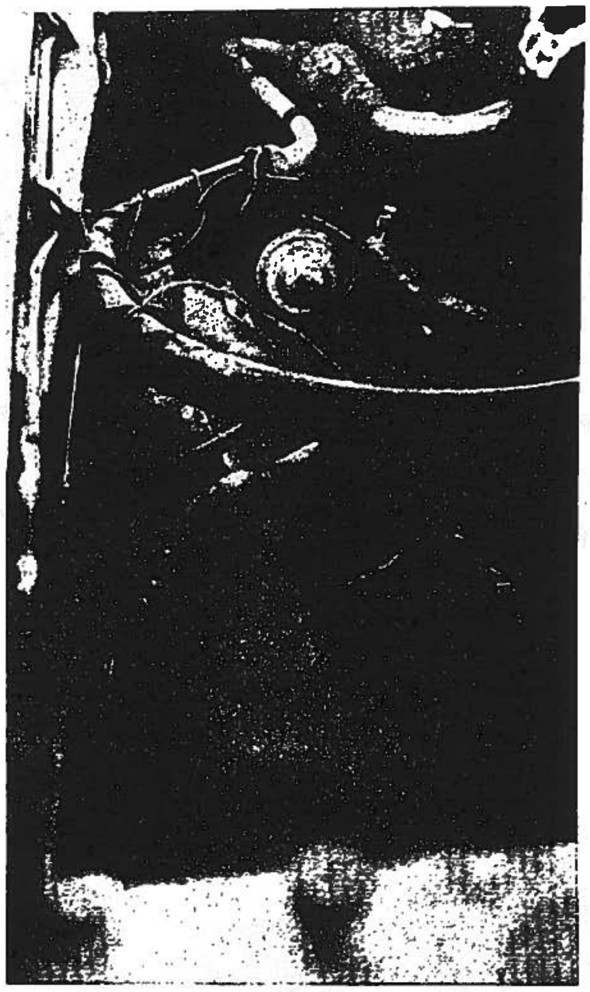

Figure 6. Bare wire from clamp to hose, and running back towards aluminum tubing.

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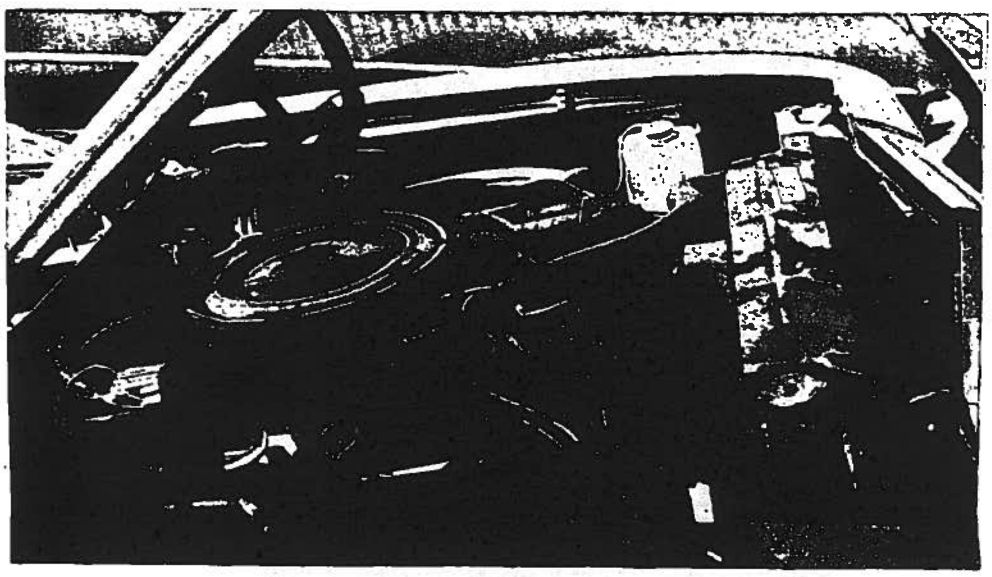


Figure 7. Note lack of burning in engine compartment.

Figure 8. Interior of vehicle showing extensive fire damage.

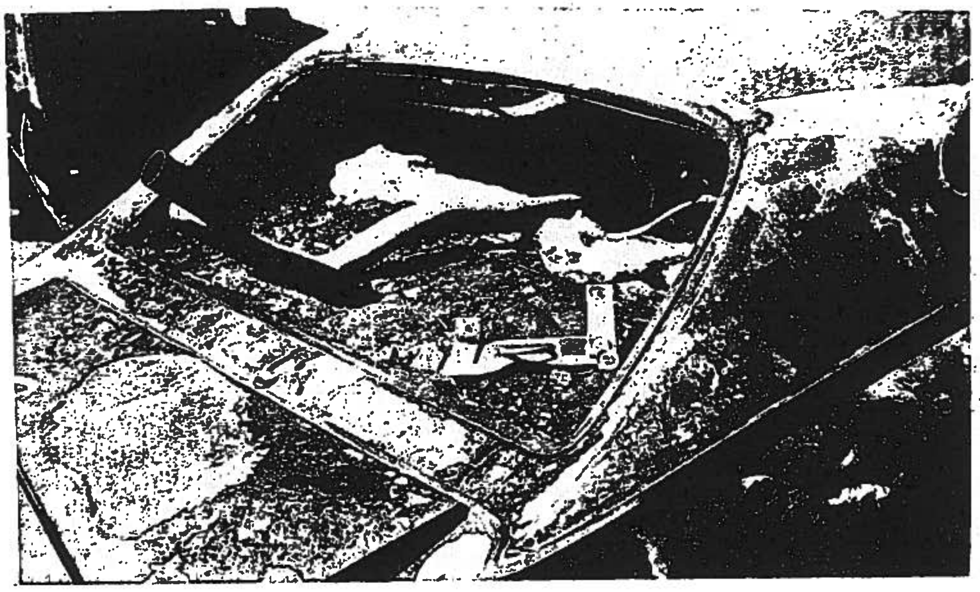


Figure 9. Note rear window glass lying on package shelf, body solder melted from roof joint.

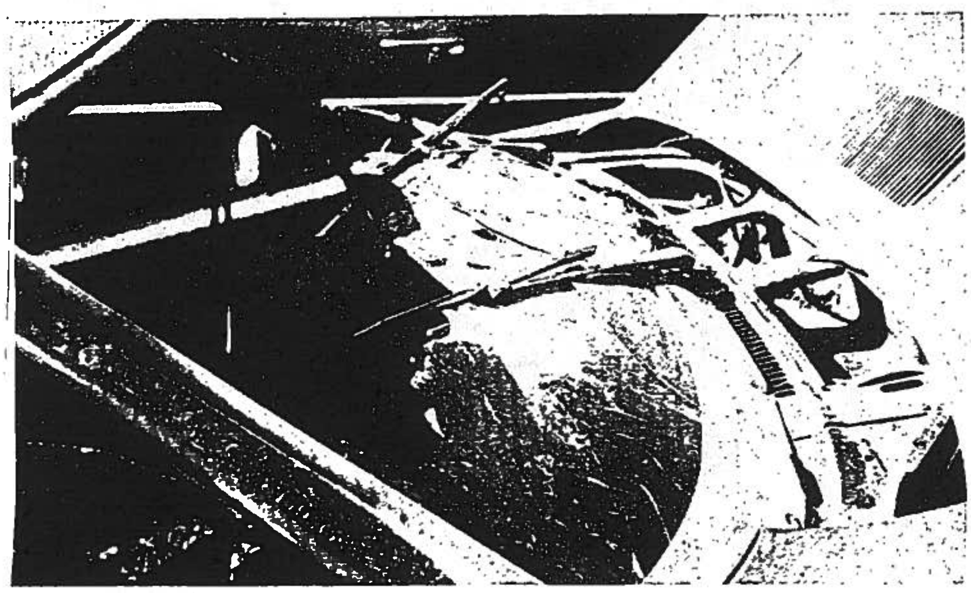


Figure 10. Windshield area. Glass from windshield is inside vehicle.

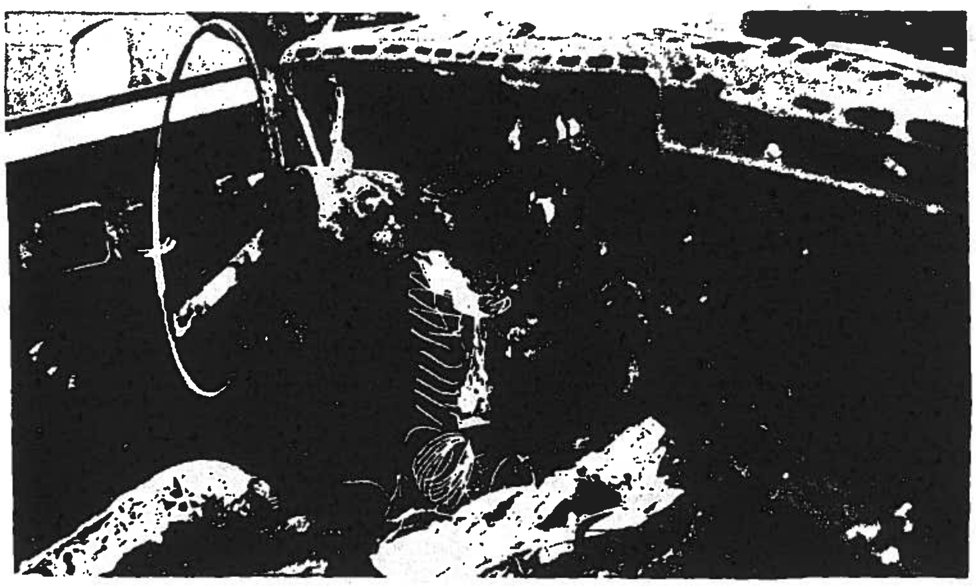


Figure 11. Instrument cluster, slight buckling of instrument panel.

Figure 12. Paint run on driver's door.

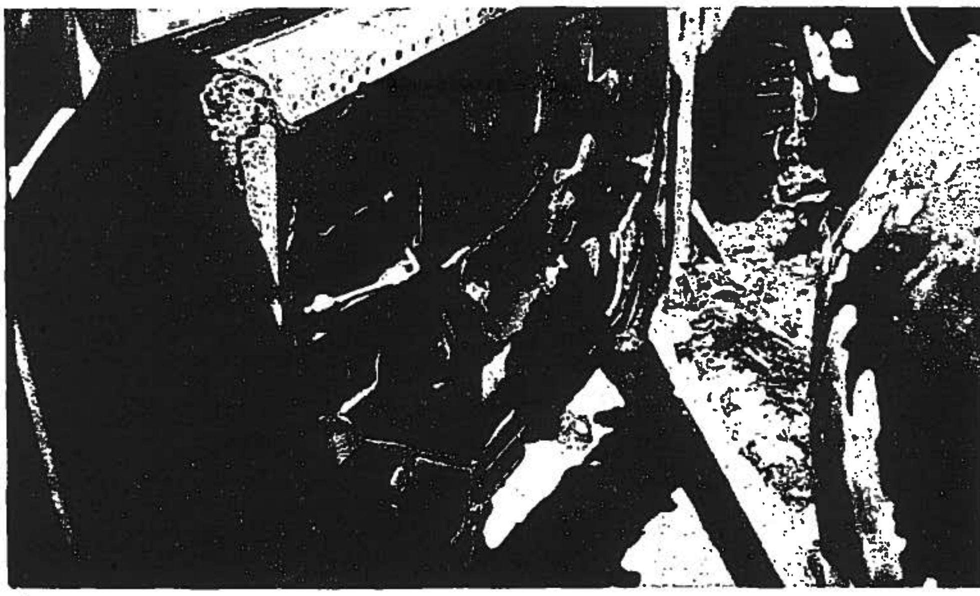


Figure 13. Interior of driver's door.

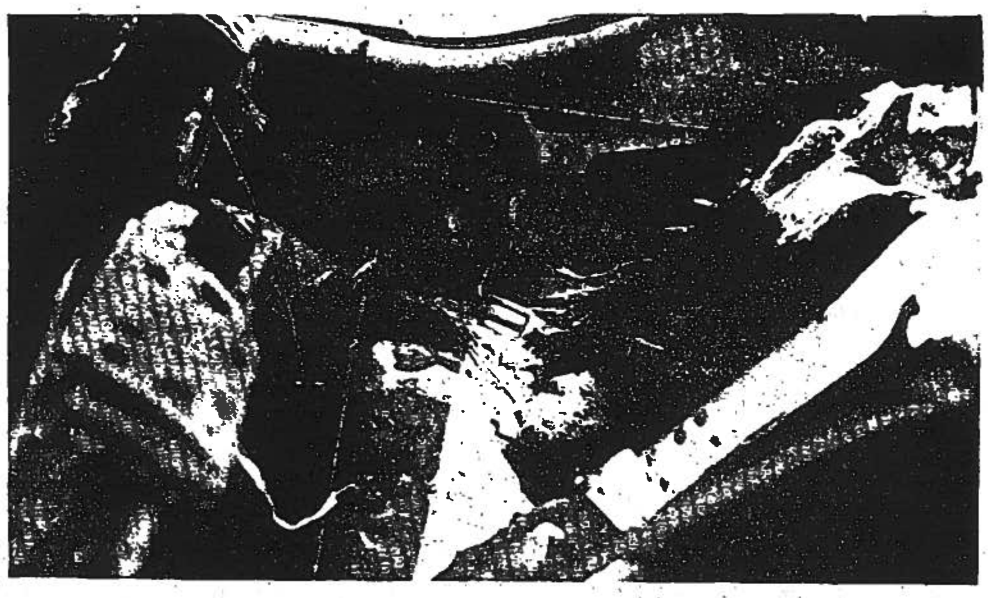


Figure 14. Rear seat area fire damage.

these glazings were intact at his arrival, although they shattered and fell as the fire progressed. Because of panel (roof and side) buckling due to the fire, there was no evidence of structural bulging from overpressure. There is a possibility that some slight deformation of the driver's door latch might have occurred as a result of overpressure, since the driver reported difficulty in opening the door, and since the door had to be tied closed during transport of the vehicle after the fire.

CONCLUSIONS:

This fire and "explosion" were probably initially fueled by propane vapors which layered on the floorboards of the vehicle. The propane leak probably occurred inside the engine compartment, and the propane was carried into the passenger compartment by a light wind blowing towards the compartment. Newspaper reports stated that "firemen (or police) said that fumes leaked from the rubber pressure hose." Any leakage from the hose would have been at a loose connection, since the hose and fittings have since been installed on another vehicle. The owner doubts that the hose leaked, since he periodically retightens all fittings.

An alternative leak source could be in the trunk. However, this possibility would have required layering of vapors in the trunk up to the level of the lowest passage into the passenger compartment. Unless the trunk was completely filled with gas and too rich to explode or burn, however, one would expect the leak itself to be ignited, and there was little evidence of fire damage in the trunk.

The original flash seen by the driver was located at and below the instrument panel. The flame might have been the burning of a pocket of incoming gas that had not yet layered at the floor. Had the gas come from the trunk, it seems extremely unlikely that it could have layered to this height and yet be unnoticed by the driver (noticed by odor).

The major vehicle damage was the result of burning interior materials. The propane was responsible only for breaking the side windows and igniting a small area of interior materials. The injury, on the other hand, resulted entirely from flash burns incurred in the propane fire.

The most probable ignition source is a spark originating either in the ignition switch, the solenoid switch, or at the brushes of the air conditioner motor. Hot wire ignition of propane vapors is relatively difficult, compared to spark ignition. Thus it is unlikely that the aforementioned charred wiring was the ignition source. More information about added wiring (solenoid switch, radio circuit, and the charred wire) and the position of accessory switches could not be obtained for clarifying the probable ignition source. The owner's memory of the wiring was sketchy and not reliable.

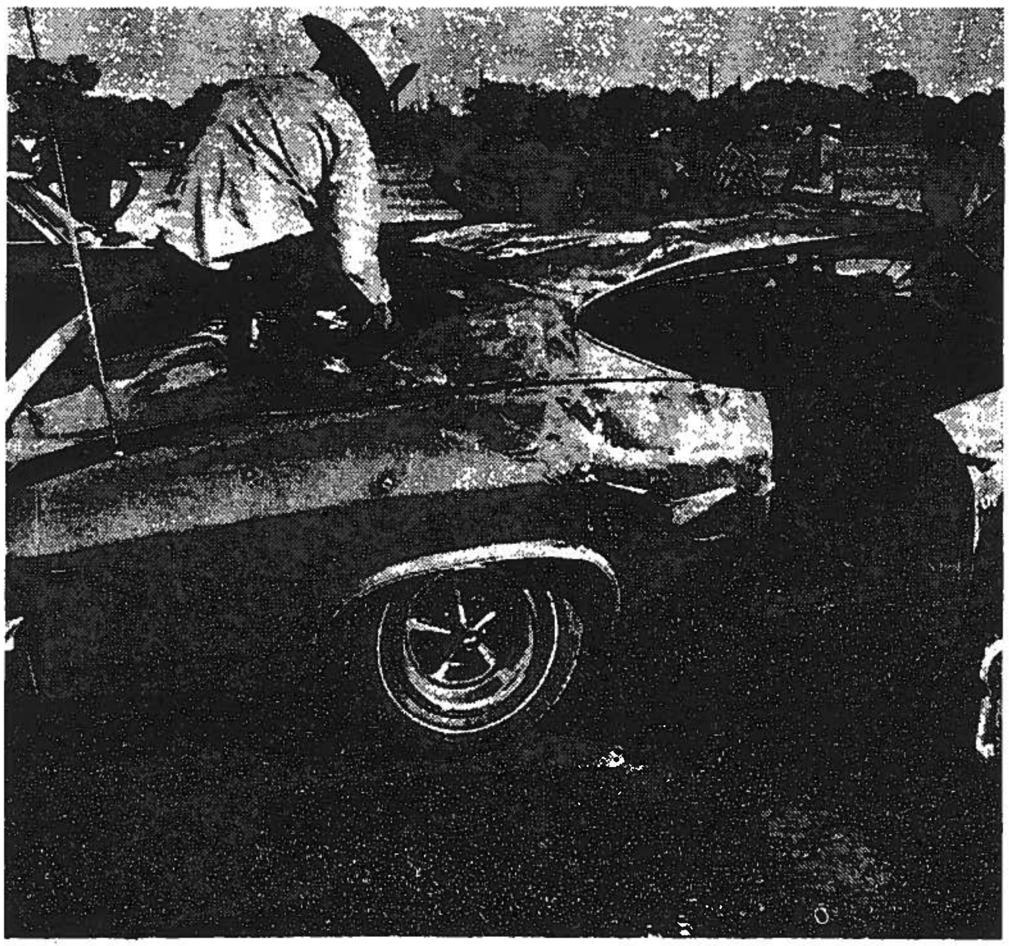
Door jamming is considered probable in this case, although the nature of the latch interaction that caused the jamming is not clear. The latch does not appear to be deformed in either jaws or latching post. The door moves freely although it does not latch.

RECOMMENDATIONS:

Specific recommendations regarding the safety or hazard of this particular installation are not warranted. However, some general recommendations about the practice of these installations can be made.

1. NHTSA or the appropriate Office of Hazardous Materials in the MCSB should review current MCSB regulations of propane as a hazardous material being transported in vehicles other than interstate.
2. NHTSA should review state and local regulations on design of propane, LNG, CNG, and LPG equipment for vehicle fuel system modification, particularly in terms of safety and performance.

3. NHTSA should review state licensing procedures to ensure that qualification of a company for the handling, storage, and sale of bulk gaseous fuels does not automatically qualify such company to modify motor vehicles for the use of such fuels.
4. NHTSA should, as recommended in our multi-year plan, review the fire and leak experience of fleets which utilize gaseous fuels to ensure that emphasis upon pollution control does not engender a much greater fire hazard.
5. It would be advisable for DOT in general and MCSB and the Office of Hazardous Materials in particular to support an investigation of the hazards inherent in the layering of gaseous fuels, not only in motor vehicles and around transports and dispensing areas of bulk storage facilities, but also from tankage and pipelines.
6. Useful research as priorities permit would be performed in the investigation of potential spark ignition sources. We have observed at least two cases in which the ignition switch was suspect and one case where the brakelight switch or turn signal may have been involved. The solution might be UL type certification of switches and brush-type motors for use in a flammable atmosphere.
7. No remedial action seems warranted for the type of door jamming that might have occurred here.



EXPLOSION BURNS STUDENT. A propane gas explosion and fire Wednesday afternoon gutted car of [redacted] College student [redacted], 20, of [redacted], and hospitalized him in "fair" condition with burns on his arms, face and back. Firemen said fumes leaked from rubber pressure hose on propane tank in trunk ignited when [redacted] started the car. First person on the scene at college's Shepler Center, [redacted] [redacted], 20, a classmate, took [redacted] to nearby Memorial Hospital. Above, Fireman [redacted] extinguishes hot embers. (Staff Photo)

Sooner Capsules

Car Explosion Hurts Student

LAWTON — A 20-year-old [redacted] State College student from [redacted], [redacted] was reported in fair condition today after being burned late Wednesday when an explosion occurred in his car.

[redacted] told officers his propane-powered car exploded when he turned on the ignition. A flash fire burned him about the face, arms and back. He was hospitalized in Lawton.

Police found a leak in a gas line running from the trunk tank of the vehicle.

INVESTIGATION OF 1970 MODEL 4-DOOR CHEVROLET IMPALA VEHICLE INTERIOR FIRE

Introduction

On August 13, 1970, the Flame Dynamics Laboratory was advised by the Fire Marshal, City of Norman, Oklahoma, of a vehicle interior fire in a new (driven less than 2,000 mi) 1970 Chevrolet sedan that was parked at the time of the fire. The fire had occurred the previous afternoon (about 4:30 p.m.) in a supermarket parking lot in Norman, Oklahoma. The vehicle had since been moved to the storage lot of the Chevrolet dealer who had originally sold the vehicle.

A cursory examination showed that the vehicle interior was virtually destroyed and that the exterior was essentially undamaged. The over-all appearance of the vehicle and the total elapsed time for the incident (maximum of 15 min from the time the vehicle was started at the owner's home until extinguishment by Norman Fire Department) indicated a very rapid rate of flame spread and/or a "flash" type fire. The high rate of flame spread did not seem consistent with the general results of horizontal burning rate test programs conducted by this laboratory and by IITRI (1). Based on these tentative conclusions it appeared most desirable to obtain the vehicle from the concerned insurance company so that a detailed investigation could be conducted. This was subsequently done, as discussed in detail in the following sections of this fire report.

Fire Background

On August 12, 1970, about 4:30 p.m. the wife of the vehicle owner drove the vehicle in question from her place of residence to a supermarket on West Main Street, a distance of less than one mi. Within 5 min after parking the car, the store manager announced over the speaker system that a red Chevrolet was on fire at the front of the store. He called the Norman Fire Department and then attempted to extinguish the fire with a 2-1/2 gal soda-acid hand extinguisher. Just moments earlier a construction worker had attempted extinguishment with an ABC dry chemical extinguisher. According to Norman Fire Department records and conversations with the Fire Marshal and firemen stationed at the responding fire station, the call was received at 4:39 p.m. on August 12, 1970, and the responding fire truck (a Class A pumper) was returned to duty in the fire station 38 min later. Based on statements by the concerned firemen, the truck arrived at the fire location in not more than three min after the call came in. Immediately upon arrival, the battery was disconnected and the fire extinguished with a water fog handline.

Again according to statements by the fire truck crew, it required less than 3 min to extinguish the fire after arrival of the fire truck.

Thus, it appears that an elapsed time period of not more than 10 min was involved from the time the car was parked at the supermarket until the interior fire was extinguished by the Norman Fire Department.

After the preliminary inspection of the vehicle, arrangements were made with the owner and his insurance company to obtain the vehicle so that a detailed investigation could be conducted to determine the cause and source of the fire as well as its probable manner of flame spread. It was also planned to conduct the proposed FMVSS 302 Horizontal Burn Tests and OURI ignition tests on the few remaining pieces of interior materials. The State Fire Marshal's office and the Norman Fire Marshal's office were contacted to provide assistance in the investigations. Additional inspections of the vehicle were made by a Special Agent of the

National Automobile Theft Bureau who is quite experienced in vehicle fires and by a Claims Manager from Associated Aviation Underwriters who is experienced in aircraft fire losses and investigations.

Fire Investigation

The detailed investigation of the burned vehicle was conducted on August 21, 1970. The results of this investigation are as follows.

As shown by Figure 1, very minor exterior damage resulted from the destructive interior fire. The right front window was approximately two-thirds open and the left rear window was fully open. This resulted in a minor cross-draft which lightly blistered the roof edge just above the right front door window (see Figure 2). The windshield was severely cracked in both the inner and outer layers. This was probably caused by the 2-1/2 gal soda-acid hand extinguisher used by the store manager in his unsuccessful effort to extinguish the fire. Foam residue on the dash panel and both sides of the windshield tend to support this conclusion. The windshield synthetic bonding material was severely blistered. According to Reference 2, this bonding material bubbles and softens at 250° to 300°F and chars black at 800° to 900°F. The absence of charring in the bonding material also supports the conclusion that rapid "quenching" induced by the soda-acid extinguisher cracked the windshield. The low temperature indications are evidence of a flash-type fire. The glass was not cracked by heating effects.

Figure 3 shows quite clearly that there was no fire damage in the engine compartment including the fire wall and lead-through lines.

An over-all view of the vehicle interior fire damage is shown in Figure 4. The entire interior was involved. Figure 5 is a view of the right front door inside trim panel.

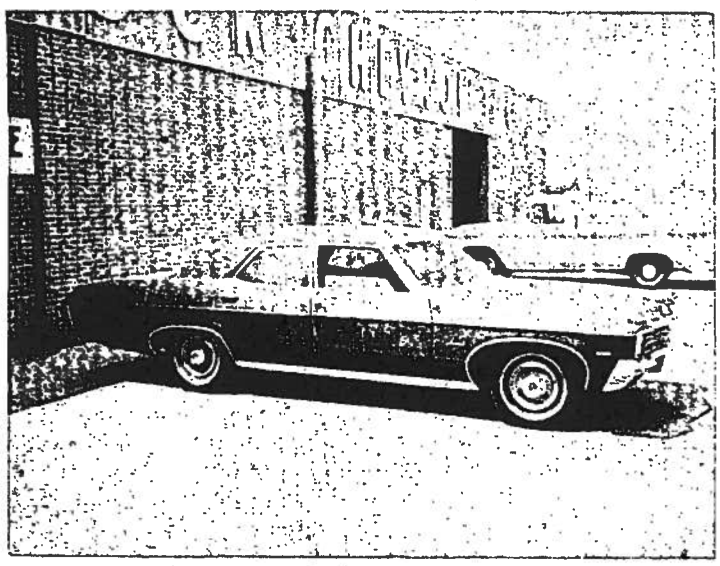


Figure 1. Over-all view of 1970 Chevrolet Impala with interior essentially destroyed by fire.

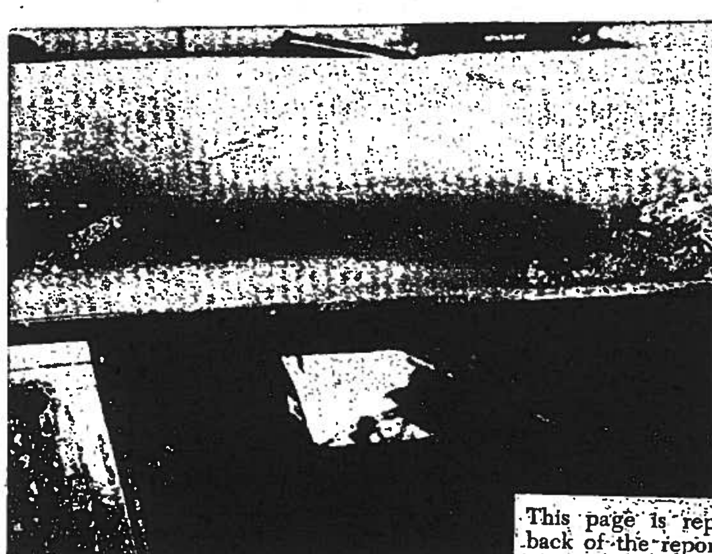


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Figure 2. View of vehicle roof area just above the partially open right front door window. Note the slight paint blistering near edge. This is only external fire damage to entire vehicle.

Figure 3. View of engine compartment.

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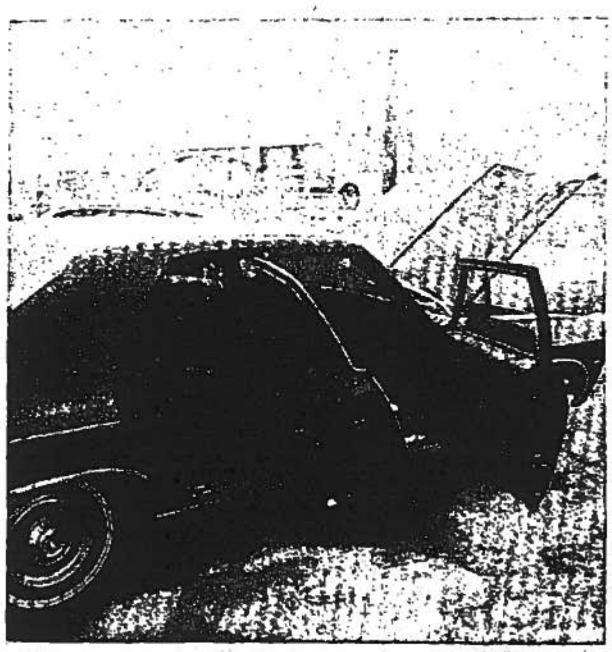


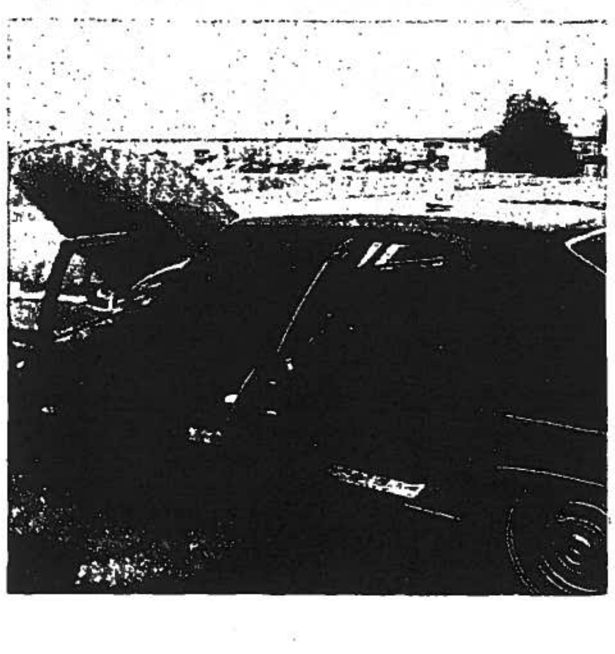
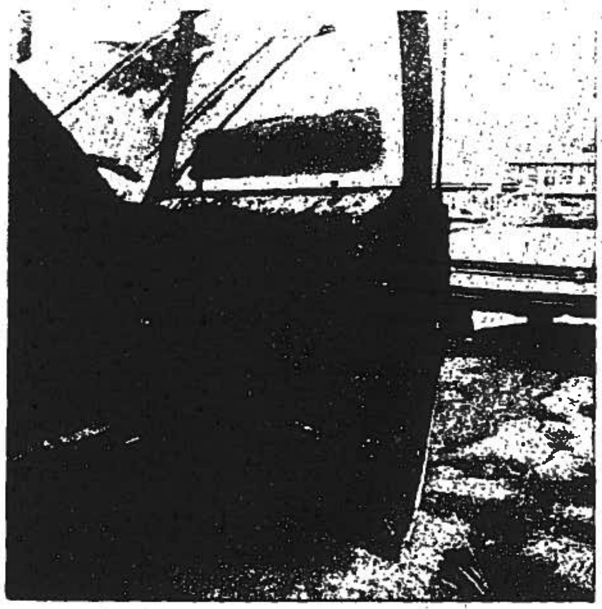


Figure 4. Over-all view of vehicle interior.



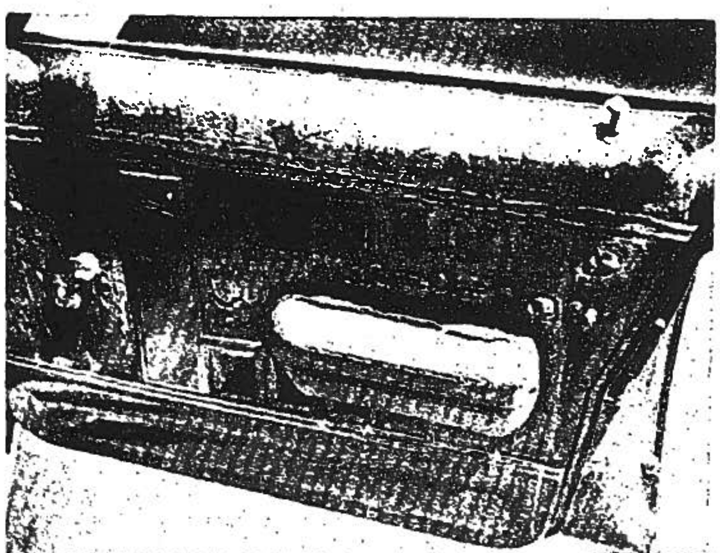


Figure 5. View of right front door side panel. Note unburned lower portion of panel.

Notice the extent of first layer burning only and the absence of fire damage to the lower portion of the panel that was protected by the front seat sides. Although not shown, the same type of burning occurred on the left door inside trim panel. This type of damage indicates that the fire did not originate near the floor line or under the front seat area. The presence of first layer damage only indicates a short-term, flash-type fire.

Figure 6 presents close-up views of the front seat area fire damage from both sides of the vehicle. The seat padding material was removed by the firementto insure that the fire was not smoldering in the cotton backing. However, note that the seat springs still retain their full tension. This indicates that the fire did not start at nor spread to the underside of the seats, that the heat build-up was not excessive, and that the fire did not penetrate through the seat cushion assembly. Although not too clearly shown in these photographs, the left side of the instrument panel sustained considerably more damage than the right side. This fact will be a significant point in the subsequent discussions. The floor area on both the driver and passenger sides did not sustain any fire damage at all. This again indicates the base of the fire was higher up in the vehicle.

Figures 7 and 8 present views of the rear seat area fire damage. The padding just below the driver's head rest is not fire damaged, but the same assembly between the head rests is virtually completely consumed. The cross draft from the left-rear toward the right-front probably kept flames from the unburned area. Again note the first layer damage only on the rear seat and back cushions. The head rests themselves were virtually destroyed. Note that the thin headliner support rods are still in place and have not lost their tension. The roof exterior is not even blistered (although scorched). The evidence of the location of the base of the

Figure 6. Close-up of front seat area and padded dash-board. NOTE: 1. Seat padding removed by firemen. 2. Observe that seat springs retained full tension.

Figure 7. Close-up of fire damage in the rear seat area.

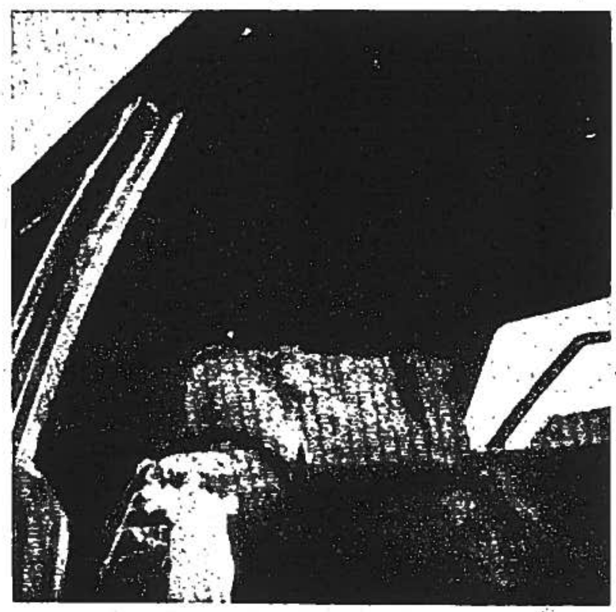


Figure 8. View of the fire damage to the headliner and head rests.

primary fire, the low heat build-up, and the damage localized on the left instrument panel establish that arson was not the cause and that a flash-type, low heat-release fire condition prevailed. This conclusion is also based upon the obvious evidence that no additional fuel such as gasoline was present, since such fuel would have increased the heat released and the total burning time.

Figure 9 presents close-up views of the instrument panel on the driver's side. Note the almost complete destruction of the crash pad covering. Considerably more damage, melting and deformation, in the polymer coverings occurred on the right than on the left of the steering column (see Figures 10 and 11). This localization of damage coupled with the total absence of fire damage to the floor area at the front seat and lack of fire damage to the engine compartment firewall area indicates that the fire base was behind the instrument panel on the right side of the steering column.

After the instrument panel face had been stripped away, it was found that the instrument cluster wiring harness had sustained only localized fire damage. The "CHECK DOOR" light lead-in-wire insulation was completely destroyed from the socket base to about 3 inches down the wire. The plastic tape used to constrain the wiring bundle was destroyed for about 4 inches on each side of this point. Small pieces of fused plexiglass were also found in this area of the harness. Figure 10 presents close-up views of this area.

As also shown in Figure 11, the plexiglass covering over the speedometer assembly had a hole burned or melted in the center. This accounts for the fused plexiglass particles found stuck to the wiring harness. This photograph also clearly shows that considerably more damage (melting and deformation) occurred to the instrument panel on the right side of the steering column. This greater localized damage is present on the rear of the instrument panel also, as shown in Figure 11.

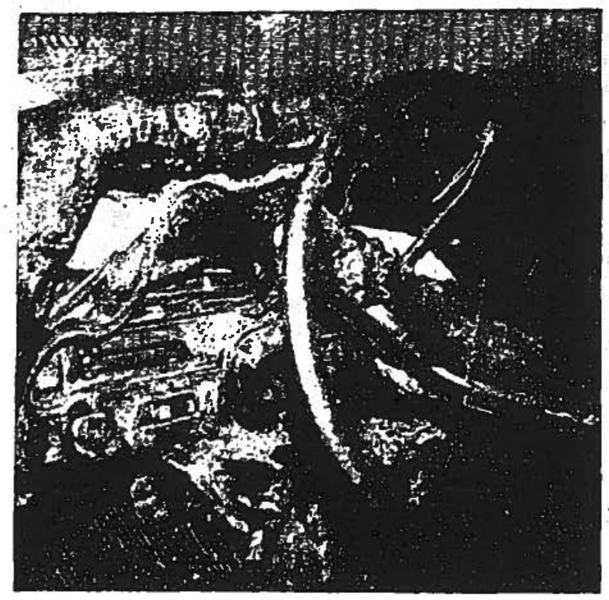


Figure 9. View of the fire damage to the instrument panel, driver's side.

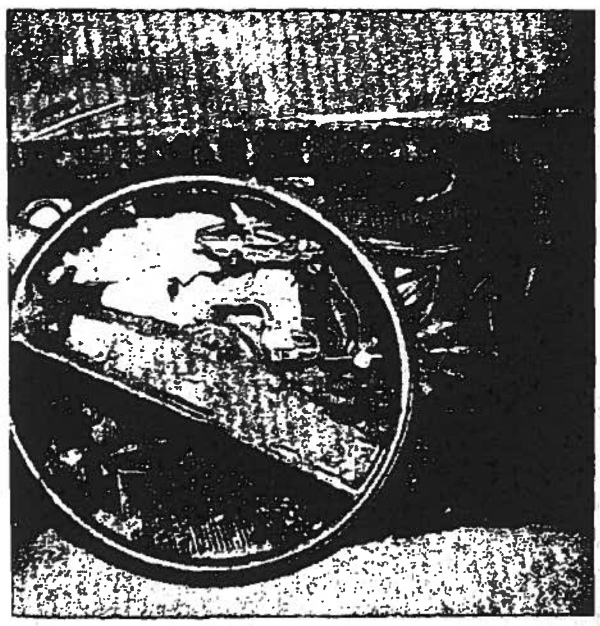
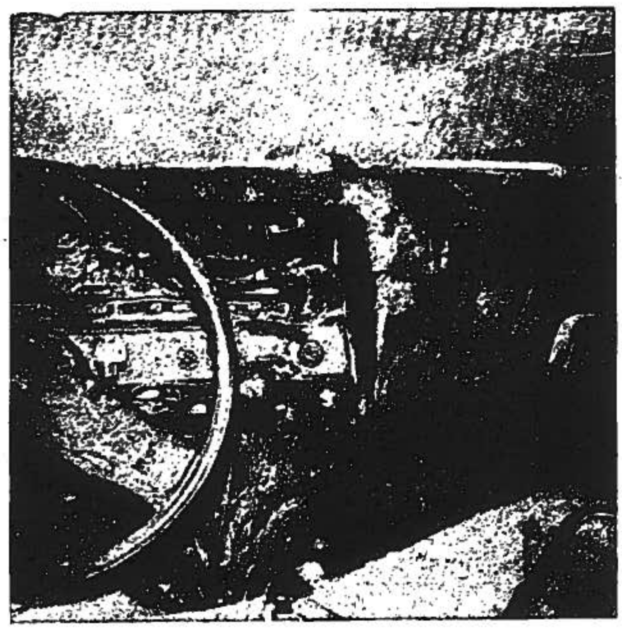
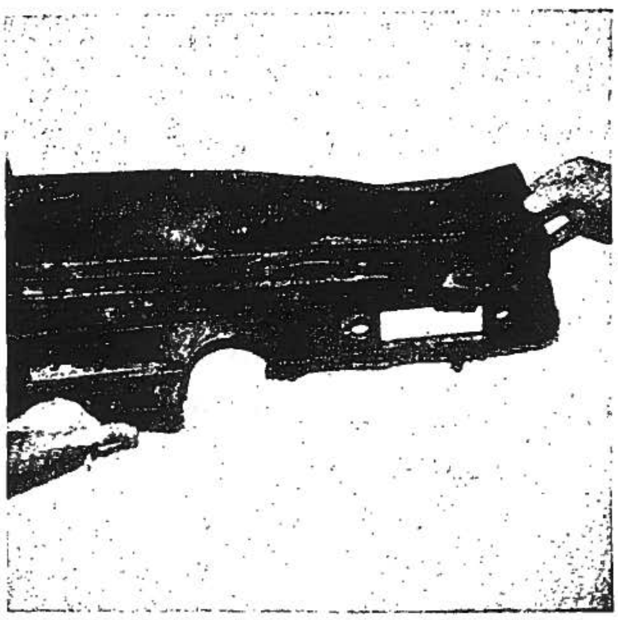


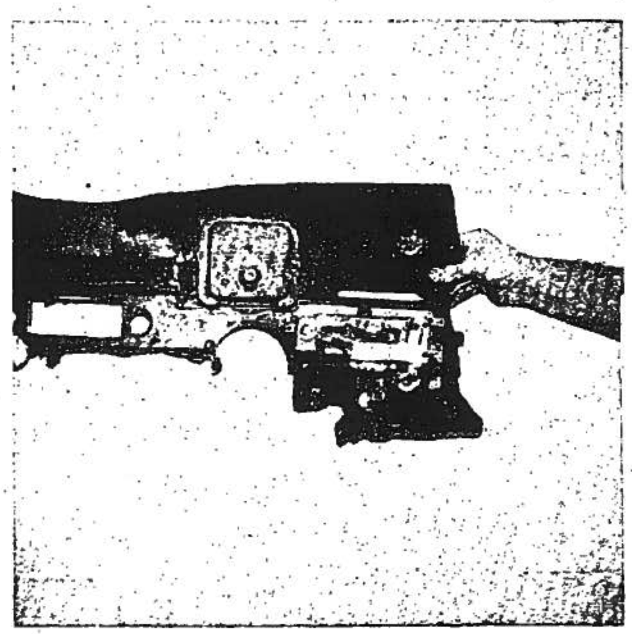
Figure 10. Views of wiring harness just behind instrument panel cluster. Note localized fire damage, especially to light socket for "CHECK DOOR."



View of instrument panel on right side of steering column



Front view of instrument panel



Rear view of instrument panel

Figure 11. 1970 Chevrolet Impala instrument panel showing the localized fire damage.

Although the crash pad vinyl covering was virtually destroyed by fire, a paper match book covering lying on the right-hand side of the instrument panel next to the windshield was only scorched. The book contained one match, unlighted. Figure 12 shows this match book in its original position on the dash panel. It might also be noted that paper napkins, plastic spoons and maps in the glove compartment were not even scorched or deformed.

The lack of fire penetration into the luggage compartment is demonstrated by Figure 13. A close-up view of the rear of the rear seat back cushion shows no fire damage of any kind.

Since the driver of the vehicle was reported to be a chain smoker, the vehicle flooring, ash tray, etc., were examined in detail for evidence of cigarette burns. None could be found. When examined, the ash try was about one-half extended and contained about 10 cigarette stubs. Even though the plastic face of the ash tray was totally melted and hanging in a lump from a single attachment point (see Figure 11, upper photograph), there was no evidence of even scorching of the cigarette stubs (see Figure 14).

As previously noted, no evidence of fire damage could be found on the front seat floor area under the instrument panel over-hang. Figure 15 presents a photograph of the driver's rubber floor mat. A soda-straw paper covering and portions of a melted plastic litter container are shown in their original position. Other than stains due to the foam residue from the 2-1/2 gal soda-acid fire extinguisher, nothing was found to indicate fire damage.

Based on this detailed investigation and examination of the evidence, it was unanimously concluded that:

1. Arson (incendiary fire) was not present.
2. Unusual debris did not contribute to the pronounced degree of destruction.

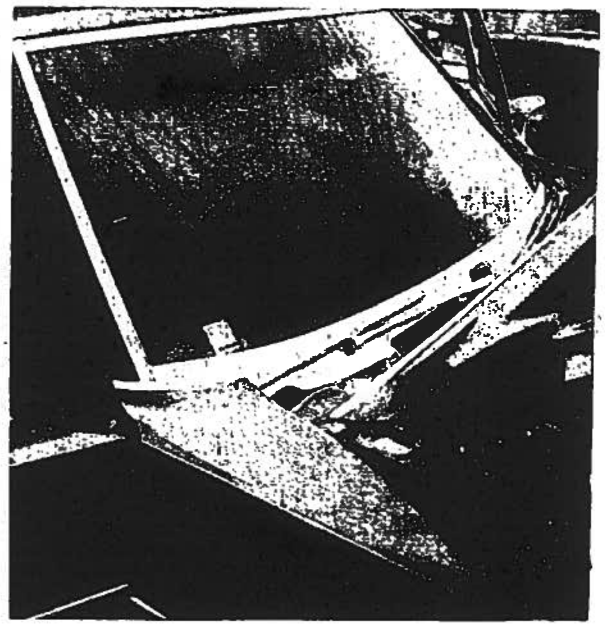


Figure 12. View of paper match cover with unlighted match inside found in place after the fire. Cover slightly scorched, vinyl crash pad covering in the immediate area totally destroyed.

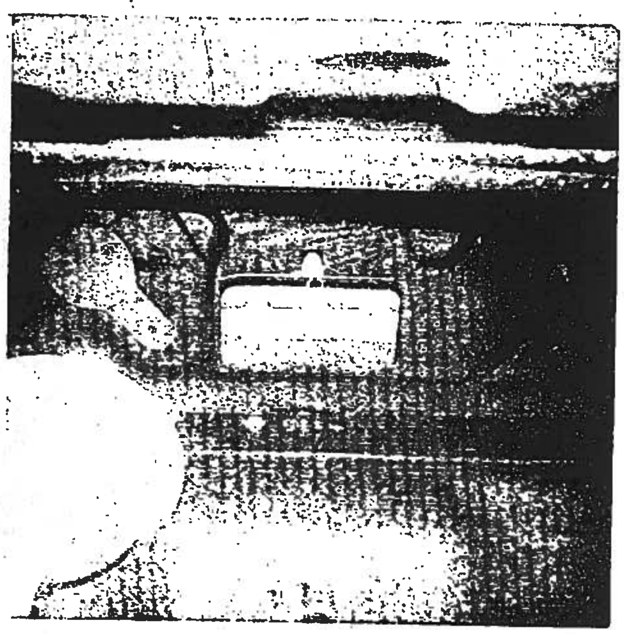


Figure 13. View of trunk interior. Note undamaged rear seat backing.

Figure 14. View of ash tray. Tray extended about one-half way. Note the unscorched condition of contents.

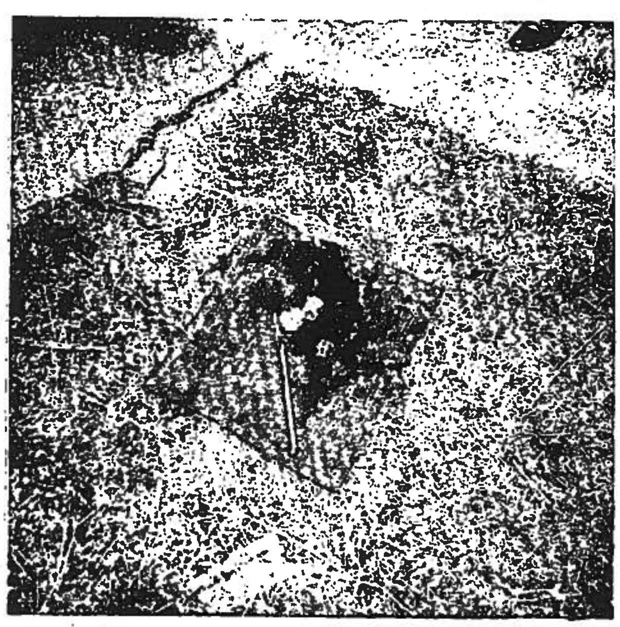


Figure 15. View of driver's rubber floor mat. Note undamaged condition. Debris is melted remains of plastic litter container.

3. The fire was electrical in origin and the most probable source of ignition was the "CHECK DOOR" light socket. Immediately following this phase of the over-all investigation, the battery (which had been disconnected, and left disconnected, at the time of the fire by the Norman Fire Department) was checked and found to be completely dead. In view of the newness of the battery and no reported starting problems, the dead battery tends to support the conclusion of a short-term, high-power drain with the engine off, i.e., a short-circuit.
4. Based on the melted hole in the speedometer plexiglass covering just above the area of maximum fire damage to the wiring harness, it is reasoned that the fire vented through this area, ignited the crash-pad liner, and propagated through the headliner to the other areas of the vehicle.
5. The total elapsed time for all events, from ignition to extinguishment, appears to be on the order of 10 minutes.

Interior Materials Fire Testing

Due to the apparent rapid involvment of the vehicle interior it was deemed prudent to conduct as many tests as possible on the apparently undamaged portions of the materials. At this point it should be emphasized that the apparently undamaged material samples could have endured some pre-heating effects. This pre-heating could have altered the material surface properties and could have partially pyrolyzed the sample. In the bench tests described here, these effects would tend to delay the ignition time, i.e., increase their resistance to ignition. Hence, the data obtained on the interior samples could be conservative. New material might ignite sooner and burn faster.

It was possible to obtain good test samples for the horizontal burn rate test from the rubber floor mats, the floor covering, the lower portions of the door side trim panels, the vertical facing of the rear seat cushion and the rear seat cushion polymer foam sub-layer. One specimen was obtained from the left rear side of the headliner covering. Horizontal Burn Rate tests were conducted in the proposed FMVSS 302 test apparatus. The test results are presented in Table I. All the materials tested, except the headliner, appear to comply with the proposed FMVSS 302 requirements of a horizontal burn rate of not more than 4 inches/minute and exhibit no surface flashing characteristics. The headliner sample had a burn rate of 7.60 inches/minute. Thus, based on the proposed FMVSS 302 standard, all of the materials in this car except the headliner would comply.

TABLE I

1970 CHEVROLET IMPALA DAMAGED INTERIOR MATERIALS
HORIZONTAL BURN RATES

Material Description and Location	Burn Time (min)	Burn Length (in)	Burn Rate (in/min)
1. Rear seat facing, black vinyl	1.30	5.0	3.84
2. Rear seat, back facing, black vinyl	2.59	5.0	1.93
3. Rear seat, underlayer, polymer foam	1.14	5.0	4.40
4. Headliner, black vinyl	0.83	6-3/8	7.60
5. Floor mat, black rubber	0.00	0.0	0.00
6. Rear floor carpeting, black nylon	12.63	5.0	0.40

Note: Horizontal Burn Rate Tests conducted per FMVSS 302 procedure. All samples burned with a relatively uniform flame front and DID NOT EXHIBIT ANY EVIDENCE OF SURFACE FLASHING.

A group of new materials for a 1970 Chevrolet Impala were ordered by manufacturer's trim number from a local Chevrolet dealer. An attempt was made to impress the dealer that the new materials should be the same as those on the burned car. Most of the materials arrived bearing GM labels and probably are the same as the original materials in the vehicle. Materials obtained were an instrument panel pad, seat fabrics, a door panel, a sun visor, and a headliner. Horizontal burn rates for these materials both in component and composite appear in Table II.

TABLE II

NEW INTERIOR MATERIALS HORIZONTAL BURNING RATES
1970 CHEVROLET IMPALA
74°F, 66% Relative Humidity

	Burning Rate in/min
#7 Door panel: vinyl with cotton backing, blue fiber matrix, gray cardboard matrix, cardboard.	
Composite	self-extin.
Vinyl (8808936)	3.52
Blue matrix	6.02
Gray cardboard	0.78
Brown cardboard	self-extin.
#8 Sun Visor 8806519 FCI: perforated vinyl, cotton padding, textile fiber matrix.	
Composite	self-extin.
Vinyl	8.00
Cotton padding	3.13
Matrix	1.69
#9 Headliner 8806475 FMO: perforated vinyl.	
Average	9.05

Sample ignition tests were conducted in the OURI ignition cabinet using benzene flames. Samples from the door trim panel assembly, floor carpets, rear seat facing, rubber floor mats were obtained. The results of these tests are presented in Figure 16 through 19. Figure 16 presents the pilot ignition times for the door trim panel assembly samples (4 in by 4 in) as a function of incident irradiance from the benzene flames. Similar data for the rear seat cushion black vinyl facing is presented in Figure 17.

A comparison of the ignition characteristics of the floor carpeting materials from the 1970 Chevrolet Impala sedan with those for a new equivalent GM carpeting material supplied to OURI by IITRI is presented in Figure 18. As shown, good agreement resulted. Figure 19 presents the ignition characteristics of the rubber floor mats in the 1970 Chevrolet Impala sedan. Figure 20 presents data on the new 1970 Chevrolet Impala interior materials.

A comparison of the black vinyl material used on 1970 Chevrolet door trim panels with similar materials obtained from other sources is presented in Figure 21. For completeness, the horizontal burn rates are also included in tabular form. The material from the 1970 Chevrolet compares favorably with similar new GM material obtained from IITRI and with a new replacement door panel facing ordered from GM. However, at an incident irradiance of about 2 cal/cm^2-sec the GM black vinyl material ignites in about one-half of the time required for ignition of a black vinyl Ford material obtained from IITRI and a black vinyl material obtained locally from an auto upholstery shop (2.5 seconds versus 5.0 seconds). The diversity of horizontal burn rates and the difficulty in correlating the test data obtained from the two different tests is clearly demonstrated by a comparison of the damaged 1970 Chevrolet materials and the locally procured vinyl materials. The damaged 1970 Chevrolet vinyl has a horizontal burn

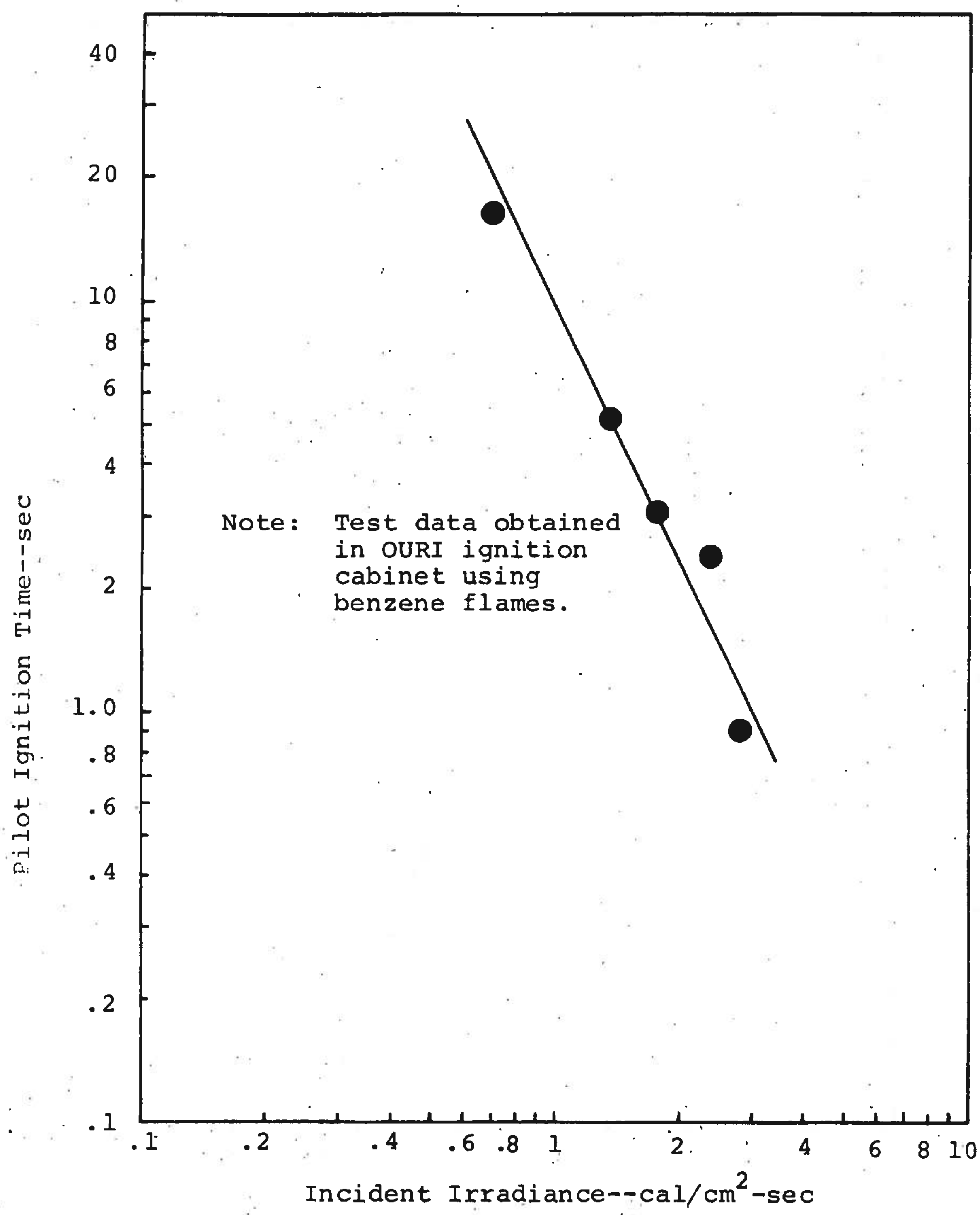


Figure 16. 1970 Chevrolet Impala interior materials ignition tests--black vinyl door side panel facing exposed to flames.

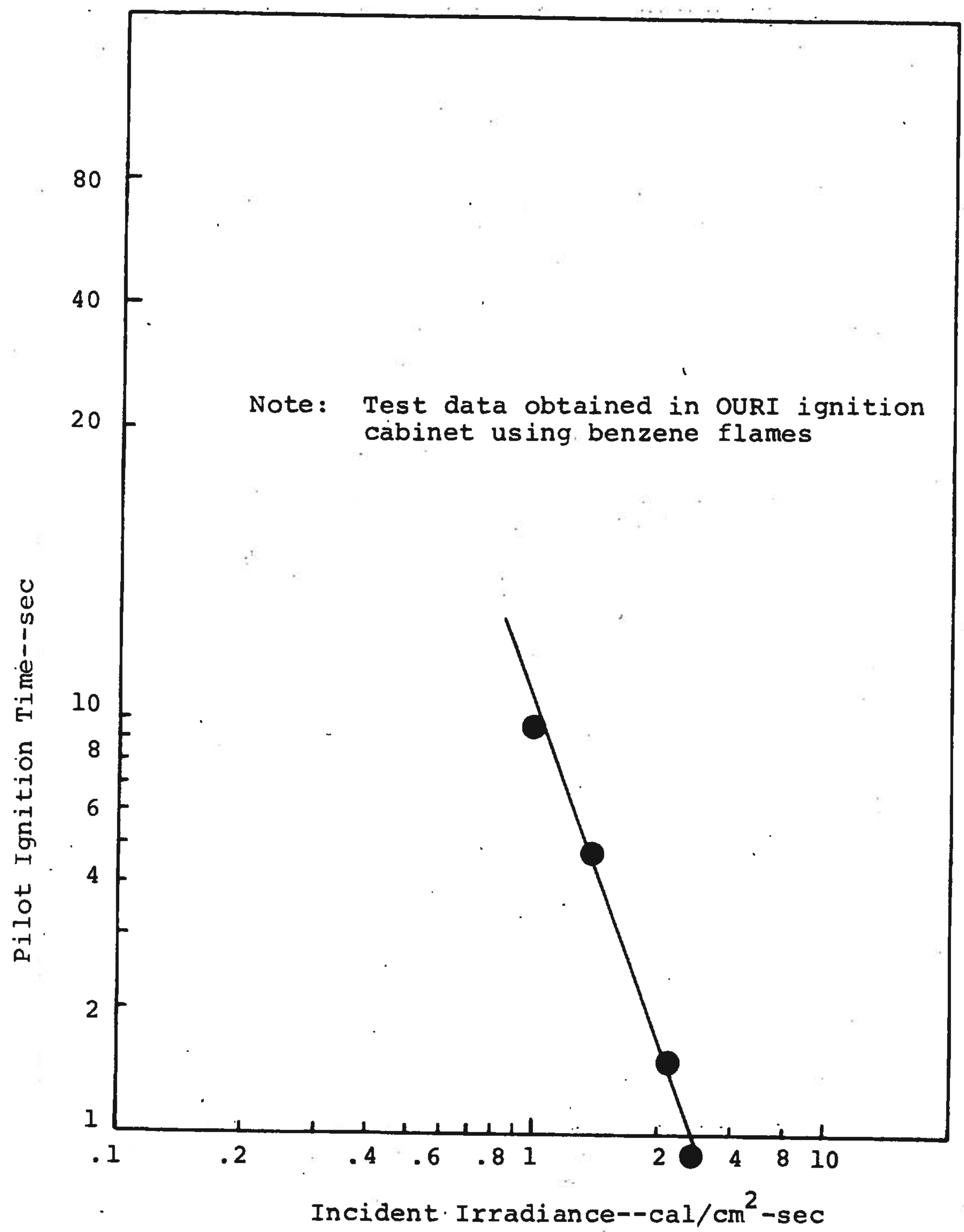


Figure 17. 1970 Chevrolet Impala interior materials ignition tests--black vinyl rear seat facing exposed to flames.

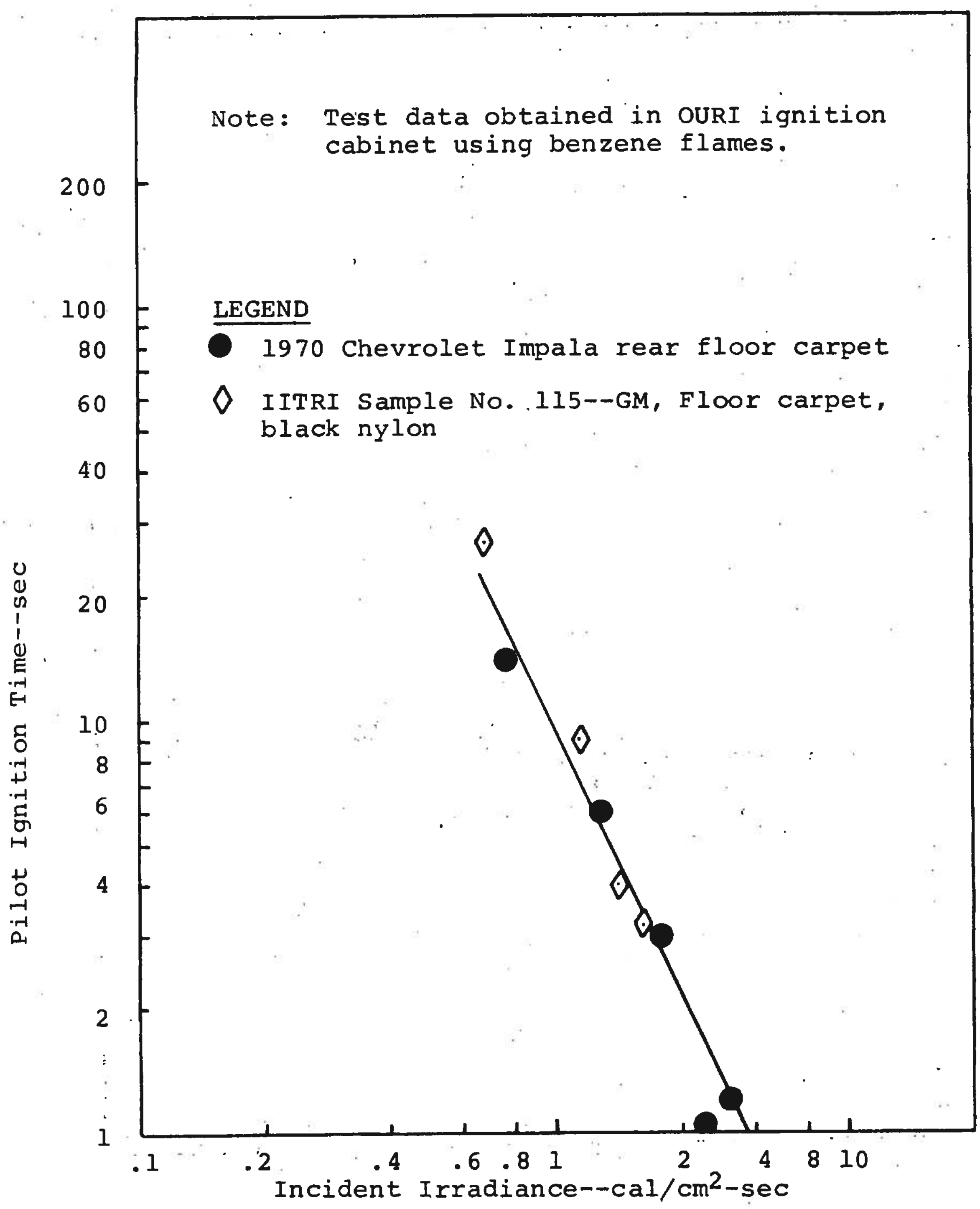


Figure 18. 1970 Chevrolet Impala interior materials ignition tests--rear floor covering (black nylon) exposed to flames.

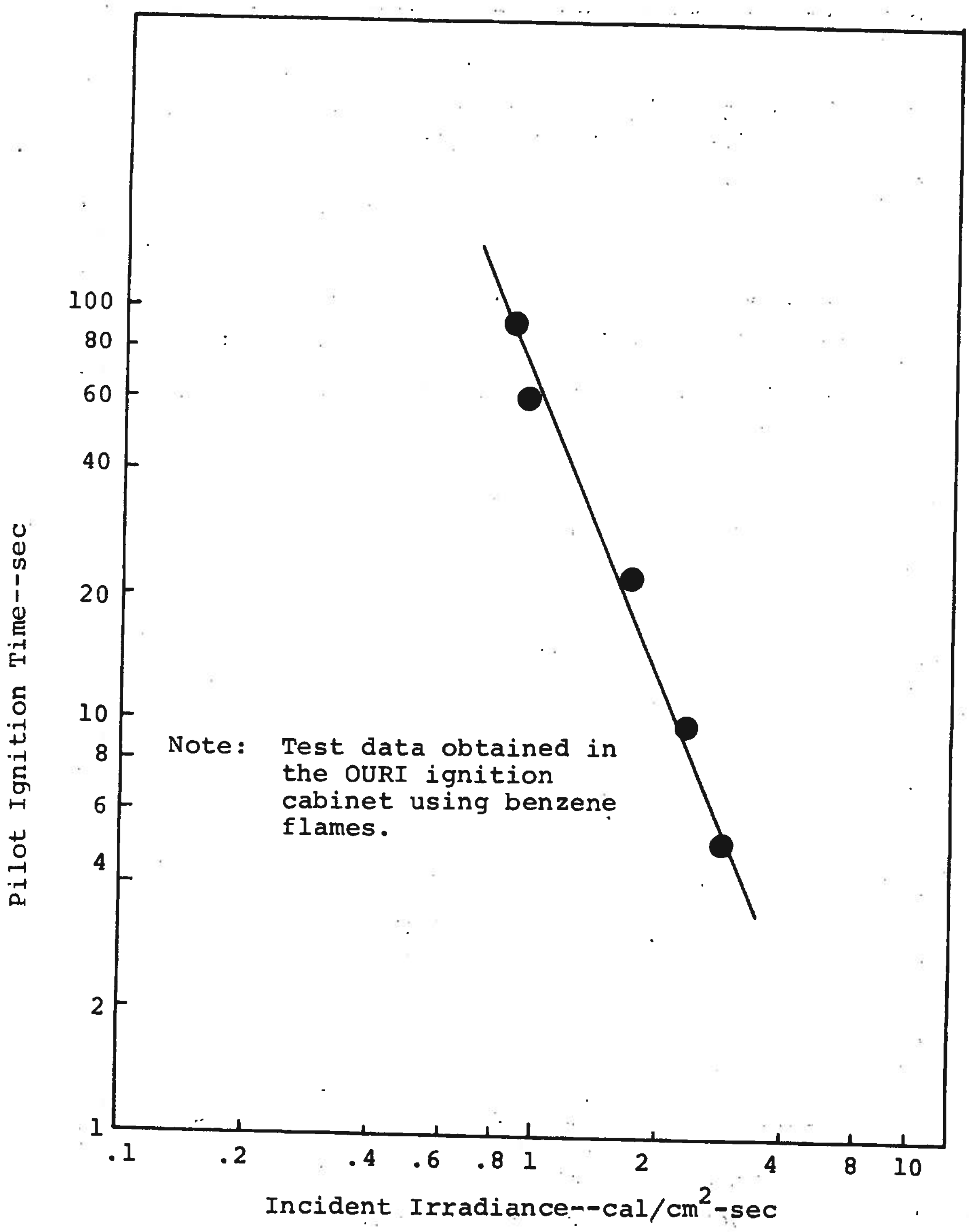


Figure 19. 1970 Chevrolet Impala interior materials ignition tests--rubber floor matting exposed to flames.

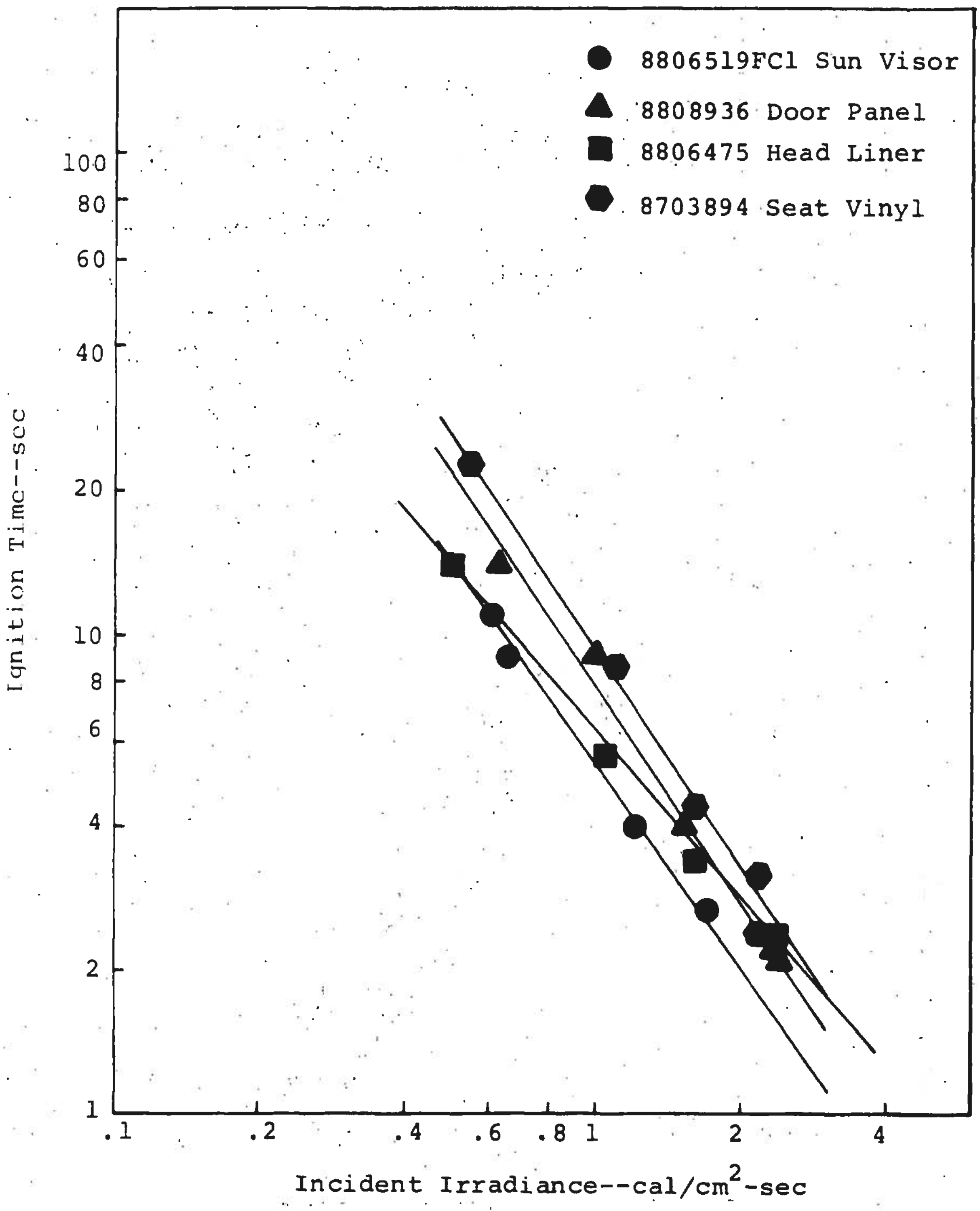


Figure 20. 1970 Chevrolet Impala new interior materials ignition tests.

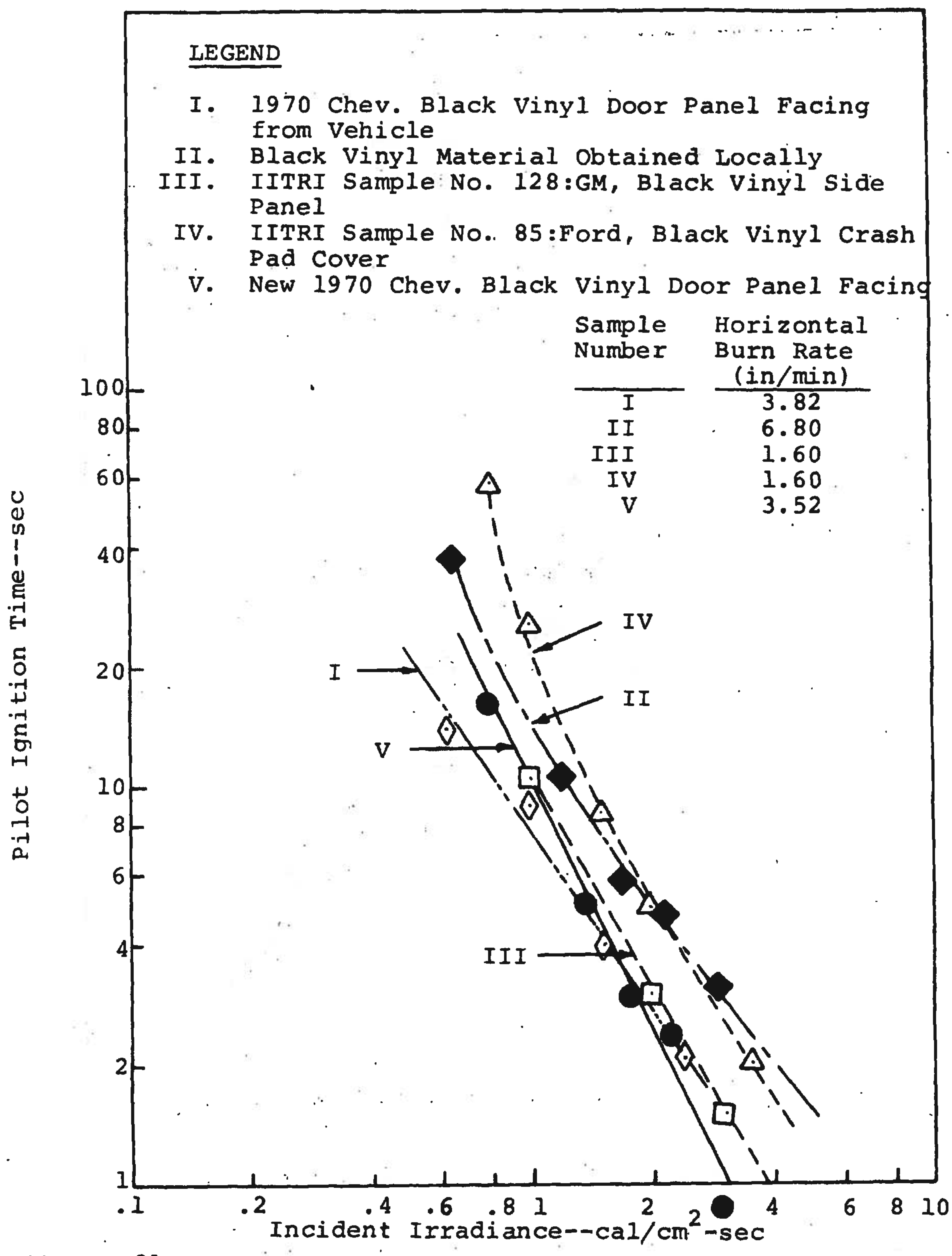


Figure 21. Comparison of the ignition characteristics of various black vinyl vehicle interior materials.

rate of 3.82 in/min (which complies with the proposed FMVSS 302 requirement) and an ignition time of 2.5 seconds at 2 cal/cm^2-sec. The new replacement 1970 Chevrolet vinyl has a burn rate of 3.52 in/min and the same ignition time. The locally procured vinyl has a higher horizontal burn rate (6.8 in/min) but is twice as difficult to ignite (5 seconds at 2 cal/cm^2-sec).

During the OURI ignition test, wherein the sample is continuously exposed to radiant heating effects, an unusually short sample burning characteristic was observed. Flaming ignition appeared, vanished, reappeared, vanished and reappeared. On further testing it was noted that appearance and disappearance of flaming ignition was not due to pulsing of pyrolysis gases as originally suspected but to the total destruction of the successive layers of the door trim panel assemblies. Figure 22 presents a typical recorder tracing of one OURI ignition test and clearly demonstrates this rapid layer burning characteristic. Figure 23 presents the actual recorded total burning (flaming) times for the surface layer only of the multi-layer door trim panel assembly. The flaming time decreases with increasing irradiance, as would be expected, and averages about one-half second over the range of irradiances used in the tests.

This observation tends to support the conclusion of a short term-flash type fire in the vehicle interior since the actual surface burning in the vehicle in most areas was confined to destruction of the first layer of trim panel and seat cushion assemblies. On most areas only slight scorching of the first sub-layer was found.

Conclusions

As a result of the vehicle fire investigation and the subsequent interior materials testing, the following conclusions can be made:

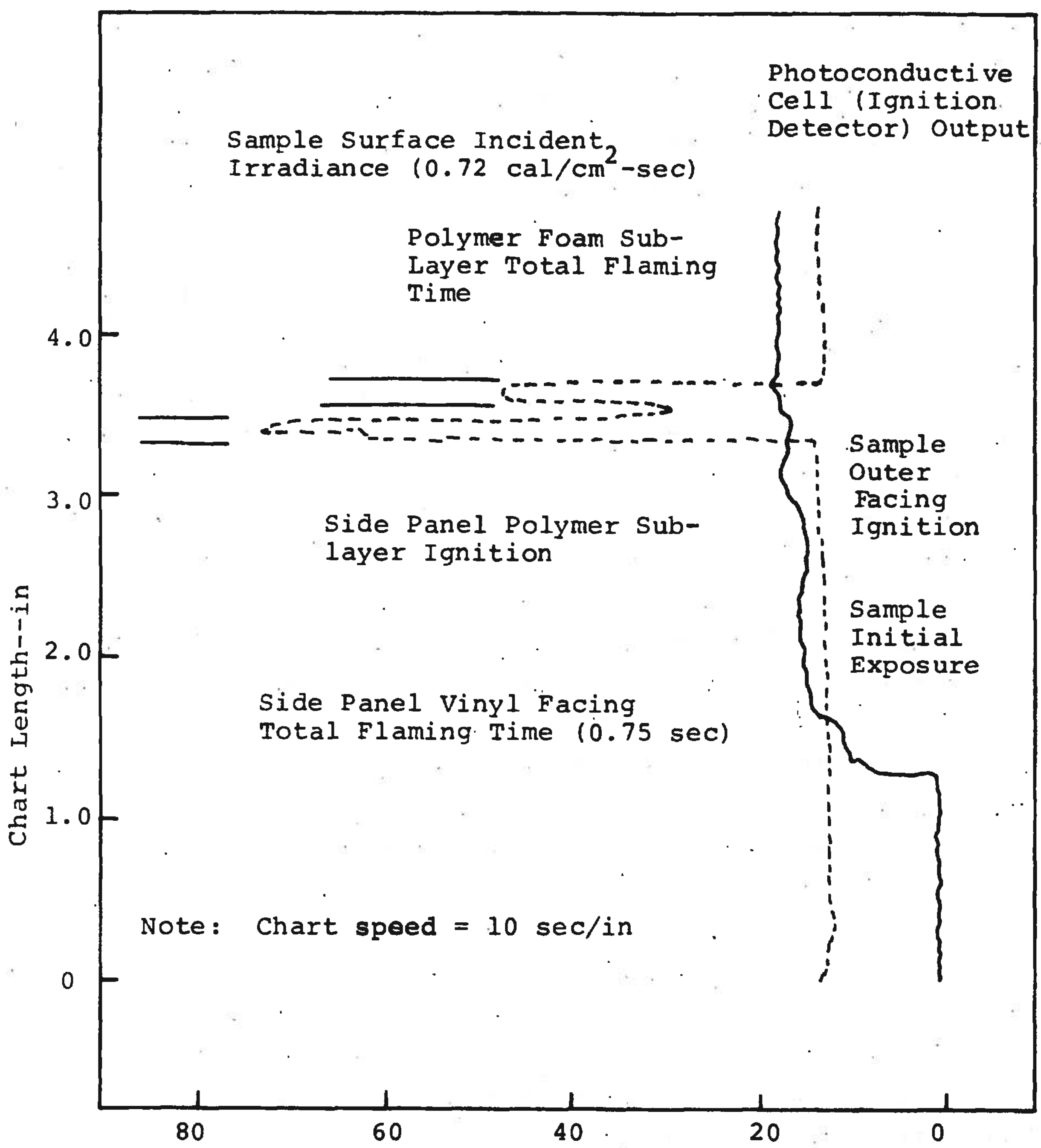


Figure 22. 1970 Chevrolet Impala interior materials ignition tests--typical instrumentation recorder outputs during continuous exposure to benzene flames in the OURI ignition cabinet: black vinyl covered side door panel.

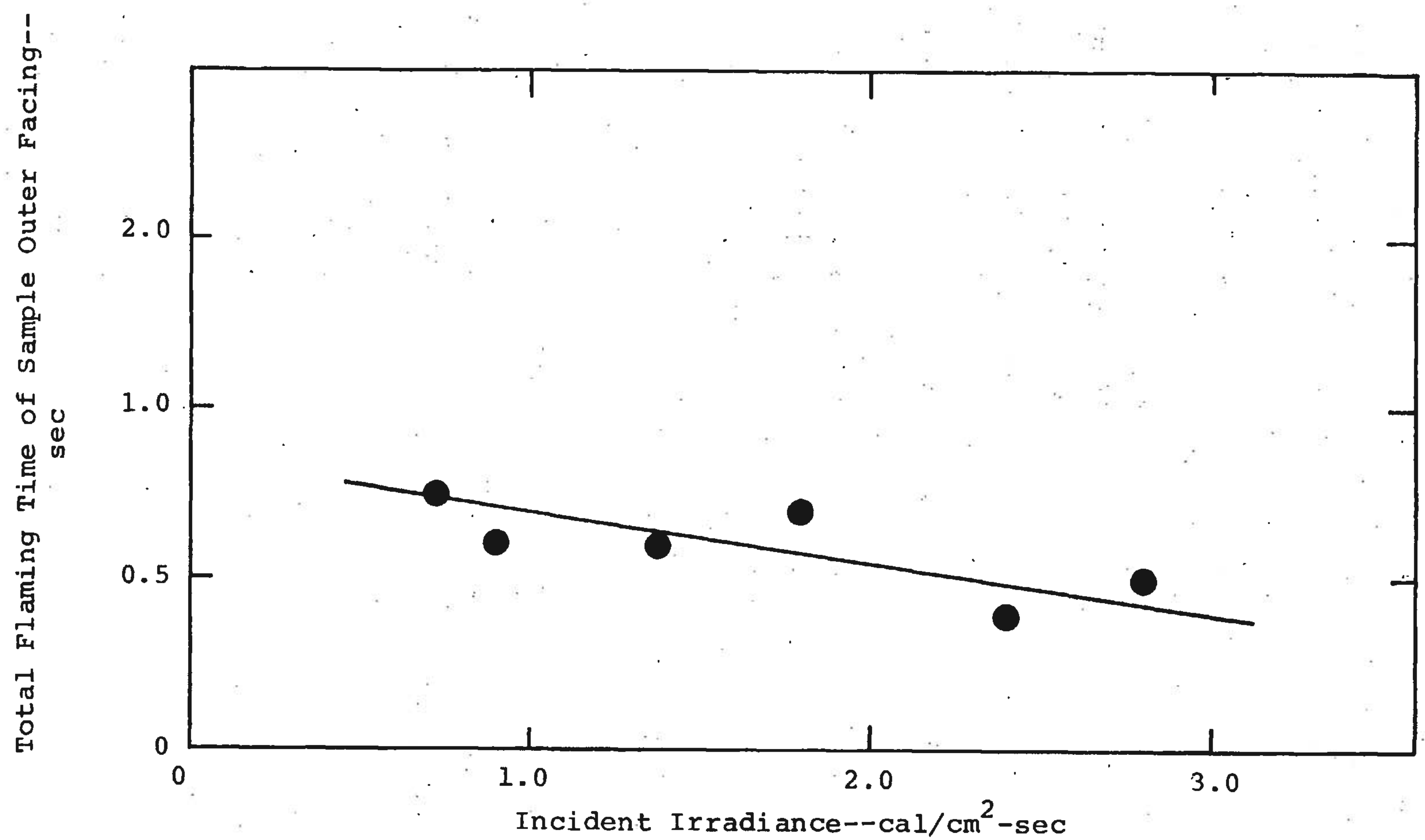


Figure 23: 1970 Chevrolet Impala interior materials ignition tests--black vinyl side door panel facing total flaming time during continuous exposure to benzene flames in the OURI ignition cabinet.

1. Arson (incendiary fire) was not the cause of the fire.
2. The fire apparently originated in an electrical short in the instrument cluster wiring and was followed by a short-term, rapid rate of spread, flash-type fire in the interior materials. All pertinent events from origin through final extinguishment encompassed not more than 10 minutes.
3. The proposed FMVSS 302 Horizontal Burn Rate Test does not appear to be indicative of the flammability characteristics of vehicle interior materials, in that it does not provide results indicative of the ease of ignition nor the rate of flame spread under real-life situations of pre-heating effects and continuous radiant heating during the flaming process.
4. The OURI ignition test with modifications and/or the Radiant Panel Test (ASTM E 162-67) with modifications appear to be more realistic of and applicable to true fire situations.

References

1. Goldsmith, A. "Flammability Characteristics of Vehicle Interior Materials." IITRI Final Technical Report, Project J6152 (May 1969).

2. National Automobile Theft Bureau. Manual for the Investigation of Automobile Fires (1969 edition).

CAR-TRUCK HEAD-ON COLLISION AND FIRE

Identification:

The accident occurred on State Highway 51 four miles west of Mannford, Oklahoma, on Monday, August 2, 1971, at about 1:30 p.m. Car-truck head-on collision, with the truck overturning on the car. Driver of the car suffered fatal injuries.

Ambience:

Daylight, clear, roadway dry.

Highway:

State Highway 51 is 24' wide, 2 lanes, undivided. Shoulders are approximately 8 feet wide, sealed crushed rock. Level with a very slight downgrade towards the general area of the collision.

Traffic Controls:

Broken white centerline, solid white edge lines. Widely spaced reflectors on 3-foot standards about 3 feet off the surfaced shoulder.

Vehicles:

Vehicle 1: 1966 Ford Galaxie 500, 4-door sedan.

Vehicle 2: 1970 Chevrolet C-50 two-ton truck with electric-line-construction-tool type bed including center-front-bed mounted hydraulic "Pole-Cat" extendable-boom drillhead.

Occupants:

Vehicle 1:

Driver 1-1. Negro male, 41, 71 in, 190 lbs.

Over 25 years driving experience, operator's license, no restrictions. No known physical, medical, or mental defects. Trip plan--returning home after taking daughter to college at Stillwater, Oklahoma, 68 miles from the home. This trip began immediately after completion of a round trip to Dallas, Texas. Driver was reported by family to have been without sleep for approximately 30 hours prior to the crash. Did not use alcohol. Sole occupant, lap belt probably not in use. Injuries: fatal. Immediate cause of death: burns, 100% of body. Autopsy not feasible.

Vehicle 2:

Driver 2-1. White male, 42, 69 in, 175 lbs. Over 25 years driving experience, "several years" as a truck driver, chauffeur's license, no restrictions. No known physical, medical, or mental defects. Trip plan--returning to pole yard of electric company after completion of morning construction job and lunch (last destination) at Mannford. No evidence of alcohol. Lap belt in use. Injuries: shock.

Occupant 2-2. White male, 19, 68 in, 160 lbs. Health--good. No evidence of alcohol. No lap belt available. Injuries: contusion to forehead from striking wind shield, soreness in upper chest from impact on instrument panel.

Occupant 2-3. White male, 26, 73 in, 215 lbs. Health--good. No evidence of alcohol. Lap belt in use. Small laceration of mid lower leg probably incurred during egress through windshield opening.

<u>Collision Description</u>:

Precrash and Crash:

Vehicle 1 proceeding eastward at approximately 50 mph "appeared to drift" abruptly into path of westbound truck. From skidmarks, Vehicle 1 was approximately centered over the trafficway-shoulder joint and attempted to steer right to return to lane and avoid oncoming truck. Total skidmark length was approximately 35 feet for right wheels, 41 feet for left wheels. Vehicle 2 truck driver observed Vehicle 1 in his lane, attempted to brake from apparent speed of about 55 mph (self-reported speed of 35 mph) leaving approximately 110 feet of very light tire marks. Vehicle 2 veered left in an avoidance maneuver just as Vehicle 1 attempted to recover to the right, resulting in an angled, head-on collision. Force of truck's impact drove Vehicle 1 backwards, both vehicles slowly rotated (Vehicle 1 clockwise; Vehicle 2 counter-clockwise) while moving westward (Vehicle 2 truck original direction of travel) for approximately 40 feet. At this point, the vehicles broke apart, Vehicle 1 continuing its rotation and coming to rest at 90° to its direction of travel. Vehicle 2, the truck, continued to rotate until at 170° to its direction of travel, it overturned to the right, coming to rest with its bed lying over the rear one-third of Vehicle 1. (Figure 1)

The vehicles almost immediately caught fire, reported by the truck (Vehicle 2) occupants as "a crackling sound behind us as soon as we were stopped. The truck carried, in tanks on either side of the tool bed (visible in Figure 2) about 30 gallons of gasoline and 20 gallons of hydraulic oil. Additional gasoline was carried in the truck's integral tank. At the time the vehicle was examined, all tanks were empty, presumably having drained out at the scene. The amount of fuel in Vehicle 1 is not known. The fuel tank on Vehicle 1 appeared to be intact although somewhat flattened. The filler neck also appeared intact. The filler cap was jammed on by deformation of the left-rear quarter panel.

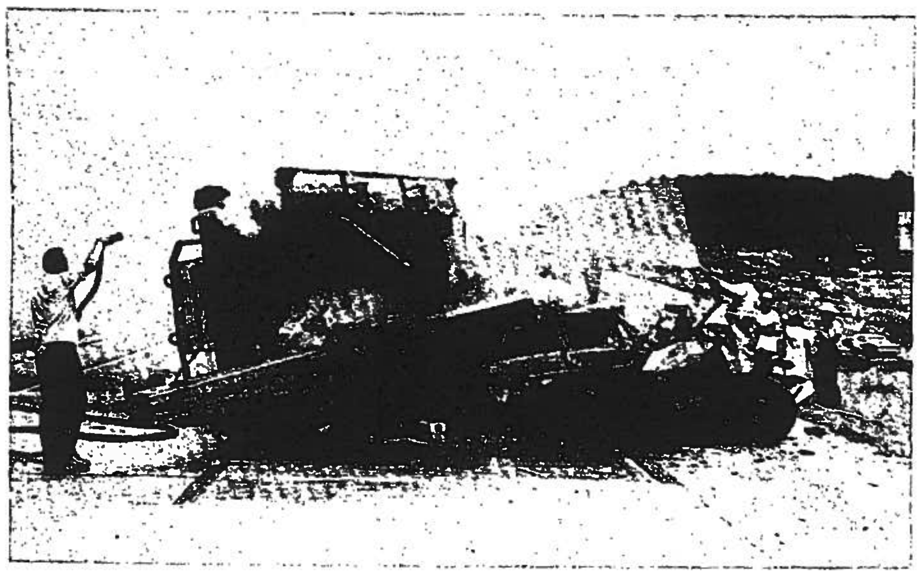


Figure 1. Collision scene showing truck overturned on passenger car, looking in the car's direction of travel.

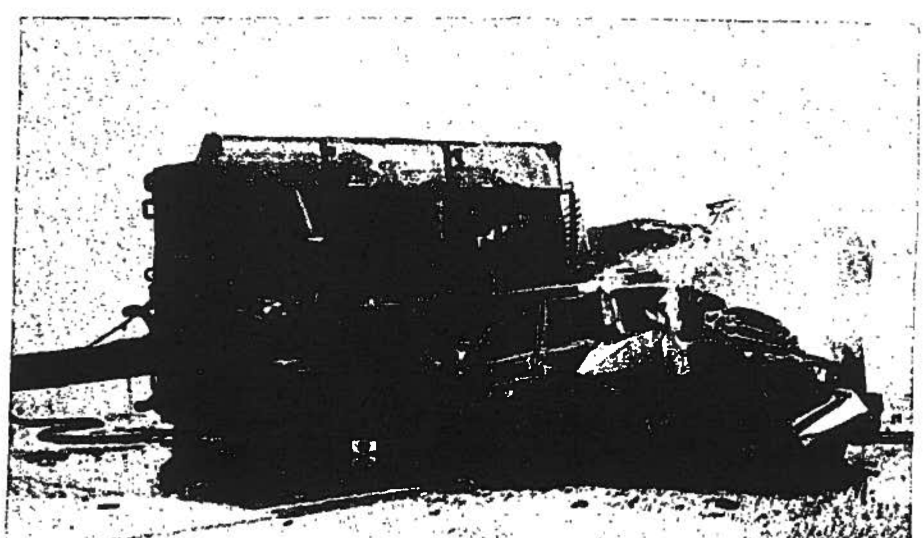


Figure 2. Photograph showing fuel tank in tool bed at front top. Note missing filler cap.

Vehicle Damage:

The original impact damage to Vehicle 1 was quite severe (Figures 3 and 4). Since the two vehicles hit at an angle, the left front of Vehicle 1 was crushed back to within 6 inches of the "A" post. The truck appeared to have over-ridden Vehicle 1, since the right front sheet metal was crushed back to just above the front axle, although the wheel and axle on the right side were approximately in their original position. Some compression bending occurred at the doors. The right front and left rear doors were jammed. The left rear and left front doors were not jammed. The battery of Vehicle 1 was crushed to about half its original length, but there was no evidence of arcing near primary posts or cables. Secondary damage occurred when Vehicle 2 overturned over the back one-third of Vehicle 1. Damage was again extensive, with the rear end of the vehicle being compressed to approximately a 14-inch height above the lower wheel rim. (Figures 5 and 6)

Damage to Vehicle 2 was also severe even prior to the fire. The right front was compressed approximately three feet, with the entire front being shoved to the left about 16 inches (Figure 7). A massive front bumper of 1/4 inch boilerplate was broken from its mounts. The front axle was completely sheared away (Figure 8).

Fire damage on both vehicles was total, involving buckling of sheet metal and frames. Even the massive centerpost (base) of the extendable boom had been heated enough to wrinkle at about midway up its height; that is, the centerpost sagged towards the left (bottom side) during the fire. Additional evidence of the intensity of the fire appears in Figure 9, in the extensive spalling of the concrete, to a depth of about 2 inches in some places. The general extent of the spill appears in Figure 10 as

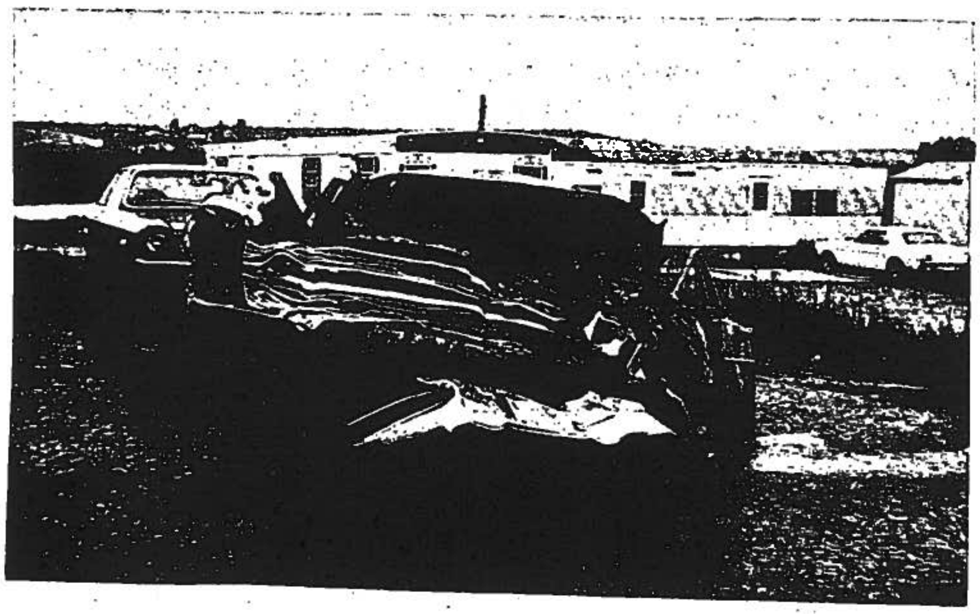


Figure 3. Vehicle 1. Front view of damage.

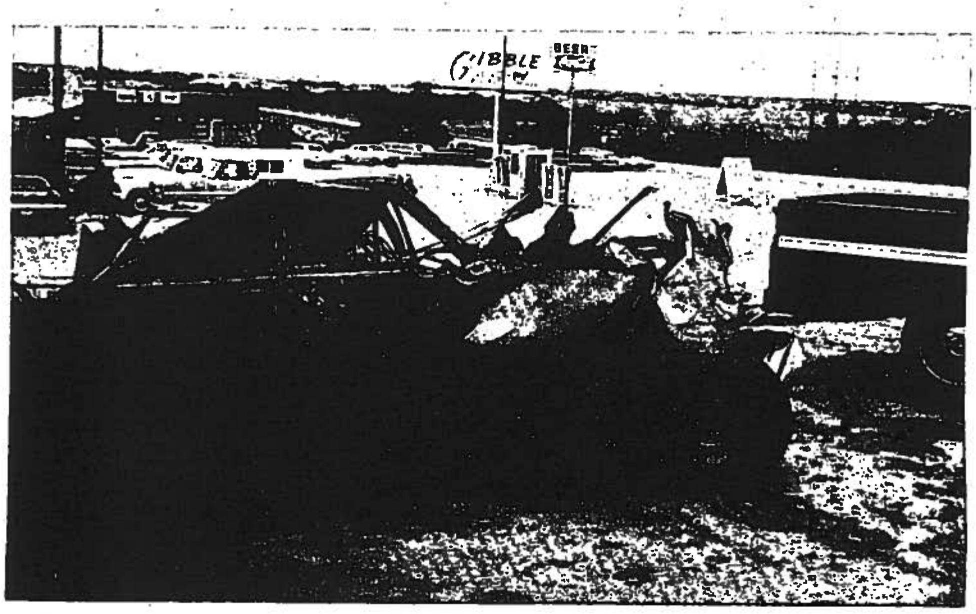


Figure 4. Vehicle 1. Side view of collision damage.

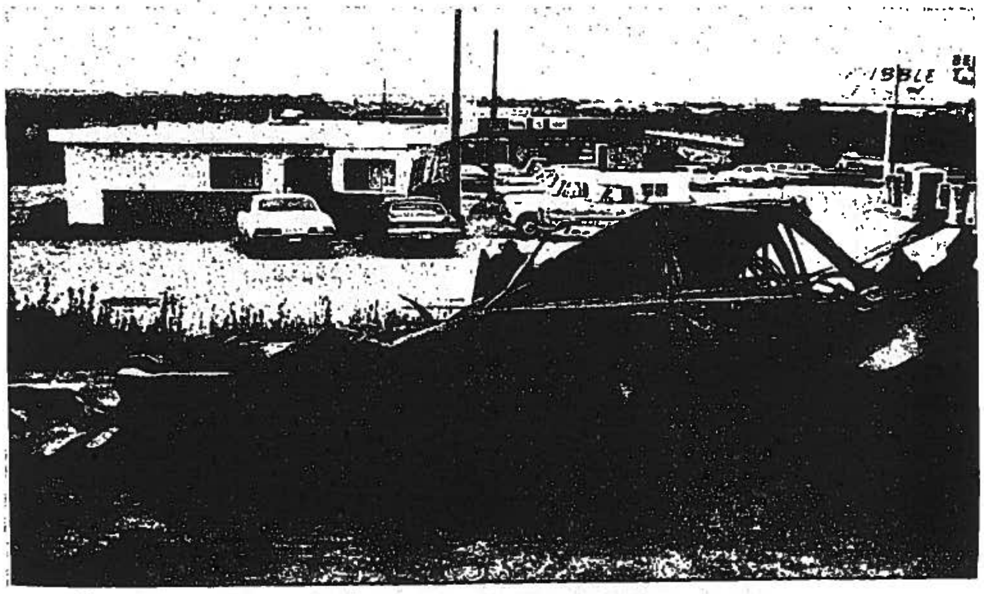


Figure 5. Vehicle 1. Side view showing extent of collapse caused by overturned truck.

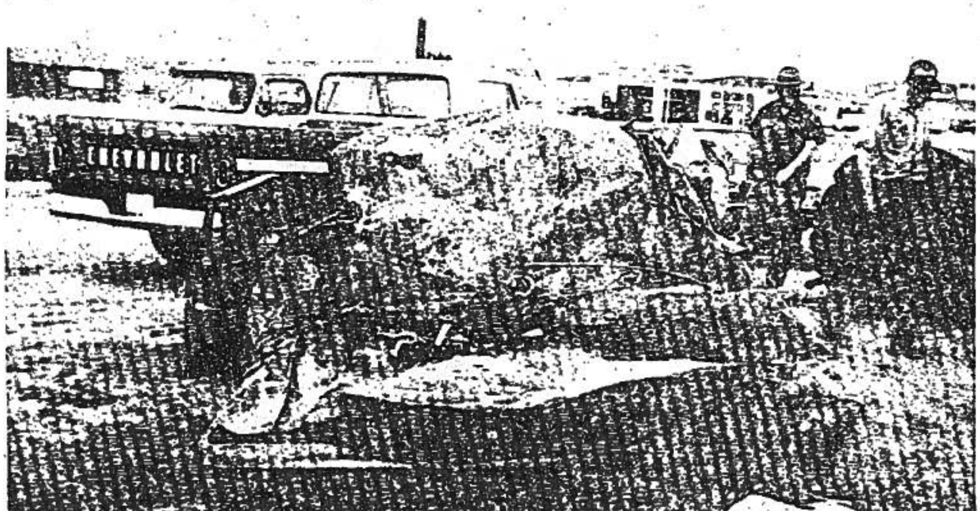


Figure 6. Vehicle 1. Rear view.

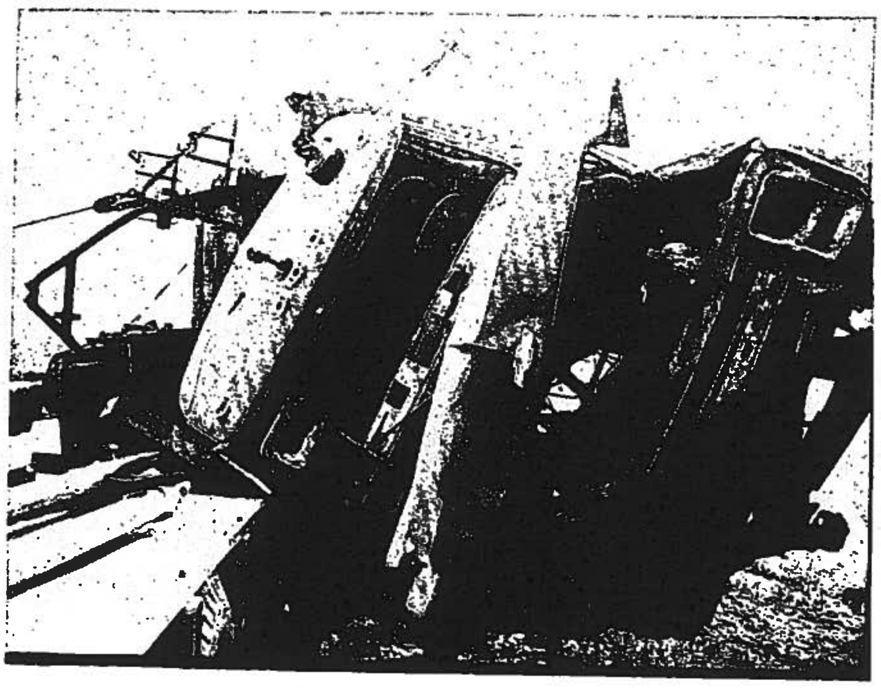


Figure 7. Vehicle 2. Front view of collision damage.

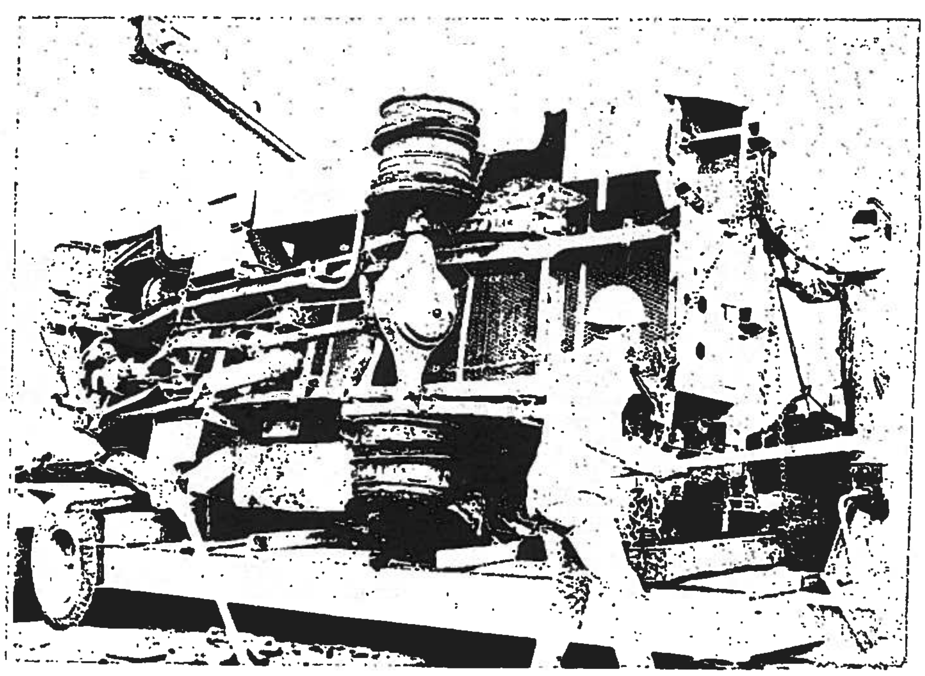


Figure 8. Vehicle 2. Note missing front axle.

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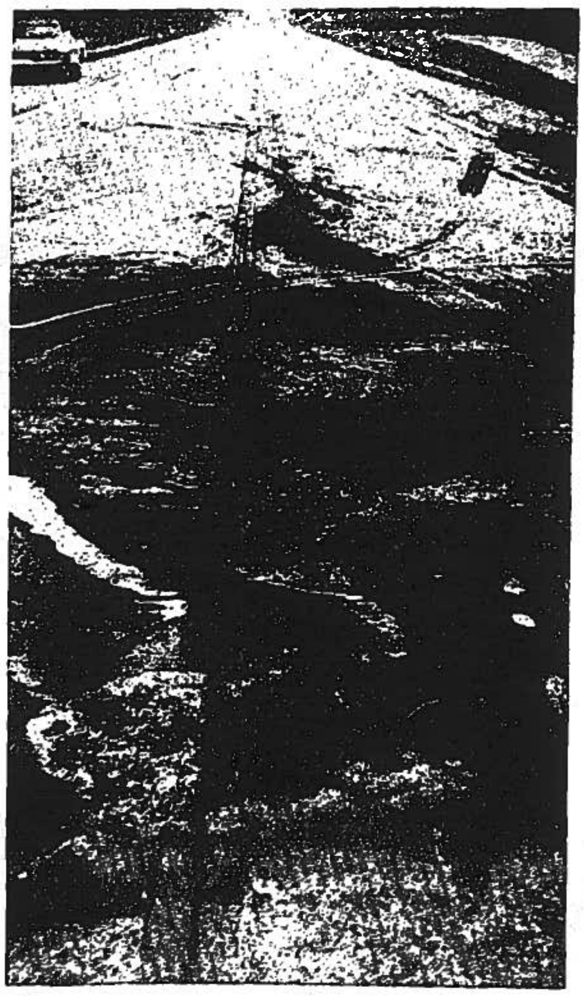


Figure 9. Both vehicles came to rest at this point. Note extensive spalling of concrete from intense heat.

Figure 10. View of Vehicle 1 (car) direction of travel.

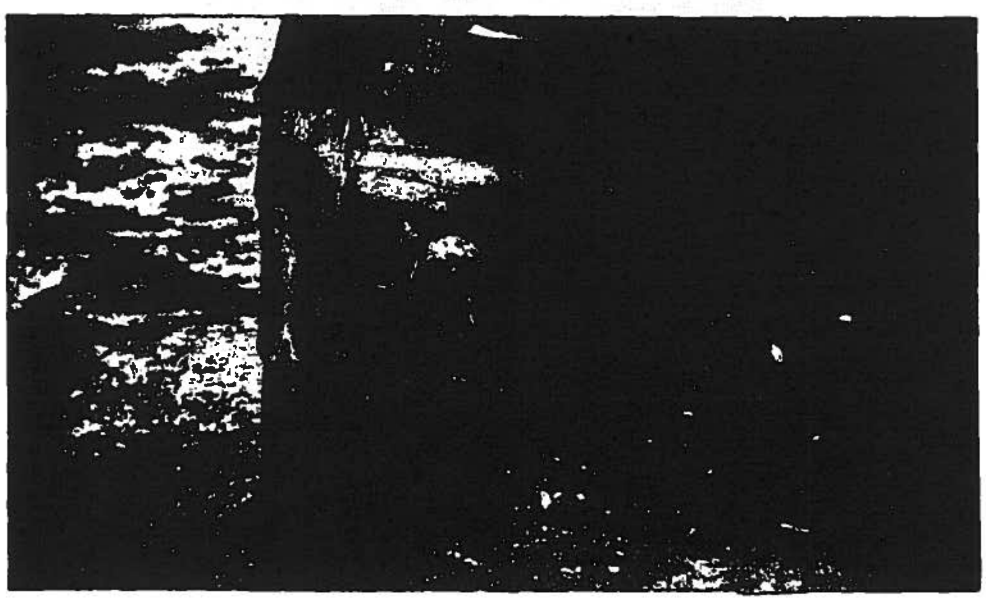


Figure 11. Vehicle 1, door latch. Note absence of twisting or bending. No evidence of tension failure.

blackened area. This photograph is approximately the view available to the driver of Vehicle 1 (i.e., looking east).

Human Factors of Escape:

This case report is considered to be incomplete since it was abandoned after the surviving driver could not be interviewed because of being released from work duties to recover from shock. However, the report is included as an example of two specific problems.

The first of these problems has to do with the assignment of cause of death in collision fires. In this instance, the cause of death of the driver of the vehicle was "third degree burns, auto accident." Considerable effort has been expended in the past to develop a means of assigning cause of death to impact injuries or to burns. In this instance, a crash of extreme severity, it would generally be assumed that the victim died instantly of impact injuries. In this case, there is a small amount of evidence that the victim did not die of impact injuries but died in the fire. This evidence consists in part of the occupants of the opposing vehicle believing that they heard at least two faint calls for help while they were attempting escape from their own vehicle. Their conviction was such that at least the driver attempted to enter the flames to rescue the victim, but was driven back, receiving minor burns.

The second piece of evidence involves the final position of the victim and the condition of the left front door. The victim was lying directly at the edge of the car in a space framed by the open door and the edge of the car as though he had slid out of the seat and slipped directly to the ground. Had he been ejected, it is almost certain that the body would have been found further away from the final resting position, since at this position the centrifugal forces tending to eject him sideways would have been dissipated, and in fact, it is probable that the rotational movement ceased abruptly when the truck overturned onto the passenger car. Thus, it is more probable that the victim would have moved to the right rather than out the door, even if the door were open.

A careful examination of the latch mechanism produced no evidence of damage despite the appearance of the door in Figures 11 and 12. There was no bending on the door or B-post, no deformation of striker or post, and the operating springs still retained some tension. Despite the bending apparent in Figure 12, the door still could be completely closed after the fire, although the springs were too weak to cause the latch to retain the door in a closed position.

The general line of speculation here is that the victim was able to release the door latch and push open the door or at least fall out the door to collapse in his final position. At some time after the vehicles came to rest, he may have called for help, probably after he was outside the vehicle. When the rescue was attempted, he was in the same position as after the fire (except that the body had assumed the "boxer's position" as a result of the fire exposure.

The second problem is only a suggestive one relating to difficulty in releasing a lap belt. In Vehicle 2, which was on its side, all passengers escaped through the windshield opening. The order of escape was Occupant 2-2, Occupant 2-3 and Occupant 2-1. Occupant 2-2 was not restrained by a belt. Occupant 2-3 was wearing a lap belt but did not believe that the belt had slowed his escape (since for a few seconds he was under Occupant 2-2).

Occupant 2-1, the driver, however, a 42-year-old, 69-inch tall, 175 pound male found himself hanging sideways from the lap belt and unable to release it. Ordinarily, it would seem that a muscular individual accustomed to heavy work should have no difficulty. In this case, the driver was unable to release himself and was in a difficult position to receive assistance for "at least a minute." Again, in this instance, this delay increased the hazard because of the encroaching fire.

Conclusions:

No conclusions are warranted for the discussion of this collision because the investigation could not be completed. This incomplete report is included because it illustrates two problems which may commonly occur: determination of the cause of death of vehicle occupants in collision fires, and the design of seat belt buckle mechanisms that require more effort for operation under preload conditions than even a muscular individual can produce, even when he knows his life may depend upon his performance.

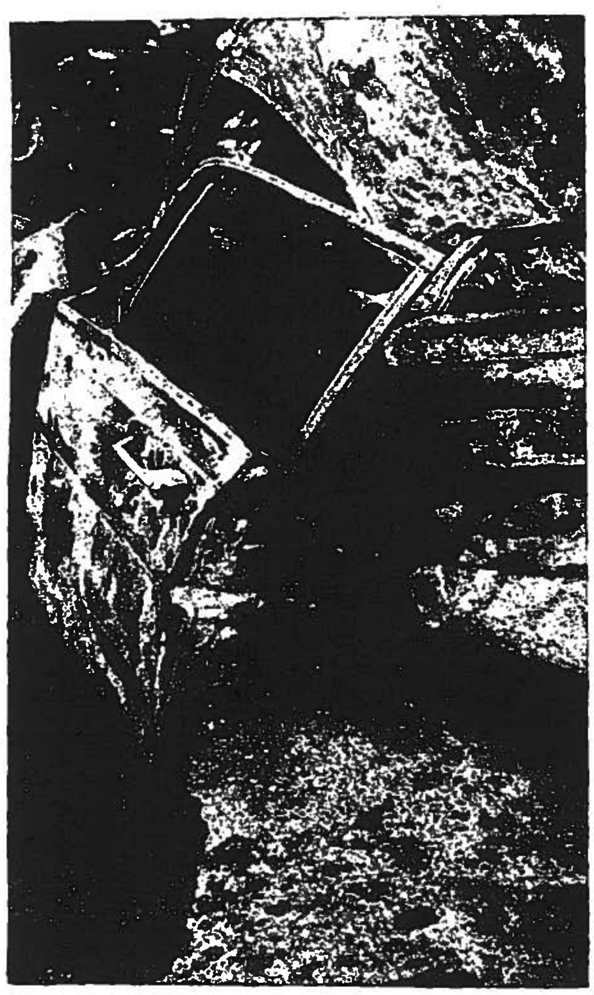


Figure 12. Vehicle 1, driver's door. Despite bending shown here, door still closed, mating with the B-post.

5

Sheet 1 of 1 — FATALITY: yes [X]

OKLAHOMA 04 — OFFICIAL POLICE TRAFFIC COLLISION REPORT

No. 1214 0048

Reporting Agency: OKLAHOMA HIGHWAY PATROL

Date: 8-2-71 — Day of Week: MONDAY — Hour: 1:40 PM — County: CREEK

Near: MANNFORD — Distance from nearest city limits: .4 mi. — Number of Motor Vehicles Involved: 2 — No. Injured: 2(?) — No. Killed: 1

Location: On STATE HIGHWAY 51 — Not at intersection: 201 ft. West of COUNTY ROAD

State Highway Code: Control No. 22 — Location 09.80 — County No. 19 — 01-97(?)

Time Notified: Date 8-2-71, Hour 1:50 PM — Arrived at Scene: Date 8-2-71, Hour 1:59 PM

Unit 1

Driver: [redacted]

Address: [redacted] TULSA - OKLA.

License: 23 OKLA [redacted] — Operator [X]

Age: 41 — Race: N(?) — Sex: M — Date of Birth: 1-18-30

Veh ID No: [redacted]

Vehicle: 1966(?) FORD [illegible] 4 DR 5

License Plate: 71 OKLA [redacted]

Owner's Name: [redacted] [redacted]

Address: [redacted] TULSA - OKLA.

Legal speed 65 MPH — Estimated speed before contact 50-60 MPH — at contact 40-50 MPH — Estimated damage $1200.00

Veh removed to: [redacted] by: NORWOOD WRECKER

Unit 2

Driver: [redacted]

Address: [redacted] OKLA. 74020

License: 71 OKLA. [redacted] — Chauffeur [X]

Age: 42 — Race: W — Sex: M — Date of Birth: 11-19-28(?)

Veh ID No: [redacted]

Vehicle: 1970 CHEV. C-50 TRUCK 5

License Plate: 1971 OKLA [redacted]

Owner's Name: [redacted]

Address: [redacted] OKLA. 74020

Legal speed 60(?) MPH — Estimated speed before contact 50-60 MPH — at contact 35-35 MPH — Estimated damage $300.00

Veh removed to: CLEVELAND by: OWNERS

Injured / Witnesses

1. [redacted] [redacted] 41 M N 1
2. [redacted] [redacted] 26 M W 2
3. [redacted] 19 M W 1

Injured Taken To:

1. [redacted] MEMORIAL HOSP. [redacted] A-1 — Time left scene 3:10 — Time arrived hospital 3:30
2. [redacted] CUSHING(?) HOSP. - PRIVATE AUTO. — Time left scene 3:36 — Time arrived hospital 3:46(?)

Damage to property other than vehicles: ROAD SHOULDER $30.00 — Owner: STATE OF OKLA. — Address: OKLAHOMA CITY, OKLA.

Investigation made at scene: Yes [X] — Investigation completed: Yes [X] — Photos taken: Yes [X]

Signature: [redacted] — Badge No: [redacted] — District & Division: 9 — 72 — Date of report: 8-2-71

WHAT VEHICLES WERE GOING TO DO | WHAT VEHICLES DID | TYPE OF ROAD | TRAFFIC CONTROL | ROAD CHARACTER | CONDITION OF DRIVERS AND PEDESTRIANS

Body defects: BODY DAMAGED

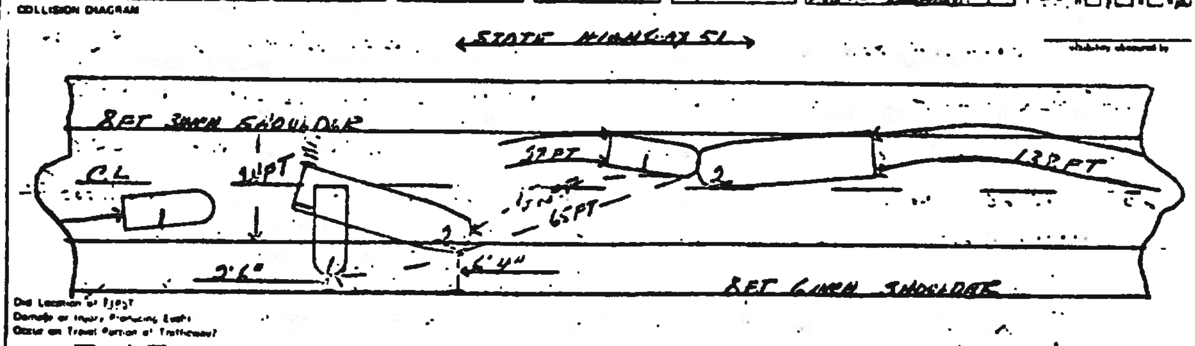
POINT OF FIRST CONTACT ON VEHICLES | LIGHT | WEATHER | WHAT PEDESTRIAN WAS DOING

OBJECT STRUCK BY VEHICLE OR LOAD ON FIRST CONTACT

ROAD CONDITION | ROAD SURFACE | LOCALITY | VEHICLE CONDITION | FIRE CHECK | DIRECTION OF TRAVEL

Vehicle condition, other: BURNED

COLLISION DIAGRAM



Did Location of First Damage or Injury Producing Event Occur on Travel Portion of Trafficway? Yes X

REMARKS

P.O.I. WAS 6FT NORTH OF CENTER LINE. VEH #2 DROVE VEH #1 BACK 65 FT FROM IMPACT. VEH #2 THEN TURNED OVER ON RIGHT SIDE ACROSS THE REAR OF VEH #1. DRIVER OF VEH #1 PARTLY EJECTED OUT LEFT DOOR. BOTH VEHICLES BURNED. UNABLE TO DETERMINE WHICH VEH CAUGHT FIRE FIRST. VEH #2 WAS EQUIPPED WITH STEEL BED AND HYDRAULIC PALLET WINCH SYSTEM.

UNSAFE, UNLAWFUL OR OTHER ACTION

1 Failed to Yield
2 Followed too Closely — IN MEETING
3 Unsafe Speed
4 Made Improper Turn
5 Changed Lanes Unsafely
6 Stopped in Traffic Lane
7 Failed to Stop
8 Unsafe Vehicle
9 Left of Center — X (Unit 1)
10 Improper Overtaking
11 Improper Parking
12 Inattention
13 Wrong way on
14 Improper Start from
15 Other Improper Act or Movement
16 Not Known — No Improper Action — X (Unit 2)
17 Other Action — not directly related to collision
18 Pedestrian Action

58

Tulsan Is Victim of Fiery Crash

Death rode left of center Monday afternoon on a straight, smooth stretch of highway four miles west of Mannford.

Victim of the collision and holocaust to follow was a 41-year-old Tulsa school teacher, [redacted], 41, of [redacted] East 33rd Street North. Mr. [redacted] was alone in a 1966 4-door sedan which collided on SH 51 with a 1970 truck with polecat, owned by [redacted], Cleveland, and occupied by three company employees. Only one of the truck passengers was injured and this reported to be slight.

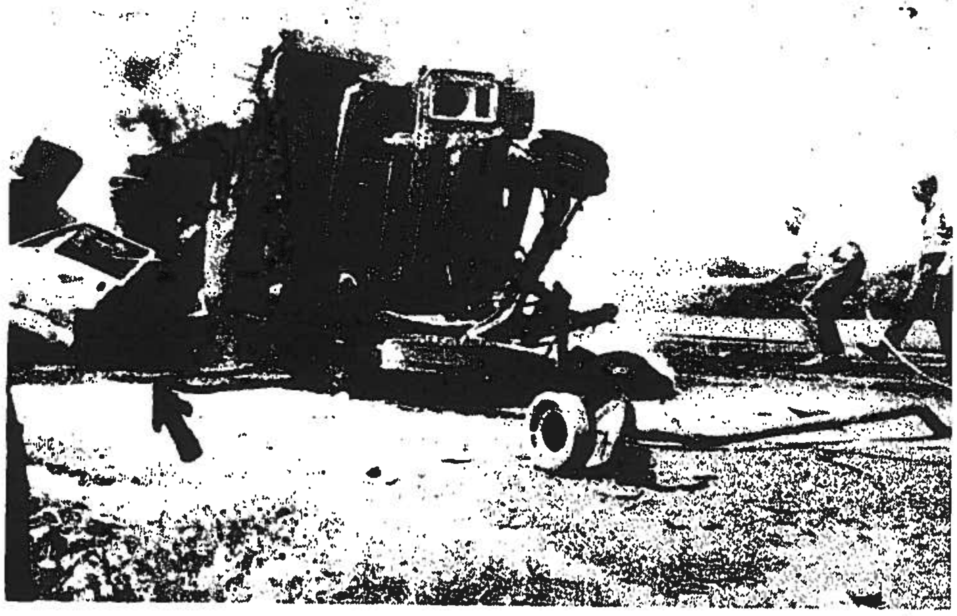
Driver of the truck was [redacted], 42, of [redacted], Cleveland. Passengers were [redacted], 26, Rt. 2, Cleveland, and [redacted], Cleveland. [redacted] sustained a slight cut below the knee but did not go to the hospital.

The two vehicles burst into flame upon impact about 1:40 p.m. Passengers in the truck scrambled to safety after first trying to locate the driver of the automobile. Flames shooting skyward drove them back. [redacted] is believed to have died instantly, Trooper [redacted], investigating officer, said. Evidence showed the accident victim's car was left of center when the vehicles met, [redacted] said.

After Mannford fire fighters arrived to quench the flames, the body was sighted near the open car door. An unburned bilfold in the victim's hip pocket, protected by his body from the flames, provided identification.

First on the scene with the fire hose was [redacted]. Other firemen arriving within seconds were [redacted] and [redacted].

Traffic piled up for more than a block east as the flaming wreck blocked the highway. Heavy black smoke, caused by burning of tires and oil, wafted skyward.



WHAT MANNFORD FIRE fighters faced Monday afternoon. The black square at left is where the charred body of Mr. [redacted] was found and has been purposely blacked out of the picture. The remains were removed by Drumright ambulance to a funeral home there, then transferred to Tulsa.

Rerouting traffic on the east side around old SH 51 to a point 8.7 miles east of the Oilton's south Y was Mannford City Marshal [redacted]. Rerouting traffic at the west side of the old highway was [redacted], with Unit [redacted], Cleveland.

After Mannford firemen quenched the flames and returned to town for more water, the fire flared up. Drumright fire fighters, [redacted], fire chief, and [redacted], put out the second fire. Drumright city ambulance driven by [redacted], with [redacted] as assistant, brought Mr. [redacted] remains to [redacted] Funeral Home, Drumright, where they were Transferred to Tulsa. [redacted] Memorial Chapel will be in charge.

Mr. [redacted] was a native of Kentwood, La. He held a BS Degree from Tennessee State University and a Master's Degree from Central State University, Edmond. He had done further graduate study at Oklahoma State University, Stillwater.

He had taught in the Tulsa school system more than 16 years. Last year he taught physical education at [redacted] elementary school and was assistant principal at [redacted] Elementary School.

APPENDIX C

ESCAPE WORTHINESS APPENDICES

Appendix C presents detailed analytical methods used in certain of the Escape Worthiness studies included in Section 3 of the Research Program presented in Part 1 of this final report. This appendix consists of five parts, the first four of which are related to the studies of vehicle submergence. These four include presentations of the program information for the computerized Water Entry Dynamics Programs, the vehicle water and air leak-rate analysis technique, the vehicle characteristic sinking time analysis technique and the gas concentration method for analysis of vehicle internal volume. The last part in this appendix is devoted to a biomechanical analysis of maximum arm and hand forces available for vehicle egress, which is related to effecting escape through normal openings in both passenger cars and buses.

TABLE OF CONTENTS

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C.1 VEHICLE WATER ENTRY DYNAMICS

In this section the program documentation, program listings and sample cases are presented for the computerized Vehicle Water Entry Dynamics Programs which have been developed under DOT Contract FH-11-7303.

Program "B" is an outgrowth of the quasi-steady water-entry analysis employing a constant drag coefficient which was presented in Appendix C of the final report of the previous contract.

Program "A," based upon the method of Shiffman and Spencer (4), was developed in the present study, and employs the "virtual mass" concept common to unsteady fluid-dynamic problems.

Program "A" is used to describe the initial phase of the vehicle water-entry process where virtual mass effects predominate, and program "B" is used to describe the remainder of the water-entry process where these effects become negligible.

Program Documentation

A. Title: Programs for Determining Vehicle Water-Entry Dynamics

Programmer: R. C. Leeper

Supervisor: J. L. Purswell

Date Completed: November, 1971

Machine Used: IBM 1130

Language Used: Fortran IV

Compiler Used: IBM WATFIV

Compilation Time: 12 seconds

Computation Time: 14 seconds for 2 cars

Lines of Output: Equals total entry time/time increment

Approximate Core Required: 4K

Additional Features: Extended precision

Standard Subroutine Used: RUNGE (Runge-Kutta) Numerical Methods and Computers, SS Kno.

B. Purpose: These programs were written to predict the water-entry dynamics of a vehicle. The first program (A) determines the time required for the car to enter the water a distance equal to the effective radius of the input of specific parameters and then calculates the time required for the vehicle to complete the entry process to a point where its velocity through the water is equal to zero.

C. Restrictions

1. Program A--entry time must be less than two minutes
2. Program B--entry time must be less than three minutes
3. Initial values of B must be in ascending order

D. Definition of Variables

1. Input Variables--Both Programs

   N--degree of differential equation (dimensionless)

   T--initial time (seconds)

   DT--time increment (seconds)

   S(1)--initial distance vehicle leading edge is underwater (feet)

W--weight of vehicle (pounds)

KD--drag coefficient (dimensionless)

KB--buoyancy coefficient (dimensionless)

LS--length of vehicle (feet)

AEFF--effective area of leading edge of vehicle (square feet)

REFF--effective radius of leading edge of vehicle (feet)

M1--number of data points (dimensionless)

B(I)--value of B in Drag Curve at point I from table (dimensionless)

CP(I)--value of C_p corresponding to B(I) from table (dimensionless)

S(2)--initial velocity of vehicle along entry axis (feet per second)

PHI--entry angle from horizontal (degrees)

2. Program Variables--Both Programs

DS(1)--deceleration of vehicle (feet per second squared)

DS(2)--deceleration of vehicle (g's)

X--time after entry of vehicle (seconds)

S(1)--distance vehicle leading edge is underwater (feet)

S(2)--velocity of vehicle on entry axis (feet per second)

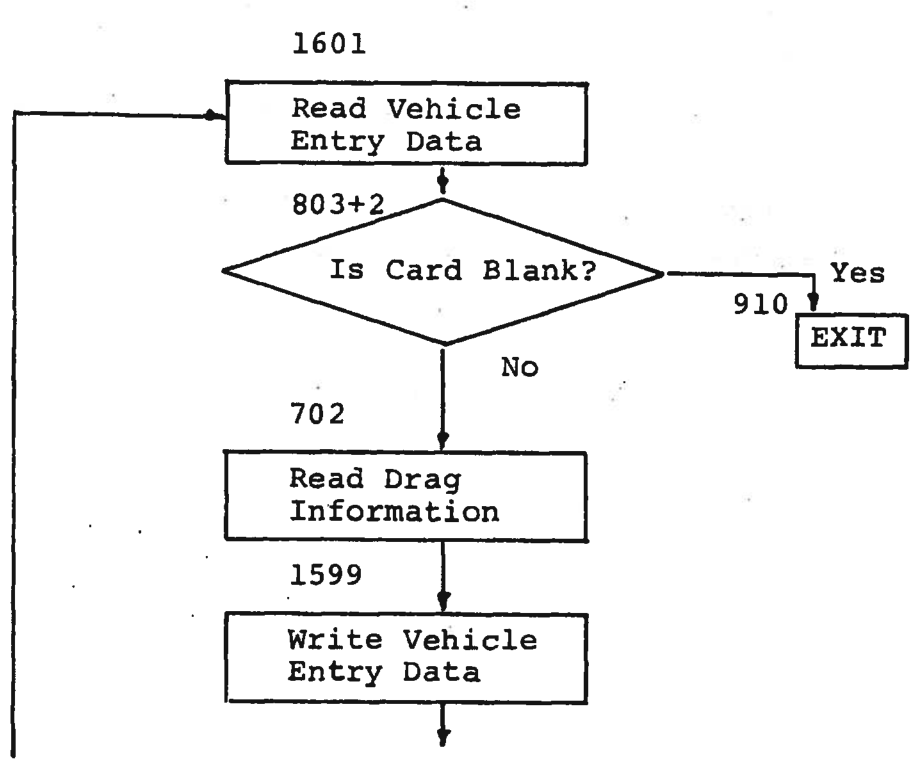
BC--calculated value for B (dimensionless)

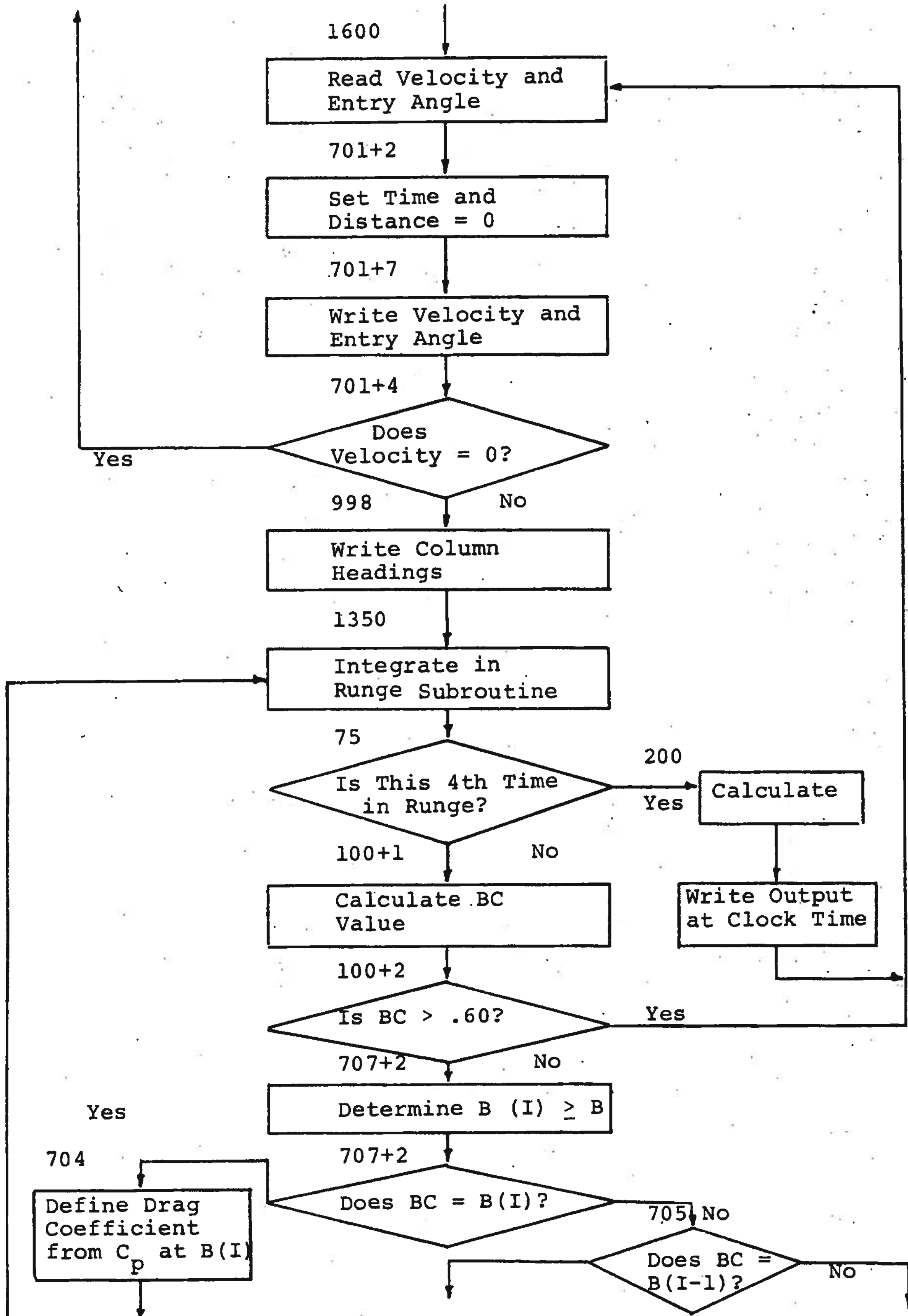
CPC--drag coefficient at specified B (dimensionless)

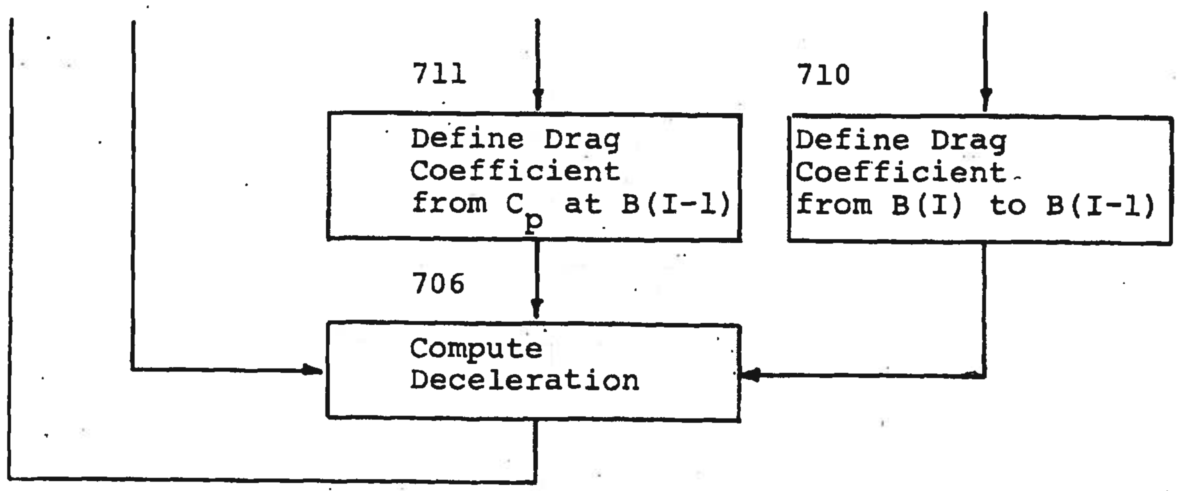
E. Input Data--Both Programs

Item	Card Column	Example
N	1-2	2
T	3-4	0
DT	5-8	.01
S(1)	9-13	0.0
W	14-20	3675.0
KD	21-26	17.526
KB	27-32	421.48
LS	33-38	17.47
AEFF	39-43	18.05
REFF	44-49	2.40
M1	1-2	25
B(1)	1-5	0.0
CP(1)	1-5	0.0
S(2)	1-5	0.0
PHI	6-10	90.

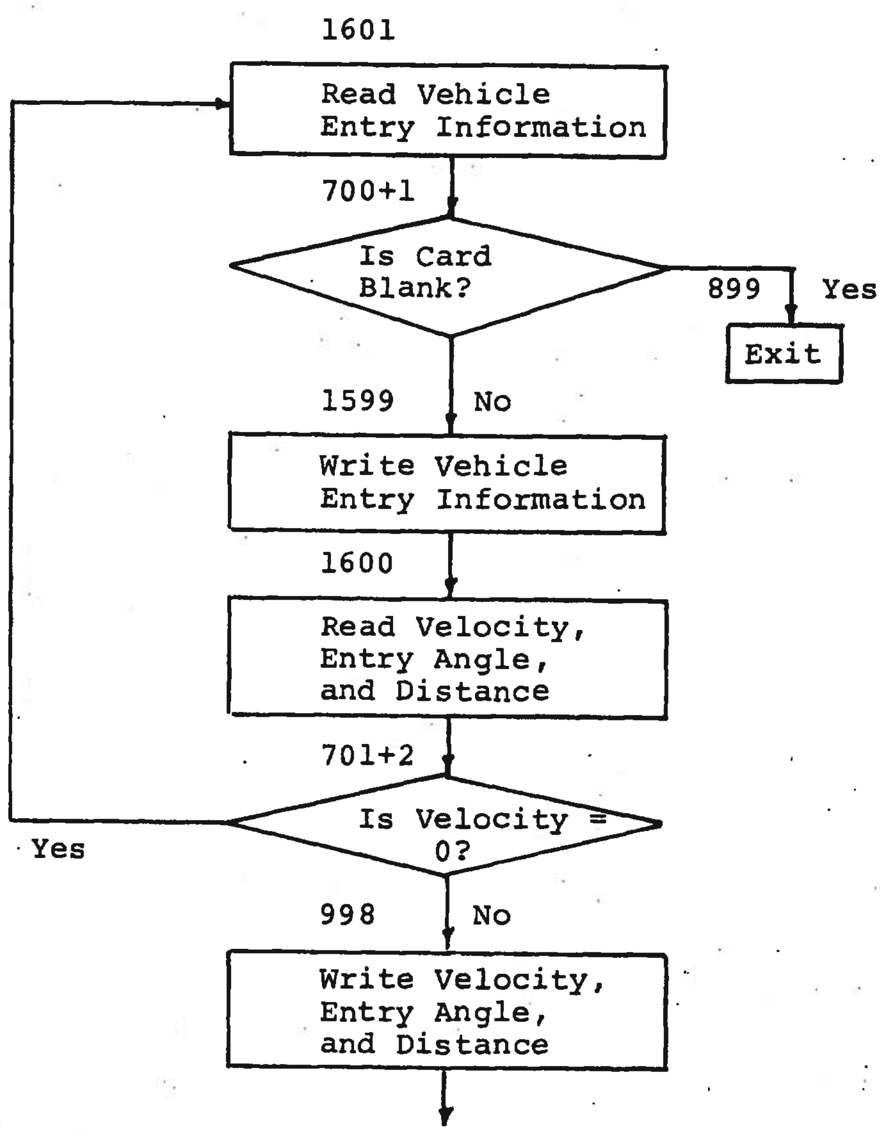
Flow Chart--Water Entry Program--A

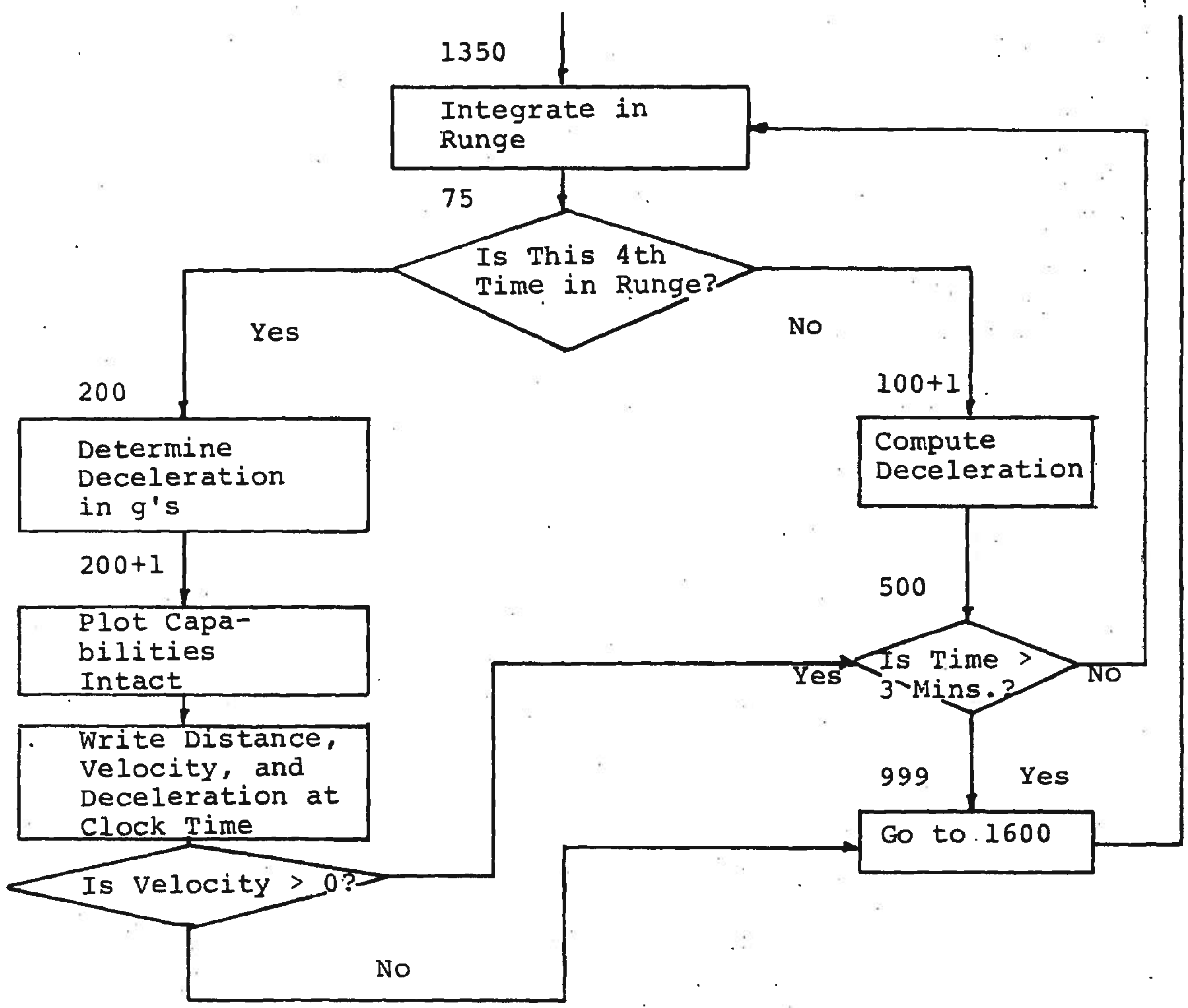



1600
Read Velocity and Entry Angle
701+2
Set Time and Distance = 0
701+7
Write Velocity and Entry Angle
701+4
Does Velocity = 0?
Yes
998
No
Write Column Headings
1350
Integrate in Runge Subroutine
75
Is This 4th Time in Runge?
200
Yes
Calculate
Write Output at Clock Time
100+1
No
Calculate BC Value
100+2
Is BC > .60?
Yes
707+2
No
Determine B (I) ≥ B
Yes
704
707+2
Define Drag Coefficient from C_p at B(I)
Does BC = B(I)?
705
No
Does BC = B(I-1)?
No



Flow Chart--Water Entry Program--B





1350
Integrate in Runge
75
Is This 4th Time in Runge?
Yes
No
200
Determine Deceleration in g's
200+1
Plot Capabilities Intact
Write Distance, Velocity, and Deceleration at Clock Time
Is Velocity > 0?
No
100+1
Compute Deceleration
500
Is Time > 3 Mins.?
Yes
No
999
Yes
Go to 1600

PROGRAM "A"

```
PAGE   1     RI090807

// JOB T                                          RI090807   445480257 GREENHAW

LOG.DRIVE   CART SPEC   CART AVAIL  PHY DRIVE
  0000         0C01        0C01       0000

V2 M09   ACTUAL  8K  CONFIG  8K

// FOR
** LARRY N. GREENHAW   RI070809   VEHILCLE SUBMERGENCE
*EXTENDED PRECISION
*LIST ALL

      SUBROUTINE RUNGE(T,DT,N,Y,DY,F,L,M,J)
      DIMENSION DY(2),Y(2),F(14)
      GO TO (100,110,300),L
100   GO TO (101,110),IG
101   J=1
      L=2
      DO 106 K=1,N
      K1=K+3*N
      K2=K1+N
      K3=N+K
      F(K1)=Y(K)
      F(K3)=F(K1)
106   F(K2)=DY(K)
      GO TO 406
110   DO 140 K=1,N
      K1=K
      K2=K+5*N
      K3=K2+N
      K4=K+N
      GO TO (111,112,113,114),J
111   F(K1)=DY(K)*DT
      Y(K)=F(K4)+.5*F(K1)
      GO TO 140
112   F(K2)=DY(K)*DT
      GO TO 124
113   F(K3)=DY(K)*DT
      GO T O 134
114   Y(K)=F(K4)+(F(K1)+2.0*(F(K2)+F(K3))+DY(K)*DT)/6.0
      GO TO 140
124   Y(K)=.5*F(K2)
      Y(K)=Y(K)+F(K4)
      GO TO 140
134   Y(K)=F(K4)+F(K3)
140   CONTINUE
      GO TO (170,180,170,180),J
```

```
170 T=T+.5*DT
180 J=J+1
    IF (J-4)404,404,299
299 K=1
    GO TO 406
300 IG=1
    GO TO 405
404 IG=2
405 L=1
406 RETURN
    END
VARIABLE ALLOCATIONS
  IG(I )=0003       K(I )=0006       K1(I )=0009       K2(I )=000C       K3(I )=000F       K4(I )=0012

STATEMENT ALLOCATIONS
 100  =007B  101  =0081  106  =00BF  110  =00D7  111  =00FC  112  =0123  113  =0137  114  =014B  124  =0188  134  =01AD
 140  =01C8  170  =01D9  180  =01E1  299  =01ED  300  =01F3  404  =01F9  405  =01FD  406  =0201

FEATURES SUPPORTED
 EXTENDED PRECISION

CALLED SUBPROGRAMS
 EADD   EADDX   EMPY   EMPYX   EDIV   ELD   ELDX   ESTO   ESTOX   SUBSC   SUBIN

REAL CONSTANTS
  .500000000E 00=001A    .200000000E 01=001D    .600000000E 01=0020

INTEGER CONSTANTS
   1=0023     2=0024     3=0025     5=0026     4=0027

CORE REQUIREMENTS FOR RUNGE
 COMMON      0  VARIABLES     26  PROGRAM    490

RELATIVE ENTRY POINT ADDRESS IS 0032 (HEX)

END OF COMPILATION

// DUP

*STORE      WS  UA  RUNGE
CART ID 0C01   DB ADDR  43DC   DB CNT   0021

// FOR
** LARRY N. GREENHAW  RI090807  VEHICLE SUBMERGENCE
*EXTENDED PRECISION
*LIST ALL
*IOCS(1403 PRINTER,CARD,DISK)
```

```
      REAL KD,KB,LS
      DIMENSION DS(2),S(2),F(14),B(25),CP(25)
      G=32.174
 1601 READ(2,700)N,T,DT,S(1),W,KD,KB,LS,AEFF,REFF
  700 FORMAT(I2,F2.0,F4.4,F5.0,F7.0,2F6.0,F6.0,2F5.0)
      READ(2,702)M1
  702 FORMAT(I2)
      READ(2,803)(B(I),CP(I),I=1,M1)
  803 FORMAT(2F5.0)
      IF (N)899,899,1599
  899 WRITE(5,910)
  910 FORMAT('1EXIT AT ST. NO. 899')
      CALL EXIT
 1599 WRITE(5,15) DT,LS,REFF,AEFF
   15 FORMAT('1', 30X,'WATER ENTRY PROGRAM',     5(/),30X,'VALUES OF CONS
     1TANTS',     3(/),  5X,'TIME INTERVAL', F9.5,' SECS', 2(/), 5X,
     2'VEHICLE LENGTH', F7.2,' FT',     2(/),  5X,'EFFECTIVE RADIUS',F6.2
     3,' FT',     2(/),  5X,'EFFECTIVE FRONTAL AREA',    F7.2,' FT',5(/))
 1600 READ(2,701)S(2),PHI
  701 FORMAT(2F10.0)
      V0=S(2)
      T=0.0
      S(1)=0.0
      IF (S(2)) 1601,1601,610
  610 I=0
      INDEX=1
      WRITE(5,888)S(2),PHI
  888 FORMAT(9(/),' INITIAL VELOCITY',F10.4,' ANGLE OF ENTRY ',F10.4)
  999 WRITE(5,900)
  900 FORMAT('0',' TIME',7X,'DISTANCE',12X,'VELOCITY',10X,' ACCELERATION
     1',3X,' DIMENSIONLESS DIST(B)', 2X,'DRAG COEFFICIENT',//)
   10 L=3
      M=0
 1350 CALL RUNGE(T,DT,N,S,DS,F,L,M,J)
      IF (M-1)75,10,75
   75 GO TO (100,200,999),L
  100 DS(1)=S(2)
      BC=S(1)/REFF
      IF (BC-0.60)707,708,1600
  707 M1M1=M1
      DO 703 I=1,M1M1
      IF (BC-B(I))705,704,703
  704 CPC=CP(I)
      GO TO 706
  705 IF (BC-B(I-1)) 997,711,710
  711 CPC=CP(I-1)
      WRITE(5,203)
  203 FORMAT('SEE STATEMENT 711')
      GO TO 706
```

```
710 SL= (CP(I-1)-CP(I)) / (B(I-1) -B(I))
    CPC= SL* (BC-B(I-1)) + CP(I-1)
    GO TO 706
703 CONTINUE
997 WRITE(5,996)
996 FORMAT('1BC GREATER THAN 1.                PROGRAM END')
    GO TO 1600
708 CPC=CP(M1)
706 DS(2)=  - ((CPC*31.2*(V0*V0)*AEFF))   / W
    GO TO 1350
200 DS2=DS(2)/G
    X=T+.00005
    WRITE(5,800)X,S(1),S(2),DS2,BC,CPC
800 FORMAT(F6.4,5E20.10)
    IF (T-2.) 1350,1600,1600
999 GO TO 1600
    END
VARIABLE ALLOCATIONS
   DS(R )=0003-0000     S(R )=0009-0006     F(R )=0033-000C     B(R )=007E-0036    CP(R )=00C9-0081    KD(R )=00CC
   KU(R )=00CF         LS(R )=00D2          G(R )=00D5          T(R )=00D8         DT(R )=00DB          W(R )=00DE
 AEFF(R )=00E1       REFF(R )=00E4        PHI(R )=00E7         V0(R )=00EA         BC(R )=00ED        CPC(R )=00F0
   SL(R )=00F3        DS2(R )=00F6          X(R )=00F9          N(I )=00FF         M1(I )=0102          I(I )=0105
INDEX(I )=0108          L(I )=010B          M(I )=010E          J(I )=0111       MIM1(I )=0114

UNREFERENCED STATEMENTS
 998

STATEMENT ALLOCATIONS
 700  =013E  702  =0146  803  =0148  910  =014B  15   =0157  701  =018E  888  =01C1  900  =01DA  203  =020F  996  =021A
 800  =0232  1601 =0253  899  =028D  1599 =0292  1600 =029E  610  =02BE  998  =02D0  10   =02D4  1350 =02DC  75   =02ED
 100  =02F4  707  =030D  704  =0323  705  =032E  711  =033C  710  =0348  703  =0379  997  =0382  708  =0388  706  =0391
 200  =03A8  999  =03B3

FEATURES SUPPORTED
 EXTENDED PRECISION
 IOCS

CALLED SUBPROGRAMS
 RUNGE  EADD  EADDX  ESUB  ESUBX  EMPY   EDIV  ELD  ELDX   ESTO  ESTOX  EDVR  CARDZ  SRED  SWRT
 SCOMP  SFIO  SIOFX  SIOF  SIOI   SUBSC  PRNZ  SNR  SDFIO

REAL CONSTANTS
  .321740000E 02=011A    .000000000E 00=011D    .600000000E 00=0120    .312000000E 02=0123    .500000000E-04=0126
  .200000000E 01=0129

INTEGER CONSTANTS
     2=012C     1=012D     5=012E     0=012F     3=0130
```

```
CORE REQUIREMENTS FOR
 COMMON       0  VARIABLES     282  PROGRAM     700

END OF COMPILATION

// XEQ
```

WATER ENTRY PROGRAM

VALUES OF CONSTANTS

TIME INTERVAL 0.00100 SECS

VEHICLE LENGTH 17.50 FT

EFFECTIVE RADIUS 2.40 FT

EFFECTIVE FRONTAL AREA 18.05 FT

INITIAL VELOCITY 25.0000 ANGLE OF ENTRY 90.0000

TIME	DISTANCE	VELOCITY	ACCELERATION	DIMENSIONLESS DIST(B)	DRAG COEFFICIENT
.0000	0.0000000000E 00	0.2500000001E 02	0.0000000000E 00	0.0000000000E 00	0.0000000000E 00
.0010	0.2499102104E-01	0.2497333045E 02	-0.1624679849E 01	0.1041292544E-01	0.5457809558E 00
.0020	0.4993589107E-01	0.2491408702E 02	-0.2057838962E 01	0.2080662128E-01	0.6912926982E 00
.0030	0.7481481795E-01	0.2484226606E 02	-0.2337705492E 01	0.3117284082E-01	0.7853086499E 00
.0040	0.9961853289E-01	0.2476422032E 02	-0.2513680476E 01	0.4150772202E-01	0.8444241699E 00
.0050	0.1243413742E 00	0.2468062932E 02	-0.2669050426E 01	0.5180890594E-01	0.8966178118E 00
.0060	0.1489787385E 00	0.2459377151E 02	-0.2730167478E 01	0.6207447439E-01	0.9171489486E 00
.0070	0.1735282628E 00	0.2450495083E 02	-0.2791066630E 01	0.7230344289E-01	0.9376068860E 00
.0080	0.1979881108E 00	0.2441461136E 02	-0.2816045342E 01	0.8249504619E-01	0.9459980188E 00
.0090	0.2223573555E 00	0.2432381331E 02	-0.2828135728E 01	0.9264889822E-01	0.9500595591E 00
.0100	0.2466356079E 00	0.2423267113E 02	-0.2831950613E 01	0.1027648366E 00	0.9513410986E 00
.0110	0.2708228179E 00	0.2414184570E 02	-0.2813950502E 01	0.1128428408E 00	0.9452942961E 00
.0120	0.2949194918E 00	0.2405159833E 02	-0.2796017770E 01	0.1228831216E 00	0.9392701275E 00
.0130	0.3189262764E 00	0.2396216272E 02	-0.2760311021E 01	0.1328859485E 00	0.9272751107E 00
.0140	0.3428442503E 00	0.2387400192E 02	-0.2719964931E 01	0.1428517710E 00	0.9137215919E 00
.0150	0.3666747120E 00	0.2378715370E 02	-0.2676620488E 01	0.1527811301E 00	0.8991608340E 00
.0160	0.3904190817E 00	0.2370186099E 02	-0.2625375892E 01	0.1626746174E 00	0.8819461660E 00
.0170	0.4140789823E 00	0.2361821408E 02	-0.2574313598E 01	0.1725329093E 00	0.8647927381E 00
.0180	0.4376560563E 00	0.2353620716E 02	-0.2523430057E 01	0.1823566902E 00	0.8476993597E 00
.0190	0.4611519412E 00	0.2345583456E 02	-0.2472721733E 01	0.1921466422E 00	0.8306648428E 00
.0200	0.4845682630E 00	0.2337709550E 02	-0.2421278527E 01	0.2019034451E 00	0.8133834551E 00

.0210	0.5079067074E 00	0.2330007857E 02	-0.2366278411E 01	0.2116277950E 00	0.7949071899E 00
.0220	0.5311690138E 00	0.2322482831E 02	-0.2311457718E 01	0.2213204225E 00	0.7764911977E 00
.0230	0.5543567503E 00	0.2315133903E 02	-0.2256812284E 01	0.2309820628E 00	0.7581340814E 00
.0240	0.5774722760E 00	0.2307960513E 02	-0.2202337965E 01	0.2406134484E 00	0.7398344485E 00
.0250	0.6005167434E 00	0.2300962073E 02	-0.2148120366E 01	0.2502153099E 00	0.7216210551E 00
.0260	0.6234920765E 00	0.2294131436E 02	-0.2097965547E 01	0.2597883654E 00	0.7047724777E 00
.0270	0.6463999031E 00	0.2287461927E 02	-0.2047958082E 01	0.2693332955E 00	0.6879734005E 00
.0280	0.6692418502E 00	0.2280953081E 02	-0.1998094458E 01	0.2788507711E 00	0.6712226434E 00
.0290	0.6920195044E 00	0.2274604440E 02	-0.1948371170E 01	0.2883414602E 00	0.6545190305E 00
.0300	0.7147344716E 00	0.2268415556E 02	-0.1898784724E 01	0.2978060299E 00	0.6378613880E 00
.0310	0.7373883430E 00	0.2262384890E 02	-0.1850194347E 01	0.3072451429E 00	0.6215383545E 00
.0320	0.7599826864E 00	0.2256509651E 02	-0.1801992205E 01	0.3166594528E 00	0.6053457416E 00
.0330	0.7825190522E 00	0.2250789298E 02	-0.1753913748E 01	0.3260496052E 00	0.5891946796E 00
.0340	0.8049989868E 00	0.2245223438E 02	-0.1705955684E 01	0.3354162446E 00	0.5730840603E 00
.0350	0.8274240340E 00	0.2239811690E 02	-0.1658114713E 01	0.3447600142E 00	0.5570127763E 00
.0360	0.8497957326E 00	0.2234552509E 02	-0.1612574547E 01	0.3540815555E 00	0.5417144054E 00
.0370	0.8721155447E 00	0.2229432823E 02	-0.1569941202E 01	0.3633814770E 00	0.5273925261E 00
.0380	0.8943848451E 00	0.2224450149E 02	-0.1527404338E 01	0.3726603521E 00	0.5131030587E 00
.0390	0.9166050029E 00	0.2219604182E 02	-0.1484961342E 01	0.3819187512E 00	0.4988451240E 00
.0400	0.9387773831E 00	0.2214894624E 02	-0.1442609605E 01	0.3911572430E 00	0.4846178464E 00
.0410	0.9609033486E 00	0.2210321088E 02	-0.1400525799E 01	0.4003763953E 00	0.4704805751E 00
.0420	0.9829842315E 00	0.2205875858E 02	-0.1362730856E 01	0.4095767631E 00	0.4577840672E 00
.0430	0.1005021270E 01	0.2201552110E 02	-0.1325010961E 01	0.4187588630E 00	0.4451127698E 00
.0440	0.1027015677E 01	0.2197349602E 02	-0.1287364032E 01	0.4279231991E 00	0.4324659856E 00

.0450	0.1048968665E 01	0.2193268105E 02	-0.1249788002E 01	0.4370702774E 00	0.4198430177E 00
.0460	0.1070881442E 01	0.2189307394E 02	-0.1212280798E 01	0.4462006012E 00	0.4072431705E 00
.0470	0.1092755209E 01	0.2185464584E 02	-0.1178004507E 01	0.4553146709E 00	0.3957286888E 00
.0480	0.1114591076E 01	0.2181725902E 02	-0.1146045696E 01	0.4644129489E 00	0.3849927209E 00
.0490	0.1136390069E 01	0.2178089953E 02	-0.1114140852E 01	0.4734958626E 00	0.3742748826E 00
.0500	0.1158153216E 01	0.2174556573E 02	-0.1082288472E 01	0.4825638405E 00	0.3635746687E 00
.0510	0.1179881541E 01	0.2171125591E 02	-0.1050487061E 01	0.4916173089E 00	0.3528915762E 00
.0520	0.1201576068E 01	0.2167796805E 02	-0.1018813308E 01	0.5006566951E 00	0.3422513684E 00
.0530	0.1223237810E 01	0.2164568161E 02	-0.9881840550E 00	0.5096824213E 00	0.3319620407E 00
.0540	0.1244867759E 01	0.2161437992E 02	-0.9575997577E 00	0.5186948995E 00	0.3216878152E 00
.0550	0.1266466897E 01	0.2158406154E 02	-0.9270590252E 00	0.5276945407E 00	0.3114282245E 00
.0560	0.1288036207E 01	0.2155472509E 02	-0.8965604675E 00	0.5366817533E 00	0.3011828021E 00
.0570	0.1309576672E 01	0.2152636924E 02	-0.8661026980E 00	0.5456569469E 00	0.2909510812E 00
.0580	0.1331089270E 01	0.2149897617E 02	-0.8384352081E 00	0.5546205297E 00	0.2816567027E 00
.0590	0.1352574892E 01	0.2147240343E 02	-0.8133848488E 00	0.5635728719E 00	0.2732415008E 00
.0600	0.1374034344E 01	0.2144663617E 02	-0.7883650003E 00	0.5725143104E 00	0.2648365487E 00
.0610	0.1395468431E 01	0.2142167342E 02	-0.7633747251E 00	0.5814451805E 00	0.2564415307E 00
.0620	0.1416877957E 01	0.2139751423E 02	-0.7384130863E 00	0.5903658163E 00	0.2480561326E 00
.0630	0.1438263726E 01	0.2137415772E 02	-0.7134791489E 00	0.5992765529E 00	0.2396800403E 00

INITIAL VELOCITY 88.0000 ANGLE OF ENTRY 90.0000

TIME	DISTANCE	VELOCITY	ACCELERATION	DIMENSIONLESS DIST(B)	DRAG COEFFICIENT
.0000	0.0000000000E 00	0.8800000005E 02	0.0000000000E 00	0.0000000000E 00	0.0000000000E 00
.0010	0.8774024527E-01	0.8731913840E 02	-0.3010133140E 02	0.3655843556E-01	0.8161142517E 00
.0020	0.1745410122E 00	0.8625820243E 02	-0.3461356025E 02	0.7272542174E-01	0.9384508435E 00
.0030	0.2602381125E 00	0.8513412120E 02	-0.3496357314E 02	0.1084325469E 00	0.9479404725E 00
.0040	0.3448143039E 00	0.8402525094E 02	-0.3366027778E 02	0.1436726266E 00	0.9126052283E 00
.0050	0.4283091202E 00	0.8297588035E 02	-0.3151625134E 02	0.1784621335E 00	0.8544758881E 00
.0060	0.5107898605E 00	0.8199783411E 02	-0.2923494905E 02	0.2128291087E 00	0.7926246938E 00
.0070	0.5923301943E 00	0.8109560182E 02	-0.2685400287E 02	0.2468042476E 00	0.7280719301E 00
.0080	0.6730057029E 00	0.8026720741E 02	-0.2465538464E 02	0.2804190430E 00	0.6684624846E 00
.0090	0.7528878920E 00	0.7950865018E 02	-0.2251494327E 02	0.3137032886E 00	0.6104303440E 00
.0100	0.8320455884E 00	0.7881796386E 02	-0.2042254143E 02	0.3466856620E 00	0.5537006622E 00
.0110	0.9105452322E 00	0.7819140610E 02	-0.1854268193E 02	0.3793938470E 00	0.5027334764E 00
.0120	0.9884482466E 00	0.7762413486E 02	-0.1676889879E 02	0.4118534361E 00	0.4546422587E 00
.0130	0.1065811432E 01	0.7711103591E 02	-0.1512816951E 02	0.4440880970E 00	0.4101584265E 00
.0140	0.1142687055E 01	0.7664792087E 02	-0.1369045817E 02	0.4761196066E 00	0.3711788649E 00
.0150	0.1219122179E 01	0.7622969976E 02	-0.1231610060E 02	0.5079675749E 00	0.3339169651E 00
.0160	0.1295160902E 01	0.7585488995E 02	-0.1098391981E 02	0.5396503761E 00	0.2977985718E 00
.0170	0.1370845781E 01	0.7552114203E 02	-0.9814220093E 01	0.5711857420E 00	0.2660854028E 00

// *

PROGRAM "B"

```
// JOB T                                        R1090807   577622994 LEEPER

LOG DRIVE   CART SPEC   CART AVAIL  PHY DRIVE
  0000        0C01        0C01        0000

V2 M09   ACTUAL  8K  CONFIG  8K

// FOR
** LARRY N. GREENHAW   R1090807  VEHICLE SUBMERGENCE
*EXTENDED PRECISION
*LIST SOURCE PROGRAM

      SUBROUTINE RUNGE(T,DT,N,Y,DY,F,L,M ,J)
      DIMENSION DY(2),Y(2),F(14)
      GO TO (100,110,300),L
  100 GO TO (101,110),IG
  101 J=1
      L=2
      DO 106 K=1,N
      K1=K+3*N
      K2=K1+N
      K3=N+K
      F(K1)=Y(K)
      F(K3)=F(K1)
  106 F(K2)=DY(K)
      GO TO 406
  110 DO 140 K=1,N
      K1=K
      K2=K+5*N
      K3=K2+N
      K4=K+N
      GO TO (111,112,113,114),J
  111 F(K1)=DY(K)*DT
      Y(K)=F(K4)+.5*F(K1)
      GO TO 140
  112 F(K2)=DY(K)*DT
      GO TO 124
  113 F(K3)=DY(K)*DT
      GO TO 134
  114 Y(K)=F(K4)+(F(K1)+2.0*(F(K2)+F(K3))+DY(K)*DT)/6.0
      GO TO 140
  124 Y(K)=.5*F(K2)
      Y(K)=Y(K)+F(K4)
      GO TO 140
  134 Y(K)=F(K4)+F(K3)
  140 CONTINUE
      GO TO (170,180,170,180),J
```

```
 170 T=T+0.5*DT
 180 J=J+1
     IF (J-4)404,404,299
 299 M=1
     GO TO 406
 300 IG=1
     GO TO 405
 404 IG=2
 405 L=1
 406 RETURN
     END

FEATURES SUPPORTED
 EXTENDED PRECISION

CORE REQUIREMENTS FOR RUNGE
 COMMON      0  VARIABLES      26  PROGRAM     490

RELATIVE ENTRY POINT ADDRESS IS 0032 (HEX)

END OF COMPILATION

// DUP

*STORE      WS  UA  RUNGE
CART ID 0C01   DB ADDR  43DC    DB CNT   0021

// FOR
** LARRY N. GREENHAW  RI090807  VEHICLE SUBMERGENCE
*EXTENDED PRECISION
*LIST SOURCE PROGRAM
*IOCS(1403 PRINTER,CARD,DISK)


      REAL KD,KB,LS
      DIMENSION DS(2),S(2),F(14),TS(25,4)
      DEFINE FILE 10(100,300,U,INDEX)
      G=32.174
 1601 READ(2,700)N,T,DT,      W,KD,KB,LS
  700 FORMAT(I2,F2.0,F4.0,5X,  F7.0,2F6.0,F6.0)
      IF (N)899,899,1599
  899 CALL EXIT
 1599 WRITE(5,15) LS,W,KB,KD,DT
   15 FORMAT('1', 30X,'COMPLETE SUBMERGENCE',   5(/),30X,'VALUES OF CONS
     1TANTS',    3(/),  5X,'VEHICLE LENGTH',  F7.2,  ' FT',   2(/), 5X,
     2'VEHICLE WEIGHT', F7.0, ' LBS',  2(/),   5X,'K(B)', F17.2, 2(/),
     35X,'K(D)',  F17.1,  2(/),
     45X,'TIME INTERVAL', F8.4, ' SECS',  9(/))
```

```
1600 READ(2,701)S(2),PHI,S(1)
 701 FORMAT(3F10.0)
     T=0.0
     IF (S(2)) 1601,1601,610
 610 I=0
     INDEX=1
     WRITE(5,888)S(2),PHI,S(1)
 888 FORMAT(//,' INITIAL VELOCITY=',F7.4, '  ANGLE OF ENTRY=',F7.4,
    1'  INITIAL DEPTH=',F7.4)
 998 WRITE(5,900)
 900 FORMAT('0',' TIME',7X,'DISTANCE',12X,'VELOCITY' ,10X,'ACCELERATION
    1')
  10 L=3
     M=0
1350 CALL RUNGE(T,DT,N,S,DS,F,L,M,J)
     IF (M-1)75,10,75
  75 GO TO (100,200,999),L
 100 DS(1)=S(2)
     DS(2)=-(G/W)*KD*(S(2)*S(2))-KB*SIN(PHI*3.1415927/180.0)*(G/W)*S(1)
    1+G*SIN(PHI*3.1415927/180.0)
     GO TO 500
 200 DS2=DS(2)/G
     I=I+1
     IF (I-25)1200,1200,1201
1201 WRITE(10'INDEX) TS
     I=1
1200 TS(I,1)=T
     TS(I,2)=S(1)
     TS(I,3)=S(2)
     TS(I,4)=DS2
     X= T+ .0005
     WRITE(5,800)X,S(1),S(2),DS2
 800 FORMAT(F6.3,3E20.10)
     IF (S(2)) 999,999,500
 500 IF (T-3.0)1350,1350,999
 999 GO TO 1600
     END

UNREFERENCED STATEMENTS
 998

FEATURES SUPPORTED
 EXTENDED PRECISION
 IOCS

CORE REQUIREMENTS FOR
 COMMON      0  VARIABLES     434  PROGRAM     552

END OF COMPILATION

// XEQ
```

COMPLETE SUBMERGENCE

VALUES OF CONSTANTS

VEHICLE LENGTH 17.49 FT

VEHICLE WEIGHT 3675. LBS

K(B) 420.95

K(D) 5.251

TIME INTERVAL 0.0100 SECS

INITIAL VELOCITY=21.5510 ANGLE OF ENTRY=90.0000 INITIAL DEPTH= 1.2904

TIME	DISTANCE	VELOCITY	ACCELERATION
0.000	0.1290400000E 01	0.2155100001E 02	0.1885088575E 00
0.010	0.1506198078E 01	0.2160710474E 02	0.1603303421E 00
0.020	0.1722512134E 01	0.2165422175E 02	0.1326400655E 00
0.030	0.1939253078E 01	0.2169250877E 02	0.1054420847E 00
0.040	0.2156333405E 01	0.2172212474E 02	0.7873945403E-01
0.050	0.2373667201E 01	0.2174322938E 02	0.5253429157E-01
0.060	0.2591170155E 01	0.2175598298E 02	0.2692782942E-01
0.070	0.2808759558E 01	0.2176054608E 02	0.1620468629E-02
0.080	0.3026354308E 01	0.2175707921E 02	-0.2309816315E-01
0.090	0.3243874908E 01	0.2174574269E 02	-0.4729915897E-01
0.100	0.3461243459E 01	0.2172669635E 02	-0.7101428802E-01
0.110	0.3678383664E 01	0.2170009937E 02	-0.9423593917E-01
0.120	0.3895220803E 01	0.2166611003E 02	-0.1169670802E 00
0.130	0.4111681746E 01	0.2162488564E 02	-0.1392112079E 00
0.140	0.4327694915E 01	0.2157658223E 02	-0.1609723036E 00
0.150	0.4543190306E 01	0.2152135451E 02	-0.1822547974E 00

0.160	0.4738097433E 01	0.2145935573E 02	-0.2030635192E 00
0.170	0.4972355357E 01	0.2138073747E 02	-0.2234036691E 00
0.180	0.5185892613E 01	0.2131564961E 02	-0.2432607742E 00
0.190	0.5398647269E 01	0.2123424021E 02	-0.2627006591E 00
0.200	0.5610556831E 01	0.2114665538E 02	-0.2816694121E 00
0.210	0.5821560267E 01	0.2105303929E 02	-0.3001933506E 00
0.220	0.6031597981E 01	0.2095351398E 02	-0.3182789983E 00
0.230	0.6240611776E 01	0.2084827941E 02	-0.3359330499E 00
0.240	0.6448544856E 01	0.2073741334E 02	-0.3531623546E 00
0.250	0.6655341787E 01	0.2062107133E 02	-0.3699738823E 00
0.260	0.6860948471E 01	0.2049938663E 02	-0.3863747107E 00
0.270	0.7065312139E 01	0.2037249023E 02	-0.4023719931E 00
0.280	0.7268381329E 01	0.2024051082E 02	-0.4179729503E 00
0.290	0.7470105330E 01	0.2010357473E 02	-0.4331848407E 00
0.300	0.7670436706E 01	0.1996180600E 02	-0.4480149538E 00
0.310	0.7869326243E 01	0.1981532626E 02	-0.4624705874E 00
0.320	0.8066727921E 01	0.1966425482E 02	-0.4765590365E 00
0.330	0.8262556417E 01	0.1950870867E 02	-0.4902075752E 00
0.340	0.8456887550E 01	0.1934880241E 02	-0.5036634518E 00
0.350	0.8649553294E 01	0.1918464837E 02	-0.5166938733E 00
0.360	0.8840566720E 01	0.1901635654E 02	-0.5293859920E 00
0.370	0.9029871985E 01	0.1884403461E 02	-0.5417469020E 00
0.380	0.9217434328E 01	0.1866778803E 02	-0.5537836269E 00
0.390	0.9403215009E 01	0.1848771997E 02	-0.5655031127E 00
0.400	0.9587176315E 01	0.1830393138E 02	-0.5769122203E 00
0.410	0.9769281554E 01	0.1811652106E 02	-0.5880177230E 00
0.420	0.9949494980E 01	0.1792558560E 02	-0.5988262977E 00
0.430	0.1012778182E 02	0.1773121947E 02	-0.6093445164E 00
0.440	0.1030410824E 02	0.1753351505E 02	-0.6195788525E 00
0.450	0.1047844129E 02	0.1733256265E 02	-0.6295356606E 00
0.460	0.1065074895E 02	0.1712845055E 02	-0.6392211937E 00
0.470	0.1082100005E 02	0.1692126505E 02	-0.6486415825E 00
0.480	0.1098916428E 02	0.1671109047E 02	-0.6578028427E 00
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0.500	0.1131911504E 02	0.1628210192E 02	-0.6753714424E 00
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0.530	0.1179767882E 02	0.1561820134E 02	-0.6999243274E 00
0.540	0.1195273069E 02	0.1539175883E 02	-0.7076503664E 00
0.550	0.1210550582E 02	0.1516286613E 02	-0.7151559763E 00
0.560	0.1225598007E 02	0.1493159337E 02	-0.7224461929E 00
0.570	0.1240412998E 02	0.1469800904E 02	-0.7295259246E 00
0.580	0.1254993277E 02	0.1446218010E 02	-0.7363999600E 00
0.590	0.1269336631E 02	0.1422417196E 02	-0.7430729642E 00
0.600	0.1283440915E 02	0.1398404859E 02	-0.7495494792E 00
0.610	0.1297304044E 02	0.1374187247E 02	-0.7558339280E 00
0.620	0.1310923995E 02	0.1349770472E 02	-0.7619306140E 00
0.630	0.1324298808E 02	0.1325160506E 02	-0.7673437219E 00

0.640	0.1337426340E 02	0.1300363190E 02	-0.7735773199E 00
0.650	0.1350305466E 02	0.1275384237E 02	-0.7791353594E 00
0.660	0.1362933677E 02	0.1250229231E 02	-0.7845216765E 00
0.670	0.1375309481E 02	0.1224903638E 02	-0.7897399999E 00
0.680	0.1387431199E 02	0.1199412805E 02	-0.7947939399E 00
0.690	0.1399297203E 02	0.1173761964E 02	-0.7996870023E 00
0.700	0.1410905921E 02	0.1147956236E 02	-0.8044225818E 00
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0.720	0.1433345450E 02	0.1095900069E 02	-0.8134343465E 00
0.730	0.1444173362E 02	0.1069659348E 02	-0.8177167961E 00
0.740	0.1454738185E 02	0.1043283184E 02	-0.8218542994E 00
0.750	0.1465038589E 02	0.1016776192E 02	-0.8258497330E 00
0.760	0.1475073287E 02	0.9901428997E 01	-0.8297058807E 00
0.770	0.1484841040E 02	0.9633877441E 01	-0.8334254268E 00
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0.820	0.1529635220E 02	0.8279335774E 01	-0.8500615318E 00
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0.840	0.1545645627E 02	0.7730452125E 01	-0.8558433537E 00
0.850	0.1553239252E 02	0.7454653611E 01	-0.8585556573E 00
0.860	0.1560554648E 02	0.7178001232E 01	-0.8611514302E 00
0.870	0.1567593981E 02	0.6900532197E 01	-0.8636324750E 00
0.880	0.1574355452E 02	0.6622281136E 01	-0.8660005116E 00
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0.900	0.1587041795E 02	0.6063588785E 01	-0.8704040565E 00
0.910	0.1592965251E 02	0.5783214155E 01	-0.8724426142E 00
0.920	0.1598608010E 02	0.5502200879E 01	-0.8743742725E 00
0.930	0.1603969451E 02	0.5220583125E 01	-0.8762003665E 00
0.940	0.1609048986E 02	0.4938394658E 01	-0.8779221570E 00
0.950	0.1613846061E 02	0.4655668839E 01	-0.8795408352E 00
0.960	0.1618360154E 02	0.4372438665E 01	-0.8810575215E 00
0.970	0.1622590779E 02	0.4088736778E 01	-0.8824732608E 00
0.980	0.1626537479E 02	0.3804595494E 01	-0.8837890324E 00
0.990	0.1630199833E 02	0.3520046835E 01	-0.8850057439E 00
1.000	0.1633577447E 02	0.3235122535E 01	-0.8861242304E 00
1.010	0.1636669962E 02	0.2949854070E 01	-0.8871452661E 00
1.020	0.1639477048E 02	0.2664272679E 01	-0.8880695530E 00
1.030	0.1641998411E 02	0.2378409386E 01	-0.8888977298E 00
1.040	0.1644233783E 02	0.2092295018E 01	-0.8896303626E 00
1.050	0.1646182926E 02	0.1805960235E 01	-0.8902679577E 00
1.060	0.1647845638E 02	0.1519435541E 01	-0.8908109543E 00
1.070	0.1649221742E 02	0.1232751310E 01	-0.8912597273E 00
1.080	0.1650311096E 02	0.9459378065E 00	-0.8916145798E 00
1.090	0.1651113583E 02	0.6590252078E 00	-0.8918757608E 00
1.100	0.1651629121E 02	0.3720436206E 00	-0.8920434473E 00
1.110	0.1651857656E 02	0.8502310569E-01	-0.8921177580E 00
1.120	0.1651799165E 02	-0.2020063038E 00	-0.8920987413E 00

INITIAL VELOCITY=75.8780 ANGLE OF ENTRY=90.0000 INITIAL DEPTH= 1.2904

TIME	DISTANCE	VELOCITY	ACCELERATION
0.000	0.1270400000E 01	0.7587800005E 02	-0.7375116242E 01
0.010	0.2037539280E 01	0.7357168385E 02	-0.6968158572E 01
0.020	0.2762249025E 01	0.7139005163E 02	-0.6599250525E 01
0.030	0.3465717352E 01	0.6932159987E 02	-0.6263916727E 01
0.040	0.4149024201E 01	0.6735615974E 02	-0.5958316003E 01
0.050	0.4813153684E 01	0.6548471075E 02	-0.5679136849E 01
0.060	0.5459004808E 01	0.6369922402E 02	-0.5423512358E 01
0.070	0.6087400687E 01	0.6199253126E 02	-0.5188950760E 01
0.080	0.6699096577E 01	0.6035821326E 02	-0.4973276190E 01
0.090	0.7294786890E 01	0.5879050543E 02	-0.4774591434E 01
0.100	0.7875111332E 01	0.5728421753E 02	-0.4591218665E 01
0.110	0.8440560286E 01	0.5583466435E 02	-0.4421686623E 01
0.120	0.8991979539E 01	0.5443760648E 02	-0.4264693111E 01
0.130	0.9529574520E 01	0.5308919918E 02	-0.4119083857E 01
0.140	0.1005391399E 02	0.5178594796E 02	-0.3983832892E 01
0.150	0.1056543331E 02	0.5052466994E 02	-0.3858025901E 01
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0.170	0.1155160388E 02	0.4811666378E 02	-0.3631562030E 01
0.180	0.1202698407E 02	0.4696484604E 02	-0.3529517245E 01
0.190	0.1249100661E 02	0.4584477719E 02	-0.3434121279E 01
0.200	0.1294397857E 02	0.4475440271E 02	-0.3344841944E 01
0.210	0.1338618732E 02	0.4369183403E 02	-0.3261198611E 01
0.220	0.1381790210E 02	0.4265532898E 02	-0.3182756414E 01
0.230	0.1423937539E 02	0.4164327858E 02	-0.3109121146E 01
0.240	0.1465084421E 02	0.4065419472E 02	-0.3039934862E 01
0.250	0.1505253122E 02	0.3968669918E 02	-0.2974871983E 01
0.260	0.1544464587E 02	0.3873951378E 02	-0.2913635892E 01
0.270	0.1582738523E 02	0.3781145150E 02	-0.2855955957E 01
0.280	0.1620093436E 02	0.3690140849E 02	-0.2801584860E 01
0.290	0.1656547002E 02	0.3600835718E 02	-0.2750296290E 01
0.300	0.1692115553E 02	0.3513133957E 02	-0.2701882881E 01
0.310	0.1726814725E 02	0.3426946173E 02	-0.2656154338E 01
0.320	0.1760659241E 02	0.3342188826E 02	-0.2612935870E 01
0.330	0.1793663008E 02	0.3258783788E 02	-0.2572066680E 01
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0.350	0.1857200199E 02	0.3095742511E 02	-0.2496795415E 01
0.360	0.1887757848E 02	0.3015973301E 02	-0.2462130862E 01
0.370	0.1917523283E 02	0.2937289775E 02	-0.2429288648E 01
0.380	0.1946507070E 02	0.2859635050E 02	-0.2398161157E 01
0.390	0.1974719232E 02	0.2782955583E 02	-0.2368648777E 01
0.400	0.2002169263E 02	0.2707200910E 02	-0.2340659223E 01
0.410	0.2028866171E 02	0.2632423432E 02	-0.2314106939E 01
0.420	0.2054818504E 02	0.2558278197E 02	-0.2288912530E 01
0.430	0.2080034366E 02	0.2485022719E 02	-0.2265002275E 01

0.440	0.2194521435E 02	0.2412516796E 02	-0.2242307665E 01
0.450	0.2128287372E 02	0.2340722354E 02	-0.2220764998E 01
0.460	0.2151336151E 02	0.2269603294E 02	-0.2200315003E 01
0.470	0.2173681273E 02	0.2199125359E 02	-0.2180902508E 01
0.480	0.2195122684E 02	0.2129256007E 02	-0.2162476120E 01
0.490	0.2216268317E 02	0.2059964287E 02	-0.2144987957E 01
0.500	0.2236523796E 02	0.1991220740E 02	-0.2128393382E 01
0.510	0.2256094465E 02	0.1922997296E 02	-0.2112650773E 01
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0.550	0.2327626479E 02	0.1654786548E 02	-0.2057461665E 01
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0.600	0.2402168509E 02	0.1328335347E 02	-0.2003684971E 01
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0.640	0.2450174430E 02	0.1072665566E 02	-0.1970953221E 01
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0.660	0.2470362434E 02	0.9462781202E 01	-0.1957614265E 01
0.670	0.2479510679E 02	0.8833910081E 01	-0.1951650772E 01
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0.690	0.2495925014E 02	0.7581559386E 01	-0.1941075586E 01
0.700	0.2503194556E 02	0.6957794491E 01	-0.1936442825E 01
0.710	0.2509841076E 02	0.6335451688E 01	-0.1932234131E 01
0.720	0.2515865897E 02	0.5714395888E 01	-0.1928441263E 01
0.730	0.2521270250E 02	0.5094494510E 01	-0.1925056837E 01
0.740	0.2526055224E 02	0.4475617222E 01	-0.1922074296E 01
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0.760	0.2533770751E 02	0.3240423211E 01	-0.1917292656E 01
0.770	0.2536702840E 02	0.2623854696E 01	-0.1915484393E 01
0.780	0.2539018630E 02	0.2007806194E 01	-0.1914059650E 01
0.790	0.2540718583E 02	0.1392154761E 01	-0.1913015719E 01
0.800	0.2541803030E 02	0.7767782101E 00	-0.1912350619E 01
0.810	0.2542272190E 02	0.1615549011E 00	-0.1912063085E 01
0.820	0.2542126152E 02	-0.4536365617E 00	-0.1912152574E 01

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C.2 VEHICLE WATER AND AIR LEAK-RATE ANALYSES

C.2.1 Vehicle Water Leak-Rate Analysis

Consider a vehicle represented simply as a body floating in water with a total given flow-rate occurring through a large number of leaks flowing into the internal vehicle air compartment volume. In a conventional passenger car, this air compartment volume consists mainly of the passenger and luggage compartments. An outside water line and an inside water line will exist at any instant of time, the locations depending upon the overall vehicle mass divided by its total volume (including the air compartment volume), and the water leak-rate. The position of the vehicle's longitudinal axis depends upon the location of the center of gravity of its various masses in relation to its center of buoyancy. The vehicle will float upright as long as the center of buoyancy is above the center of gravity yielding a positive metacentric height.*

Making use of the fundamental relations of fluid dynamics, an analysis can be made to determine an expression for the flow-rate of water through the multiple vehicle leaks at any instant in time.

Consider the following simplified sketch showing a body with an internal void (representing the vehicle). The leaks for simplicity sake are shown as occurring at one location, and the external water line is the zero reference coordinate with the upward vertical direction positive.

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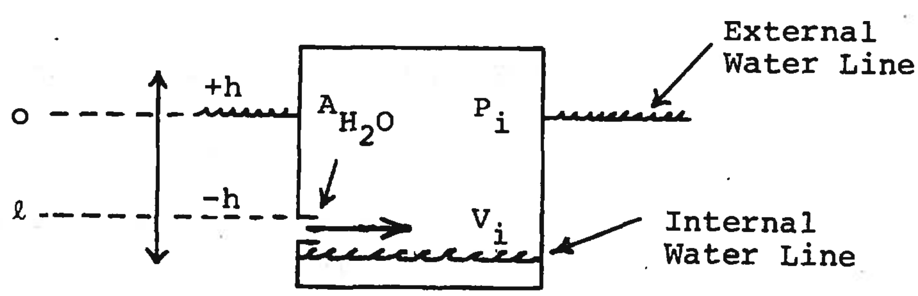
*See the Final Report on Contract FH-11-7303 for a detailed discussion.



Defining the following terms:

P_o = Ambient atmospheric pressure

P_i = Interior air compartment pressure

A_{H_2O} = Total area of all water leaks

V_i = Velocity of the water leak into the air compartment

ρ = Specific weight of water

and making the following usual simplifying assumptions:

1. Incompressible flow of water ($\rho_o = \rho_\ell = \rho_{H_2O}$)
2. Inviscid flow of water (the fluid inertial forces are much greater than those due to viscosity)
3. The air compartment pressure, P_i, is equal to the ambient atmospheric pressure, P_o, during the sinking process (a good assumption if there are even small leak areas above the external vehicle water-line).
4. The water velocity at the external water surface, V_o, is zero.

Bernoulli's equation for inviscid flow relates flow conditions (for water) between the inlet of a typical leak in the passenger compartment and the exterior water level as:

$$P_o + \rho_o \underbrace{\frac{V_o^2}{2g}}_{0} + \rho_o h_o = \rho_i \frac{V_i^2}{2g} + P_i + \rho_i\ (-h_\ell)$$

Using assumptions 1, 3, and 4:

$$V_i^2 = \left(\frac{2g}{\rho_{H_2O}}\right) \rho_{H_2O}(h_o + h_\ell) = \frac{2g}{\rho_{H_2O}} (\rho_{H_2O}\ h_\ell)$$

Since $\rho_{H_2O}\ h_\ell$ is simply the pressure head of the water at the leak location, designate this quantity by h_{H_2O}. Then it follows that:

$$V_i = (2g/\rho_{H_2O})^{1/2}\ (h_{H_2O})^{1/2} \qquad \text{(II-1)}$$

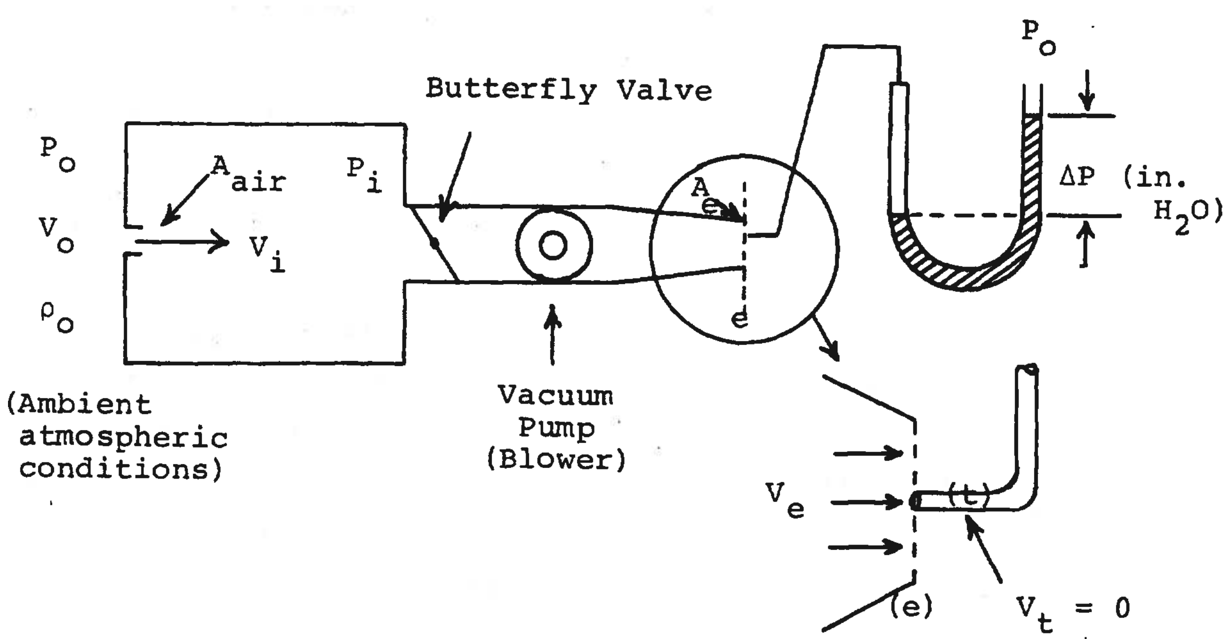
If the area of the water leak, or in the actual case of multiple leaks, the total area of the water leaks is A_{H_2O} then the volume leak-flow rate can be written:

$$Q_{H_2O} = V_i A_{H_2O} = (2g/\rho_{H_2O})^{1/2}\ (h_{H_2O})^{1/2}\ (A_{H_2O}) \qquad \text{(II-2)}$$

where the pressure head h_{H_2O} is now the mean pressure head for the multiple leaks. If this pressure head is expressed in the units lbf/ft^3 and the specific weight, ρ_{H_2O}, in lbf/ft^3 with A_{H_2O} in ft^2, and the acceleration due to gravity, g, in ft/sec^2, V_i is in ft/sec and the volume flow rate , Q_{H_2O}, is in ft^3/sec.

C.2.2 Vehicle Air-Leak Analysis

Consider a vehicle being used in dry-land leak-rate simulation studies employing air as the fluid. The vehicle is represented simply in the following sketch showing the air compartment of the vehicle connected to the intake of a blower used as a vacuum pump. Again, the multiple air-leaks for simplicity are shown as occurring at one location (A_{air}). Also shown on the sketch is the method for determining the volume flow rate of the air leak measured by determining the total head of the flow at the outlet to the blower (e). Depending upon the capacity of the blower and the leak area, a given differential in pressure between ambient atmospheric pressure, P_o, and the air compartment pressure, P_i, is maintained. For a vehicle of a given leak area and using a blower of a given capacity, this pressure level (vacuum), P_i, existing in the air compartment and the corresponding air leak flow rate can be conveniently adjusted by means of a butterfly valve located in the intake line of the blower.



Again, defining the following terms:

P_o = ambient atmospheric pressure

P_i = interior air-compartment pressure

A_{air} = total area of all the air leaks

V_i = velocity of the air leak into the air compartment

ρ = specific weight of air

and making the following simplifying assumptions.

1. Incompressible flow of air $\rho_o = \rho_i = \rho_{air}$ = constant. (This is a good assumption for air flow velocities, $V_i < 300$ ft/sec)
2. Inviscid flow of air.
3. The air velocity, V_o, of the ambient atmospheric air is zero.
4. Neglect the gravity head effect for air.

Write Bernoulli's equation, relating the flow conditions (for air) between the inlet of a leak in the passenger compartment and the exterior ambient atmosphere, as:

$$P_o + \frac{\rho_o V_o^2}{2g} = \frac{\rho_i V_i^2}{2g} + P_i$$

(the term $\frac{\rho_o V_o^2}{2g}$ is struck through with an arrow to 0)

Using assumptions 1 and 3:

$$V_i^2 = \frac{2g}{\rho_{air}} (P_o - P_i)$$

$$V_i = (2g/\rho_{air})^{1/2} (P_o - P_i)^{1/2} \qquad \text{(II-3)}$$

$$\text{Let } P_o - P_i = \Delta P_{air}$$

Again, if the total area of all the air leaks is designated A_{air}, then the volume leak flow rate for air can be written:

$$Q_{air} = V_i A_{air} = A_{air}(2g/\rho_{air})^{1/2}(\Delta P_{air})^{1/2} \qquad \text{(II-4)}$$

Now if consistent units in the above relation are used, Equation II-4 can be divided by Equation II-2 (previously developed for the water-leak flow rate) to yield:

$$\frac{Q_{air}}{Q_{H_2O}} = \frac{A_{air}}{A_{H_2O}}(\rho_{H_2O}/\rho_{air})^{1/2}(\Delta P_{air}/h_{H_2O})^{1/2} \qquad \text{(II-5)}$$

This equation represents, then, within the limits of the assumptions in the analysis, the air-to-water leak rate ratio for a given body with an internal void. The cases considered are where the body is immersed in water where the average head of all the leaks is h_{H_2O}, and in air where a given ΔP_{air} is maintained, e.g., by means of a vacuum pump. It is of interest to note that the expression contains three factors, i.e., the pressure differential to pressure head ratio of the two fluids, the density ratio factor and the leak area-ratio factor.

C.2.3 Air Flow-Rate Measurement Analysis

In order to minimize the flow losses which would decrease the blower's maximum capacity, the air flow velocity, V_e, is measured at the outlet of the blower (discharging into the ambient atmosphere) by means of a total head tube placed at the center of the discharge area, A_e, in the exit plane, e, of the exhaust. The air flow-rate, Q_{air}, can be determined if the discharge coefficient, C_d, of the exhaust is known.

In order to determine an expression for the measured air leak flow-rate, Q_{air}, Bernoulli's equation is written for the air flow between the exit plane, e, and conditions inside the total head probe, t (referring to the previous sketch) to give:

$$P_e + \frac{\rho_e V_e^2}{2g} = P_t + \frac{\rho_t V_t^2}{2g}$$

(with the last term struck through and marked → 0)

Again with the usual assumptions:

$\rho_e = \rho_t = \rho_{air}$ also, $P_e = P_o$ (ambient atmospheric pressure)

and $V_t = 0$ (total or stagnation conditions)

$$V_e = (2g/\rho_{air})^{1/2}(P_t - P_o)^{1/2}$$

The difference between the pressure P_t (referred to as the total head of the flow) and P_o (the ambient static pressure) is usually referred to as the dynamic pressure of the flow and designated q. It can be measured usually in inches of water for low flow velocities by means of a water manometer (or inclined manometer for more accuracy). Then,

$$V_e = (2g/\rho_{air})^{1/2}(q_{air})^{1/2}$$

The volumetric flow rate, Q_{air}, can be expressed in terms of the mean velocity, $\overline{V_e}$, at the exit plane where $\overline{V_e} = C_d V_e$ and $Q_{air} = A_e \overline{V_e}$ and where C_d is a measured discharge coefficient relating the flow velocity, V_e, at the center line of the discharge area, A_e, and the mean velocity, $\overline{V_e}$.

Equation II-6 can be rewritten in terms of the measured volumetric air flow rate:

$$Q_{air} = \overline{V_e}A_e = C_dA_e(2g/\rho_{air})^{1/2}(q_{air})^{1/2} \quad \text{(II-7)}$$

Now, equating the above expression II-7 with Equation II-4, assuming steady-flow mass continuity between the leak area, A_{air}, and the discharge area, A_e:

$$A_{air}(2g/\rho_{air})^{1/2}(\Delta P_{air})^{1/2} =$$

$$C_dA_e(2g/\rho_{air})^{1/2}(q_{air})^{1/2}$$

or simply:

$$q_{air} = \Delta P_{air} \; (A_{air}/A_eC_d)^2$$

It can be concluded from the above equation that the measured dynamic pressure at the center line of the discharge area, A_e, is a linear function of the air pressure differential existing between the vehicle interior and the ambient atmosphere, if the factor A_{air}/A_eC_d remains constant in the range of ΔP_{air} measured for a given vehicle. This situation exists if the total air-leak areas and the discharge area as well as the discharge coefficient, C_d, remain constant for all ΔP_{air} conditions imposed on the vehicle.

It appears that an experimental study would be fruitful in order to observe the experimental behavior of the q_{air} versus ΔP_{air} curve for a given vehicle. Any departure in the linear nature of this dependence would be a measure of the combined variable effects of the factors A_{air}, A_e, and C_d. It can be generally assumed that A_e, the discharge area, remains a constant, but the discharge coefficient can be a function of the flow rate, Q_{air}. If this variation of C_d is measured, then the measured Q_{air} can be equated to Equation II-4, yielding:

$$(Q_{air})_{measured} = A_{air} \underbrace{(2g/\rho_{air})^{1/2}}_{const.} (\Delta P_{air})^{1/2}$$

or

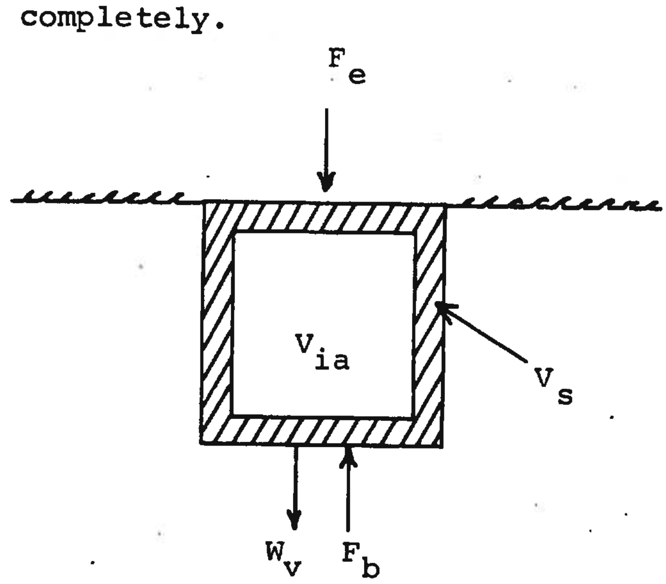
$$(Q_{air})^2_{measured} = (A_{air})^2 \underbrace{(2g/\rho_{air})}_{const.} (\Delta P_{air}) \quad (II-8)$$

Since ρ_{air} is usually constant if the atmospheric conditions do not vary during an experiment, then the above relation shows a linear dependence between the square of the measured air-leak flow rate and the pressure differential, ΔP_{air}, existing on the vehicle if the total area through which air leaks occur is not a function of ΔP_{air}. Conversely, if the dependence of $(Q_{air})^2$ measured and the measured ΔP_{air} is not a linear function, then the total leak area must change, i.e., it must be a function of ΔP_{air}. This situation is possible if some of the leak areas are made up of deformable, elastic materials, as would be the case around rubber door and window seals, grommets and other deformable plugs.

C.3 VEHICLE CHARACTERISTIC SINKING TIME ANALYSIS

This section develops an expression for the time it takes an automotive vehicle to sink, i.e., the time required to pass completely beneath the surface of the water, beginning with the instant the vehicle enters the water and assumes its initial floating position. Desirably, this sinking time should be in terms of easily measurable vehicle properties and characteristics.

Consider the following sketch which shows a vehicle represented by a simple body with an internal void which comprises the total vehicle internal air volume. This volume is comprised mainly of the passenger and trunk compartments for the average passenger sedan. Consider further that an external force, F_e, is applied in a vertical direction of sufficient magnitude to submerge the vehicle completely.



Utilizing the fundamental law of hydrostatics, i.e., Archimedes' principle, which states that a submerged body is acted upon (buoyed up) by a force which is equal in magnitude to the weight of the liquid which is displaced by the body, the following equilibrium of forces can be written:

$$F_b = (V_s + V_{ia})\rho_{H_2O} = F_e + W_v \qquad \text{(III-1)}$$

where F_b = buoyancy force (lbf)

W_v = total vehicle weight (lbf)

V_s = total vehicle structural volume (ft^3)

V_{ia} = total vehicle internal air volume (ft^3)

ρ_{H_2O} = specific weight of water (lbf/ft^3)

Now if some typical values for W_v, V_s, and V_{ia} are assumed as follows:

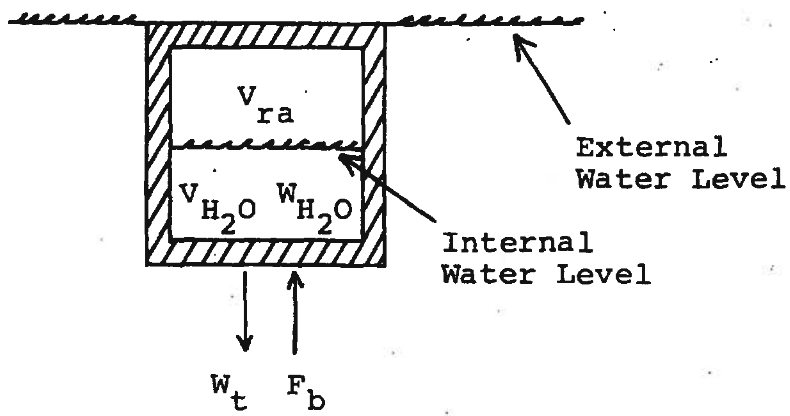
W_v = 3500 lbm (including the weight of air contained in V_{ia})

V_s = 6 ft^3

V_{ia} = 150 ft^3

and using 62.4 lbf/ft^3 as the specific weight of water, a value of 9734 lbf is obtained for the buoyancy force, F_b. Thus, for this case an external force of 9734 - 3500 = 6234 lbf is required to submerge the vehicle. Note that for low values of V_{ia} and/or high values for W_v, the possibility exists that the direction of the external force, F_e, is reversed; that is, an upward vertical force in addition to the force of buoyancy is required for equilibrium. It is apparent that this case occurs if, for instance, the vehicle weight increases to over 6240 lbf and the internal air volume decreases to less than about 94 ft^3 for the same V_s.

Now, consider the situation that occurs in an actual sinking process. Referring to the following sketch where the vehicle again is represented by a simple body with an internal void at the instant in time that it just passes underneath the surface of the water



and defining the additional terms:

W_t = total weight of the vehicle plus the weight of the internal water, W_{H_2O}, with $W_t = W_v + W_{H_2O}$ (neglecting the weight contained in V_{ia} compared to the water)

V_{ra} = volume of the residual air.

Again, applying Archimedes' principle to this case, the equilibrium of forces is given by:

$$F_b = (V_s + V_{ia})\rho_{H_2O} = W_v + W_{H_2O} \qquad \text{(III-2)}$$

Weight of Water Displaced — Total Weight of Vehicle Plus Internal Water

Writing the weight of the internal water, $W_{H_2O} = \rho_{H_2O} V_{H_2O}$, and solving for this expression in Equation III-2:

$$\rho_{H_2O} V_{H_2O} = (V_s + V_{ia})\rho_{H_2O} - W_v \qquad \text{(III-3)}$$

From Equation III-3 the volume of the internal water, V_{H_2O}, can be expressed as:

$$V_{H_2O} = W_v/\rho_s + V_{ia} - W_v/\rho_{H_2O} \qquad \text{(III-4)}$$

where $V_s = W_v/\rho_s$

ρ_s = specific weight of the vehicle structure

Now, define t*, the characteristic sinking time, as that time required for a given vehicle to pass just completely beneath the surface of the water, beginning with the instant the vehicle enters the water. This characteristic time can be defined in terms of the volume of the internal water, V_{H_2O}, and the average water flow rate, $\overline{Q}_{H_2O}$, of the leaks during the sinking process as follows:

$$t^* = V_{H_2O}/\overline{Q}_{H_2O} \qquad \text{(III-5)}$$

Substituting the expression for V_{H_2O} appearing in Equation III-4 into Equation III-5:

$$t^* = \frac{W_v/\rho_s + V_{ia} - W_v/\rho_{H_2O}}{\overline{Q}_{H_2O}} \qquad \text{(III-6)}$$

It can be seen that Equation III-6 is an expression for the characteristic sinking time of a given vehicle which depends upon three rather easily determined quantities, i.e., the vehicle structural weight, W_v, the vehicle structural specific weight, ρ_s, and the total internal air volume, V_{ia}.

The characteristic sinking time, t*, is also seen to depend upon the average water leak flow rate, $\overline{Q}_{H_2O}$.

While this quantity can only be accurately determined by measurement in an actual vehicle submergence, it is informative to make use of the air leak flow rate measurement, Q_{air}, obtained from a simulated dry-land experiment. Utilizing the theoretical relationship for Q_{air}/Q_{H_2O} developed in Appendix C.2 and appearing as Equation II-5 in that section, and substituting that expression into Equation III-6 of this section, yields:

$$t^* = \frac{W_v/\rho_s + V_{ia} - W_v/\rho_{H_2O}}{(Q_{air})(A_{H_2O}/A_{air})(\rho_{air}/\rho_{H_2O})^{1/2}(h_{H_2O}/\Delta P_{air})^{1/2}} \quad \text{(III-7)}$$

The above expression, then, represents the characteristic vehicle sinking time, t^*, which can be determined from easily measured vehicle properties. Then if a simulated dry-land air leak flow experiment is performed, the air leak flow rate, Q_{air}, and the corresponding pressure differential can be obtained. In addition, an estimated average head of the vehicle leaks, h_{H_2O}, is also required to determine t^* completely. It is also necessary to make a further simplifying assumption that the area of the water leaks, A_{H_2O}, is equal to the area of the air leaks, A_{air}. It will be noted that this assumption is reasonable during the latter stages of the sinking process where there is only a small portion of the vehicle remaining above water. However, for the case where a large portion of the vehicular structure is above the external water line during much of the sinking process, a different situation would occur. It is apparent that if this area of the vehicle structure contains leaks, the measured value of Q_{air} would be too large and the predicted value of t^* would be too small.

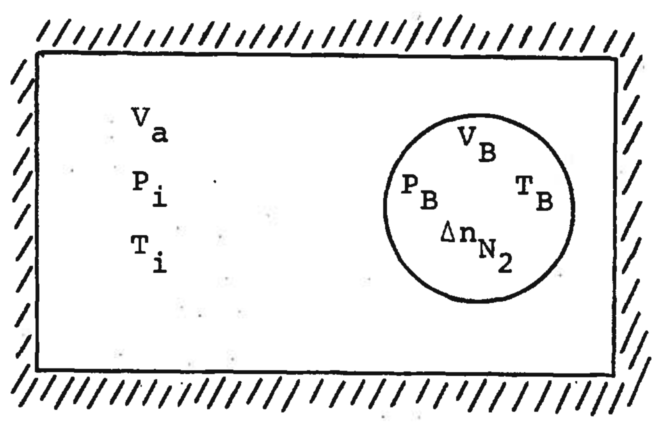
However, within the assumptions of this analysis, it is possible to obtain an estimate of the sinking time of a vehicle without resorting to the costly and time consuming task of actual vehicle submergence.

C.4 VEHICLE INTERNAL AIR-VOLUME MEASUREMENT ANALYSIS USING GAS CONCENTRATION METHOD

By applying the perfect gas law for mixtures, it is possible to obtain an expression for the total volume occupied by a known quantity of a particular gas, if the concentration of this gas in the volume of interest is available. In the following section expressions are developed for the volume of interest, i.e., the total internal air volume of a typical passenger car, composed mainly of the passenger and luggage compartments. The cases where the test gas is one of the atmospheric gases (oxygen or nitrogen) or a different gas, e.g., carbon dioxide or carbon monoxide, are treated separately.

C.4.1 Test Gas Either Molecular Oxygen (O_2) or Nitrogen (N_2)

Consider the following simplified sketch describing the internal volume, V_a, of a given space occupied by air at the initial pressure and temperature conditions, P_i and T_i, respectively:



Inside the space a balloon (or similar frangible container) is placed and filled with a given number of moles of gaseous nitrogen, Δn_{N_2}, at the conditions of P_B and T_B, respectively, occupying the volume, V_B.

Making use of the perfect gas law for mixtures, the relation for the initial conditions of the air volume, V_a, is:

$$P_i(V_a) = \left[(n\ O_2)_i + (n\ N_2)_i\right] R_u T_i \qquad \text{(IV-1)}$$

and a second relation for the final conditions after the balloon is broken and the added moles of nitrogen, Δn_{N_2}, mix completely with the initial air:

$$P_f(V_a + V_B) = \left[(n\ O_2)_i + (n\ N_2)_i + \Delta n_{N_2}\right] R_u T_f \qquad \text{(IV-2)}$$

In both Equations IV-1 and IV-2, R_u is the universal gas constant. Defining the initial mole-fraction of O_2 as:

$$(X_{O_2})_i = \frac{(n\ O_2)_i}{(n\ O_2)_i + (n\ N_2)_i}$$

and the final mole-fraction of O_2 as:

$$(X_{O_2})_f = \frac{(n\ O_2)_f}{(n\ O_2)_i + (n\ N_2)_i + \Delta n\ N_2}$$

Equation IV-1 can be rewritten as:

$$P_i(V_a) = \left[(n\ O_2)_i/(X_{O_2})_i\right] R_u T_i \qquad \text{(IV-3)}$$

and Equation IV-2 as :

$$P_f(V_a + V_B) = \left[(n\ O_2)_i/(X_{O_2})_f\right] R_u T_f \quad \text{(IV-4)}$$

Dividing Equation IV-3 by IV-4 and rearranging,

$$V_a = \frac{P_f}{P_i}\frac{T_i}{T_f}\left[\frac{V_B}{\frac{(X_{O_2})_i}{(X_{O_2})_f} - 1}\right] \quad \text{(IV-5)}$$

Making use of the following relation between the total volume, V_T, occupied by the mixture and the initial volumes, V_a and V_B, occupied by the air and the nitrogen, respectively,

$$V_T = V_a + V_B \quad \text{(IV-6)}$$

and substituting Equation IV-6 above into Equation IV-5 with $V_a = V_T - V_B$,

$$V_T = V_B \frac{P_f}{P_i}\frac{T_i}{T_f}\left[\frac{(X_{O_2})_i}{(X_{O_2})_i - (X_{O_2})_f}\right] \quad \text{(IV-7)}$$

Equation IV-7 is an expression for the total volume, V_T, occupied by the mixture of gases in terms of $(X_{O_2})_f$ the final measured mole-fraction of O_2, and $(X_{O_2})_i$, the initial mole-fraction of O_2 present in V_a. It will be noted that for cases where the pressure and temperature of the N_2 in the balloon is very nearly equal to the initial air conditions, then $P_i \approx P_f$ and $T_i \approx T_f$ so that the relation can be simplified further.

For the case of an oxygen addition scheme, i.e., where the balloon contains a given number of moles of O_2, Δn_{O_2}, instead of N_2 the following similar relation can be developed:

$$V_T = V_B \frac{P_f}{P_i} \frac{T_i}{T_f} \left[\frac{(X_{N_2})_i}{(X_{N_2})_i - (X_{N_2})_f} \right] \qquad \text{(IV-8)}$$

If the concentration of O_2 is the desired measurement rather than N_2, then assuming that air consists simply of a mixture of O_2 and N_2, then:

$$(X_{N_2})_i = 1 - (X_{O_2})_i$$

and

$$(X_{N_2})_f = 1 - (X_{O_2})_f$$

Substituting into IV-8 above,

$$V_T = V_B \frac{P_f}{P_i} \frac{T_i}{T_f} \left[\frac{1 - (X_{O_2})_i}{(X_{O_2})_f - (X_{O_2})_i} \right] \qquad \text{(IV-9)}$$

Equations IV-7 and IV-9, then, represent expressions for the total volume, V_T, when there is a means for measuring the O_2 concentration of the gas mixture, for the case of N_2 addition and O_2 addition of the balloon gas respectively.

C.4.2 Test Gas Neither Molecular Oxygen (O_2) nor Nitrogen (N_2)

Many times it is more convenient to measure concentrations of gases other than oxygen or nitrogen, especially if the instrumentation for detecting such gases as carbon dioxide (CO_2) or carbon monoxide (CO) is more readily available.

Referring to the previous sketch, substitute carbon dioxide in the balloon volume, V_B. If the number of moles of this gas occupying V_B is designated n_{CO_2}, then again making use of the perfect gas law relating the conditions for this gas, CO_2, in the volume, V_B:

$$P_B V_B = n_{CO_2} R_u T_B \qquad \text{(IV-10)}$$

Also, the following equation can be written relating the final conditions after the balloon containing CO_2 is broken and the gas is allowed to mix completely with the air inside the internal volume, V_T:

$$P_f (V_a + V_B) = (nO_2 + nN_2 + nCO_2) R_u T_f \qquad \text{(IV-11)}$$

where, as before, $V_T = V_a + V_B$.

Now defining the final mole-fraction of N_2 measured in the total internal volume, V_T:

$$X_{CO_2} = \frac{nCO_2}{nO_2 + nN_2 + nCO_2}$$

Equation IV-11 can be rewritten:

$$V_T = nCO_2 \left[\frac{1}{X_{CO_2}}\right] \frac{R_u T_f}{P_f} \qquad \text{(IV-12)}$$

Using Equation IV-10, the initial number of moles of CO_2 are:

$$nCO_2 = \frac{P_B V_B}{R_u T_B} \qquad \text{(IV-13)}$$

Now substituting Equation IV-13 into IV-12, a final expression for V_T follows:

$$V_T = V_B \frac{P_B}{P_f} \frac{T_f}{T_B} \left[\frac{1}{X_{CO_2}} \right] \qquad \text{(IV-14)}$$

Equation IV-14 then represents an expression for the total internal volume, V_T, in terms of the initial volume of the added gas (in this case CO_2) and the measured final concentration, X_{CO_2}, of this gas. Also, in this case the initial pressure and temperature conditions in the balloon (P_B and T_B) as well as the pressure and temperature conditions of the final mixture (P_f and T_f) are required.

In comparing Equation IV-14 with Equations IV-7 and IV-9 developed for the case where the test gas is either N_2 or O_2, it is apparent that the expression for V_T in Equation IV-14 is more simple in that the factor on the right hand side contains only the measured quantity, X_{CO_2}. It does not depend upon the initial concentration of the gases in the internal air volume. What is perhaps more significant is that it does not contain the difference of two measured quantities, and as such is inherently a more accurate expression. (Note that this is the case when the differences in two measured quantities appearing in the denominator of Equations IV-7 and IV-9 are small compared to the initial concentration of either N_2 or O_2.)

C.5 A BIOMECHANICAL ANALYSIS OF MAXIMUM POSSIBLE ARM AND HAND FORCE EXPENDITURES OF SELECTED POPULATION GROUPS FOR VEHICLE EGRESS IN EMERGENCY SITUATIONS

by

Larry Eugene Long

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CHAPTER I

INTRODUCTION

Statement of Problem

Perhaps the most studied, most researched, and most controversial man-machine system is that of the vehicle-driver system. Its effectiveness as a man-machine system has been studied extensively under normal conditions. In comparison, surprisingly little research has been accomplished for situations when the system is subjected to adverse conditions (Starks, Gratten, 1969).* It is the intent of this thesis to prepare and present data that will be valuable in itself and for the continuation of post-crash research as it relates to the ability of a driver to escape.

This study relates to a subsystem of this complex vehicle-driver system. More specifically, this subsystem involves the motion of and forces exerted by the driver's left arm and those forces applied to

*All references can be found in the Bibliography and will be presented in the following order: author(s), date published.

the movement of the door and the door handle. The interior lever which releases the door latch will be referred to as the door handle.

Little is known about the forces which an individual can apply to the door of a vehicle during an emergency egress situation. The initial application of this force requires the individual to exert a torque on the interior door handle so that the latch will release. The forces involved in pushing the door open and in turning the door handle must be applied concurrently, hence, the left arm is said to act in concert in order to effect the opening of the door.

When emergency egress is imminent, normal, everyday problems of opening the door are intensified. The driver's door could very well be jammed such that the strength required is greater than that which he can produce, and would necessitate his seeking an alternative exit. However, it is possible that a force at or below the subject's "maximum possible" force limit applied to the door handle and the door would cause the door to open. There are many cases in which the aforementioned situation may occur. For example, in a post-crash situation, the door may be only partially jammed where extra force may provide an immediate escape route. In another case, a vehicle may come to rest on an incline with the front end or the driver's side up the incline. In either case the jammed door or the weight of the door will be of significance when determining the ability of an individual to escape. The actual scope of the problem is not known at present. However, as regulations (reinforced doors and stronger locking mechanisms) are introduced to enhance the safety of a crash, the preliminary indications are that there is a greater chance that the doors will not only be jammed more frequently but will be more thoroughly jammed due to the added safety equipment in the door (Purswell, 1970). Also, with the inclusion of extra safety equipment, there are more people surviving more severe crashes; therefore, more impetus is given to the need for research in post-crash egress.

This thesis addresses the problem of which position of the driver's left arm and hand will allow him to exert a maximal force to the door handle and the door. By varying the position of the handle on the door and the type of door handle used, the results substantiate the hypothesis that there is an optimum position of the arm and of the hand such that a person can exert a maximum force. This phase (Phase I) of the study limited the movement of the individual to the use of his left arm in an attempt to determine an optimal location and type of door handle. The other phase (Phase II) of the study investigated what maximal force could be applied to the movement of the door by an individual when he is unrestricted in his body movement.

The subjects used were representative of that portion of the population who would be less capable of opening the door under adverse conditions. The subjects and selection of subjects is discussed in more detail in Chapter III. The logic behind this choice of subjects was that the results obtained could be applied to the total population in the sense that they could be used as minimum standards.

Summary of Results

An objective of this study was to determine a location and type of door handle for a vehicle. The criteria was to maximize the amount of torque applied to the door handle and the amount of force applied to the movement of the door. This was accomplished by varying the position of the subject's arm relative to the door, and by varying the position of the subject's hand relative to the door handle. A subject's preference was also a factor in the final analysis. Their choice coincided with the final recommendation. Using these criteria, the best location and type of door handle of those tested, was found to be a location that requires the arm to be in a position where the elbow is flexed at 120 degrees with the forearm parallel to the ground and a handle type that requires the hand to be in a neutral palm-in position. Also, an objective was to find an average maximum force which can be applied to the movement of the door for a selected population group. This was found to be 103.2 pounds (31 inches from pivot of door hinge).

Related Research

Due to the unique implications of this study, little research has been accomplished that is directly related to this study; however, considerable research has been conducted on individual facets of this study. Provins (1955) has varied the position of the limb in order to determine the effects on torque exerted about the elbow and shoulder. This study was done using both arms simultaneously, but in a later study, Provins (1955) considered each side separately. Provins teamed with Salter (1955) and they limited their endeavors to the torque exerted about the elbow joint. This study viewed certain factors which limit the strength of elbow flexion. Another study (Salter, Darcus, 1952) dealt directly with pronation and supination and their effect on maximum torque expenditures.

Biomechanical models have been developed, such as the one by Chaffin and Baker (1970), to analyze forces at particular joints; however, each is concerned with forces in a single plane, usually the sagittal plane.

This previous research added dimension to the objectives of this thesis with respect to measurement techniques and notation of dependent variables. Although the parameters of these experiments varied slightly from those depicted in this experiment, many similarities are present. Maximum torques at the shoulder, elbow, and wrist were determined for conditions remotely similar to those of this experiment. These results gave insight into the breakdown of the independent variables.

CHAPTER II

EQUIPMENT AND MEASUREMENT

Equipment

The apparatus used for this experiment was a combination of electrical and mechanical equipment comprised of the following elements:

1. 1967 Mustang (Test Vehicle)
2. a simulated door that was mounted to the test vehicle on the driver's side
3. Narco Physiograph strip-chart recorder
4. DC/AC amplifier
5. strain gauge amplifier
6. two-channel Wheatstone bridge

Figures 1, 2, and 3 show the interior of the vehicle with the simulated door in its proper position for testing and a detailed view of the three handle types. The moveable section of the simulated door (see Figure 4) was attached only to the door hinges and was allowed to move freely about the movement of the actual door. This section of the simulated door will be referred to as the moveable section. The front section was firmly mounted to the automobile and was used for positioning of the door handle (see Figure 4). This section of the simulated door will be referred to as the fixed section.

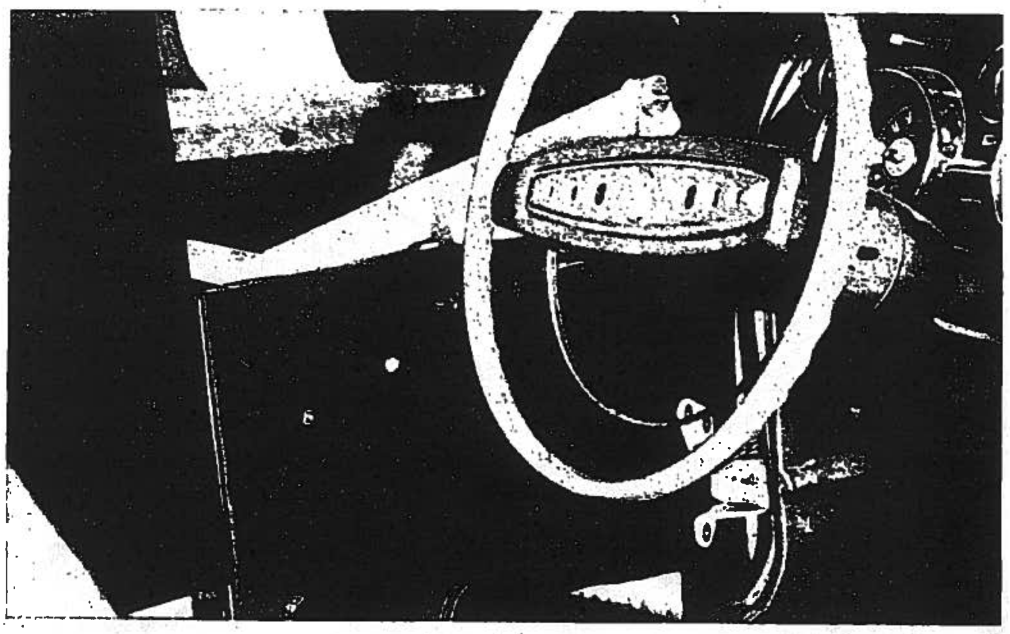


Figure 1. Interior view of simulated door-handle type one in handle position one.

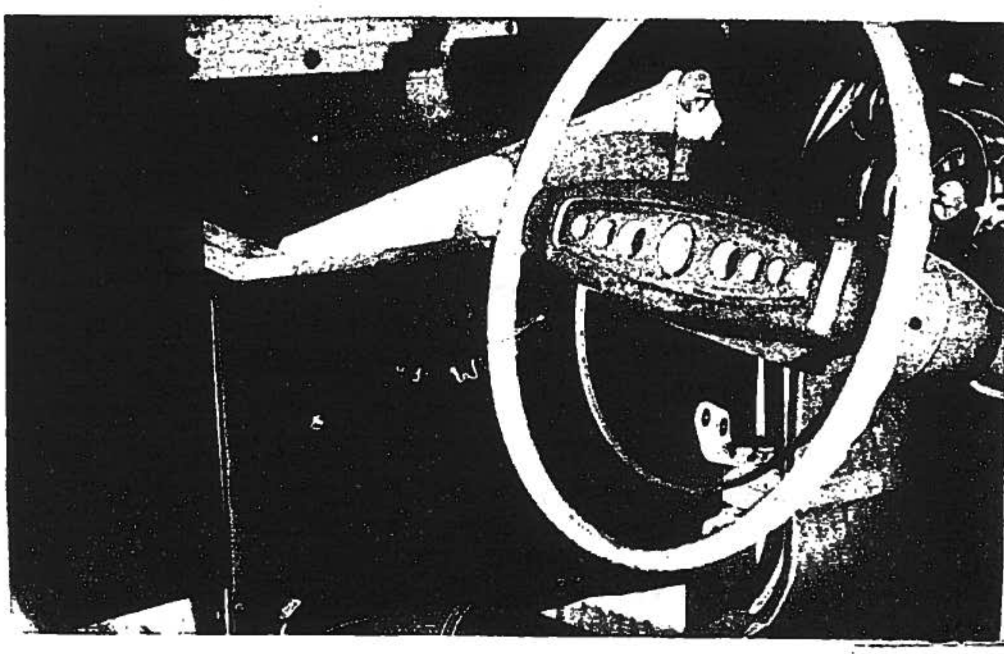
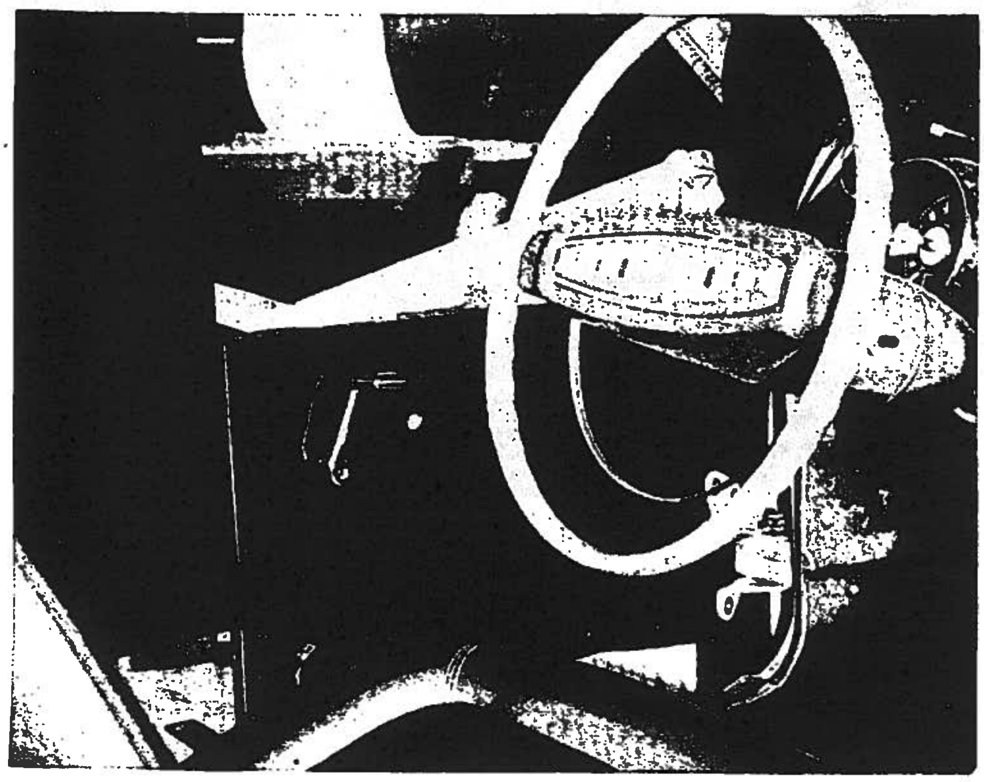


Figure 2. Interior view of simulated door-handle type two in handle position two.



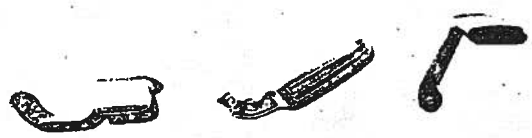


Figure 3. (Top View) Interior view of simulated door-handle type three in handle position three.

(Bottom view) Handle types-
a. type one b. type two c. type three

As the bar was deflected, the electrical characteristics of the bar were altered; thus, the force which was applied to the movement of the door was measureable (one dependent variable).

The mount mechanism (see Figure 4) which holds the various handles was taken from a vehicle and altered so that it could be easily moved and mounted for the various arm positions. The handles were also selected from vehicles such that they would encompass the necessary characteristics for facilitation of the various hand positions. Three wing nuts held the mount mechanism in place for each position. On the mount mechanism was a two inch moment arm that protruded down and was perpendicular to the platform. The force applied by the moment arm of the mount mechanism was transferred to the aluminum bar number two via a steel cable (see Figure 4). As the handle was turned, the aluminum bar was deflected towards the vehicle. This deflection was the source of the other dependent variable (torque applied to the handle).

As the mounting mechanism was remounted for another arm position, it would be necessary to change the cable's relationship to the aluminum bar. When arm position two was being tested, the cable was perpendicular to the bar. The other two positions caused about plus or minus two degrees of variation from perpendicular. However, this variation was not significant (less than one percent change). Therefore, all measurements were treated the same.

Electrical Equipment

The device about which the experimental apparatus was constructed was the electrical strain gauge. The electrical strain

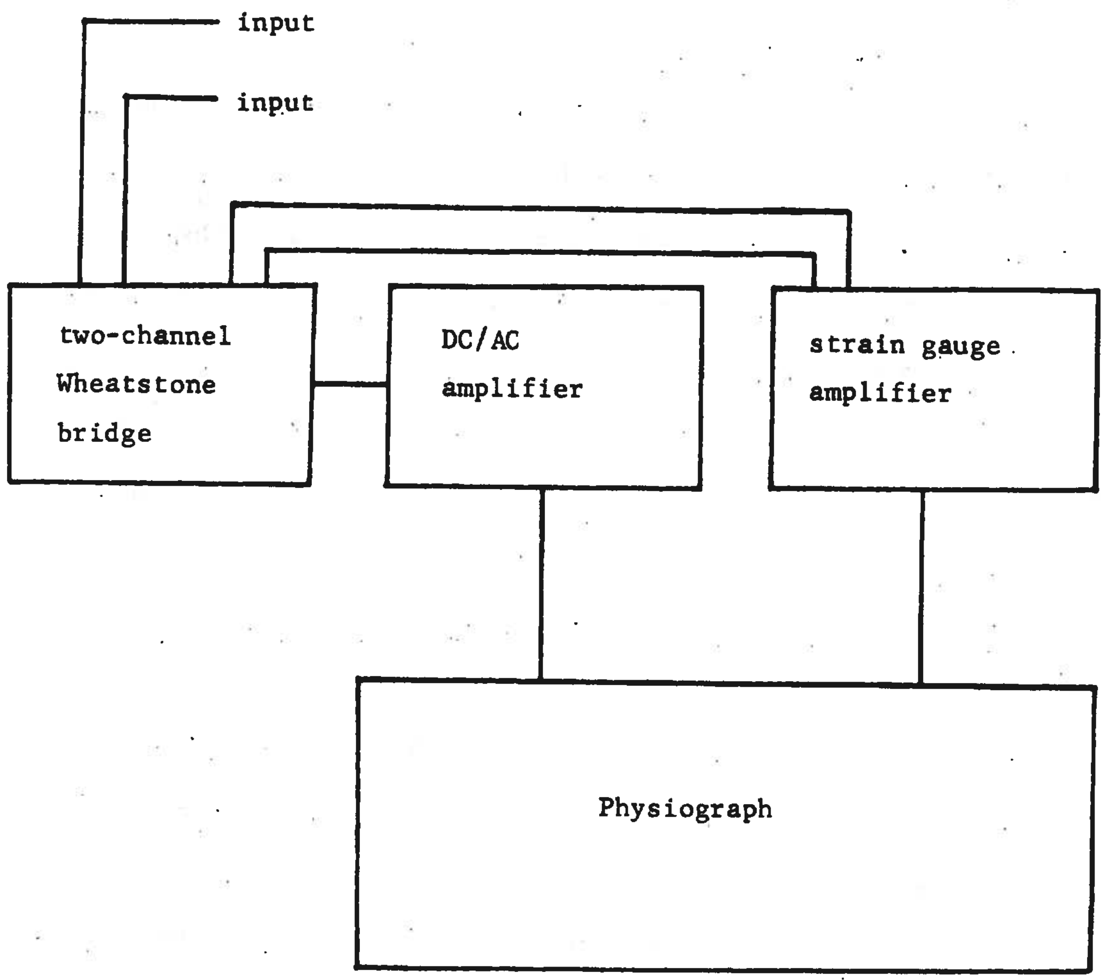


Figure 5. Block diagram of electrical components

gauge is "a device in which a change in length (strain) produces change in some electrical characteristic." (Dove, Adams, 1964). Strain gauges allow output from mechanical systems to be monitored by electrical equipment.

Etched foil strain gauges were mounted to both sides of both of the aluminum bars as shown in Figure 4. They were mounted on the section of the bar that displayed the most bending which was near the base. The gauges were mounted back to back on each side of each bar.

Each gauge is a variable-resistor and changes its electrical characteristics when the bar is distorted. Since the gauges were mounted on opposite sides of the bar, one measures a tensile and the other a compressive strain, and consequently the resistance is greater in one case and smaller in the other. When the gauges are initially mounted the resistances are the same.

The most common circuit used for metallic variable-resistors is the Wheatstone-bridge. A two-channel bridge with its own DC-power supply was constructed especially for this experiment (see Figure 6). Referring to Figure 6, R_1 and R_2 are equal resistance strain gauges. R_3 and R_4 are resistors of equal value. R_5 is a null potentiometer since the resistances must be exactly equal. When a voltage, E, is applied to the bridge, E_{BD}, is zero. However, when R_1 is greater than R_2, or R_2 is greater than R_1, E_{BD} is measureable; thus, the output is produced.

The excitation voltage can be either DC or AC. For this experiment both types of power were used because of available equipment. A DC power supply from the two-channel bridge was used for one bar and the AC power supply from an amplifier was used for the other.

There were two types of Amplifiers (see Figure 5). One amplifier contained an AC power supply and calibration capabilities. The other amplifier was a DC/AC amplifier that required a power supply (in this case, DC). Each had more than sufficient gain capabilities.

These amplifiers were attached to the physiograph which reflected the output. The change of potential of E_{BD} was registered on the physiograph as a pen deflection on the strip chart.

Calibration

Prior to testing, the simulated door was dismounted from the vehicle so that the gauges could be calibrated. This was accomplished by dead loading. The platform was positioned such that cables could be attached at right angles to the bars. Calibration results can be seen in Figure 7.

After reviewing results of the first two days of testing it became apparent that the gain on the amplifiers could be readjusted so that the output could be more easily read for the replication during the other two days of testing. In all, there were five calibrations used. The equations were linear over the useable range. With, x as pen deflection, and y as pounds force, the relationships were as follows:

Days 1 and 2

$y = x + 7$ for force to handle
$8 < x < 100$

$y = .75x + 2$ for both unrestricted and restricted force to the door
$8 < x < 120$

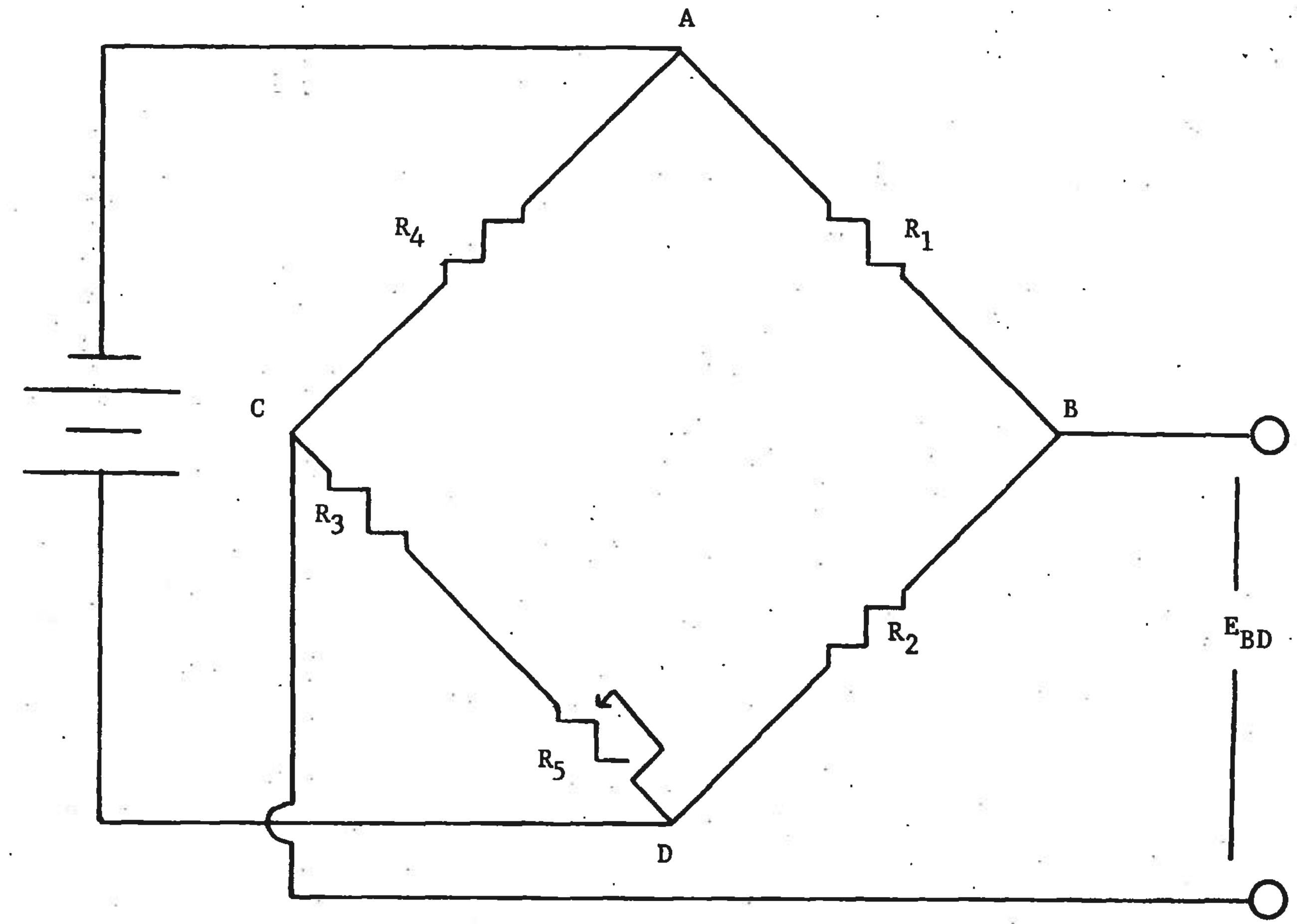


Figure 6. Wheatstone-bridge circuit

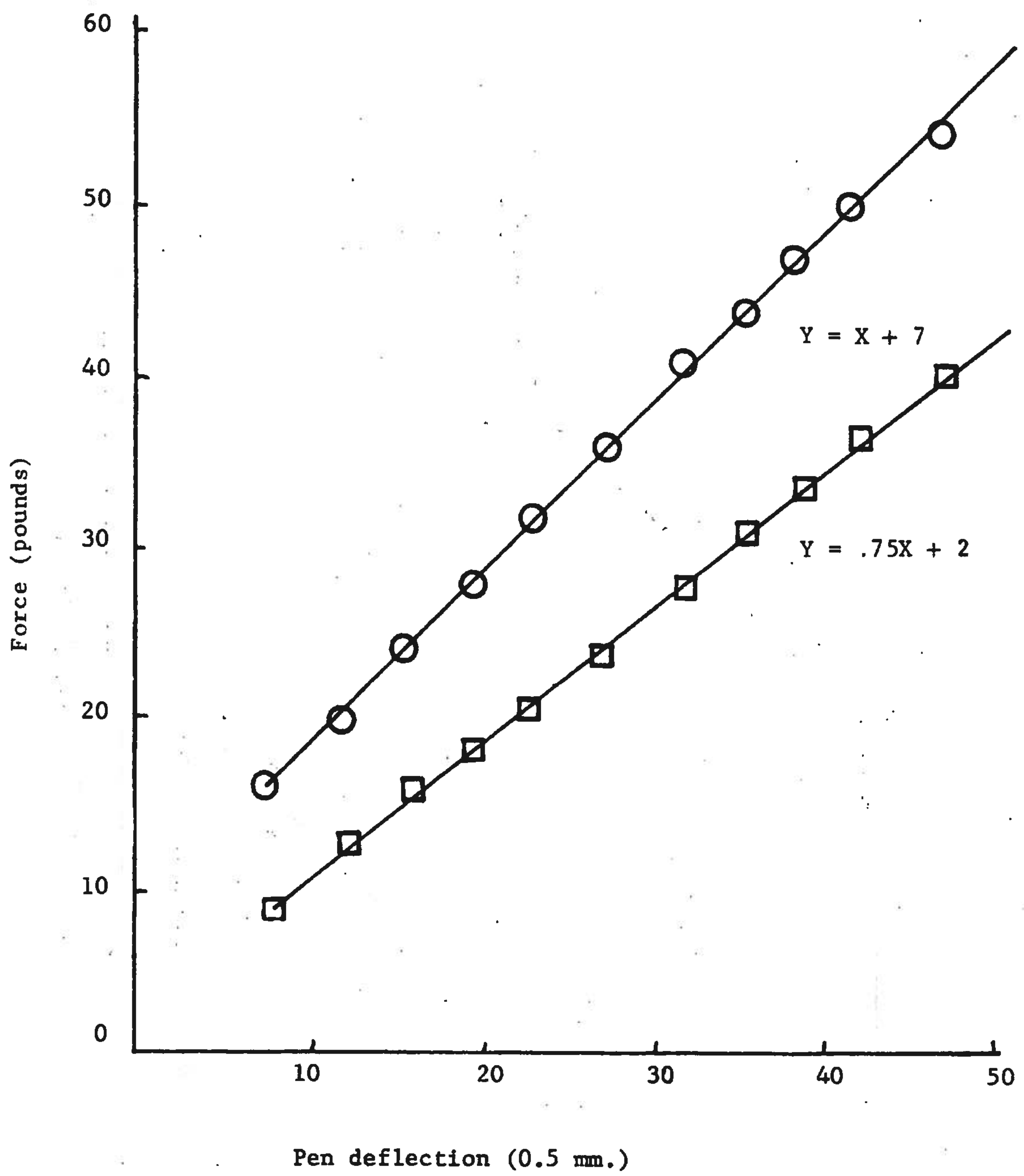


Figure 7. Strain gauge calibration curves for testing days one and two

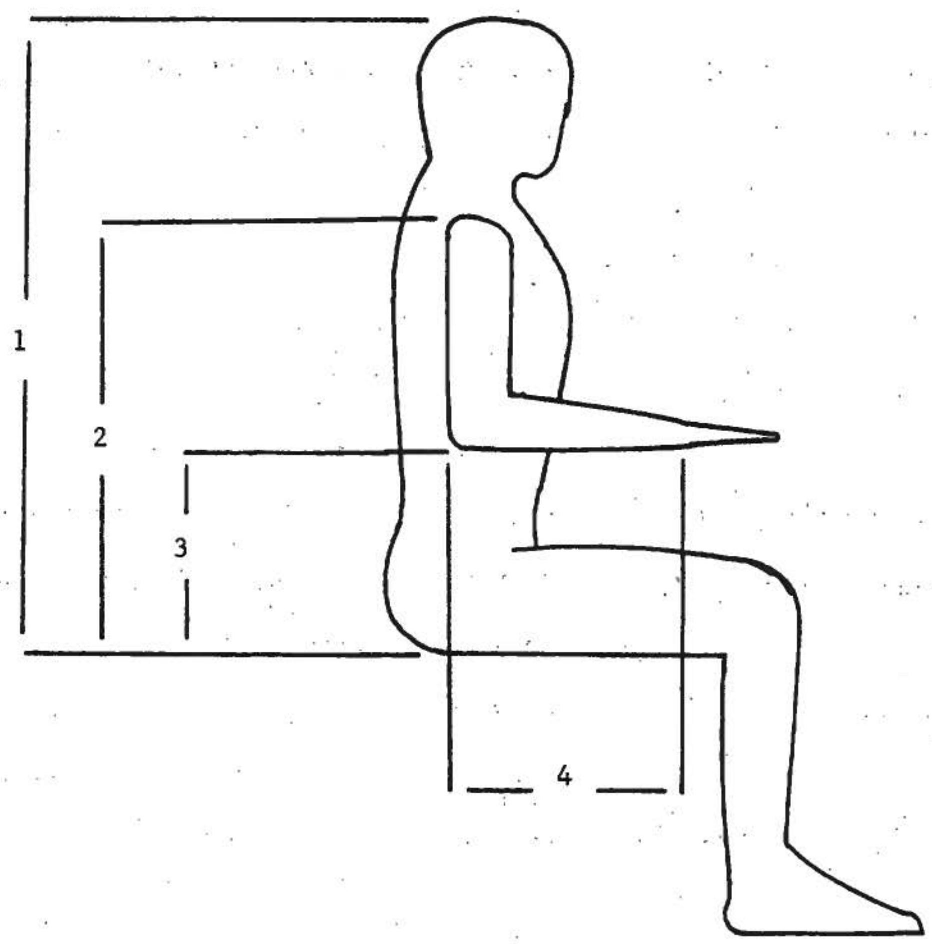


Figure 8. Anthropometric measurements

Days 3 and 4

$y = .64x - 2$ for force to handle
$8 < x < 100$

$y = .93x$ for restricted force to the door
$0 < x < 80$

$y = 1.58x + 4$ for unrestricted force to the door
$2 < x < 100$

Measurements

Subject Anthropometric Measurements. There were certain anthropometric measurements taken prior to testing. These were:

1. sitting height (erect)
2. shoulder height
3. elbow rest height
4. forearm length.

Reference Figure 8 for clarity of measurements. The implication of these measurements will be discussed in more detail in Chapter III.

Dependent Variables. The other measurements were, of course, the dependent variables. The deflection registered on the physiograph due to the bending of the aluminum bars was converted to a torque (foot-pounds) in the case of the force applied to the door handle and to force (pounds) in the case of the door movement.

CHAPTER III

EXPERIMENTAL DESIGN AND PROCEDURE

Subjects

Since the experiment is concerned with a driver's ability to escape from a vehicle via a less maneuverable door, the element of strength is paramount. Certainly the stronger person can open the door more easily than the weaker person. Those persons representing the weaker physical qualities could be drawn from a broad spectrum of sizes, shapes and weights. It would be most effective if a population that exhibited similar strength capabilities in the direction in question could be tested. Rather than search for this select diverse population, a uniform population with similar anthropometric characteristics which intuitively represent a population that has minimal force capabilities was used. The preliminary characteristics that were to be met were as follows:

1. female
2. 18 to 24 years of age
3. 5 feet to 5 feet 5 inches tall
4. 90 to 120 pounds
5. right handed.

There are studies (Kaare, Astrand, 1970) which enable inferences of strength capabilities to be made for various age groups.

Table 1 is a summation of subject data. It might be noted that

TABLE 1

SUBJECT SUMMARY

Subject	Age	Height (inches)	Weight (inches)	Sitting Height Erect (inches)	Shoulder Height (inches)	Elbow Rest Height (inches)	Forearm Length (inches)
1	24	64.5	109	33.00	21.25	8.25	9.75
2	19	64.0	120	34.00	23.00	11.00	9.50
3	20	65.0	115	34.5	23.00	11.00	9.50
4	20	64.0	90	34.5	22.25	12.50	9.50
5	18	61.0	100	32.00	21.75	8.75	8.75
6	19	63.0	105	34.00	23.00	10.50	9.00
7	19	63.5	120	32.00	21.50	10.25	9.50
8	21	60.0	105	31.25	20.25	8.25	9.50
9	19	63.0	108	32.00	21.50	8.50	10.00
10	18	61.0	115	32.50	21.25	10.25	9.50
11	21	61.0	115	30.50	22.50	8.75	9.50
12	18	60.0	105	30.75	20.25	9.00	9.25
13	20	63.0	114	33.25	22.50	9.50	9.75
14	18	62.0	120	32.50	22.50	10.75	9.25
15	18	64.0	118	33.50	22.25	10.25	9.00
16	19	64.0	114	34.00	23.00	9.50	10.00
17	18	61.0	106	29.50	20.25	8.75	10.00
18	18	63.0	115	33.50	22.00	10.50	9.25
Maximum	24	65.0	120	34.50	24.25	12.50	10.00
Minimum	18	60.0	90	29.50	20.50	8.25	8.75
Mean	19.1	62.8	111.2	33.00	21.10	10.30	9.30
Median	19.0	63.0	114.0	33.0	22.0	10.25	9.50

the subjects covered the range of each of the preliminary characteristic of age, weight and height. This data was compared to the total population of women using a study done by the Department of Health, Education, and Welfare (H.E.W., 1965). It was convenient that their breakdown for age was 18 to 24 years old; therefore, direct comparisons could be made to the subject data.

Only average data were considered for the following discussion of percentile groupings. For the age group in question, the subjects were in the lower 38th percentile for weight. However, they were in the lower 48th percentile for height and lower 10th percentile for weight when compared to the total population of women in the United States. It can be noted that the subjects were not only small for their age group, but particularly small for all women. Strength curves (**Kaare**, 1970) show that an older population would be less capable of exerting force; however, the younger population that was selected exhibit the qualities desired and were readily available for testing. Therefore, this population displayed those characteristics of minimum strength capabilities without being inordinate in selection. Those qualities are namely size and sex.

One of the major assumptions in the experiment was that the arm geometry as it relates to the door was uniform throughout the subjects. The sitting height varied five inches but the shoulder height varied less than four inches. There is about one to two inches deviation from the average shoulder height which did not have an appreciable affect on the angle of elbow flexion ($\pm$ 2 degrees). The forearm length deviated only about one-half inch from the average, and, again, did not affect the arm geometry. Although the elbow rest height varied about two inches from the average, it varied directly with the shoulder height, and consequently, tended to keep the arm geometry similar.

The sitting height was in the lower 30th percentile and the elbow height was in the lower 20th percentile for all women. The other measurements were not available in the H.E.W. survey for comparison.

Discussion of Variables

Independent Variables

Hand Position. Hand position was dictated by the type of handle used, which were selected such that the hand would be in three different positions. They were the three levels of the independent variable of hand position. Different muscles of the shoulder and arm are used when the position of the hand is changed. For this reason hand position was chosen as a main effect. This main effect involves the hand in the simultaneous actions of twisting the handle, pulling the handle, and the elbow in pushing towards the door. This unique action demands the study of hand position.

For analysis of variance, hand position had three fixed, qualitative levels. For multiple linear regression analysis numerical values were associated with each level in order to give them properties of quantitative levels. The levels were pronation, neutral palm-in, and supination. Pronation was arbitrarily set at 0 degrees and called level 1. The neutral palm-in position, level 2, was 90 degrees out of phase with pronation and was set at 90 degrees. Similarly, the position of supination, level 3, was set at 180 degrees.

Arm Position. The other independent variable was arm position. This factor was chosen as a main effect because arm position had a marked effect on the mechanical advantage of the lifting action of the arm. They were the extended position (level 1), middle position (level 2), and retracted position (level 3).

These levels were standardized for use by taking a subject whose anthropometric measurements corresponded very closely to the means of Table 1. Each measurement of this "representative subject" was within .25 inches of the means of Table 1. The subject was seated in the vehicle to determine the positions. From Figure 9, angle E, flexion at the elbow, was set at 150 degrees for level 1, 120 degrees for level 2, and at 90 degrees for level 3. The forearm was horizontal for each level. Angle S and angle E of Figure 9 can be thought of as a functionally related two-tuple and since these angles determine the arm position, angle of elbow flexion and arm position can be used interchangeably as levels of the main effect. Arm position (qualitative) was used for analysis of variance and elbow flexion (quantitative) was used for multiple linear regression analysis.

Once the arm position was set, the point of rotation of the handle was set at approximately two inches below the wrist.

Dependent Variables

Torque Applied to the Handle. The amount of torque applied to the handle was a dependent variable (referred to as torque). The formula used for calculating the torque was:

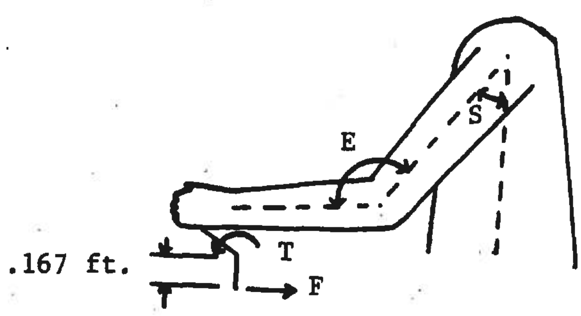


Figure 9. Left subject profile

$$T = .167F$$

where,

T = torque applied to door handle (ft-lbs)

F = force applied tangent to moment arm of mount mechanism (lbs).

Reference Figure 9 for graphic explanation. This torque was measured about the point of rotation of the door handle, which was at a position approximately two inches below the wrist. For the most part, this torque is a result of flexion at the elbow and the upper arm at the shoulder in the sagittal plane and a rotation of the hand at the wrist and is applied simultaneously with the restricted force to the door. The units of this torque are foot-pounds. The torque was calculated from the force which was registered on the strip-chart recorder.

Force Applied to the Door. The other dependent variable was the amount of force applied to the movement of the door at a point 31 inches from the pivot point on the hinges. There are actually two dependent variables for the force on the door, since in one case the subject is restricted to the use of his elbow with no body movement (referred to as restricted force), and in the other case the subject is unrestricted in his body movement (referred to as unrestricted force). In the first case, the force is a result of abduction of the arm at the shoulder in the frontal plane and is applied simultaneously with the torque to the handle. (see Phase I instructions Appendix A) The subjects were not required to maintain this simultaneous maximal force for a certain duration of time; however, most subjects applied these forces for approximately one second. In the second case the force is a result of the subject's ability to apply as much force to the door as possible. (see Phase II instructions in Appendix A) This force was in all cases a more instantaneous force (duration of approximately 0.2 seconds). The forces were registered on the strip-chart recorder.

Controls. In an attempt to collect valid results, rigid controls were enforced for subjects and the testing environment. Subjects were tested from 2:00 P.M. to 5:00 P.M. on Wednesday and Thursday afternoons at a room temperature of 70 degrees ($\pm$ 2 degrees). These days were selected because they represent days of similar activity in a student's life (all of the subjects were students). All subjects were requested to adhere to normal eating and sleeping habits one day prior to testing time. They said that they did comply with this request (results from Questionnaire 2 in Appendix B). Only right handed subjects were used. Each subject was in good health and had no physical defects.

Experimental Design

The independent variables have been discussed in some detail in the previous sections and are illustrated in Table 2. The main factors of this experiment were the following:

1. Arm position (3 levels, fixed, denoted by A)
2. Hand position (3 levels, fixed, denoted by H)
3. Subjects (18 levels, random, denoted by S)

There were three dependent variables measured for this experiment. They were:

1. Torque applied to the door handle
2. Restricted force applied to the movement of the door

Arm position	A1			A2			A3		
Hand position	H1	H2	H3	H1	H2	H3	H1	H2	H3

Table 2. Experimental Design by Subject (18 Subjects - 1 replication)

3. Unrestricted force applied to the movement of the door.

The two dependent variables (torque and restricted force), which were the results of hand and arm position combinations, employed the same mathematical model for analysis. Another model tested arm position and its effect on the unrestricted force (hand position two was the only hand position used).

The mathematical models were easily determined for all cases. The first two were 3X3X18 full factorial mixed models (two fixed factors and one random factor) with one replication. For analysis involving both arm and hand positions the following mathematical model was used:

$$X_{ijkl} = \mu + S_i + A_j + SA_{ij} + H_k + SH_{ik} + AH_{jk} + SAH_{ijk} + E_{ijkl}$$

where,

X_{ijkl}	torque or restricted force
μ	grand mean
S_i	subjects effect i = 1, 2, ... 18
A_j	arm position effect j = 1, 2, 3
H_k	hand position effect k = 1, 2, 3
SA_{ij}, SH_{ik}, AH_{jk}, SAH_{ijk}	interaction terms
E_{ijkl}	error term l = 1, 2.

The other mathematical model was a 3X18 full factorial model with one fixed and one random factor with one replication. The model is

$$X_{ijl} = \mu + S_i + A_j + SA_{ij} + E_{ijl}$$

where,

X_{ijl}	unrestricted force
μ	grand mean
S_i	subjects effect $i = 1, 2, \ldots 18$
A_j	arm position effect $j = 1, 2, 3$
SA_{ij}	interaction term
E_{ijl}	error term $l = 1, 2$

Since the mathematical models were of the mixed type it was necessary to construct E.M.S. tables in order to test the main effects and interactions using the F-ratio. They are shown in Table 3 and Table 4.

Experimental Procedure

Subjects were divided into six groups and were tested three groups per day. The entire experiment was replicated the following week with each group testing at the same time on the same day. Testing sessions lasted approximately one hour per group.

When a group of subjects arrived at the testing center they were given a group orientation as shown in Appendix A. After the orientation, one subject was seated in the vehicle and given the phase I (restricted body movement) individual instructions as shown in Appendix A. The subject completed three trials of phase I and

TABLE 3

E.M.S. for 3X3X18 Model

Source of Variation	18 R i	3 F j	3 F k	2 R l	E.M.S.
S	1	3	3	2	$\sigma_E^2 + 18\sigma_S^2$
A	18	0	3	2	$\sigma_E^2 + 108\sigma_A^2 + 6\sigma_{SA}^2$
SA	1	0	3	2	$\sigma_E^2 + 6\sigma_{SA}^2$
H	18	3	0	2	$\sigma_E^2 + 108\sigma_H^2 + 6\sigma_{SH}^2$
SH	1	3	0	2	$\sigma_E^2 + 6\sigma_{SH}^2$
AH	18	0	0	2	$\sigma_E^2 + 36\sigma_{AH}^2 + 2\sigma_{SAH}^2$
SAH	1	0	0	2	$\sigma_E^2 + 2\sigma_{SAH}^2$
E	1	1	1	1	σ_E^2

TABLE 4

E.M.S. for 3X18 Model

Source of Variation	18 R i	3 F j	2 R l	E.M.S.
S	1	3	2	$\sigma_E^2 + 6\sigma_S^2$
A	18	0	2	$\sigma_E^2 + 36\sigma_A^2 + 2\sigma_{SA}^2$
SA	1	0	2	$\sigma_E^2 + 2\sigma_{SA}^2$
E	1	1	1	σ_E^2

was then given in phase II (unrestricted body movement) individual instructions as shown in Appendix A. It might be noted that phase I and phase II overlap in testing. Once a subject had completed three trial in phase I (nine in all) and one trial in phase II (three in all), another subject was seated and given the same instructions. Once each subject had been given the initial instructions, it was not necessary to repeat them for further trials, since the routine was the same for each time a subject was seated in the vehicle (three times per testing day, six times in all).

Since this experiment involved muscular fatigue precautions were taken to eliminate the effects of fatigue as much as possible. This muscular fatigue was a result of repeated application of forces by the arm and hand of a subject. Subjects were given at least twenty seconds to rest between each trial and only asked to perform four trials at any one time in the vehicle. The experiment was spread over approximately one hour which allowed ample time for a subject to rest before entering the vehicle again. The ordering of combinations was counterbalanced so that fatigue would not bias any particular factor. The three sequences were as follows:

sequence 1
- phase I
  - A1-H1
  - A1-H2
  - A1-H3
- phase II
  - A1-H2

sequence 2
- phase I
  - A2-H2
  - A2-H3
  - A2-H1
- phase II
  - A2-H2

sequence 3 phase I
A3-H3
A3-H1
A3-H2

phase II
A3-H2

Furthermore, in order to counterbalance the effect of each sequence, if any, the order among sequences was altered. The experiment proceeded as follows:

for groups 1 and 2,
sequence 1
sequence 2
sequence 3

for groups 3 and 4,
sequence 2
sequence 3
sequence 1

for groups 4 and 5,
sequence 3
sequence 1
sequence 2.

When a subject was not involved with testing, anthropometric data for Table 1 was collected, so as to make productive use of a subject's time.

After the completion of the first round of testing, subjects were asked to complete Questionnaire 1 (found in Appendix B). The subjects were not required to answer question no. 5, but instead this response was left as the theme for a recorded group discussion. After the completion of the first replication, the subjects were asked to complete Questionnaire 2, which is found in Appendix B.

The experiment involved three research assistants. One assistant took anthropometric data, administered questionnaires, and conducted the recorded debriefing sessions. The other two assistants were

Figure 10. Experimental testing configuration.

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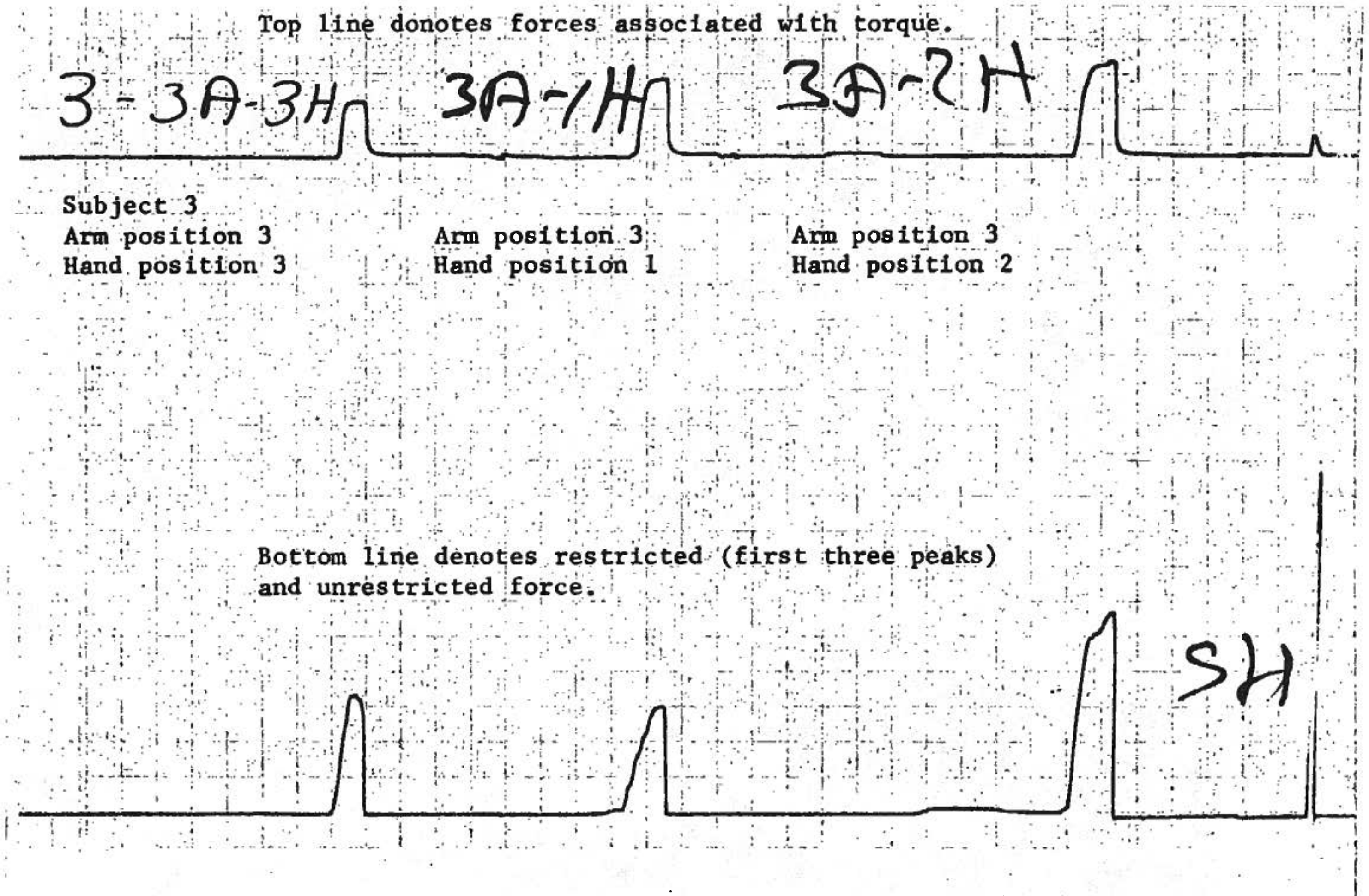

Figure 11. Physiograph output by subject

directly involved with testing. Figure 10 illustrates the relative positions of the two assistants and the subject. The assistant nearest the subject gave individual instructions and changed the position and type of handle according to the before-mentioned sequence. The other assistant monitored the strip-chart recorder and nulled the bridge periodically to adjust for drift.

As each subject was seated before each trial, the assistant monitoring the sequence would call out the particular combination of factors (subject, arm position, hand position) and the other assistant would note this on the strip-chart output. An example showing the result of one subject for one time in the vehicle is shown in Figure 11. The top pen deflections are the results of torque applied to the door handle. The bottom pen deflections are caused by the corresponding force applied to the movement of the door. The first three are taken under restricted conditions and the last one, marked "SH", was taken under unrestricted conditions. Each subject had six similiar outputs which ultimately yielded 42 data points per subject.

CHAPTER IV

RESULTS

Introductions

For clarity of understanding, this chapter was divided into sections for each of the analysis techniques. The analysis of variance (ANOVA) was used for phase I and phase II data. Also orthogonal contrasts were used to determine significance of linear and quadratic relationships of independent and dependent variables. A ranking analysis was used to add dimension to the results of the ANOVA. Regression analysis was employed in an attempt to establish a linear relationship between variables. The subject's preference of positions was incorporated in a separate discussion. Group discussion sessions were analyzed for pertinent comments.

The Biomedical Statistical programs were employed for ANOVA and multiple linear regression (MLR) analysis. They were run on an IBM 360 Model 50 computer located at the University of Oklahoma at Norman.

The χ^2 Goodness of Fit test was used to test the data for normality. The hypothesis that the phase I data is normal, for force and for torque as dependent variables could not be rejected at the 5 percent level (χ^2 = 15.67 and χ^2 = 14.88, respectively).

Caution was taken to counterbalance the effects of within subject fatigue in order to minimize dependence of data points.

Phase I - Analysis of Variance

Torque Applied to Door Handle as the Dependent Variable

The independent variables for phase I were subjects, arm position and hand position. The resultant ANOVA is shown in Table 5 (for torque as the dependent variable). The main effects that were significant were subject and hand position, at the one percent level. There were two first order interactions of significance. The interaction between subject and arm position was significant at the five percent level. The interaction between arm position and hand position was significant at the one percent level.

A graphic analysis makes the significance and non-significance of the main effects and interactions more readily apparent. In a strength test, it would be expected that there would be a significant variation between subjects. Viewing Figure 12, it can be noted that there is a pronounced trend between hand position and torque. A plot of means for arm positions one and two display definite additive qualities and follow the trend of the overall means plots. However, the combination of hand position two and arm position three is comparatively high making arm position three less representative of the general trend. The greatest deviation of the position means from the grand means by hand position is approximately 0.24 ft-lbs. One standard deviation is 1.4 ft-lbs.; therefore, 0.24 ft-lbs. is but a small deviation and supports the significance of hand position. Using orthogonal contrasts, it was found that there is a very significant

TABLE 5

ANOVA - Torque to Handle

Source	d.f.	S.S.	M.S.	F-Ratio	Significance
S(Subject)	17	139.32	8.20	5.42 (S/E)	1 percent
A(Arm Pos.)	2	3.67	1.84	.779 (A/SA)	N.S.
H(Hand Pos.)	2	69.32	34.66	28.30 (H/SH)	1 percent
SA	34	80.65	2.37	1.57 (SA/E)	5 percent
SH	34	41.77	1.23	.81 (SH/E)	N.S.
AH	4	10.36	2.59	3.74 (AH/SAH)	1 percent
SAH	68	47.11	.70	.46 (SAH/E)	N.S.
Error	162	243.59	1.50		
Total	323	635.79			

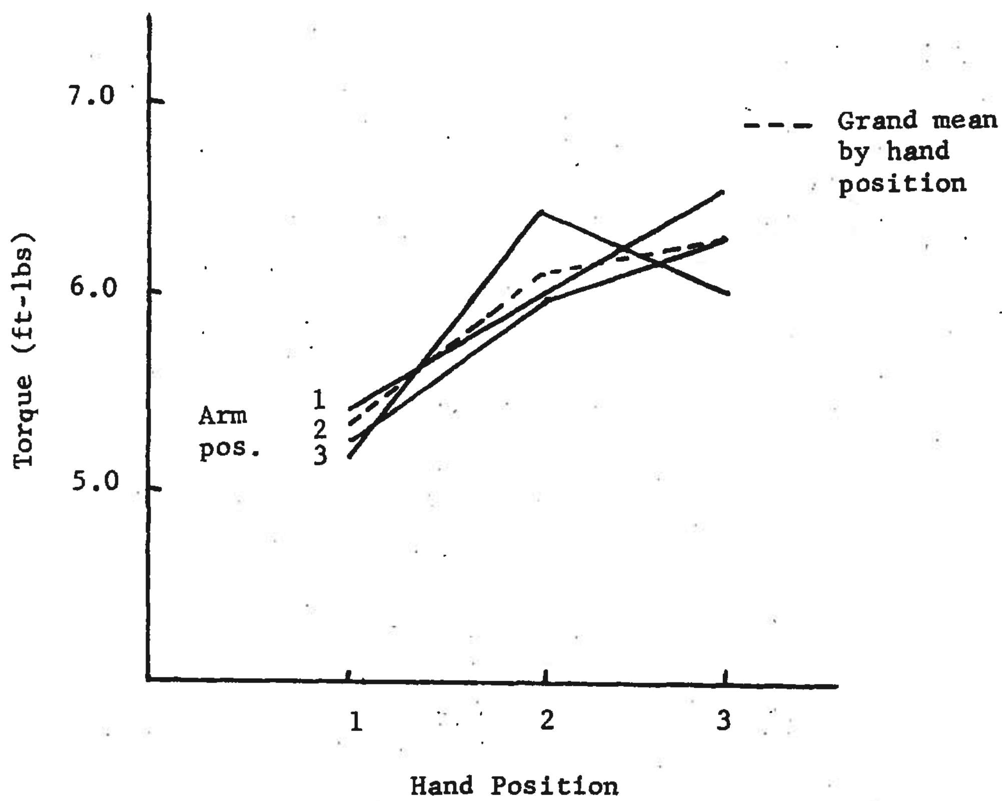

Figure 12. Torque versus hand position for various arm positions

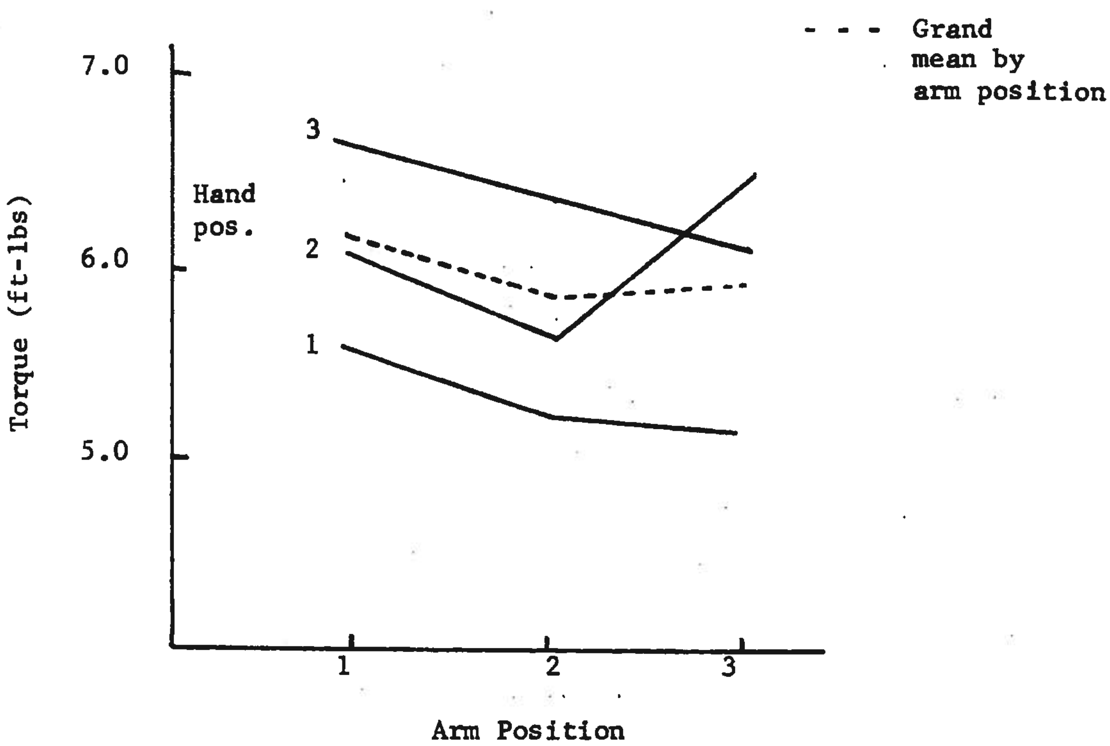

Figure 13. Torque versus arm position for various hand positions

linear relationship between hand position and torque (F = 40.00).

Figure 13 is a plot of mean values of arm position versus torque. It was found that arm position was not significant and this result is displayed graphically in Figure 13. Observing the plot of the overall mean there is little deviation between arm positions. It would seem that arm position one would give a subject a certain advantage. It is interesting that means of arm positions for hand positions one and three follow the general trend of the grand means. Hand position two follows this trend for arm positions one and two but arm position three is unique. This particular combination (H2-A3) resulted in a high torque output and will be viewed more closely in Chapter V. As would be expected, since arm position was not a significant main effect, there was no linear (F = 1.55) or quadratic (F = .86) trend.

Restricted Force Applied to the Movement of the Door

The independent variables are the same as for torque. The resultant ANOVA for restricted force is shown in Table 6. All of the main effects were highly significant. The only significant interaction was that between hand and arm position at the one percent level.

Again, subjects were a significant main effect. Further investigation of Figure 15 shows an extremely good relationship between torque and hand position with hand position two clearly resulting in the highest torques for all arm positions. The plot of the overall means for each hand position indicates that hand position two had the highest mean value, position three was next and then position one. Each arm position followed this general trend with one slight

TABLE 6

ANOVA - Restricted Force to Door

Source	d.f.	S.S.	M.S.	F-Ratio	Significance
S(Subject)	17	13706.43	806.26	7.10 (S/E)	1 percent
A(Arm Pos.)	2	4376.19	2188.09	16.40 (A/SA)	1 percent
H(Hand Pos.)	2	3286.19	1643.10	36.40 (H/SH)	1 percent
SA	34	4531.25	133.27	.46 (SA/E)	N.S.
SH	34	1528.92	44.97	1.18 (SH/E)	N.S.
AH	4	879.89	219.97	4.88 (AH/SAH)	1 percent
SAH	68	3080.50	45.30	.40 (SAH/E)	N.S.
Error	162	18389.00	113.51		
Total	323	49778.37			

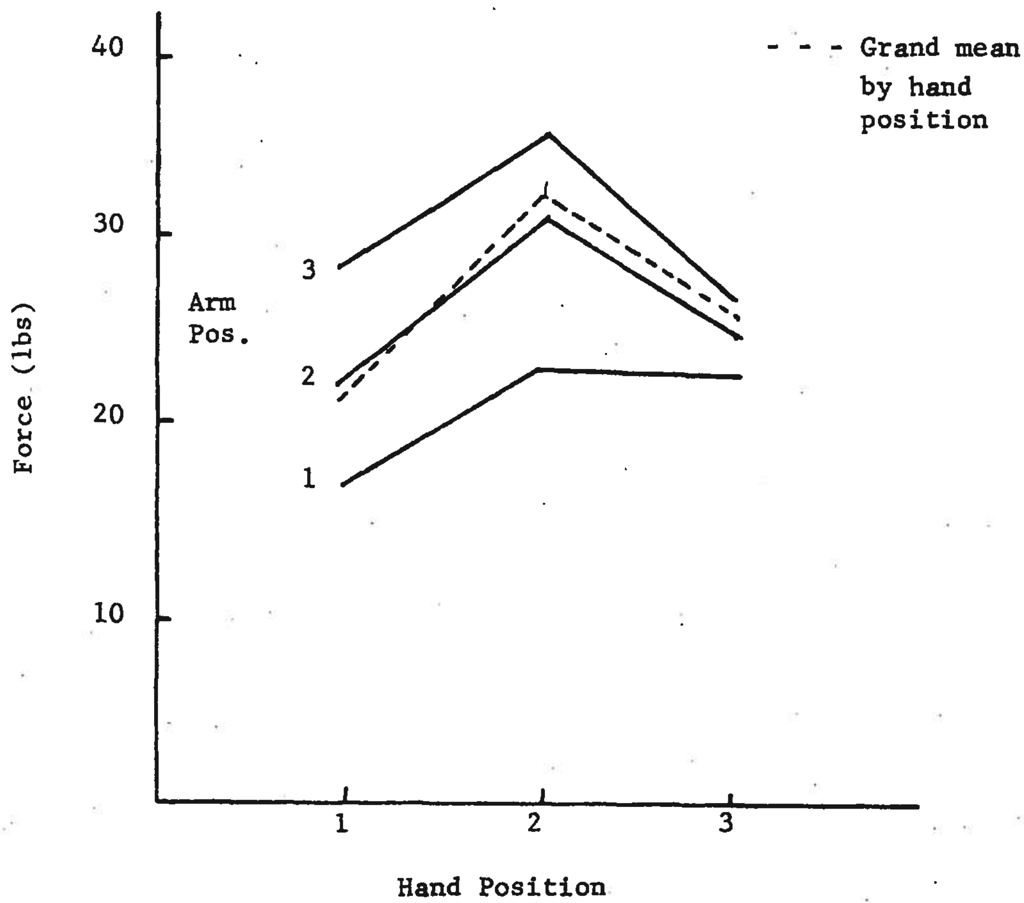

Figure 14. Restricted force versus hand position for various arm positions

exception. That is the combination of hand position three and arm position three. Orthogonal contrasts gave evidence of a highly significant quadratic trend (F = 26.3). The linear trend was not significant (F = 2.56).

Figure 15 is a plot of the mean values of arm position versus restricted force. Arm position had a highly significant effect on force as is clearly displayed by a plot of the overall mean values of the three arm positions. Each hand position displayed the same general trend as that displayed by the overall mean, with arm position three giving the highest value in each case. Notice that arm position had a less pronounced effect on hand position three. As is obvious, arm position has a highly significant linear trend (F = 37.5). There is no quadratic trend (F = 1.04).

Phase II - Analysis of Variance

Unrestricted Force Applied to the Movement of the Door.

For phase I, the body movement was unrestricted and only arm position and subjects were used as independent variables. For phase II, the only dependent variable was unrestricted force to the door. An analysis of variance was accomplished using one replication (see Table 7) and another accomplished using only those maximum values per cell (see Table 8) since the primary concern of phase II was to examine maximum force.

The ANOVA of Table 7 showed that there was no significant effect for either main effect or the interaction. This was not surprising since most of the force was applied with the shoulder which was not so dependent upon arm position.

TABLE 7

ANOVA - Unrestricted Force to Door

Source	d.f.	S.S.	M.S.	F-Ratio	Significance
S(Subject)	17	22094.04	1299.65	1.57 (S/E)	N.S.
A(Arm Pos.)	2	994.30	497.15	1.24 (A/SA)	N.S.
SA	34	13602.72	400.08	.48 (SA/E)	N.S.
Error	54	44656.50	826.97		
Total	107	81347.56			

TABLE 8

ANOVA - Unrestricted Force to Door
(maximum value per cell)

Source	d.f.	S.S.	M.S.	F-Ratio	Significance
S(Subject)	17	17688.76	1040.51	3.02 (S/E)	1 percent
A(Arm Pos.)	2	631.26	315.63	.92 (A/E)	N.S.
Error	34	11716.64	344.61		
Total	53	30036.66			

Unlike the previous ANOVA, subjects were a significant effect when only maximum cell values were considered. Again, arm position was of no consequence. By eliminating a replication, the interaction term was also ommitted.

Ranking Analysis

Figures 12, 13, 14, and 15 display a general ranking and overall ranking as to which position would allow subjects to apply the most torque and force. In order to add greater dimension to the mean value, each hand position was ranked for each position by subject, and each arm position was ranked for each hand position for both torque and force (four in all). The number of each first, second and third rankings were tallied for each combination.

As an example, for arm position two, hand positions were ranked according to the dependent variable by subject. Subject one applied the most force with hand position two (rank 1), then position three (rank 2), and then position one (rank 3). The total number of data points ranked 1, 2, and 3 were tallied for each hand position. To illustrate this procedure more clearly using an actual example,

TABLE 9

Ranking Example

		arm position two		
hand positions		1	2	3
Number of Rankings	1st	3	[28]	8
	2nd	10	6	[19]
	3rd	[23]	2	9

TABLE 10

RANKING COMPARISONS

Force as Dependent Variable

AP	1			2			3			overall		
HP	1	2	3	1	2	3	1	2	3	1	2	3
IR	3rd	1st	1st	3rd	1st	2nd	2nd	1st	2nd	3rd	1st	2nd
ROM	3rd	1st	2nd	3rd	1st	2nd	2nd	1st	3rd	3rd	1st	2nd

HP	1			2			3			overall		
AP	1	2	3	1	2	3	1	2	3	1	2	3
IR	3rd	2nd	1st	3rd	1st	1st	3rd	1st	1st	3rd	2nd	1st
ROM	3rd	2nd	1st	3rd	2nd	1st	3rd	2nd	1st	3rd	2nd	1st

Torque as Dependent Variable

AP	1			2			3			overall		
HP	1	2	3	1	2	3	1	2	3	1	2	3
IR	3rd	2nd	1st	3rd	2nd	1st	3rd	1st	1st	3rd	2nd	1st
ROM	3rd	2nd	1st	3rd	2nd	1st	3rd	1st	2nd	3rd	2nd	1st

HP	1			2			3			overall		
AP	1	2	3	1	2	3	1	2	3	1	2	3
IR	1st	2nd	2nd	2nd	1st	1st	1st	2nd	3rd	1st	3rd	2nd
ROM	1st	2nd	3rd	2nd	3rd	1st	1st	2nd	3rd	1st	2nd	3rd

AP - arm position
HP - hand position
IR - Individual Ranking
ROM - Ranking of Means

(see Table 9) hand position two had more "lst" rankings, position three had more "2nd" rankings, and position one had more "3rd" rankings. The criteria is the greatest number of occurrences per column. For arm position two the cell means for hand position one, two, and three were 22.1, 32.1, and 25.7 pounds respectively. This complies with the actual individual rankings of Table 9 (H2-lst, 32.1; H3-2nd, 25.7; H1-3rd, 22.1). The complete set of results is listed in Table 10.

Table 10 shows that the grand mean and cell means were not the result of inordinately high and low values of the dependent variables, but, in fact, are representative values. That is, it can be observed that individual rankings coincide with the ranking of means. The most important point is that individuals repeated themselves as to which combinations were best according to the actual means. The only ranking analysis which displayed questionable results was that of arm position within hand position for torque (bottom of Table 10). This relationship was not significant anyway.

The original rankings were tested against the replication rankings and it was found that there was no justification to reject the hypothesis that rankings were from the same population for both trials. The non-parametric Sign-Test was the test for this analysis.

Regression Analysis

Multiple linear regression was run with selected combinations of independent and dependent variables. These combinations were:

1. restricted force versus arm and hand position
2. torque versus arm and hand position
3. restricted force versus arm position

4. restricted force versus hand position

5. torque versus hand position.

Those relationships which were not significant were not considered for regression analysis.

In combinations one and two, the analysis of variance was significant; however, only nine percent of the total variation (coefficient of determination) was explained by the independent variables. The correlation coefficients were approximately zero. In an attempt to find a linear relationship those independent variables which were significant were investigated separately.

Restricted force versus arm position was highly significant for linear trends and had a correlation coefficient of .30. The resultant equation was

$$F = .15A + 8$$

where,

A = arm position

F = restricted force.

This equation yields values within five tenths pounds of the grand means and could be considered to be a good predictor (standard deviation = 12.4 lbs., 324 data points). The coefficient of "A" is significantly different from zero at the 0.005 level (t = 5.49).

Since, combination four was expected to have a quadratic trend, it was not necessary to run a linear regression.

Combination five had a highly significant linear trend and a correlation coefficient of .31. The resultant equation was:

$$T = .0059H + 5.4$$

where,

H = hand position

T = torque.

This equation yields values within two tenths foot pounds of the grand means and could be considered to be a good predictor (standard deviation = 1.4 ft.-lbs., 324 data points). The coefficient of "H" is significantly different from zero at the 0.005 level (t = 5.80).

Preferential Analysis

Subjects were asked (Questionnaire 1) which positions of the arm and hand they thought were most beneficial in allowing them to exert the greatest force. Also, subjects were asked which positions of the arm and hand they liked best. No attempt was made to differentiate between torque to the handle or force to the door. The motives of these questions were two-fold. First, the data would relate if subjects were cognizant of their performance. Second, the data would give insight as to which positions the subjects preferred from a practical standpoint.

The data was compiled and grouped together for Figures 16 and 17. Figure 16 shows arm positions one and three to be very unpopular with arm position two being the almost unanimous choice of the subjects. It is interesting that for arm position, the subjects were realistic of their evaluation of what they thought best for force, yet more subjects actually applied greater torques in arm position one but only one person thought so.

Figure 17 gives hand position two the nod as being the subject's

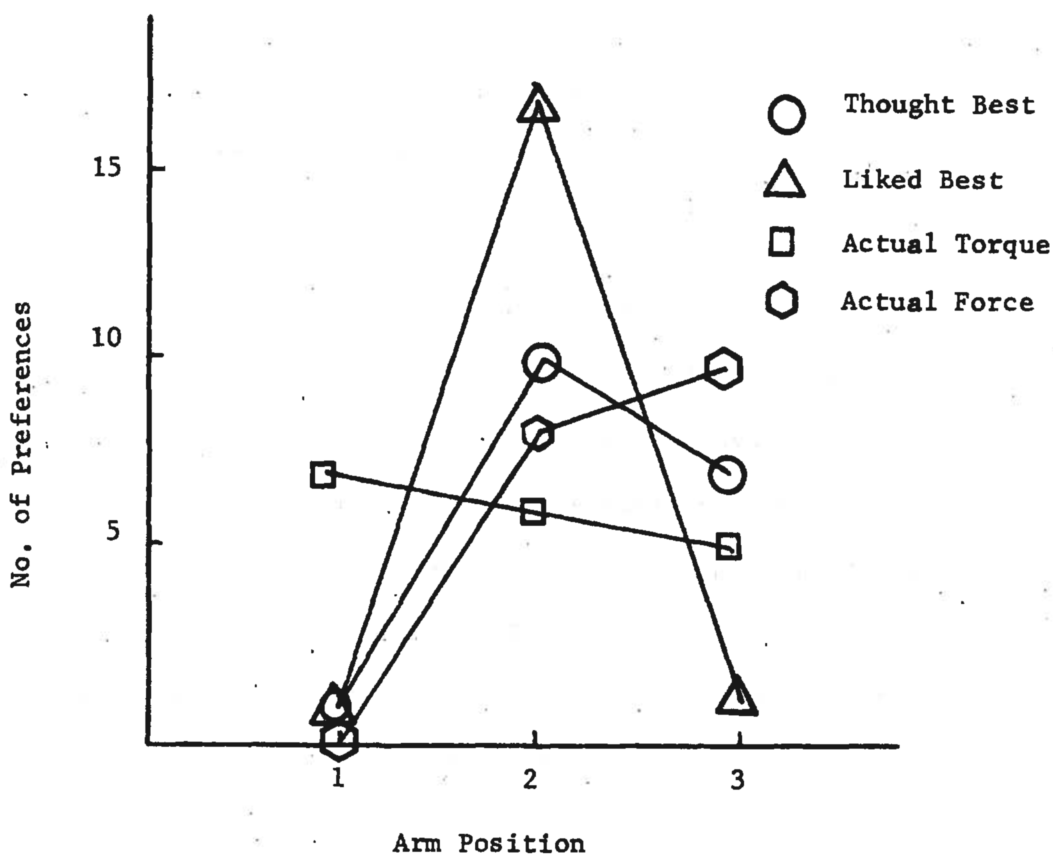

Figure 16. Arm position versus number of preferences

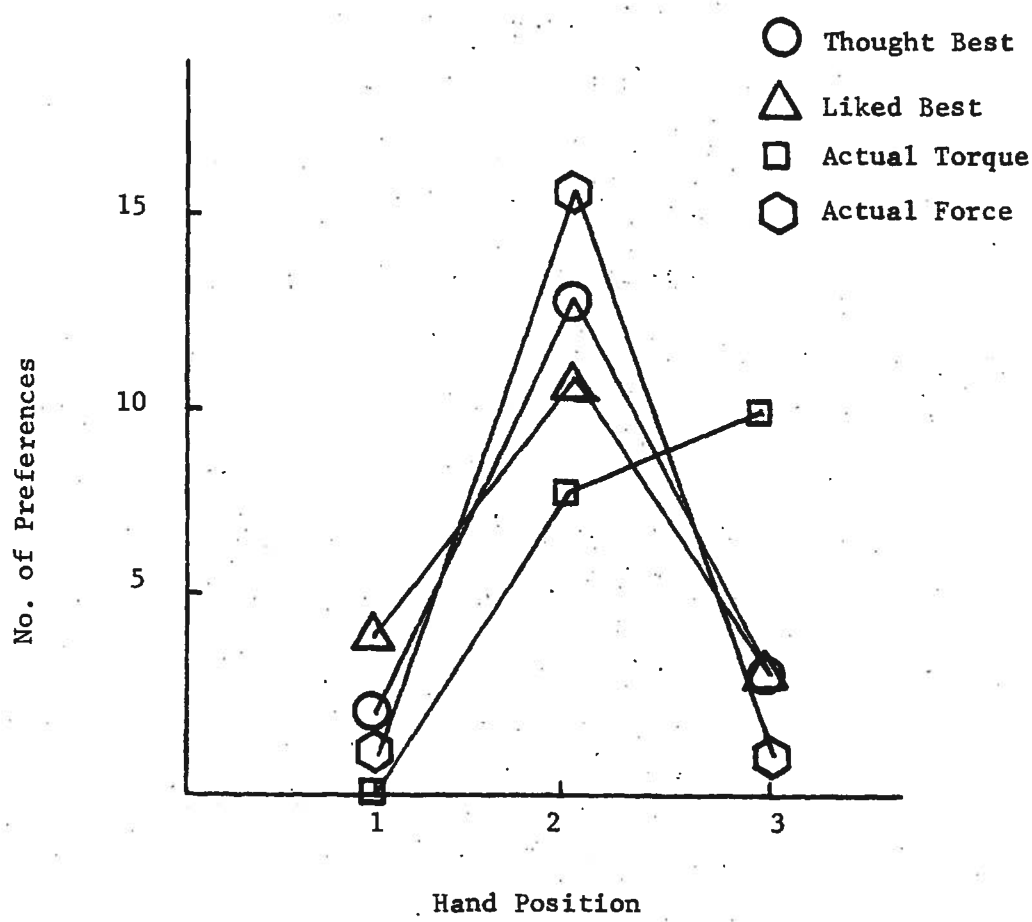

Figure 17. Hand position versus number of preferences

preferrence. Again the subjects were keenly aware of which position they were able to apply the greatest force. Again, the torque was the most elusive consideration for subject evaluation.

Debriefing Analysis

The subjects were debriefed in their respective groups after the first day of testing with question number five of Questionnaire 1 as the theme of the discussion. The following are some comments that were relevant to the experiment.

The majority of the subjects preferred arm position two because it felt "natural." On the other hand, some of the subjects preferred arm position three because it felt "natural." This is but one example of a number of discontinuities in opinions.

Most of the subjects were comfortable with hand position one and felt it would enable them to grasp the handle more quickly in an emergency situation. Hand position three was unpopular and was considered "awkward" and gave them an "insecure" feeling.

A few were of the opinion that a handle that was pushed down would be more effective for application of a maximal force, since they would be able to use their body weight. All were of the opinion that more research was needed in designing a handle that was more easily grasped.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Position and Type of Door Handle

It is apparent from the ANOVA of Chapter IV that both hand and arm position are significant in determining an optimum position and type of door handle. The six criteria and the respective rankings by position are shown in Table 11.

TABLE 11

Criteria and resultant rankings for various positions

Criteria	Hand Position (1st, 2nd, 3rd)
1. Maximum torque	3---2---1
2. Maximum restricted force	3---2---1
3. Subject's preference	2---3---1
	Arm Position (1st, 2nd, 3rd)
4. Maximum torque	1---2---3
5. Maximum restricted force	2---3---1
6. Subject's preference	2---3---1

Assigning an arbitrary value of five points to best output (first) and three points to the next best (second) and one point to the worst (third), hand positions three and two tie with eleven points each, and arm position two is the obvious choice. Hand position three was considered awkward by the subjects and gave them an insecure feeling. This may have some bearing on a person's ability to grasp or manipulate the door handle during an emergency egress. For this reason, hand position two is recommended over hand position three. The final conclusion is that the handle should be designed such that the hand is in a neutral palm-in position and the door handle should be located at a position where the driver's forearm is horizontal and his elbow is flexed at 120 degrees. This arm position should be determined by the average anthropometric measurements of Table 1 when the seat is in the correct position. This is not at all unreasonable since the arm geometry for individuals of different anthropometric measurements is similar because the angle of elbow flexion, which is determined by the handle position, varies only slightly. Once the seat is adjusted the variation in forearm length is no longer a factor. A deviation in elbow rest height of $\pm$ 3 inches changes the angle of elbow flexion by less than 13 degrees. This deviation includes 95 percent of the adult population. One of the basic assumptions for optimizing the location and type of door handle is that a larger person will have a very similar arm geometry, yet, he will be capable of applying a greater force. Therefore, the optimal position should cater to those who are unable to exert as much force.

Maximum Force Applied to the Door

It would be reasonable to assume that if an individual could not open a jammed door on the first try, he would try again, especially in an emergency situation. Arm position had no significant effect on the maximum force that could be applied to the door; therefore, the grand mean for phase II could be used as a standard. The average force applied at a position 31 inches from the pivot of the hinges of the door was 84.6 pounds. However, the grand mean of the maximum values of each cell was 103.2 pounds. The latter could be considered more representative since an individual will surely try at least twice. Therefore, one can conclude that the average maximum force which can be applied to the movement of a vehicle door by the selected population (31 inches from pivot of hinges) is approximately 103 pounds. Values of these maximum forces ranged from 80 pounds to 148 pounds.

Recommendations

Recent unpublished studies at the University of Oklahoma of vehicle escape worthiness have demonstrated that a major hindrance to an individual's ability to escape is the numerous types and locations of door handles in vehicles. When a person rides in a strange vehicle he does not familiarize himself with the operation of passenger apparatus such as the door handle and the seat belt until it is too late. It is recommended that the location and type of door handle be standardized according to the specifications set in the conclusion section, so that unfamiliarity will no longer be such a hindrance during emergency vehicle egress.

Further research is required as to the design of the door handle, so that it will not only allow an individual to exert the maximum force but also minimize hazards caused by its protrusion from the door.

Another area for continued research would be to follow up on the concept of maximum unrestricted force to the door and investigate exactly what force is required to open the door under a certain given circumstance (see Chapter I).

The window crank and the door lock afford ample opportunity for extensive research in biomechanical analysis and in design.

Plots of day of the menstrual cycle versus each of the dependent variables revealed considerable scatter for this experiment. This was probably due to the variation between subjects. However, if subjects were tested throughout their menstrual cycle it might be found that a female's hormone secretion rate has a direct bearing on her strength capabilities. If subjects were controlled on the day in the menstrual cycle of minimum strength capabilities and the experiment was repeated, it is possible that average values may be significantly less.

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APPENDIX A

INSTRUCTIONS

Group Orientation

The purpose of this study is two-fold. For the first phase we are attempting to establish standards for an optimum location and type of interior door handle. To accomplish this, we are varying the location of the handle on the door and the type of door handle for each location. The other phase is to find exactly what maximum force can be applied to the movement of the door.

Phase I - Individual Instructions (when seated in vehicle)

Locate your right hand at 4:00 on the steering wheel. Place your feet as if you were driving. Sit comfortably in the seat but remain erect (positions were checked for uniformity at this time). Place your hand on the door handle and your elbow against the door. Pull each door handle as if you were opening the door, but apply as much force as possible. Put as much force as possible on the door with your elbow at the same time. Maintain your present sitting position through each phase. Let me impress upon you the importance of applying the maximum force possible. You will have sufficient time to rest between each trial. Once each handle has been mounted you may proceed at your discretion. Are there any questions?

Phase II - Individual Instructions (when seated in vehicle)

This time it will not be necessary to remain seated erect. You may use any part of your body for leverage. The object is to apply as much force as possible to the door. The manner in which you do this is left to your discretion. The only limitation is that you keep your left hand on the door handle. Once each handle has been mounted you may proceed at will. Are there any questions?

APPENDIX D

FLAMMABILITY APPENDICES

This appendix contains detailed listings of the ignition and burning rate data for motor vehicle interior materials. Figures 1 through 43 show the ignition times of the interior materials obtained from Illinois Institute of Technology Research Institute. (Samples were not available for all the materials IITRI tested.) The figures are preceded by a copy of IITRI's description of the materials. The sample numbers referred to on the figures correspond to the sample numbers in IITRI's description.

Tables 1 through 3 are listings of the individual results of the burning rate tests. Table 1 lists burning rates of the fabric and carpet samples, Table 2 summarizes the burning rates of materials used in automobile interior fire tests, and Table 3 summarizes the results of angled burning rate tests.

Table 4 presents a summary of the time dependence of light attenuation coefficients for the automobile interior fire tests.

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TABLE OF CONTENTS

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DESCRIPTION OF TEST MATERIALS

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 1	UPHOLSTERY COVER MATERIALS, CLOTH			
1	Chrysler	6.3	Tan	100% Nylon
2	Ford	8.4	Red	100% Nylon
3	Ford	12.0	Green	100% Nylon
4	Chrysler	8.3	Blue	100% Nylon
5	Cadillac	14.7	Gray	28.7% Nylon, 71.3% cotton
6	Oldsmobile	10.3	Tan	62.1% Nylon, 37.9% rayon
7	Pontiac	12.3	Blue	62.1% Nylon, 37.9% rayon
8	AMC	10.1	Blue	58.5% Nylon, 41.5% rayon
9	Cadillac	9.6	Blue	57.75% Nylon, 42.25% rayon
10	Cadillac	10.4	Green	57.5% Nylon, 42.5% rayon
11	Mercury	11.0	Blue	55.8% Nylon, 44.2% rayon
12	Cadillac	10.5	Green	55% Nylon, 45% rayon
13	Cadillac	10.4	Blue	54.52% Nylon, 45.48% rayon
14	AMC	8.6	Blue	54.3% Nylon, 45.7% rayon
15	Pontiac	8.8	Blue	53.5% Nylon, 46.5% rayon
16	Oldsmobile	11.4	Blue	52.71% Nylon, 47.29% rayon
17	Cadillac	11.2	Blk&Wh	48.6% Nylon, 51.4% rayon
18	Buick	9.2	Gold	47.55% Nylon, 52.45% rayon
19	Buick	9.9	Blue	47.55% Nylon, 52.45% rayon
20	Buick	11.3	Blue	46.82% Nylon, 53.18% rayon
21	Chevrolet	12.5	Maroon	40.4% Nylon, 59.6% rayon

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 1 CONTINUED				
22	Cadillac	14.4	Green	39.6% Nylon, 60.4% rayon
23	Oldsmobile	15.7	Maroon	38.57% Nylon, 61.43% rayon
24	Cadillac	13.3	Black	71.9% Nylon, 28.1% viscose
25	Dodge	9.6	Blue	60.9% Nylon, 39.1% viscose
26	Dodge	10.1	Green	60.9% Nylon, 39.1% viscose
27	Chrysler	9.1	Green	58.6% Nylon, 41.4% viscose
28	Oldsmobile	10.6	Black	57.54% Nylon, 42.46% viscose
29	Plymouth	8.6	Red	54.08% Nylon, 45.92% viscose
30	Plymouth	9.6	Green	53.97% Nylon, 46.03% viscose
31	Plymouth	9.4	Black	53.97% Nylon, 46.03% viscose
32	Pontiac	9.3	Black	52.53% Nylon, 47.47% viscose
33	Plymouth	9.6	Blue	52.16% Nylon, 47.84% viscose
34	Chrysler	10.9	Black	49.8% Nylon, 50.2% viscose
35	Chrysler	10.7	Blue	49.8% Nylon, 50.2% viscose
36	Chevrolet	9.6	Green	49.1% Nylon, 50.9% viscose
37	Dodge	10.2	Blue	47.9% Nylon, 52.1% viscose
38	Plymouth	11.1	Gold	44.62% Nylon, 55.38% viscose
39	Plymouth	11.3	Green	44.62% Nylon, 55.38% viscose
40	Oldsmobile	10.5	Tan	53.19% Nylon, 0.75% dacron, 46.06% averil
41	Buick	14.2	Gold	37.18% Nylon, 24.34% cotton, 38.48% rayon
42	Buick	21.0	Gold	29.02% Nylon, 49.76% cotton, 21.22% rayon
43	AMC	11.1	Dk.Blue	36.1% Nylon, 8.9% polypropylene, 55.0% rayon

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 1 CONTINUED				
44	AMC	11.7	DkBlue	36.1% Nylon, 8.9% polypropylene, 55.0% rayon
45	Chevrolet	10.3	Blue	53.41% Nylon, 4.2% metallic, 42.39% rayon
46	Chevrolet	13.1	Black	42.2% Nylon, 28.7% cotton, 29.1% viscose
47	Chevrolet	8.4	Blue	46.59% Nylon, 2.7% polypropylene, 50.71% viscose
48	Dodge	9.6	Brown	41.25% Nylon, 7.12% polypropylene, 51.63% viscose
49	Chevrolet	8.8	Blue	42.06% Nylon, 7.28% polypropylene, 49.95% viscose, 0.71% metallic
50	Ford truck	9.1	Rd&Blk	100% Saran
78	Ford	10.1	Black	Woven nylon and rayon
79	Ford	8.5	Black	100% Nylon knit
86	Chrysler	9.2	Gold	Cloth; nylon warp, rayon fill
87	Chrysler	11.4	Gold	Cloth; nylon warp, rayon fill (different weave than No. 86)
97	Gen Motors	15.9	Gray	Cloth; nylon, rayon
98	Gen Motors	9.2	Black	Cloth; nylon, rayon
99	Amer Motors	14.4	Platinum	Cloth ("velour"); 73.2% nylon, 26.8% avril
100	Amer Motors	7.7	Gray	Cloth ("madison"); 40.45-40.51% nylon, 59.49-59.55% rayon
101	Amer Motors	9.5	Blue	Cloth ("aragon"); 58.5% nylon, 41.5% rayon
102	Amer Motors	12.4	Gl&Blk	Cloth ("glengarry"); 52.06% nylon, 47.94% viscose
104	Amer Motors	12.6	Black	Cloth ("brigadier"); 55% rayon, 36.1% nylon, 8.9% acetate
105	Amer Motors	11.1	Brown	Cloth("doric"); 53.32% viscose, 46.68% nylon

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 1 CONTINUED				
106	Amer Motors	10.0	Gold	Cloth ("carthage"); 54% viscose, 36.4% nylon, 9.6% avril
107	Amer Motors	9.3	Brown	Cloth ("cloister"); 54.25% nylon, 45.75% rayon
109	Amer Motors	8.8	Tan	Cloth ("trafalgar"); 50.2% avril, 49.8% nylon
199	Volvo	15.5	Grey	Cloth; 65% wool, 35% rayon; impregnated with water repellant (Volvo part No. 93520)
232	Gen Motors	31.2	Blue (69)	Fabric by Deering Milliken, Inc., finished construction 170 X 47, for Buick and Oldsmobile; 15 oz/sq yd
233	Gen Motors	28.4	Gold (69-29)	Fabric by Deering Milliken, Inc., finished construction 142 X 50, for Pontiac Catalina; 14 oz/sq yd
234	Gen Motors	40.4	Green (69-31)	Fabric by Deering Milliken, Inc., finished construction 171 X 76, for Chevrolet Caprice; 17 oz/sq yd
CATEGORY 2 UPHOLSTERY COVER MATERIALS, VINYL FABRICS				
53	Chrysler	33.0	Gold	100% Vinyl
56	Ford	10.8	Turq	12-Gauge vinyl
58	Gen Motors	18.0	Gray	Vinyl face, cotton back
59	Gen Motors	15.6	Gray	Vinyl face, cotton back
60	Ford	23.6	Blue	Vinyl face, cotton back
61	Chrysler	14.4	Burgundy	Vinyl face, cotton sateen back
62	Ford	24.1	Beige	Vinyl face, cotton moleskin back
63	Ford	19.7	Beige	Vinyl face, cotton jersey back

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 2 CONTINUED				
64	Ford	21.5	Fawn	Vinyl face, cotton jersey back
65	Chrysler	25.2	Black	Vinyl face, cotton jersey back
66	Ford	35.2	Aqua	Vinyl face, cotton jersey back
67	Gen Motors	12.6	Gold	Vinyl face, coated paper back
68	Chrysler	21.0	Gray	Vinyl face, synthetic nonwoven back
69	Ford	17.2	Red	Vinyl face, synthetic nonwoven back
70	Gen Motors	25.4	LtBlue	Dynel face, synthetic nonwoven back
71	Ford	15.5	DkBlue	Vinyl face, coated cotton knit back
76	Ford	28.5	Black	Vinyl face, cotton knit back
77	Ford	23.7	Black	Vinyl face, broken twill cotton back
91	Chrysler	24.9	Gray	Vinyl face, knit cotton (6 oz/yd^2) back
103	Amer Motors	28.5	Green	Vinyl ("ventilair," "cloister")
108	Amer Motors	22.4	Green	Vinyl ("basketweave")
110	Gillig Bros	24.1	Yellow	Bus seating; vinyl on cotton knit; 80% vinyl, 20% cotton (Interchem. Corp. No. 2700-03562)
111	Gillig Bros	27.0	Green	Bus seating; vinyl on cotton sateen; 65% vinyl, 35% cotton (Interchem. Corp. No. 1201-45858)
112	Gillig Bros	34.0	Green	Bus seating; vinyl on cotton sateen; 72% vinyl, 28% cotton (Interchem. Corp. No. 0901-45851)
131A	Gen Motors	23.9	Black	Vinyl coated cotton outer cover
132B	Gen Motors	23.1	Black	Vinyl coated cotton (backrest trim)
133	Gen Motors	22.2	Green	Vinyl face, sateen back (T-9412 item U32-61 by UniRoyal)

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 2 CONTINUED				
135	Gen Motors	21.6	Black	Vinyl face, elastic back (T-9012 item U31-101 by UniRoyal)
136	Gen Motors	15.0	Green	Vinyl face, elastic back (T-3112 item U32-60 by UniRoyal)
197	Volvo	21.1	Tan	Vinyl face, cotton twill back (Volvo part No.91701)
210A	Datsun	20.9	---	Cover only; vinyl face, fabric back
211A	Datsun	42.8	---	Cover only; vinyl face, fabric back
228A	Volkswagen	23.2	---	Outer cover; vinyl face, fabric back
CATEGORY 3 CUSHIONING MATERIALS				
81	Ford	30.24	Beige	Seat pad; garnetted cotton
82	Ford	12.2	White	Seat pad; urethane foam on cotton sheeting 1/2-in.thick
131C	Gen Motors	56.5	Cream	Latex foam from backrest, approx. 1-in. thick; cores of 3/4-in. diam, 1/2-in deep, on 1-1/8 in. centers
131D	Gen Motors	119	Cream	Latex foam from seat; approx. 1-7/8-in.thick; cores of 3/16-in diam, 1-in. deep, on 7/8-in. centers
131E	Gen Motors	34.5	---	Burlap and cotton pad assembly; approx. 1/2-in.thick
132H	Gen Motors	33.3	White	Foam cushion, approx. 1-3/8-in. thick
175	Chrysler	46.2	White	Seat pad; molded urethane foam, 2-in.thick
176	Chrysler	93.7	Cream	Seat pad; molded latex foam, 2-in.thick cores of 3/4-in diam, 1-1/2-in. deep, on 1-5/16-in.centers
177	Chrysler	73.8	---	Seat pad; cotton fiber with burlap and tobacco cloth support, 2-in. thick
178	Amer Motors	33.7	---	Seat pad; foamed; 1-1/2-in.thick
179	Amer Motors	53.6	White	Seat pad; molded foam; apparently latex; 3/4-in.thick cores of 9/32-in.diam, 5/16-in deep, on 1-1/8-in. centers

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 3 CONTINUED				
181	Amer Motors	125.4	Cream	Seat pad; molded and stiffened foam; 1-1/4-in.thick
228C	Volkswagen	8.3	---	Foam layer, approx. 9/32-in.thick
228D	Volkswagen	52.3	---	Matted fiber pad, approx. 7/8-in.thick
235	None	121.6	White	Latex foam; 2-in.thick; cores of 11/16-in.diam, 1-5/8-in.deep, on 1-1/16-in. centers
CATEGORY 4 ASSEMBLIES OF SEATING COMPONENTS				
131	Gen Motors	---	Black	Bucket seat assembly; vinyl cushion and back in-inserts of vinyl skin, vinyl foam and cotton back (total 27 oz/yd^2); vinyl side facings of vinyl face and cotton back (total 21.6 oz/yd^2)
A		23.9	Black	Vinyl coated cotton outer cover
B		48.5	Black	Cover assembly of vinyl fabric, foam, and cloth
C		56.6	Cream	Latex foam from backrest, approx. 1-in.thick; cores of 3/4-in. diam, 1/2-in. deep, on 1-1/8-in.centers
D		119	Cream	Latex foam from seat; approx. 1-7/8-in.thick; cores of 3/16-in. diam, 1-in. deep, on 7/8-in. centers
E		34.5	---	Burlap and cotton pad assembly; approx. 1/2-in.thick
F		100	Black	Solid plastic rear panel of backrest, approx. 1/8-in.
G		140	Black	Complete backrest cushion assembly (B, C, E above)
H		202	Black	Complete seat cushion assembly (B, D, E above)
132	Gen Motors	---	Black	Front seat assembly, bench-type
A		6.0	Gray	Cloth for tying cushion to spring
B		23.1	Black	Vinyl coated cotton (backrest trim)
C		35.6	Black	Trim assembly of vinyl fabric, foam, and cloth

IITRI SAMPLE NO.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 4 CONTINUED				
D	Gen Motors	32.2	Black	Cover assembly of fabric (53.2% nylon, 46.8% viscose) foam, and cloth
E		7.2	---	Burlap
F		7.9	Green	Dust cover pad, approx. 1/8-in. thick
G		131	Black	Complete backrest assembly (D, + burlap and approx. 2-3/4-in. cotton pad assembly)
H		33.3	White	Foam Cushion, approx. 1-3/8-in. thick
I		102	Black	Complete seat cushion assembly (D, H and approx. 1/2-in. cotton pad assembly)
J		35.9	Black	Seat belt
210	Datsun	---	Aqua	Driver seat back (Datsun part No. 87620-23102)
A		20.9	---	Cover only; vinyl face, fabric back
B		45.8	---	Cover, foam filler, cloth back
211	Datsun	---	Red	Driver seat cushion (Datsun part No. 87320-22000)
A		42.8	---	Cover only; vinyl face, fabric back
B		23.8	---	Cover, foam filler, cloth back

IITRI SAMPLE NO.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 4 CONTINUED				
228	Volkswagen	---	Red	Rear Backrest
A		23.2		Outer cover; vinyl face, fabric back
B		40.4	---	Cover, felt backing (approx. 1/8-in. thick) and cloth
C		8.3	---	Foam layer (approx. 9/32-in. thick)
D		52.3	---	Matted fiber pad (approx. 7/8-in. thick)
E		89.4	---	Cover and felt backing over matted fiber pad (B&D of above)
F		147.8	---	Back panel (floor when seat is folded); plastic (or rubber) - covered fabric bonded to approx. 1/8-in. hardboard
235	None	121.6	White	Latex foam; 2-in. thick; cores of 11/16-in. diam, 1-5/8-in. deep, on 1-1/16-in. centers
236	None	174	---	Assembly of cover material, latex foam, and cotton pad; Samples No. 58, 235, and 131E
237	None	171	---	Assembly of cover material, latex foam, and cotton pad; Samples No. 5, 235, and 131E

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 5 HEADLINER MATERIALS				
51	Gen Motors	7.1	Gray	100% Cotton
52	Gen Motors	6.0	Green	100% Cotton
54	Gen Motors	12.2	Green	Vinyl face, cotton back
55	Gen Motors	10.8	Red	Vinyl face, cotton back
57	Ford	12.6	Pink	Vinyl face, cotton back
88	Chrysler	4.4	Tan	Headlining; napped knit nylon fabric
89	Chrysler	11.5	Aqua	Headlining; discontinuous vinyl coated 1.85 cotton drill fabric
90	Chrysler	11.5	Beige	Headlining; perforated vinyl coated 1.85 cotton drill fabric
94	Gen Motors	12	Black	Headlining; perforated; vinyl face, cotton back
95	Gen Motors	4.2	Black	Headlining; napped nylon
134	Gen Motors	11.6	Gold	Headlining; vinyl face, cotton osnaburg back (T-6012 item U32-67 by UniRoyal)
185	Amer Motors	51.8	White	Headliner assembly; foam padded; multilayered (6 layers), approx. 5/8-in.thick
186	Amer Motors	49.4	Red	Headliner assembly; foam padded; multilayered (4 layers); approx. 5/8-in.thick
187	Amer Motors	34.2	Blue	Headliner assembly; fabric over 1/2-in.thick glass-fiber pad; with paper back
198	Volvo	14.2	White	Vinyl face, knitted back of 67% cotton and 33% rayon (Volvo part No. 91702)
205	Datsun	11.0	White	Headliner; vinyl face, fabric back (Datsun part No. 73910-22500)
214	Volkswagen	111.8	White	Headliner; vinyl face, fabric back

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 6 FLOOR COVERINGS				
80	Ford	47.6	Black	Carpet, loop pile; 80% rayon, 20% nylon
92	Chrysler	45.0	Black	Carpet; 80% rayon, 20% nylon; loop pile with a polyethylene-polymethylene backing
93	Chrysler	36.6	Brown	Carpet; 100% nylon cut pile with a polyethylene-polymethylene backing
115	Gen Motors	---	Black	Front floor molded carpet assembly; nylon and viscose face, jute back
A		93.4	---	Complete assembly, carpet with jute back
B		45.4	---	Carpet only; jute back removed
116	Gen Motors	---	Black	Front floor molded carpet assembly; nylon face, jute back
A		81.0	Black	Complete assembly; carpet with jute back
B		41.7	Black	Carpet only; jute back removed
C		37.1	Black	Carpet only; originally without jute back
125	Gen Motors	112.7	Black	Front floor mat, rubber
188	Amer Motors	40.6	Blue	Cut pile carpet
189	Amer Motors	39.9	Green	Cut pile carpet
190	Amer Motors	43.6	Red	Cut pile carpet
191	Amer Motors	41.3	Black	Cut pile carpet
192	Amer Motors	43.2	Olive	Cut pile carpet
193	Amer Motors	44.1	Brown	Cut pile carpet
202	Volvo	62.8	Grey	Carpet, 100% nylon pile with two-layer base of hessian fabric bonded with latex (Volvo part No. 95600)

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 6 CONTINUED				
203	Datsun	---	Red	Carpet, loop pile (Datsun part No. 74902-23500)
A		37.5	---	Carpet alone
B		151.4	---	Carpet with footrest of black rubber sheet sewn over pile
220	Volkswagen	48.5	Grey	Loop pile carpet; front quarter-panel
224	Volkswagen	71.9	Black	Floor covering; dimpled rubber (or plastic)
225	Volkswagen	41.4	Grey	Closed loop carpet; dash sealer
CATEGORY 7 DOOR PANELS				
84	Ford	5.6	Blue	Padding for door panel; resinated rayon-vinyon fibers with flame retardant treatment
127	Gen Motors	---	---	Front door trim assembly; vacuum formed; ABS, foam
A		108.2	---	Carpet over hardboard
B		61.6	---	Fabric, 1/8-in.thick padding, 2 layers of card-board backing
C		109.2	---	Plastic cover over hardboard
D		157	---	Plastic cover, 1/2-in.thick foam, hardboard backing
128	Gen Motors	---	---	Front door trim assembly; vinyl coated fabric (21.6 oz/yd^2), aluminum trim panel, metallized ABS back plate, metal molding
A		90	---	Vinyl coated fabric, fiber pad, 2-layer cardboard back; decorative stripes with heat-sealed seams 1-11/16-in. apart
B		96.7	---	Metallized ABS back plate, approx. 3/16-in.thick
137	Gen Motors	15.1	Olive	Door panel material; vinyl face impregnated paper back (T-10512 item U6-100 by UniRoyal)

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 7 CONTINUED				
180	Amer Motors	90.3	Black	Door panel; bottom section; carpet on 3/32-in. cardboard
183	Amer Motors	97.6	Silver	Door panel; vinyl coated fabric, fiber pad, cardboard back
184	Amer Motors	68.0	Brown	Door panel; vinyl coated fabric on cardboard back
195	Chrysler	---	Gold	Door trim panel
A		111.8	---	Carpet over hardboard
B		105.8	---	Vinyl coated fabric, fiber pad, and hardboard
196	Chrysler	---	Brown	Door trim panel
A		97.5	---	Unsupported vinyl film, fiber pad, and hardboard
B		109.0	---	Vinyl coated paper (simulated wood grain), unsupported vinyl film, fiber pad, and hardboard
212	Datsun	96.2	Blue	Door panel; vinyl film, fiber layer, and paper hardboard back (Datsun part No. 80900-23102)
CATEGORY 8 QUARTER PANELS, FILLER PANELS, COWL PANELS				
83	Ford	64.3	Black	Package tray, painted pressed wood panel board
113	Gen Motors	46.5	Black	Rear window panel; painted cardboard
114	Gen Motors	63.4	Black	Rear window panel; painted woven fiber cardboard
161	Amer Motors	68.4	Charcoal	Rear quarter panel; sedan; polypropylene (AM part No. 3623840)
162	Amer Motors	105.7	Charcoal	Cowl panel assembly; ABS type D (AM part N. 3623976)
174	Chrysler	62.7	Blue	Cowl panel; injection-molded polypropylene
207	Datsun	103.0	Red	Trim panel (apparently filler panel or rear window shelf); vinyl film, urethane foam, and hardboard paper (Datsun part No. 79910-22000)

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 8 CONTINUED				
216	Volkswagen	110.8	Red	Wall panel; plastic cover over approx. 3/32-in. hardboard
CATEGORY 9 INSULATION AND SOUND DEADENERS (INCLUDING DASH SEALS AND UNDERCARPET PADS)				
117	Gen Motors	---	Black	Dash insulator assembly, rubber face, wood conversion pad back
A		123.6	Black	Approx. 1/32-in.thick rubber over 1/2-in.thick padding
B		219.5	Black	Approx. 1/32-in. cardboard, over 1/8-in. rubber and 1/2-in. thick padding
194	Chrysler	75-85	Brown	Jute padding; under-carpet pad
201	Volvo	167.0	Grey	Insulating mat (carpet underlayer); 3-5-mm thick face of PVC with heavy filler over approx. 3/16-in. thick polyether foam back (foam density, 22 kg/cu.m.) Volvo part No. 95505-1
213	Datsun	32.3	Tan	Floor mat; jute felt (Datsun part No. 74921-21400)
215	Volkswagen	180.1	Tan	Dash sealer; tar-like black material between 2 layers of felt
217	Volkswagen	117.5	Black	Floor pad (carpet underlayer); impregnated cardboard, cushioning, and tarlike backing
218	Volkswagen	122.0	Tan	Filler panel underlayer; plastic sheet between 2 layers of felt
219	Volkswagen	14.4	Tan	Roof insulation; felt and jute layers
221	Volkswagen	36.1	Black	Underlayer for wall panel; impregnated cardboard
222	Volkswagen	186.9	Grey	Rear floor mat underlayer; tarlike material over pressed fiber backing
227	Volkswagen	14.7	Grey	Matted fiber pad (apparently cotton)

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 10 DASHBOARD AND INSTRUMENT PANEL COMPONENTS				
85	Ford	34.0	Black	Crash pad skin, ABS
129	Gen Motors	---	---	Instrument panel cover assembly; ABS and foam over sheet metal; nonuniform thickness
159	Amer Motors	92.3	Charcoal	Instrument cluster bezel; ABS type C, with lacquer paint (AM part No. 3623572)
160	Amer Motors	93.8	Green	A/C bezel assembly; ABS type E, with lacquer paint and nylon parts (AM part No. 3623593)
165	Amer Motors	121	---	I.P. panel overlay 6800; ABS type C, with acrylic parts
172	Chrysler	39.5	Turq	Instrument panel crash pad; ABS over urethane foam, with metal reinforcement
173	Chrysler	316	Black	Instrument panel crash pad; vinyl plastisol over urethane foam, with metal reinforcement
CATEGORY 11 SUN VISORS				
130	Gen Motors	184.6	---	Sunshade assembly; perforated vinyl coated fabric face, resinated cotton padding; approx. 1-in.thick
170	Chrysler	158.2	Blue	Sun visor; vinyl coated 2.35 osnaburg (total weight of cover, 11.3 oz/yd^2); padded
182	Amer Motors	212.1	Gold	Sun visor; padded; 1-in.thick
204	Datsun	49.0	White	Sun visor; 2 layers of urethane foam covered by vinyl sheets (Datsun part No. 9640-2162)
229	Volkswagen	52.5	White	Sun visor; approx. 5/8-in. thick
CATEGORY 12 ARM RESTS				
126	Gen Motors	---	---	Front door arm rest assembly; polypropylene base, foam padding, vinyl coated fabric

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 12 CONTINUED				
126				
A		78.5	---	Polypropylene base alone
B		138	---	Vinyl coated fabric cover over foam
166	Amer Motors	201	Blue	Armrest; vinyl face, foam fill, and high-impact styrene (AM part No. 3620360)
169	Amer Motors	---	White	Armrest plug; vinyl (AM part No. 3620387)
171	Chrysler	---	Tan	Armrest; vinyl plastisol over urethane foam
208	Datsun	573.5	Black	Armrest; vinyl over urethane foam with metal insert (Datsun part No. 80940-21600)
CATEGORY 13 RESTRAINT BELTS				
132J	Gen Motors	35.9	Black	Seat belt
209	Datsun	44.7	Black	Seat belt; nylon (Datsun part No. 88820-22904)
230	Volkswagen	42.8	Black	Seat belt
CATEGORY 14 LUGGAGE COMPARTMENT LINERS				
118	Gen Motors	71.5	Blk&Wht	Trunk compartment mat; rubber
119	Gen Motors	17.9	Blk&Wht	Trunk compartment mat; vinyl coated cotton on foam
120	Gen Motors	10.0	Black	Trunk compartment mat; needled rayon
231	Volkswagen	202.2	Grey	Liner for package space behind rear seat; 4 layers
CATEGORY 15 WHEELHOUSING COVERS AND CARGO PANELS				
96	Gen Motors	22.9	Black	Wheelhouse cover; vinyl face, rayon back
156	Amer Motors	70.8	Blue	Cargo panel; polyethylene (AM part No. 3623870)
157	Amer Motors	83.2	Blue	Spare wheel cover; polyethylene (AM part No. 3620545) over 1/8-in.thick pad

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 15 CONTINUED				
223	Volkswagen	65.7	Grey	Rear wheel cover; dimpled plastic (or rubber) with impregnated cardboard backing
CATEGORY 16 CONVERTIBLE AND HARDTOP COVER MATERIALS				
72	All	21.4	Black	Single texture hardtop covering, closed cloth backing
73	All	23.9	Black	Double texture hardtop covering, open cloth backing
74	All	24.2	Black	Double texture hardtop covering, closed cloth backing
75	Chrysler	21.2	Black	Double coated nylon convertible topping, no cloth backing
CATEGORY 17 ADHESIVES, SEALERS, ETC.				
122	Gen Motors	---	Tan	Cement (typical), by Armour
123	Gen Motors	---	White	Sealer (typical)
124	Gen Motors	---	Black	Deadener (typical), by Mortell
138	Chrysler	---	White	Thumb grade Curable plastisol (300°F flash point[(1)])*
139	Chrysler	---	Clear	Trim adhesive; solvent based (33°F flash point[(1)])
140	Chrysler	---	Gray	Roof bow adhesive-sealer (105°F flash point[(1)])
141	Chrysler	---	White	Seam sealer; curable plastisol (280°F flash point[(1)])
142	Chrysler	---	Gray	Thumb grade mastic, hole sealing (350°F flash point[(1)])
143	Chrysler	---	Buff	Weldable seam sealer, heat expanding (187°F flash point[(1)])

*See footnotes at end of table.

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 17 CONTINUED				
144	Chrysler	---	Gray	Trunk compartment sealer (280°F flash point[1]
145	Chrysler	---	Yellow	Trim adhesive; solvent based (12°F flash point[2])
146	Chrysler	---	Tan	Trim adhesive; solvent based (0°F flash point[1])
147	Chrysler	---	Black	Underbody seam sealer (400°F flash point[1])
148	Chrysler	---	Gray	Weldable seam sealer, structural (145°F flash point[1])
149	Chrysler	---	Gray	Gun-grade mastic, windshield and backlight (100°F flash point[3])
150	Chrysler	---	Buff	Trim adhesive, water based (175°F flash point[2])
151	Chrysler	---	Black	Underbody seam sealer (400°F flash point[1])
152	Chrysler	---	White	Mastic, ribbon form (250°F flash point[2])
153	Amer Motors	---	Tan	Edge trim adhesive for door panels, solvent based (No. EC4482 by 3M Co.)
154	Amer Motors	---	Black	Floor seam sealer, passenger compartment, asphaltic (No. 88-22 by Mortell Co.)
155	Amer Motors	---	Red	Metal-to-metal mastic for hoods, deck lids, and roof bows; plastisol (No. E-611 by Protective Treatments, Inc.)
CATEGORY 18 ELECTRIC WIRING				
121	Gen Motors	---	---	Wire harness assembly
A		---	---	Smallest single conductor, SAE wire size 20
B		---	---	Largest single conductor, SAE wire size 10
C		40.1	---	Outer sheath, flat black plastic tube, approx. 0.040-in. wall

IITRI SAMPLE No.	VEHICLE MANUFACTURER	WEIGHT oz/yd^2	COLOR	DESCRIPTION
CATEGORY 18 CONTINUED				
121				
D		21.5	---	Outer sheath, round black plastic tube, approx. 0.030-in. wall
E		---	---	Assembly of conductors in round sheath
206	Datsun	---	---	Wire harness (Datsun Part No. 24012-A2600)
226	Volkswagen	47.8	---	Wire harness
CATEGORY 19 MISCELLANEOUS INTERIOR TRIM MATERIALS				
158	Amer Motors	88.0	Brown	Side window trim; ABS Type C, with lacquer paint (AM part No. 3623854)
163	Amer Motors	---	Olive	Hook retainer, nylon (AM part No. 3620505)
164	Amer Motors	53.2	Blue	Steering column cover; polyethylene (AM part No. 3193694)
167	Amer Motors	60.1	Black	Seat side cover; polyethylene (AM part No. 3623664)
168	Amer Motors	92.1	Brown	Rear window garnish molding; ABS Type E with lacquer paint (AM part No. 3620038)
200	Volvo	27.6	Tan	Leather; 1.25 ± 0.25 mm thick; (Volvo part No. 94202)

1. Cleveland Open Cup Method
2. Tag Open Cup Method
3. Pinsky-Martin Closed Cup Method

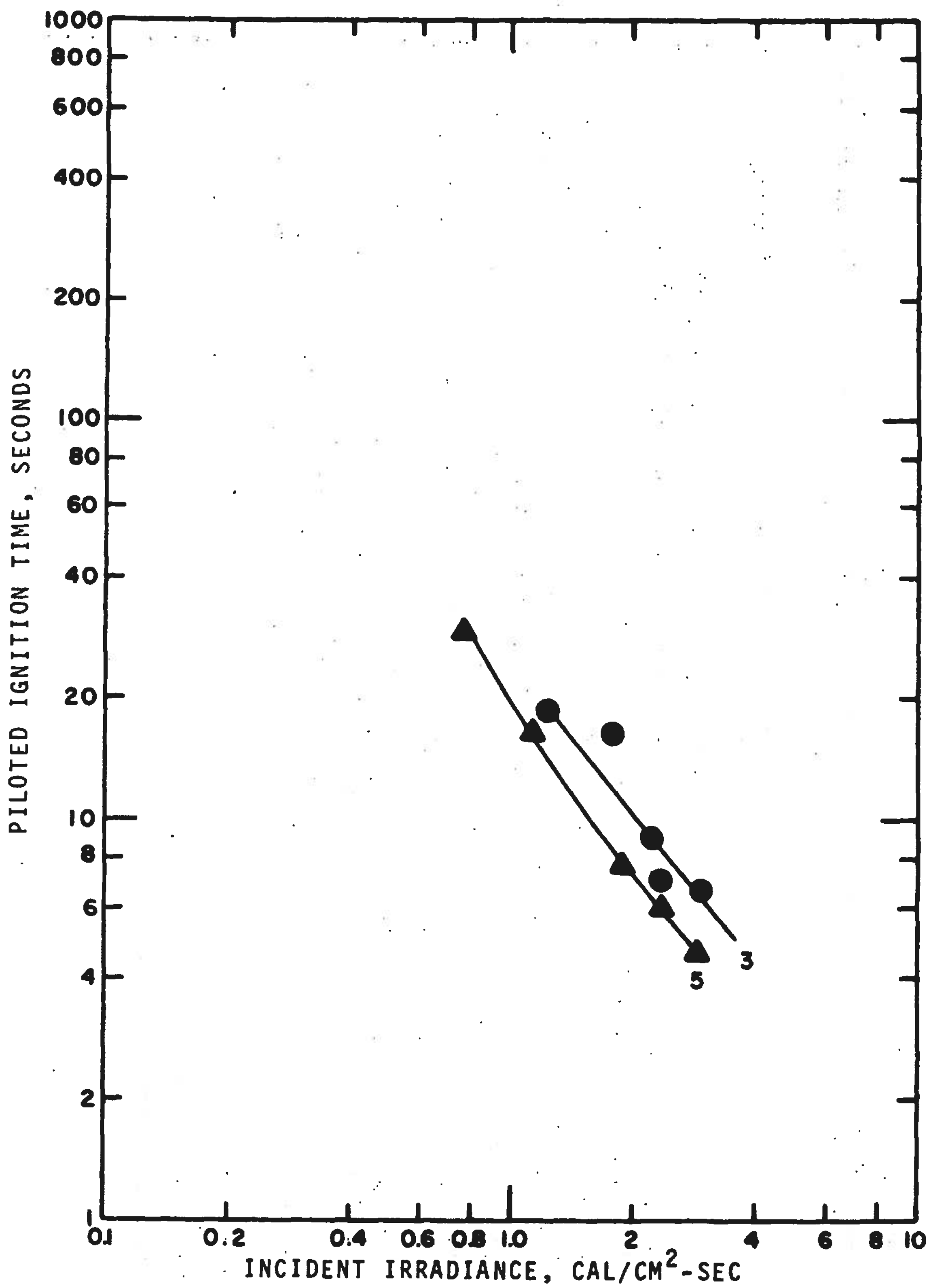


Figure 1. Ignition of IITRI samples Nos. 3 (nylon fabric) and 5 (nylon-cotton fabric).

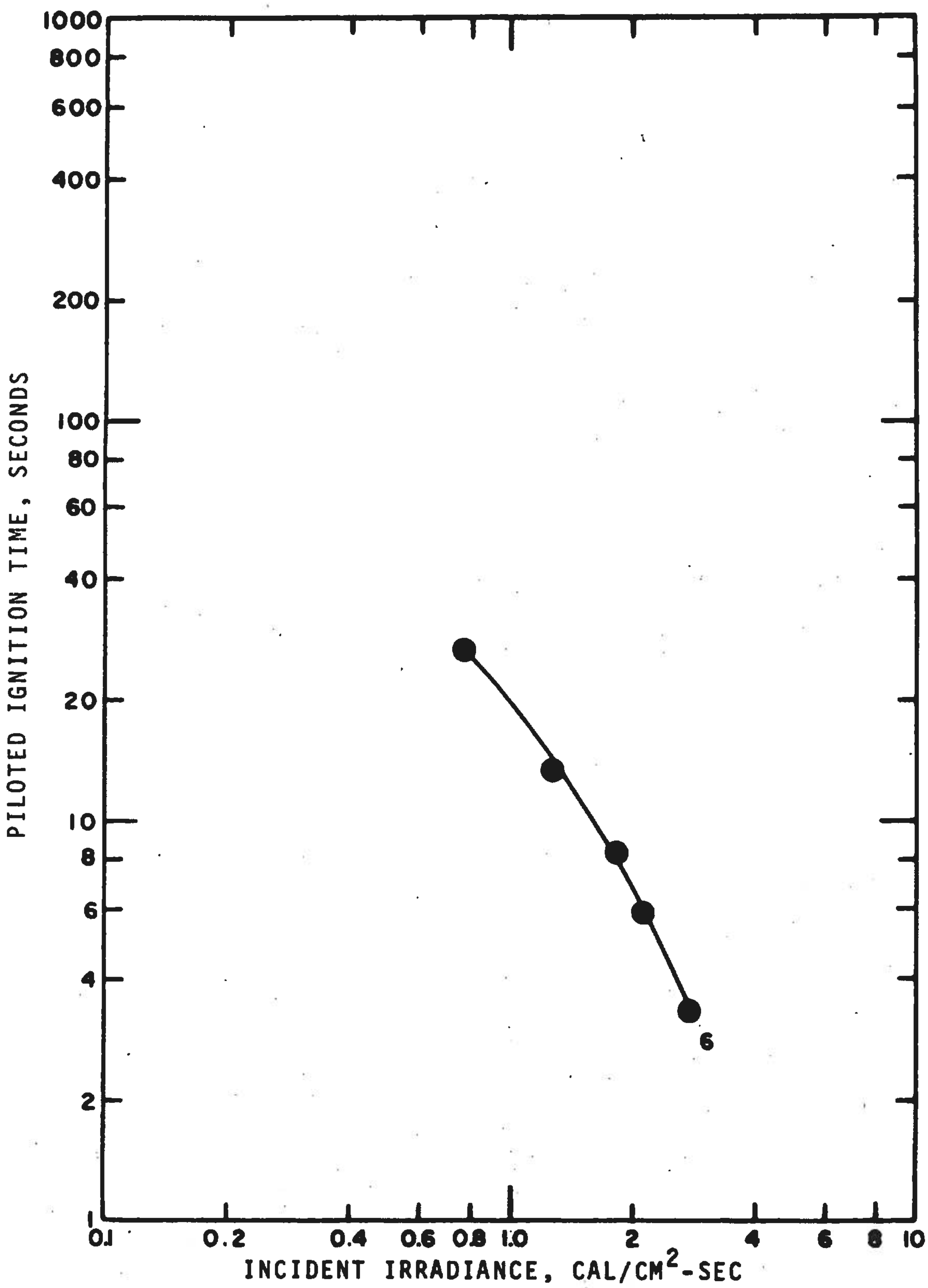
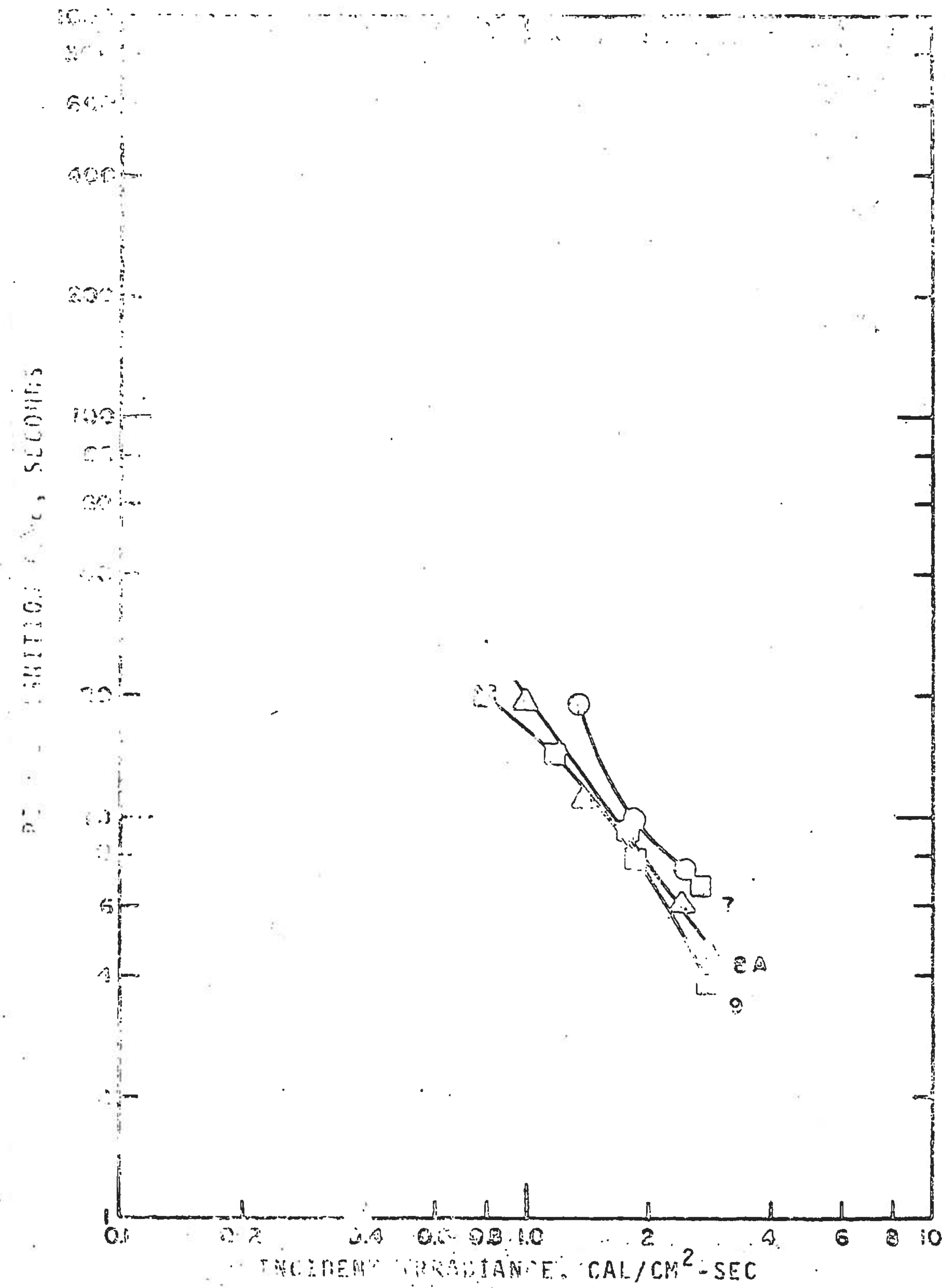


Figure 2. Ignition of IITRI sample No. 6 (nylon-rayon fabric).



[illegible] of [illegible] samples Nos. 7 (nylon-rayon fabric), 8A (nylon-rayon fabric), and 9 (nylon-rayon fabric).

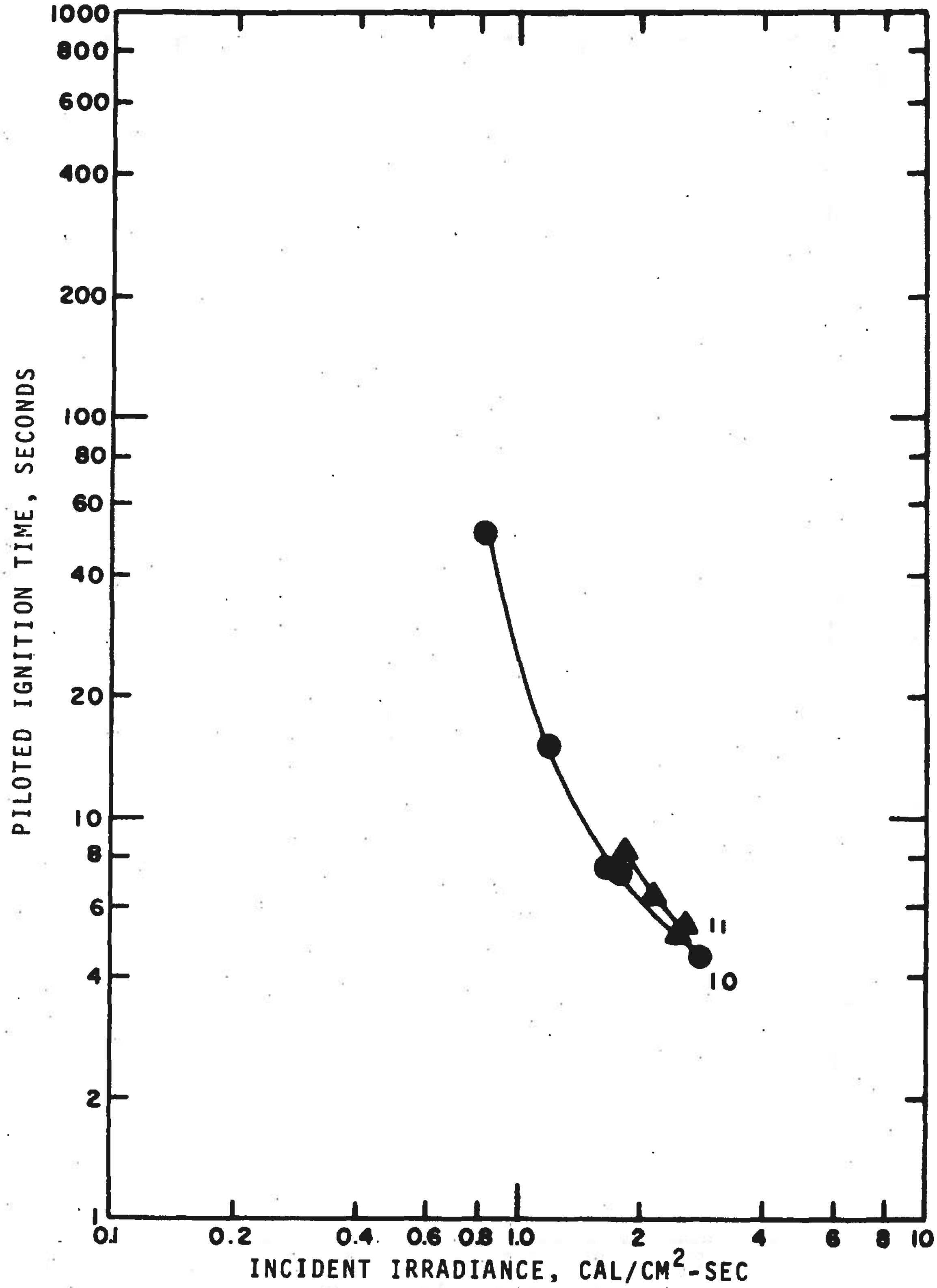


Figure 4. Ignition of IITRI samples Nos. 10 (nylon-rayon fabric) and 11 (nylon-rayon fabric).

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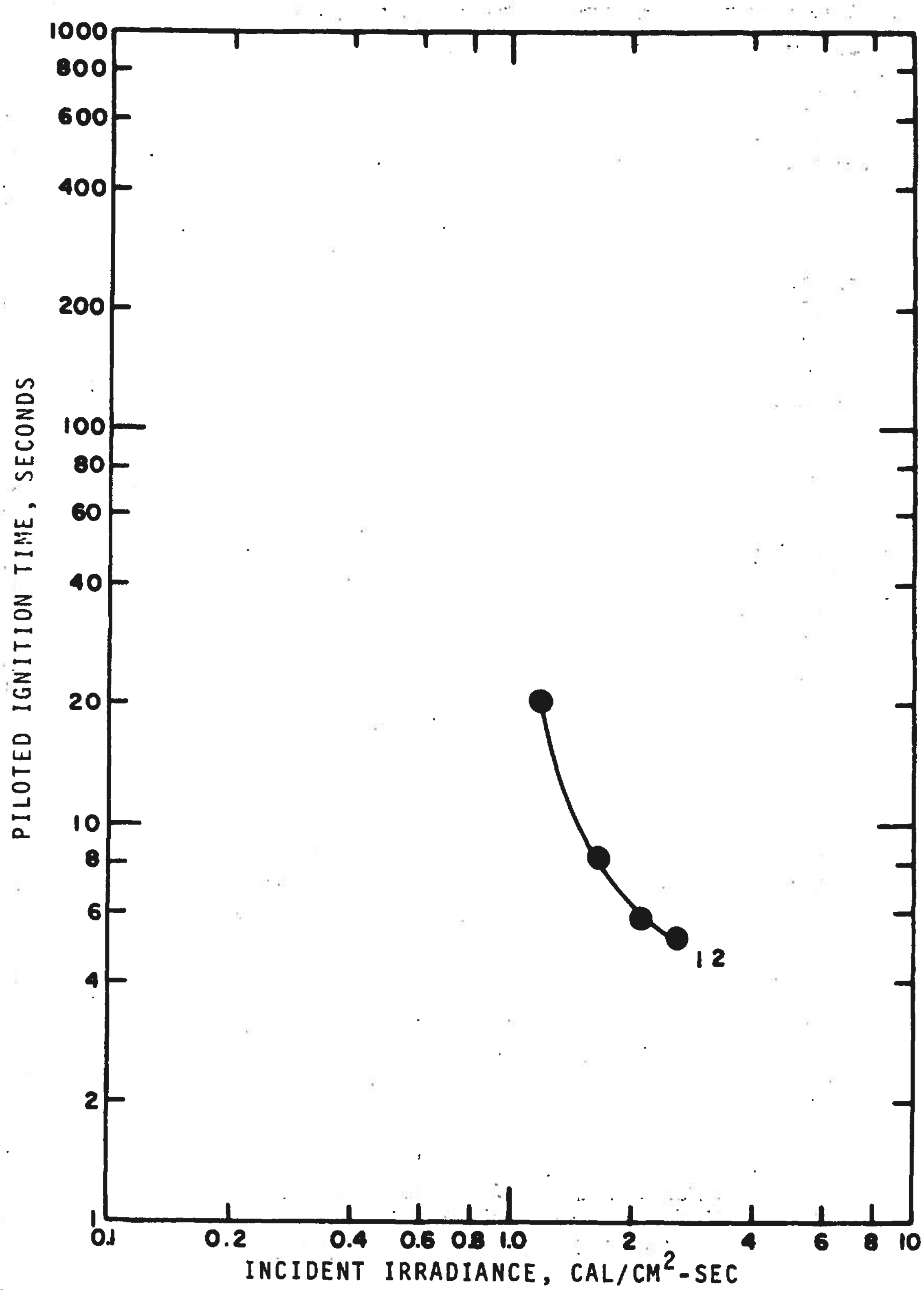

Figure 5. Ignition of IITRI sample No. 12 (nylon-rayon fabric).

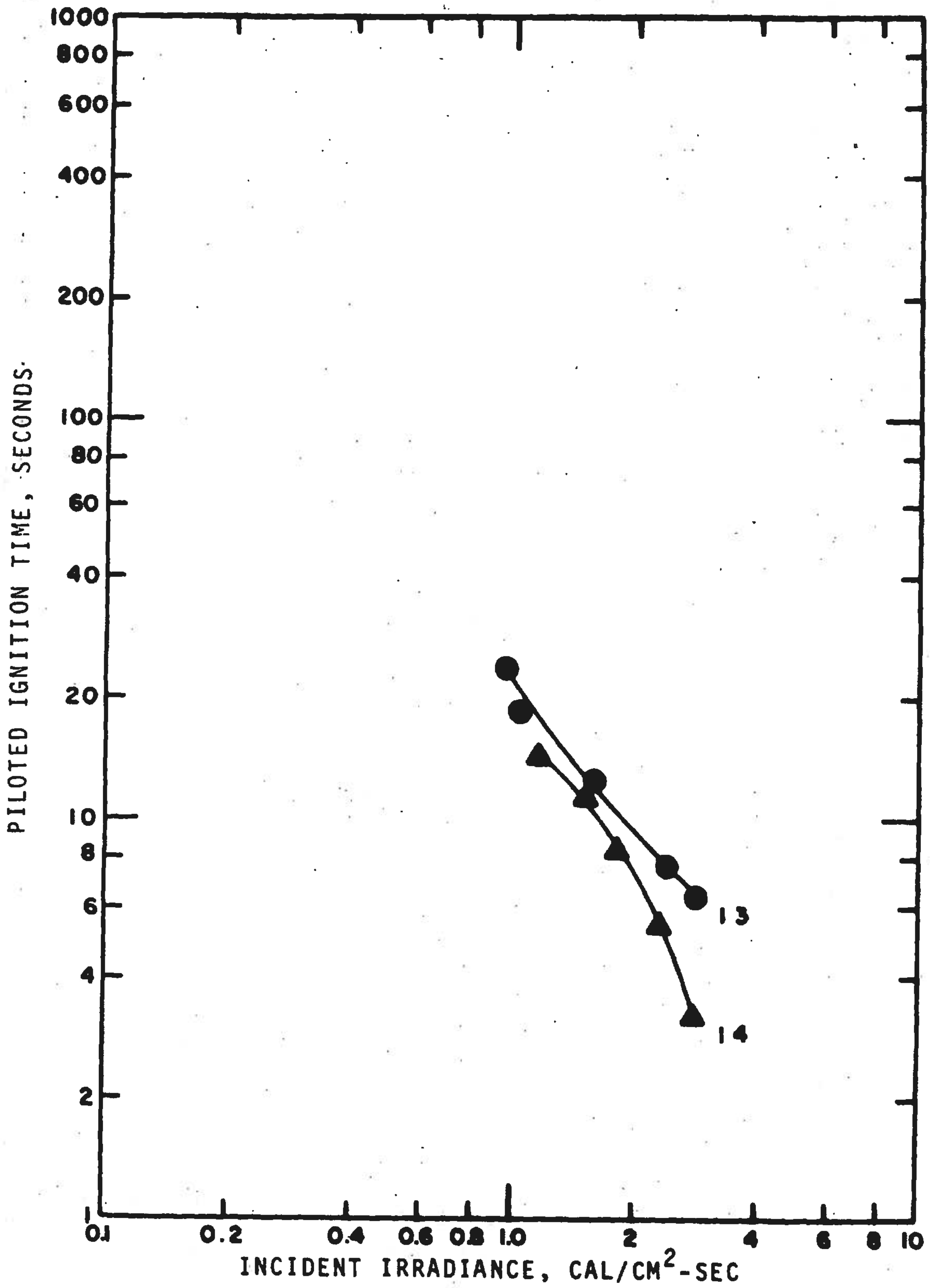

Figure 6. Ignition of IITRI samples Nos. 13 (nylon-rayon fabric) and 14 (nylon-rayon fabric).

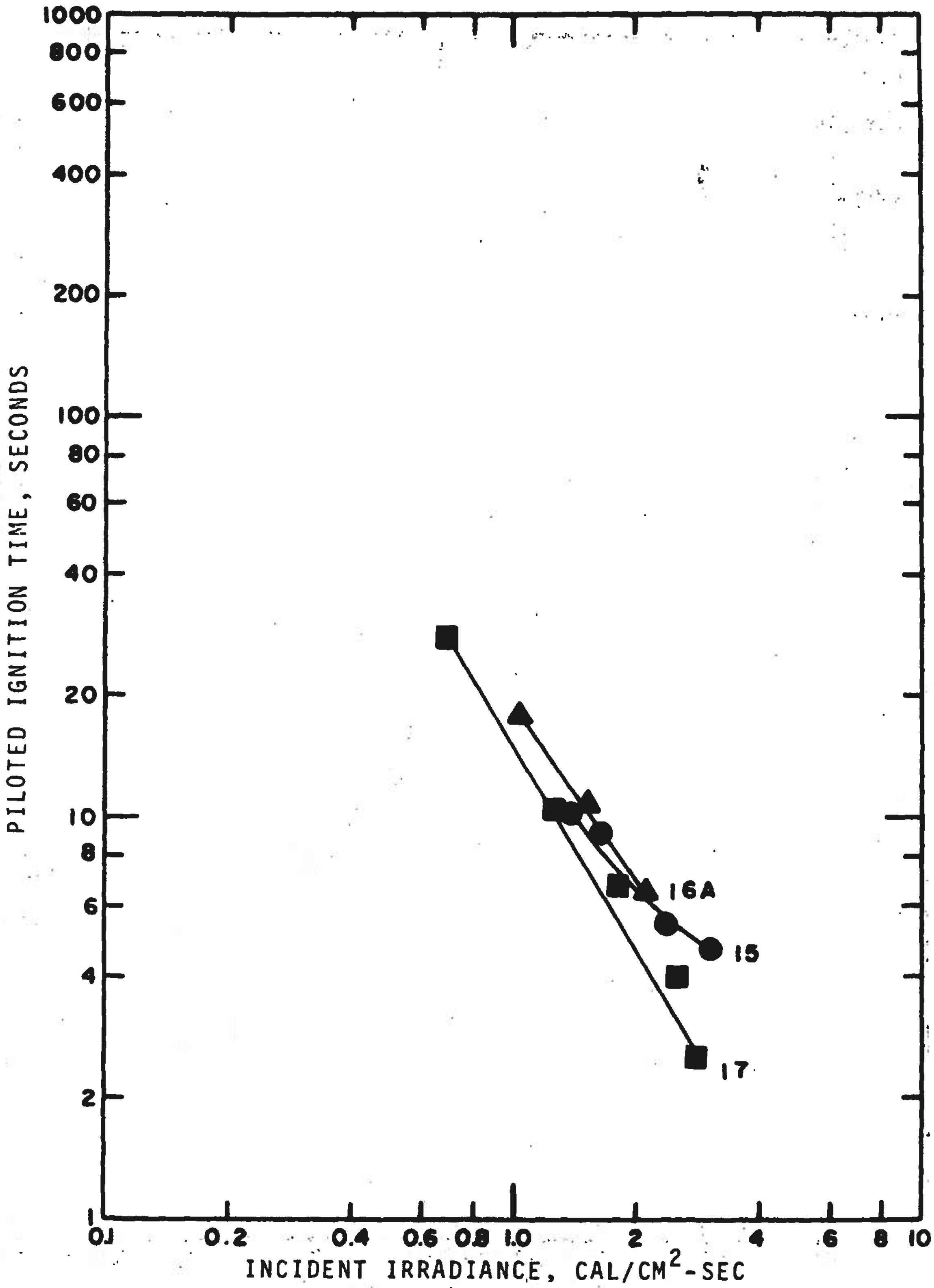

Figure 7. Ignition of IITRI samples Nos. 15 (nylon-rayon fabric), 16A (nylon-rayon fabric), and 17 (nylon-rayon fabric).

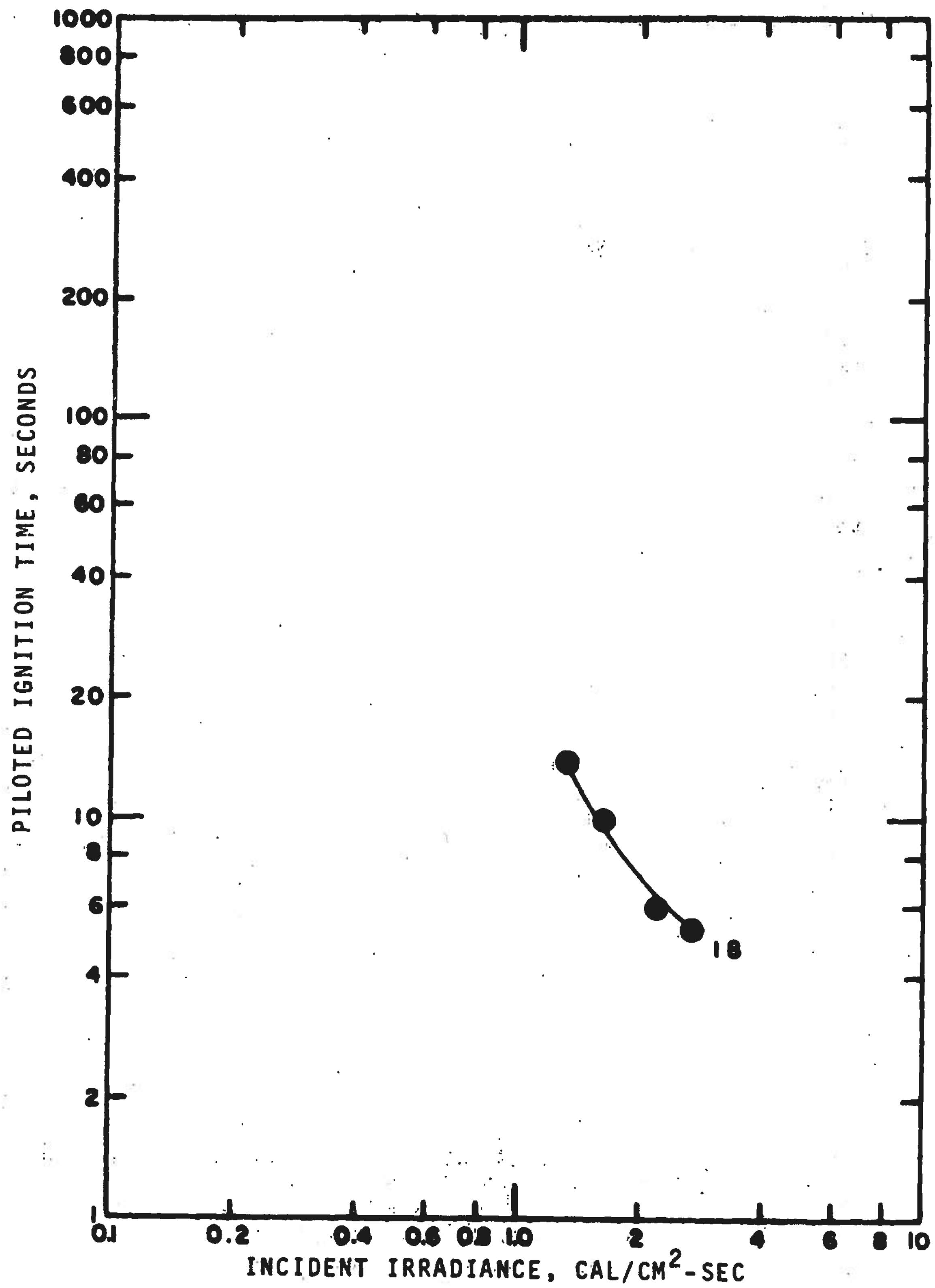

Figure 8. Ignition of IITRI sample No. 18 (nylon-rayon fabric).

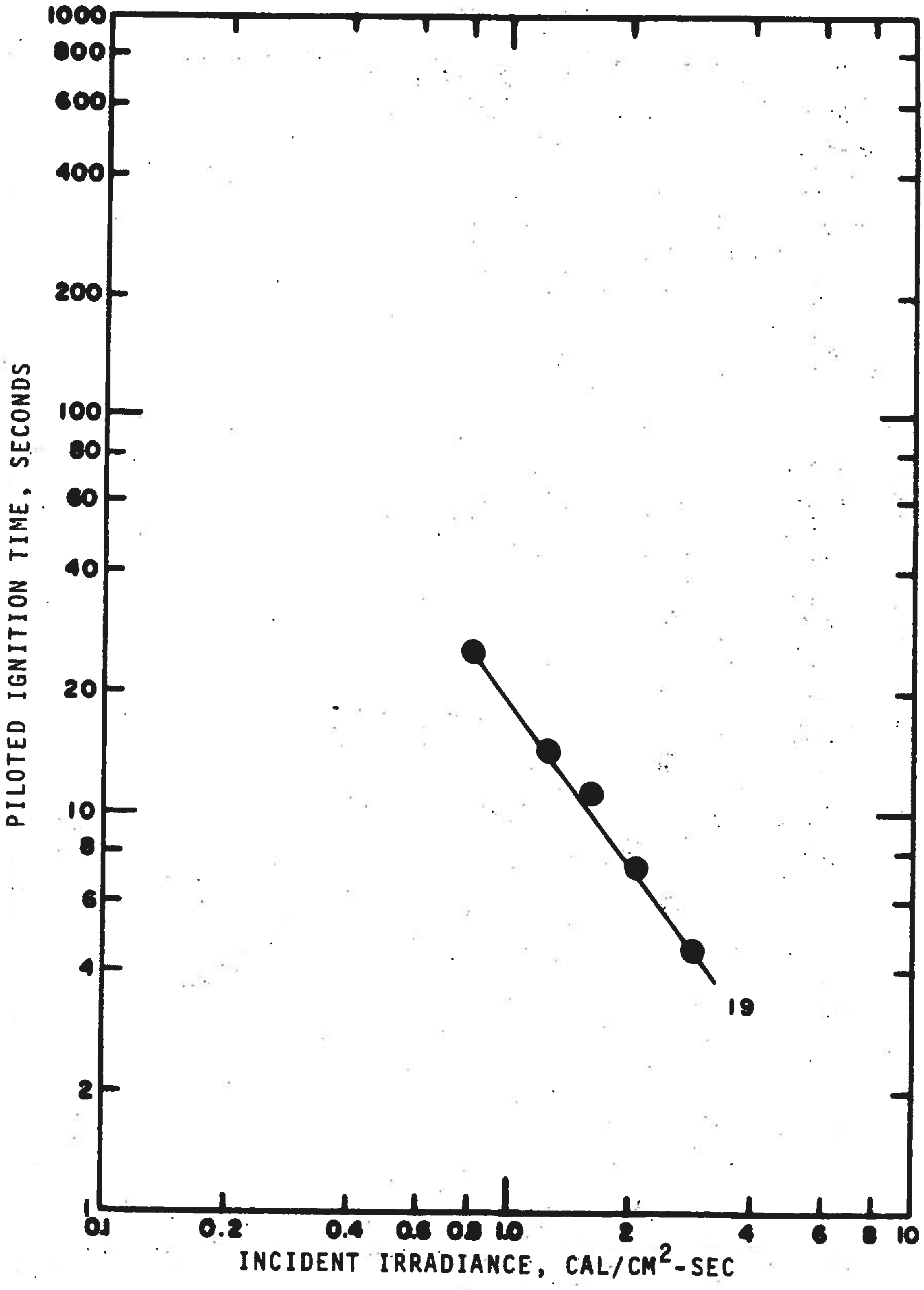

Figure 9. Ignition of IITRI sample No. 19 (nylon-rayon fabric).

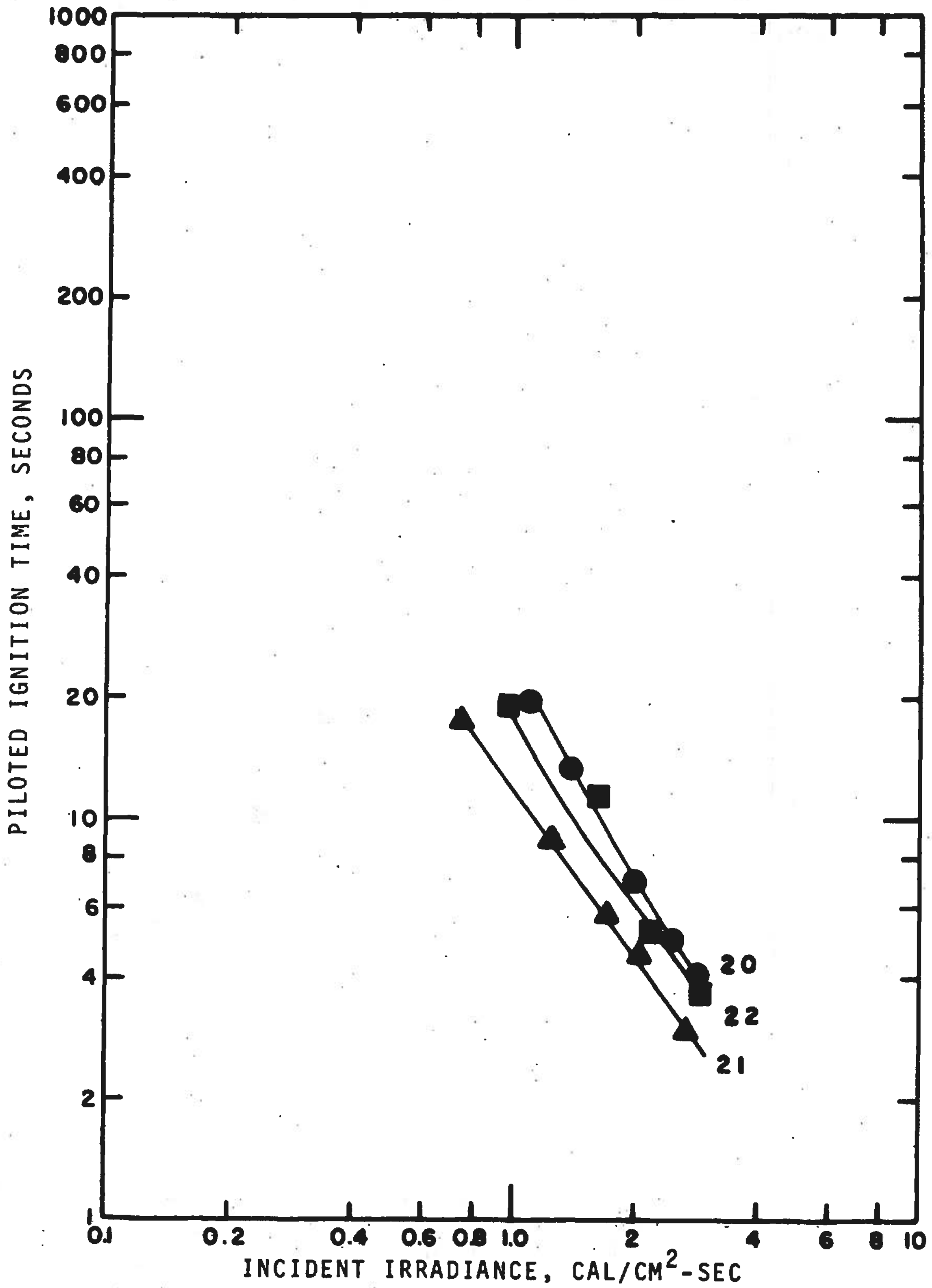

Figure 10. Ignition of IITRI samples Nos. 20 (nylon-rayon fabric), 21 (nylon-rayon fabric), and 22 (nylon-rayon fabric).

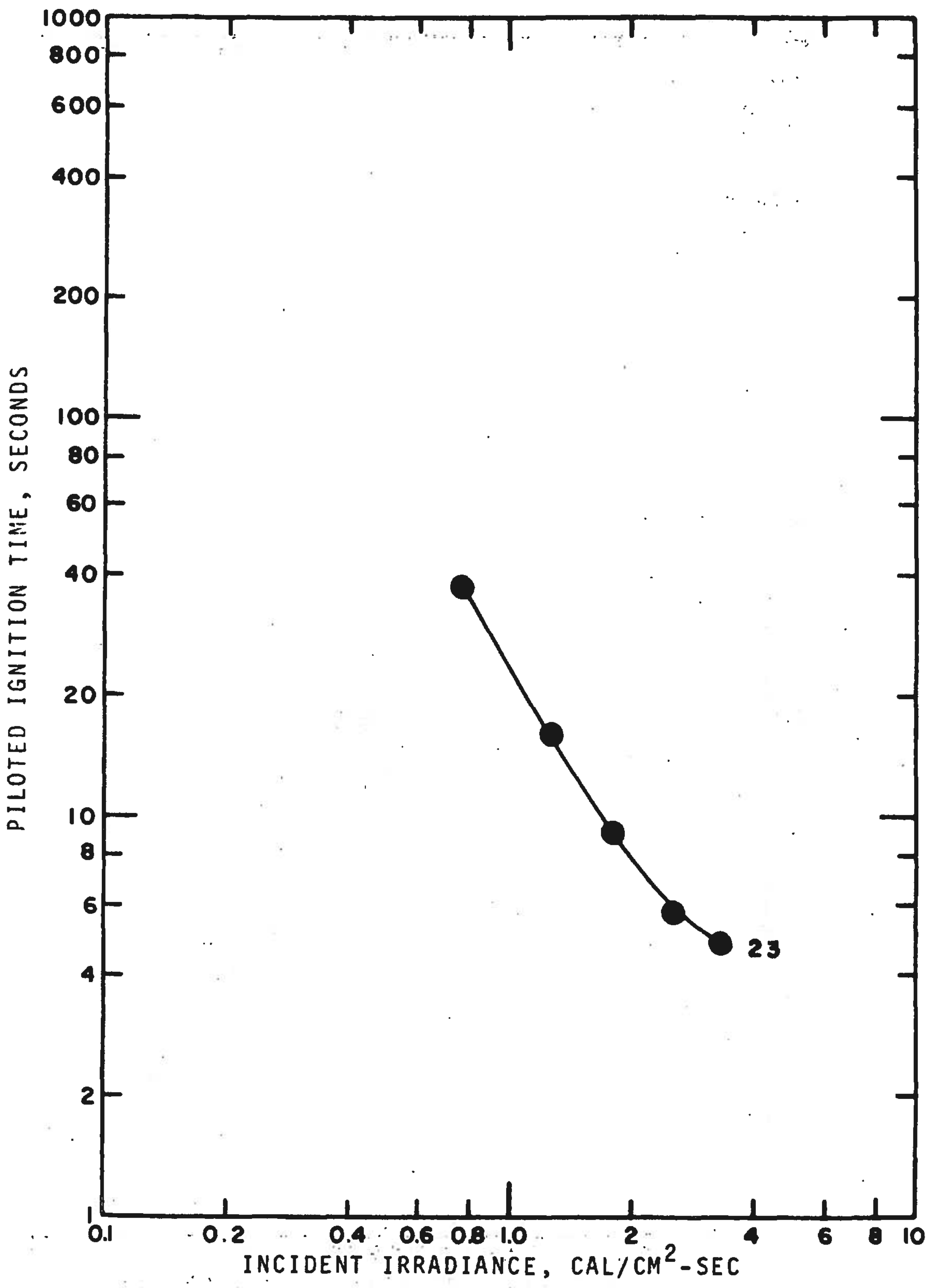

Figure 11. Ignition of IITRI sample No. 23 (nylon-rayon fabric).

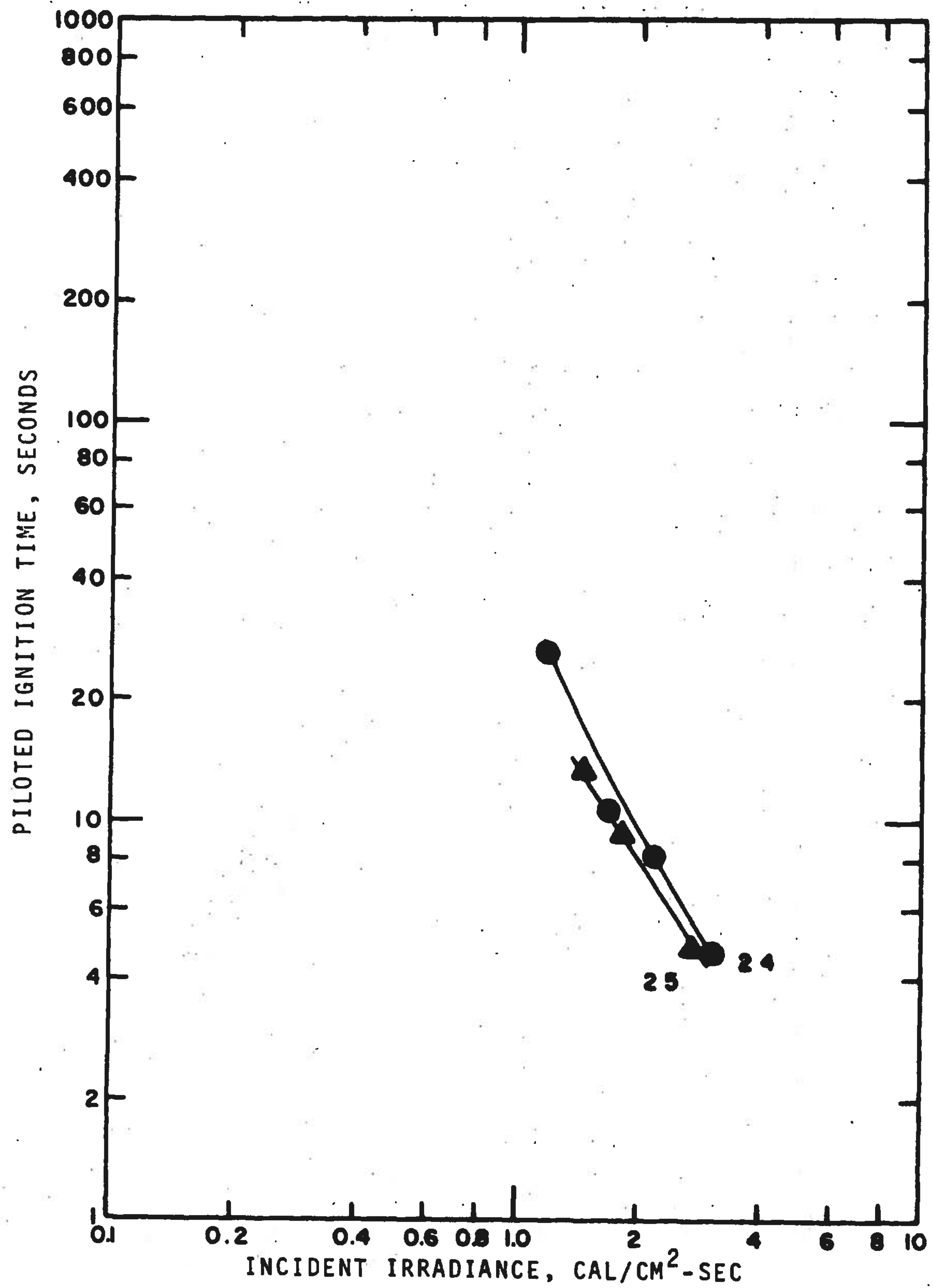

Figure 12. Ignition of IITRI samples Nos. 24 (nylon-viscose fabric) and 25 (nylon-viscose fabric).

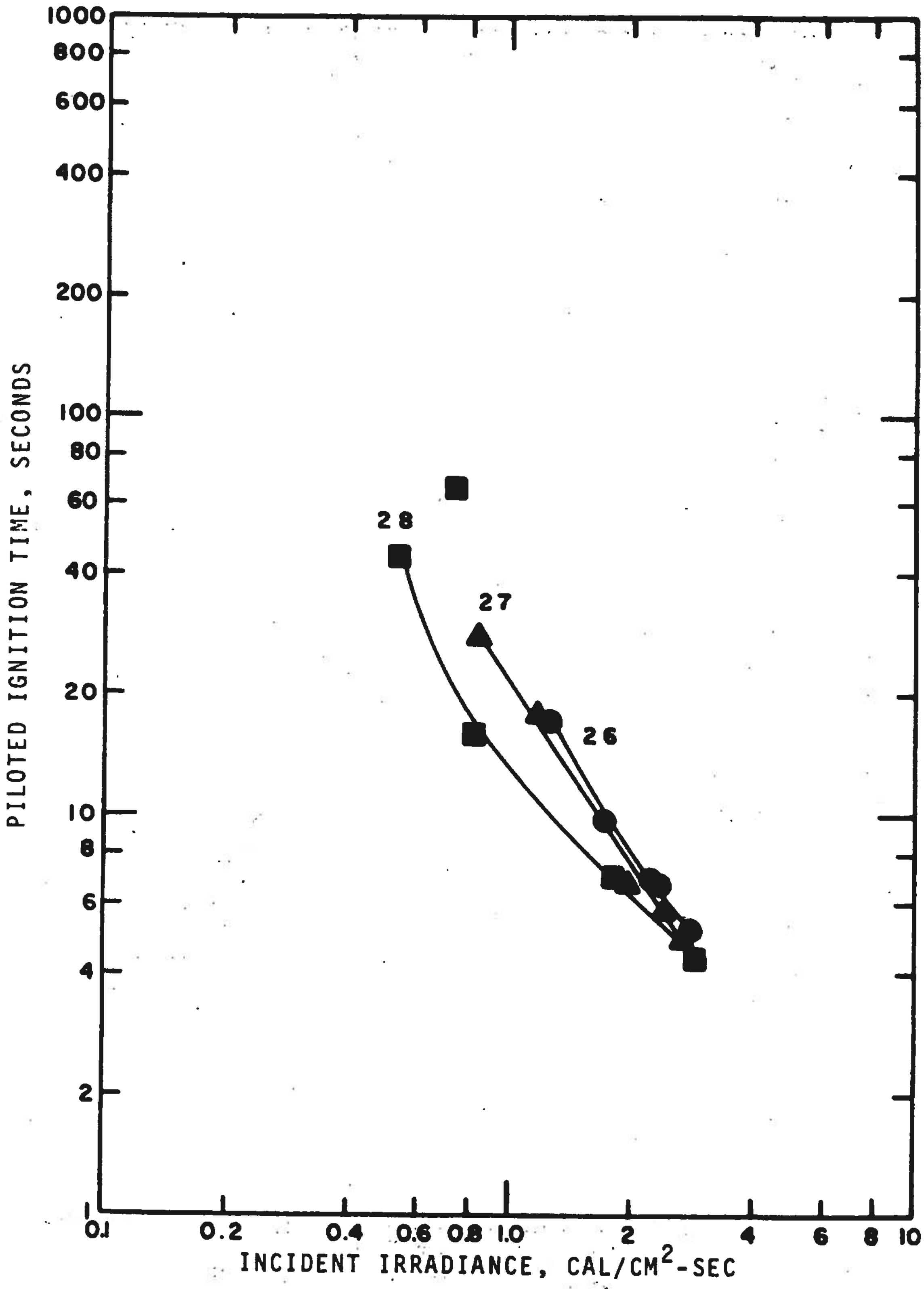

Figure 13. Ignition of IITRI samples Nos. 26 (nylon-viscose fabric), 27 (nylon-viscose fabric), and 28 (nylon-viscose fabric).

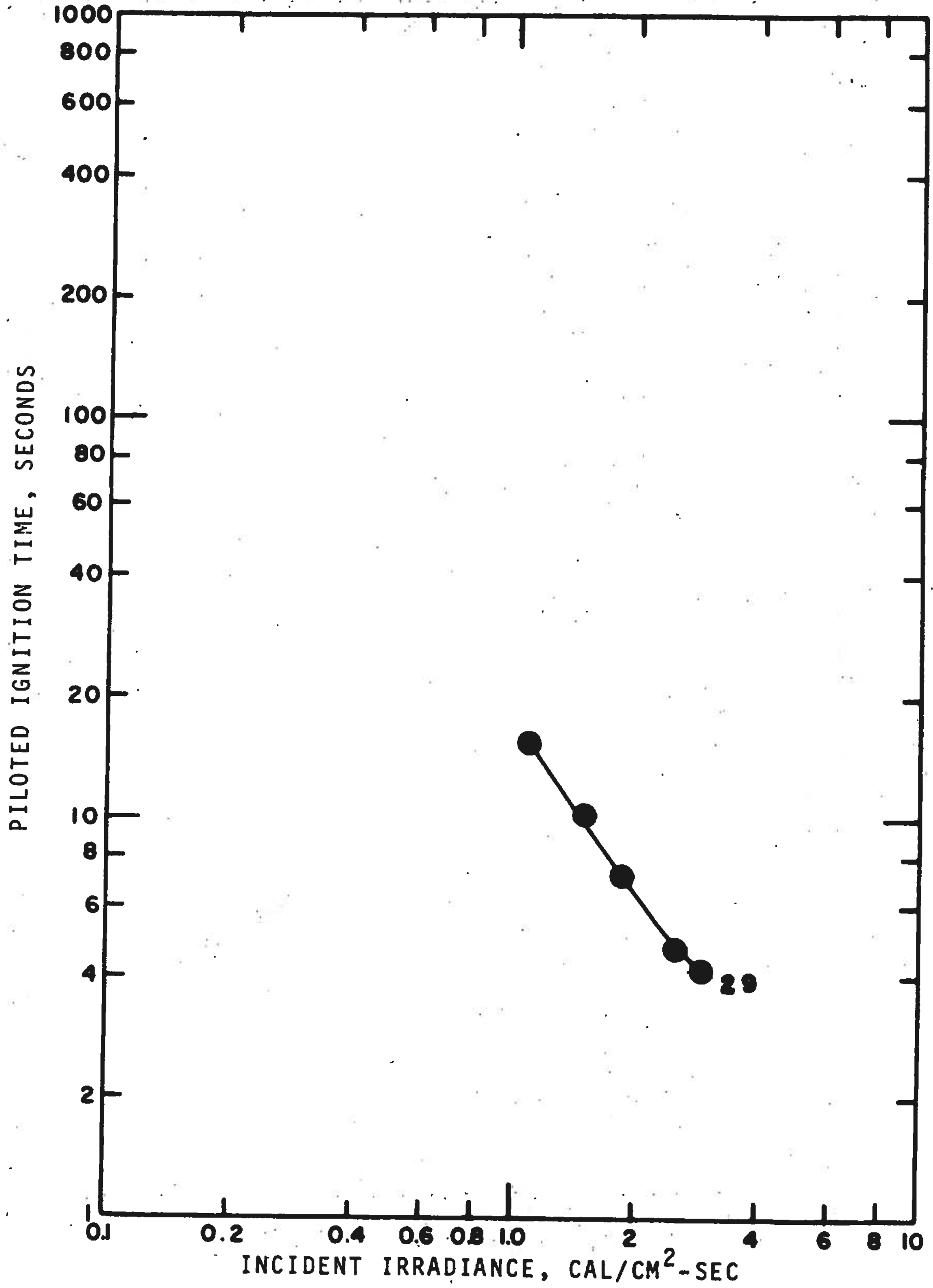

Figure 14. Ignition of IITRI sample No. 29 (nylon-viscose fabric).

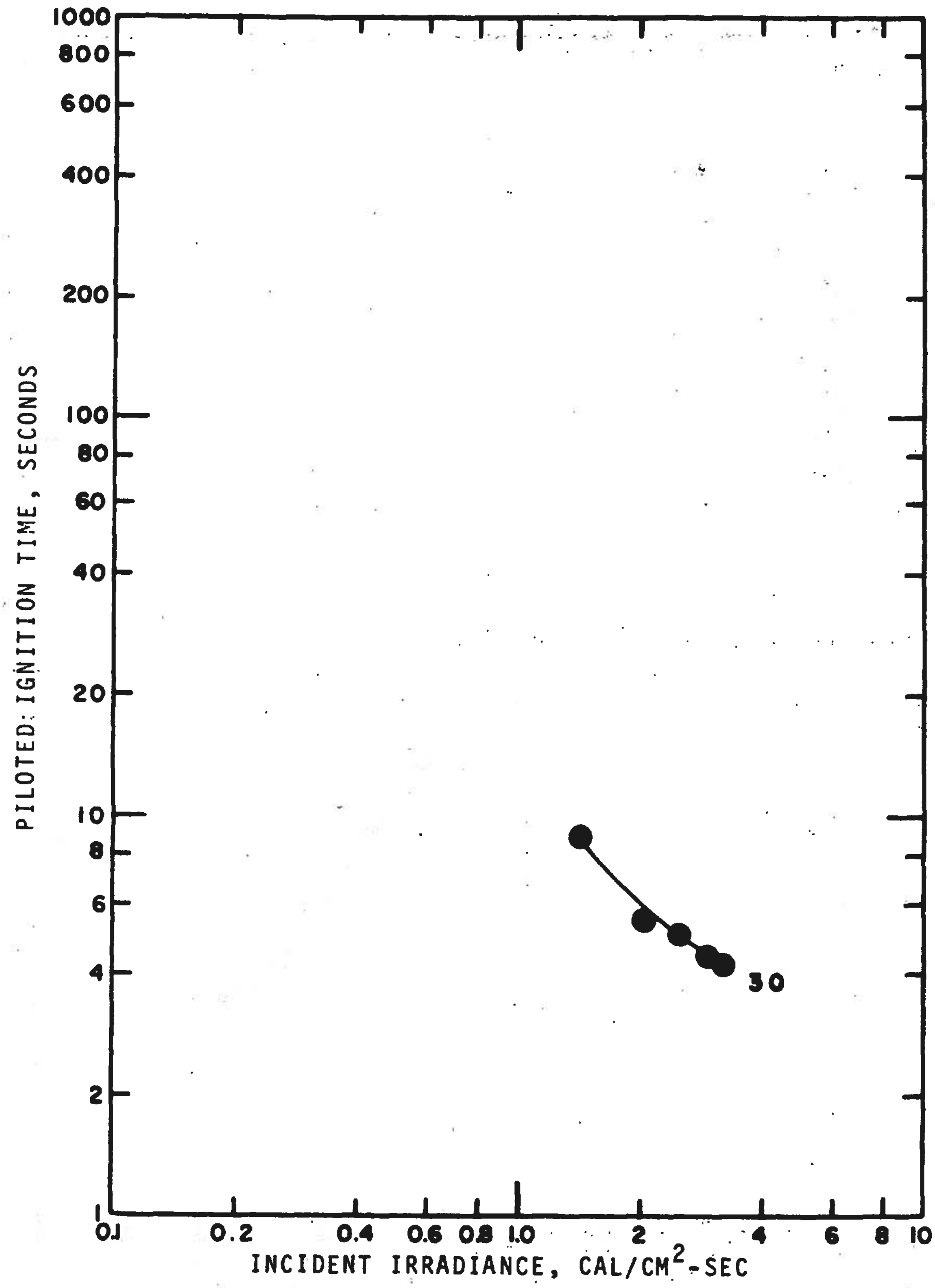

Figure 15. Ignition of IITRI sample No. 30 (nylon-viscose fabric).

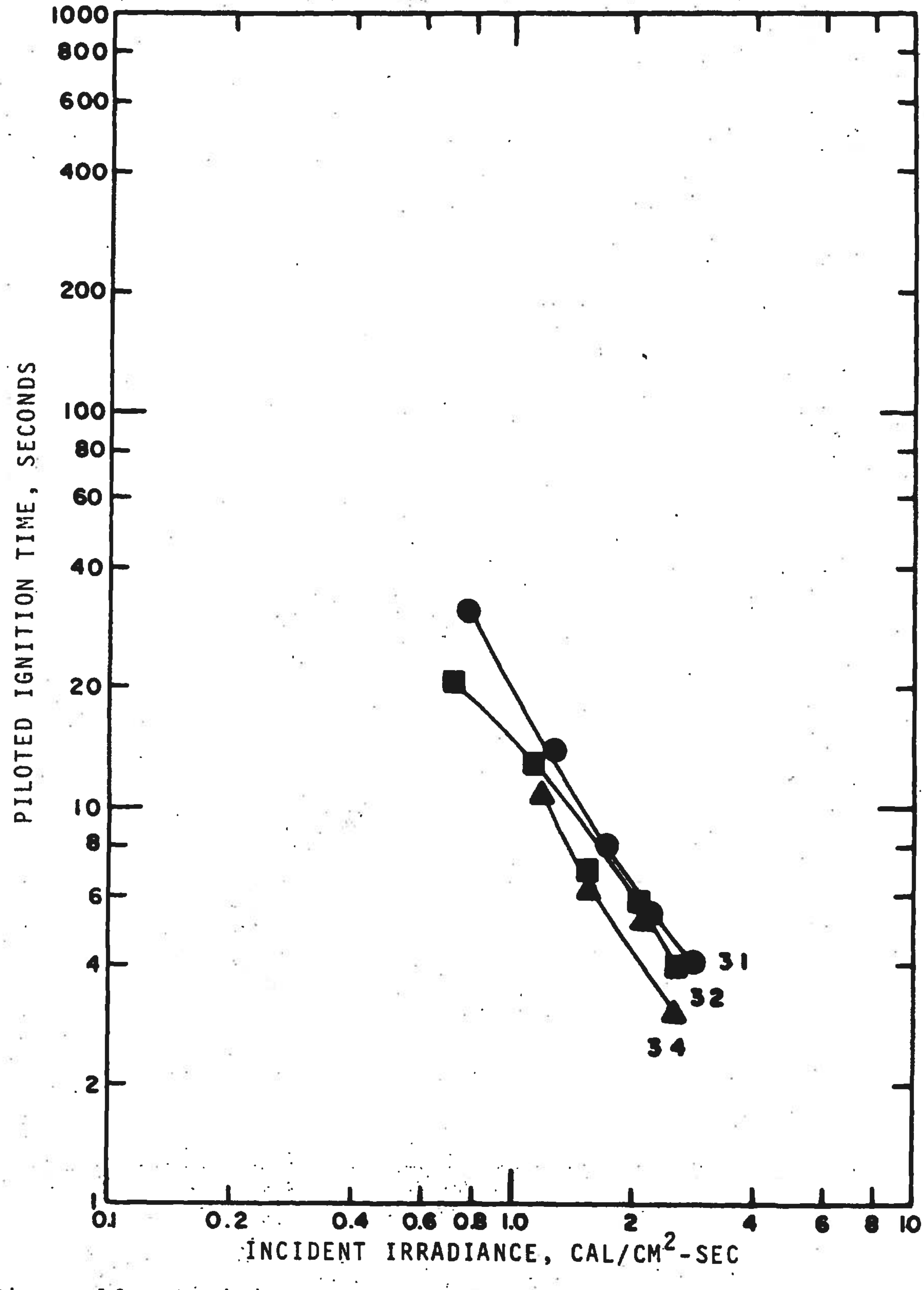

Figure 16. Ignition of IITRI samples Nos. 31 (nylon-viscose fabric), 32 (nylon-viscose fabric), and 34 (nylon-viscose fabric).

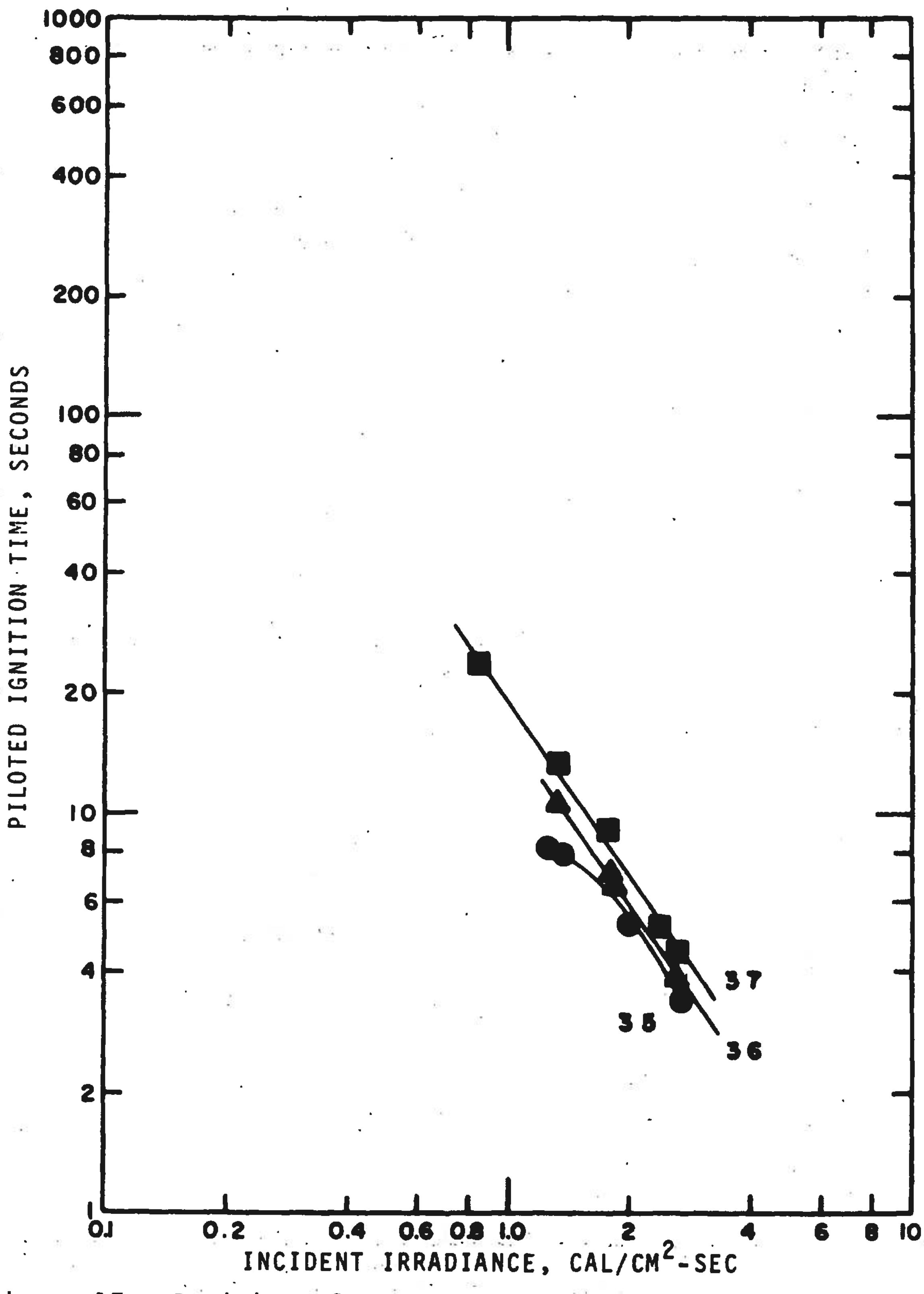

Figure 17. Ignition of IITRI samples Nos. 35 (nylon-viscose fabric), 36 (nylon-viscose fabric), and 37 (nylon-viscose fabric).

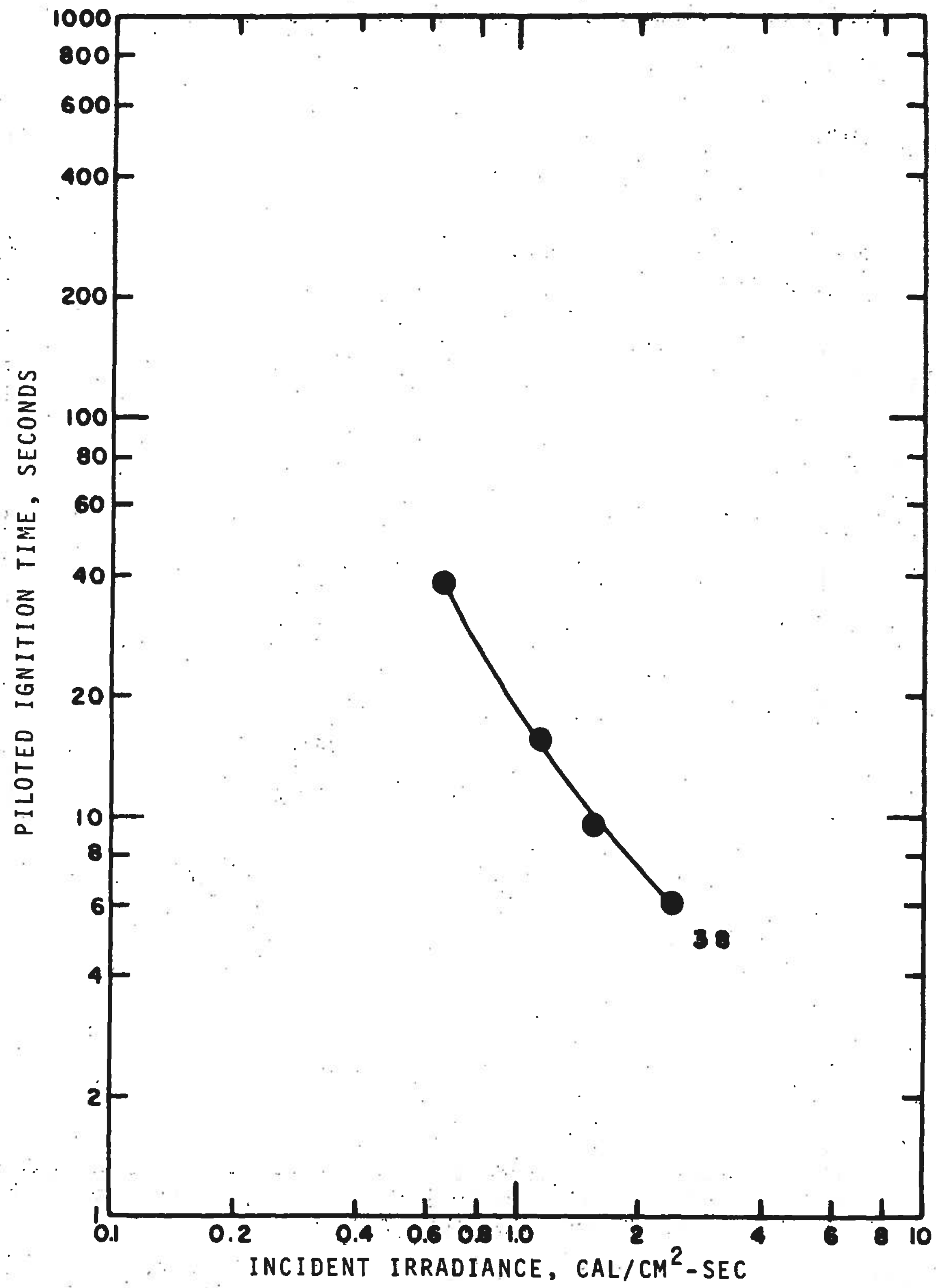

Figure 18. Ignition of IITRI sample No. 38 (nylon-viscose fabric).

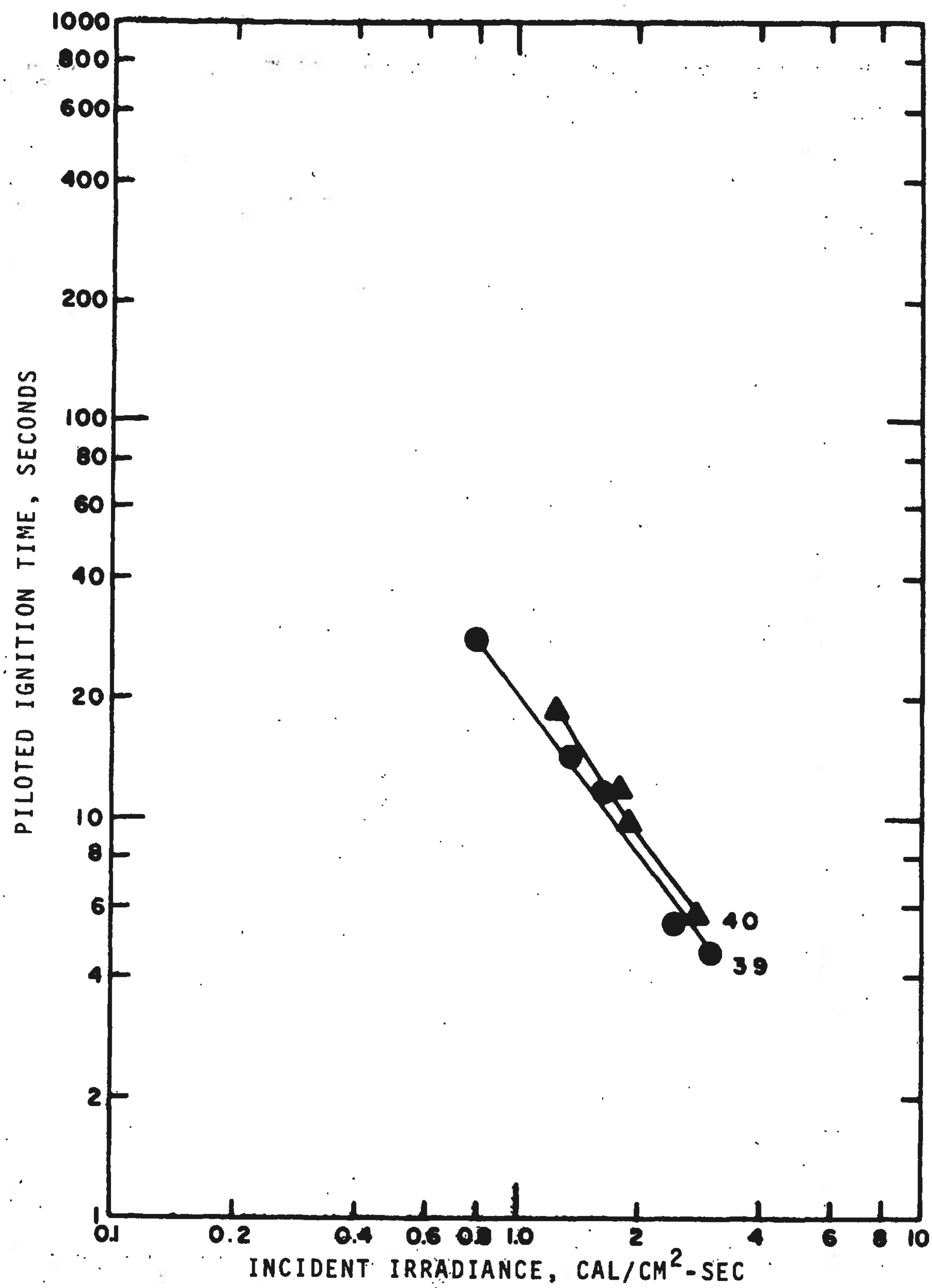

Figure 19. Ignition of IITRI samples Nos. 39 (nylon-viscose fabric) and 40 (nylon-Dacron-Averil fabric).

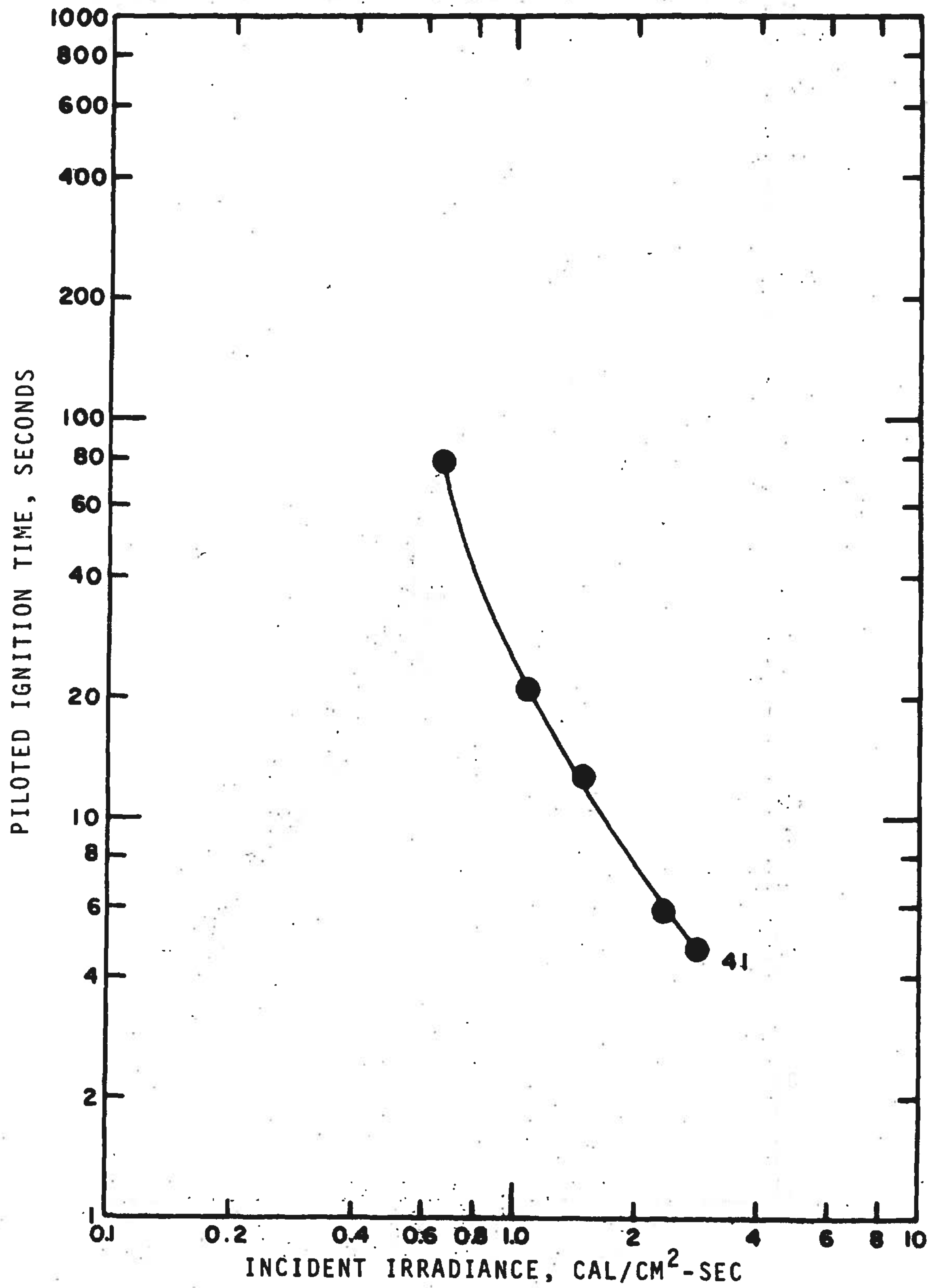

Figure 20. Ignition of IITRI sample No. 41 (nylon-cotton-rayon fabric).

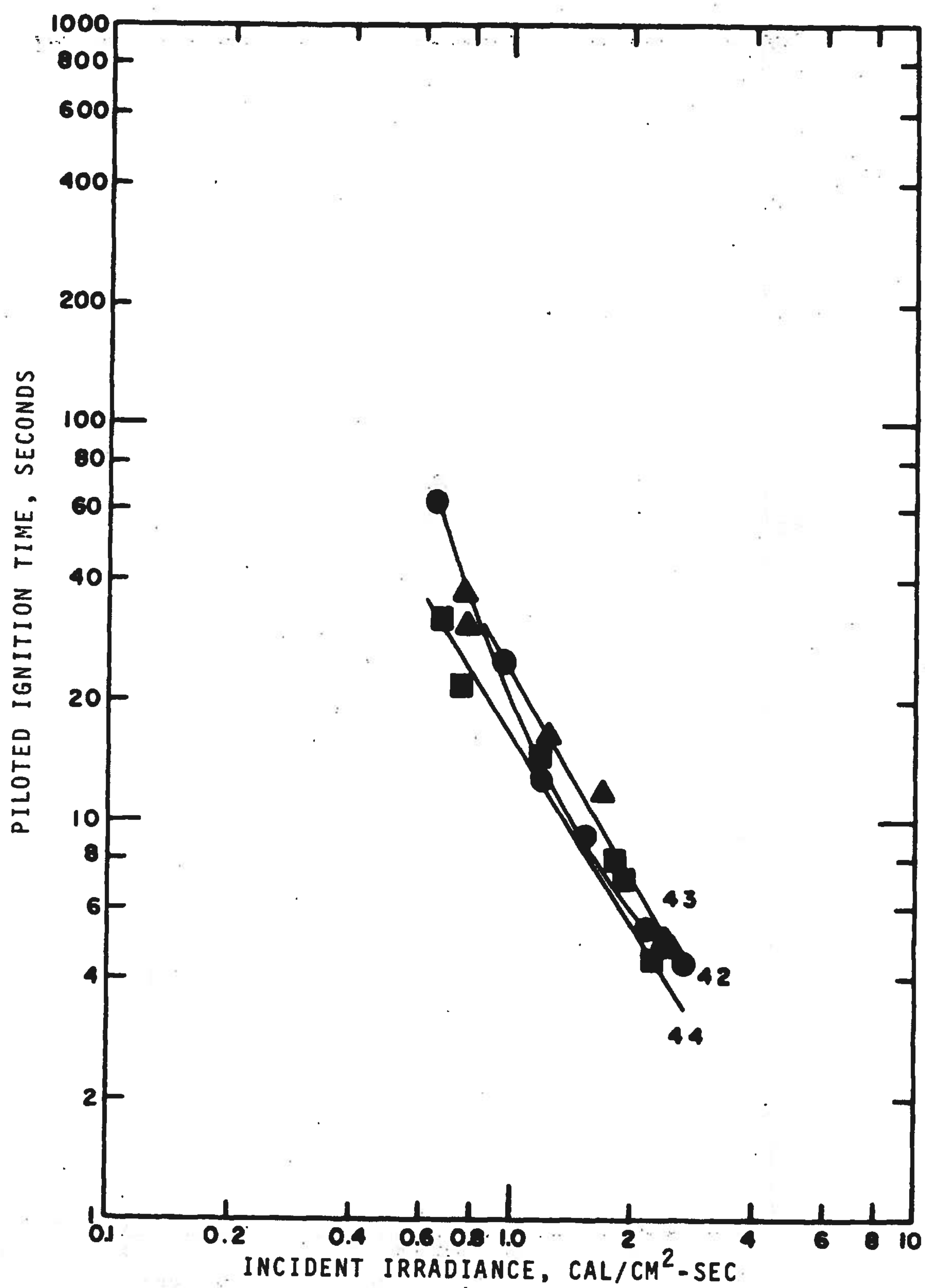

Figure 21. Ignition of IITRI samples Nos. 42 (nylon-cotton-rayon fabric), 43 (nylon-polypropylene-rayon fabric), and 44 (nylon-polypropylene-rayon fabric).

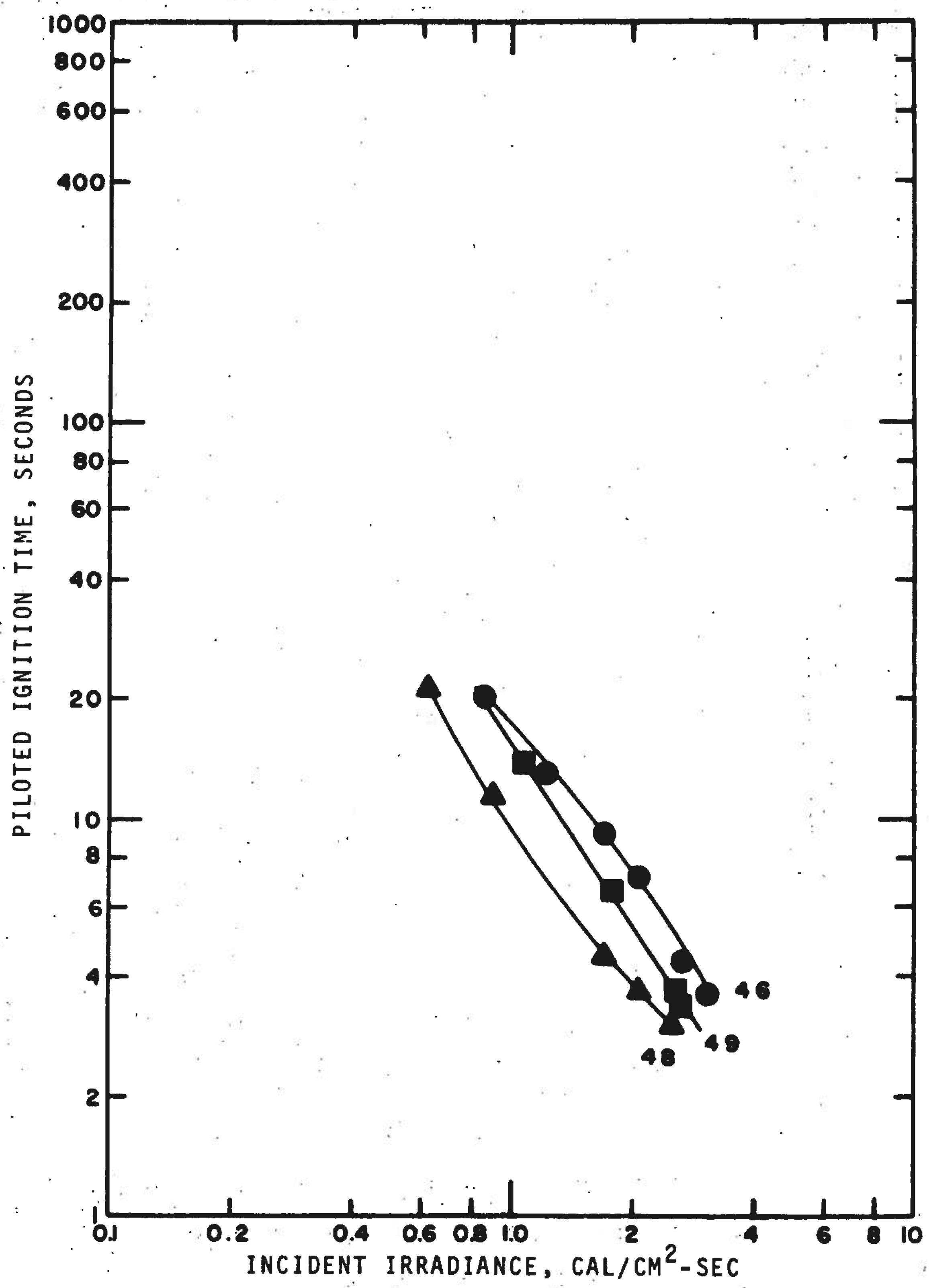

Figure 22. Ignition of IITRI samples Nos. 46 (nylon-cotton-viscose fabric), 48 (nylon-polypropylene-viscose fabric), and 49 (nylon-polypropylene-viscose-metallic fabric).

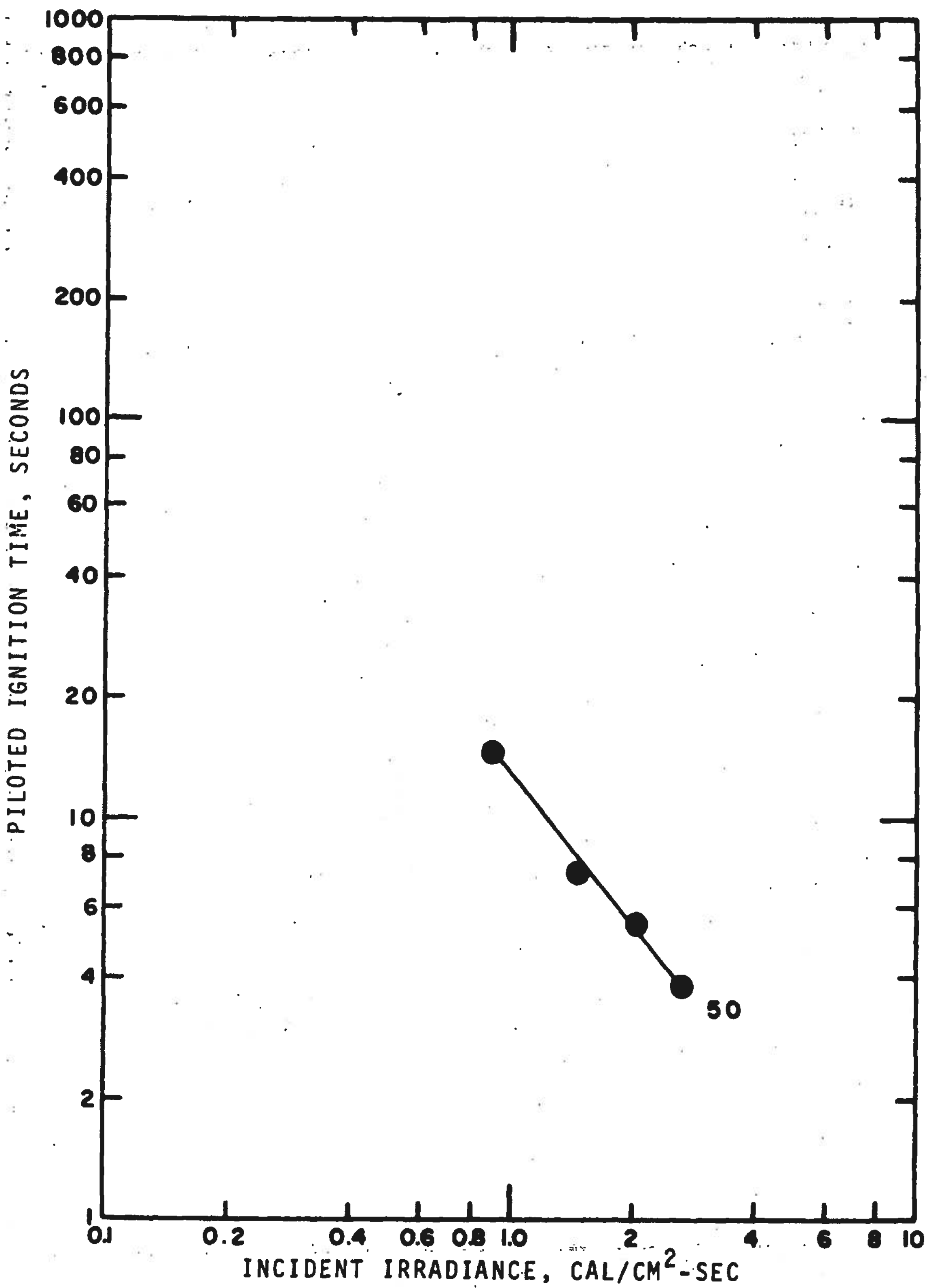

Figure 23. Ignition of IITRI sample No. 50 (saran fabric).

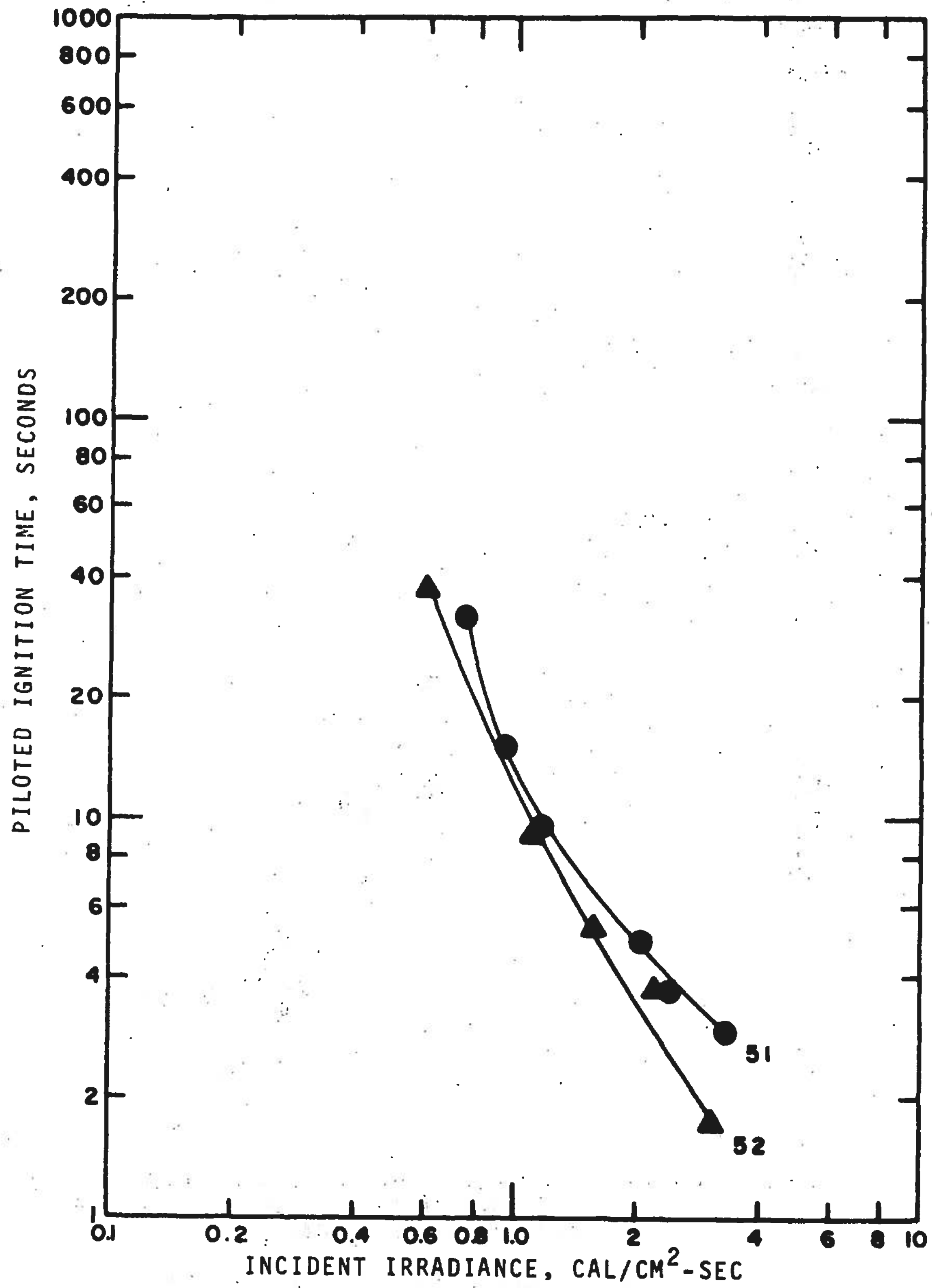

Figure 24. Ignition of IITRI samples Nos. 51 (cotton fabric) and 52 (cotton fabric).

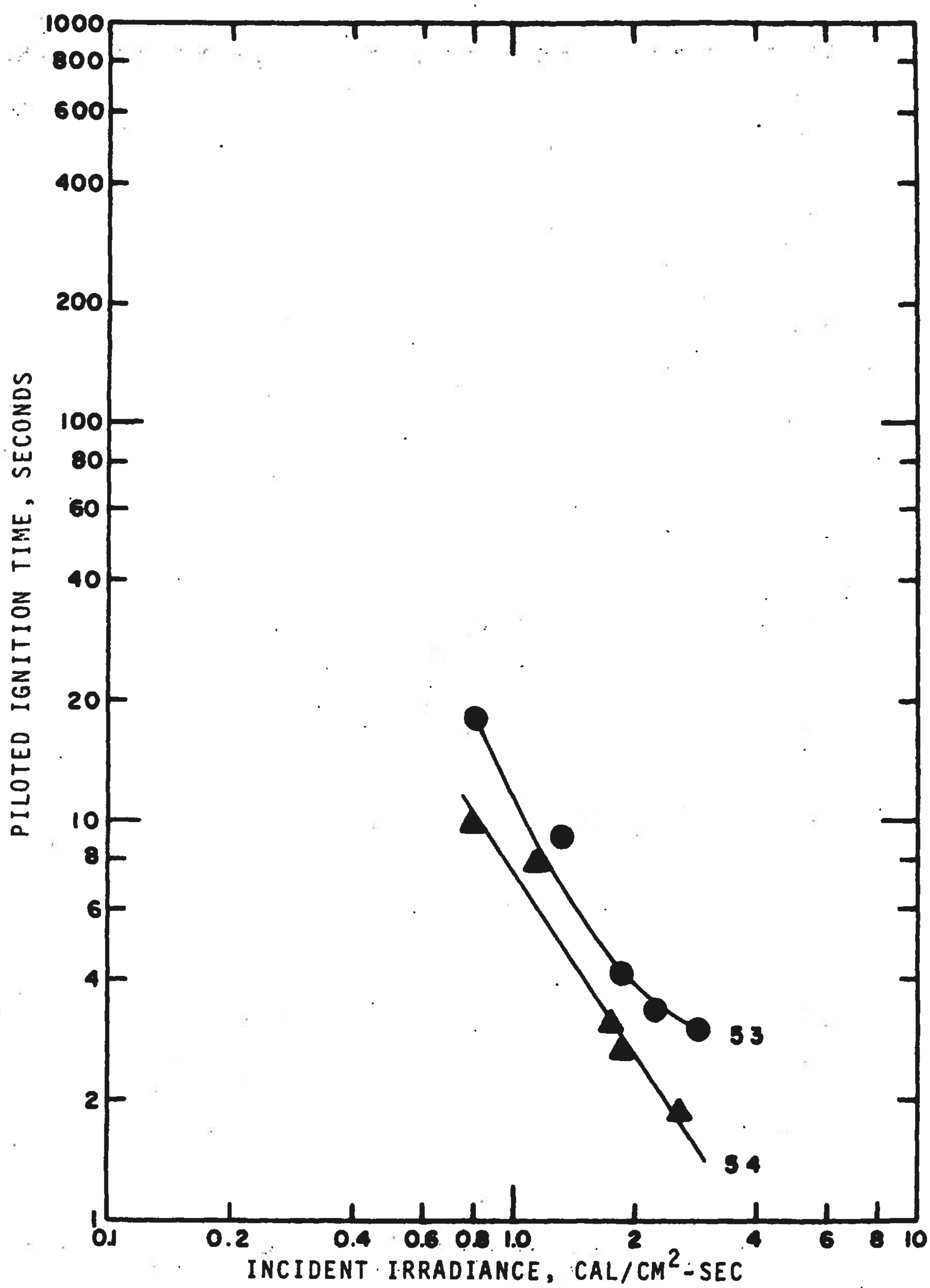

Figure 25. Ignition of IITRI samples Nos. 53 (vinyl fabric) and 54 (vinyl-cotton fabric).

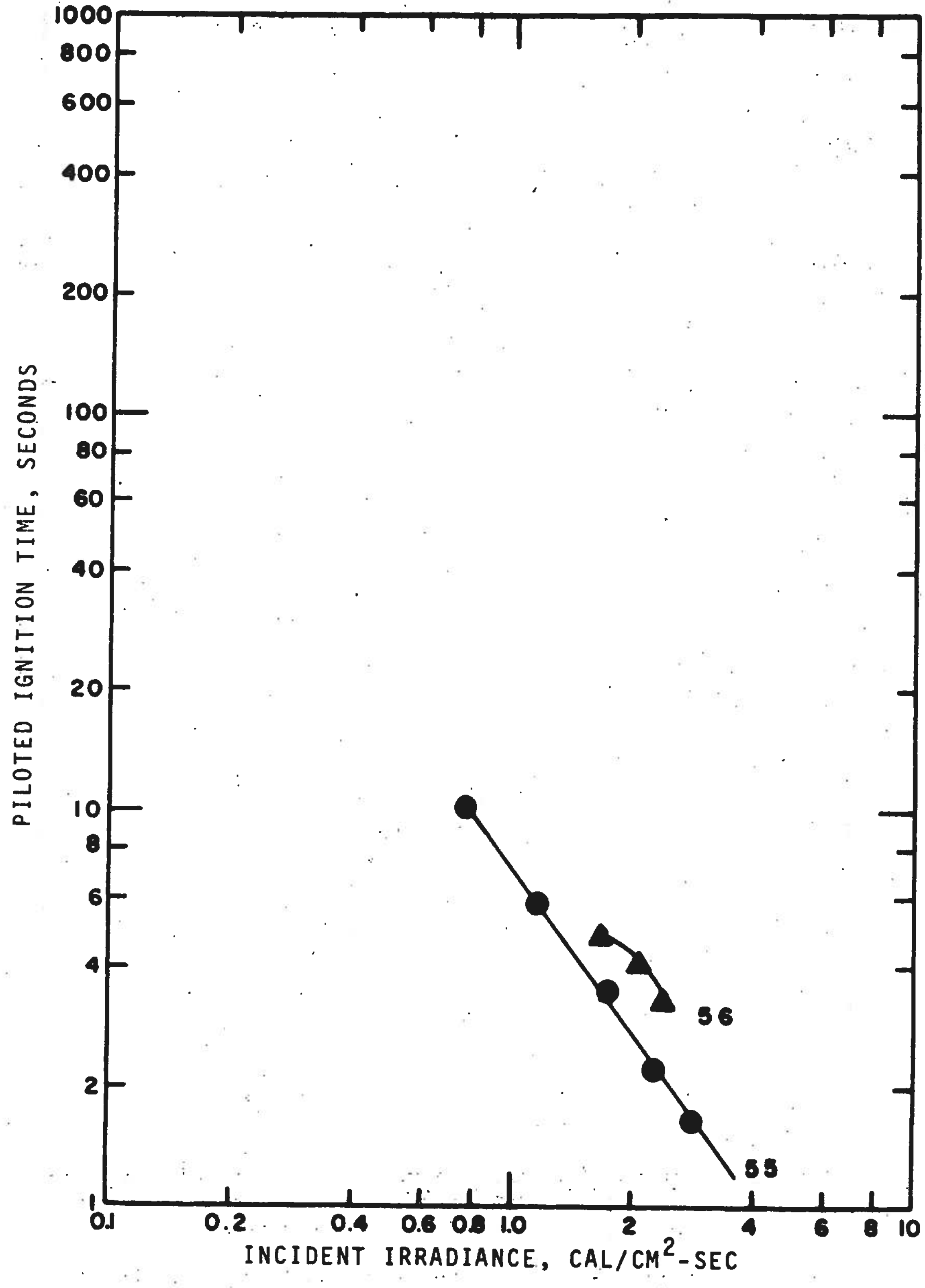

Figure 26. Ignition of IITRI samples Nos. 55 (vinyl-cotton fabric) and 56 (vinyl fabric).

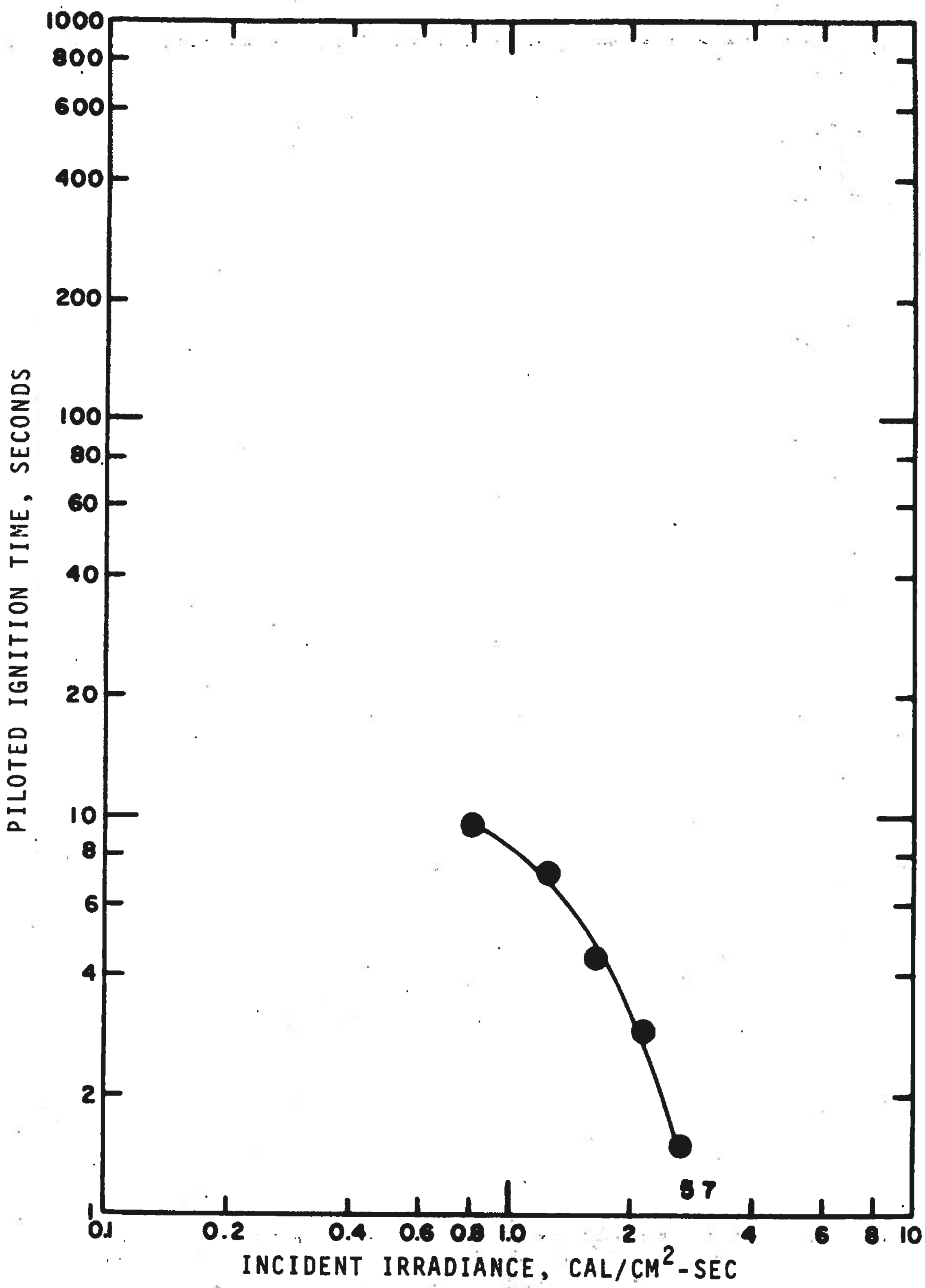

Figure 27. Ignition of IITRI sample No. 57 (vinyl-cotton fabric).

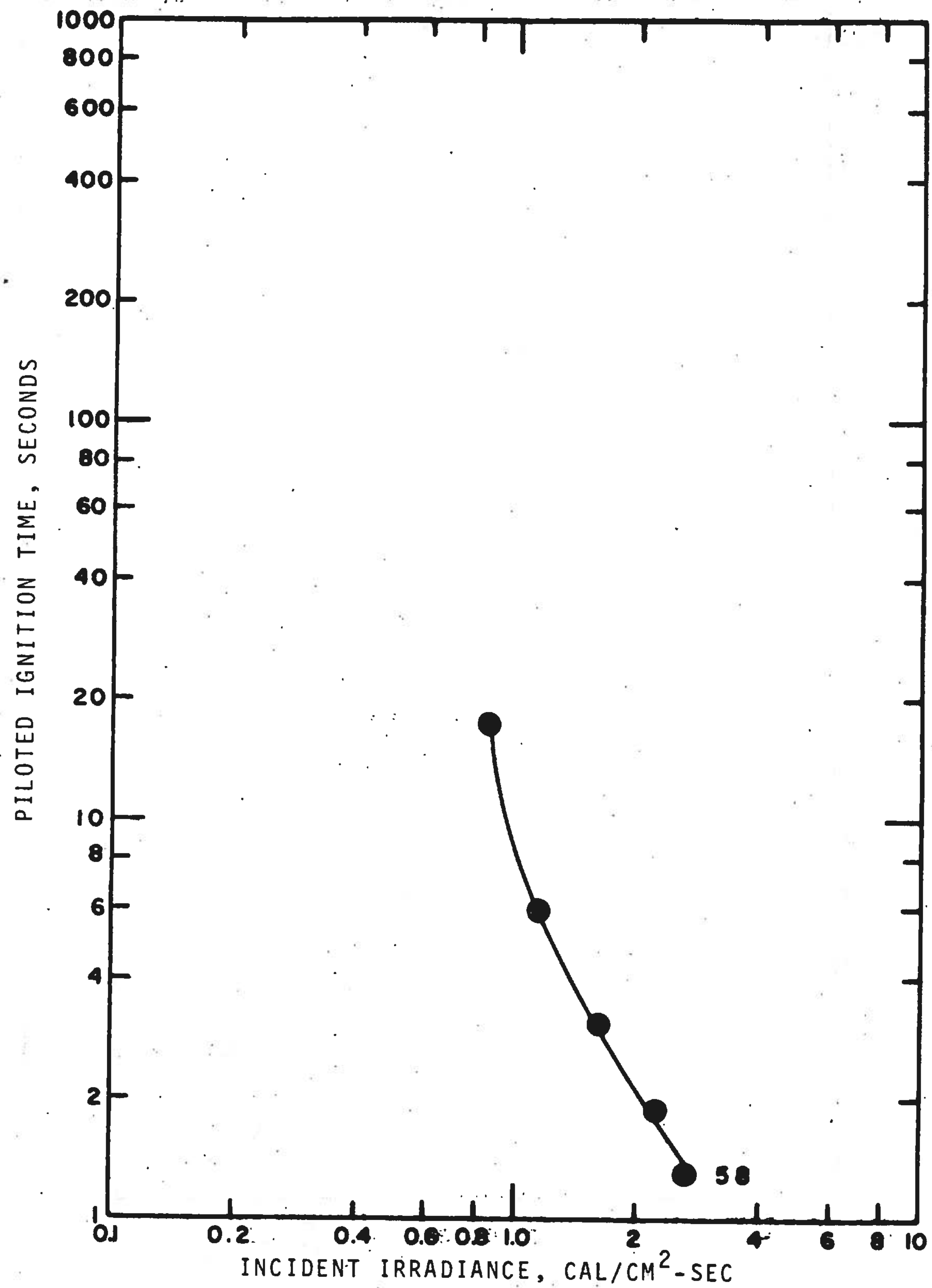

Figure 28. Ignition of IITRI sample No. 58 (vinyl-cotton fabric).

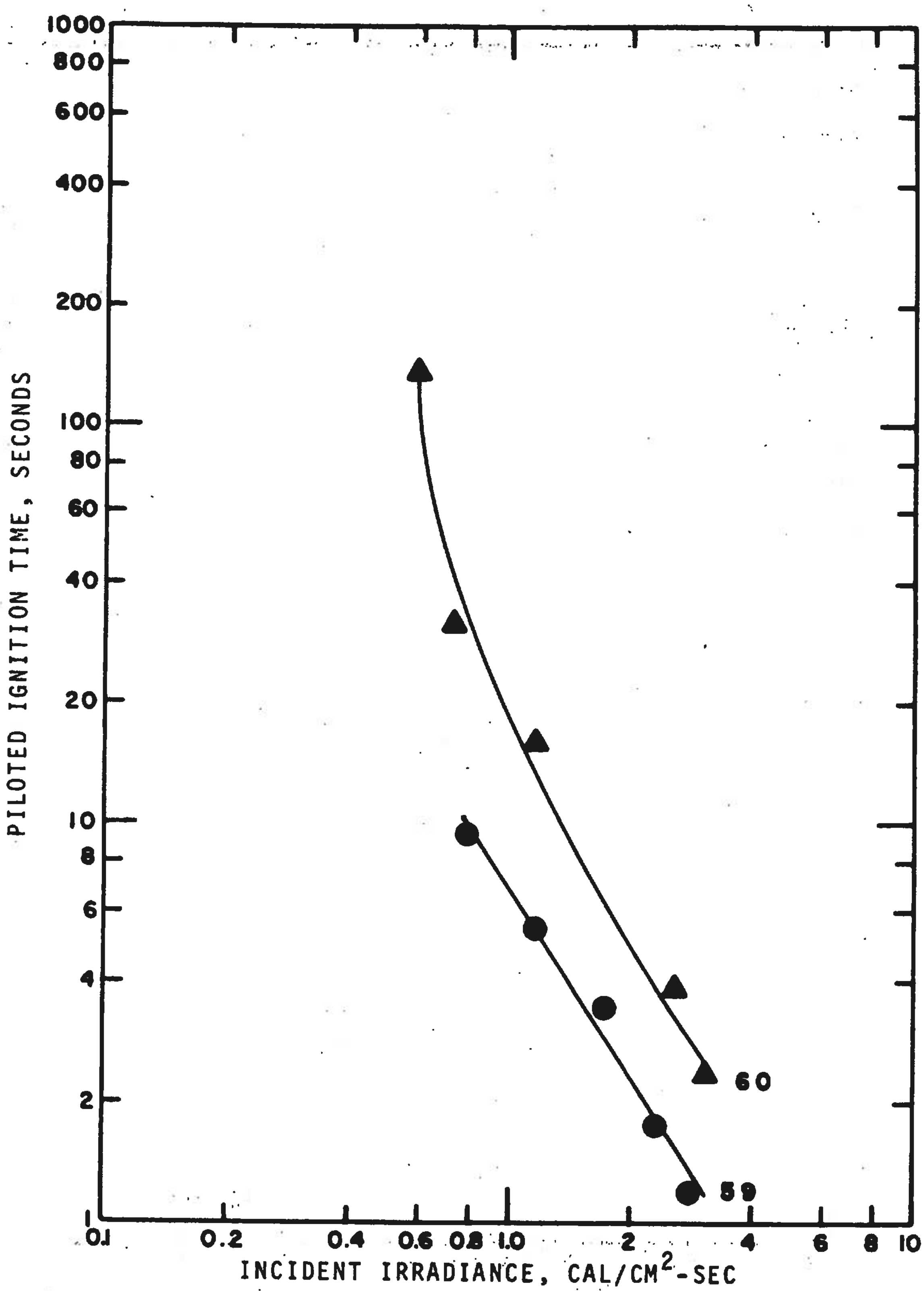

Figure 29. Ignition of IITRI samples Nos. 59 (vinyl-cotton fabric) and 60 (vinyl-cotton fabric).

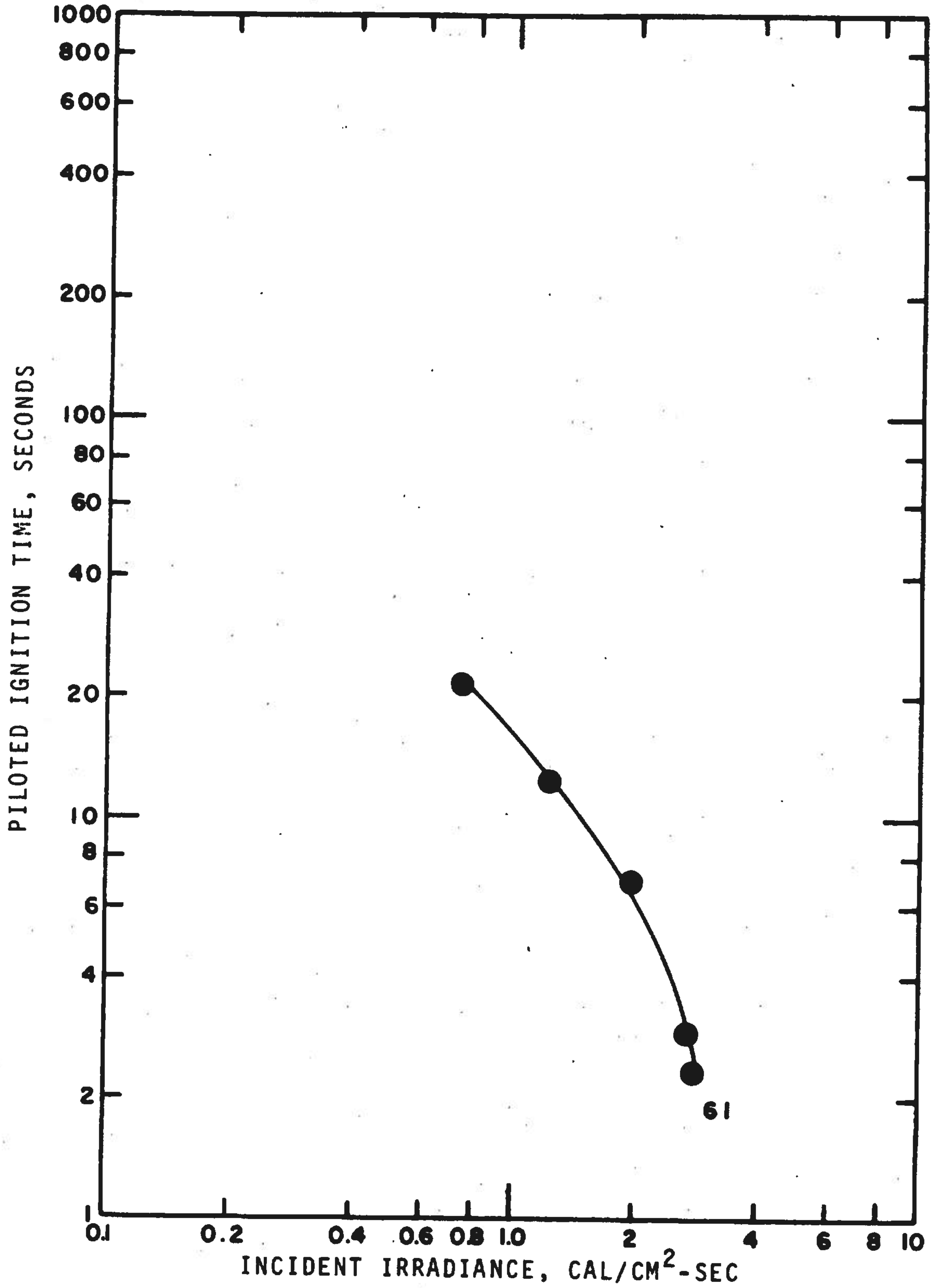

Figure 30. Ignition of IITRI sample No. 61 (vinyl-cotton fabric).

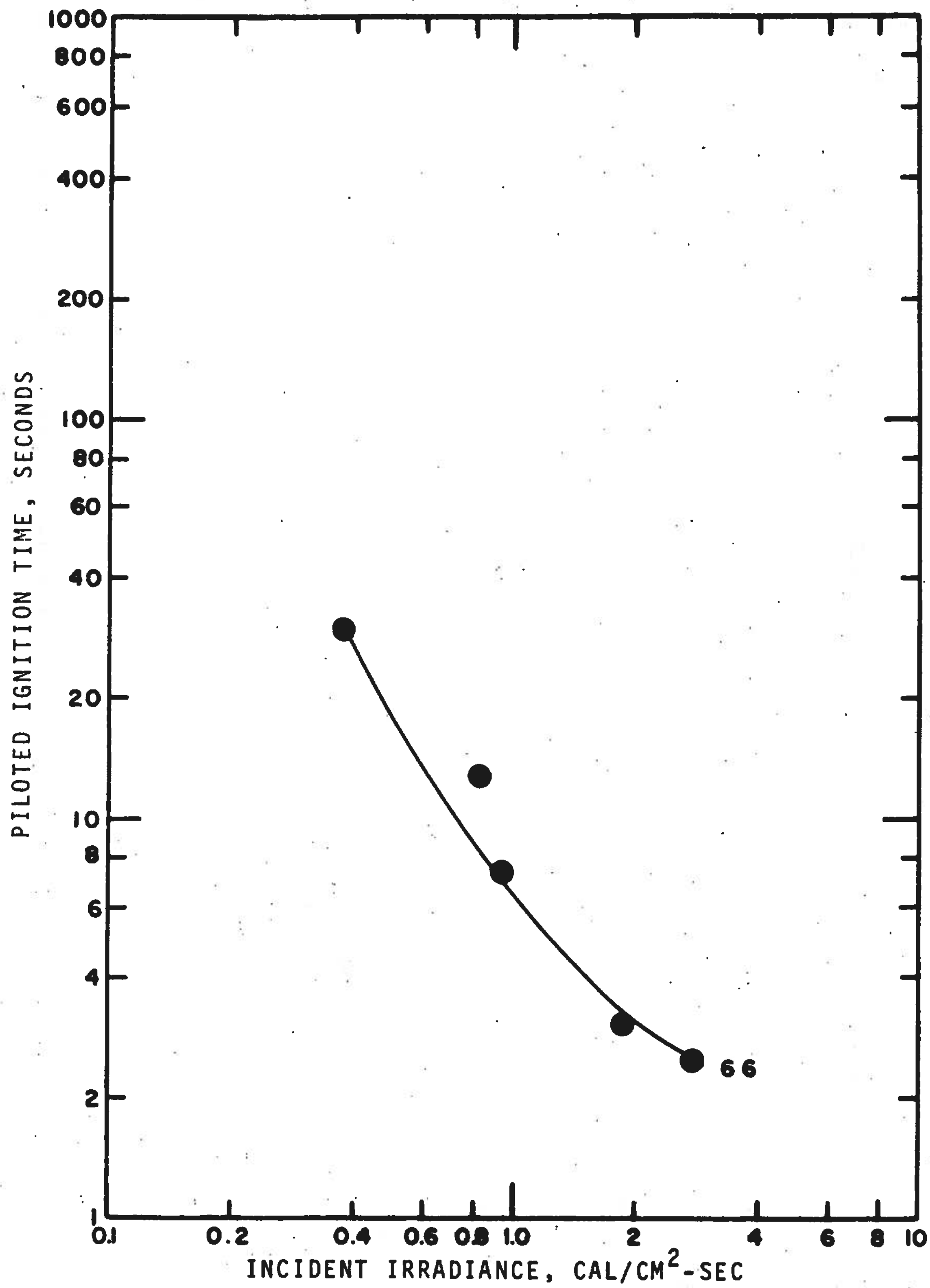

Figure 32. Ignition of IITRI sample No. 66 (vinyl-cotton fabric).

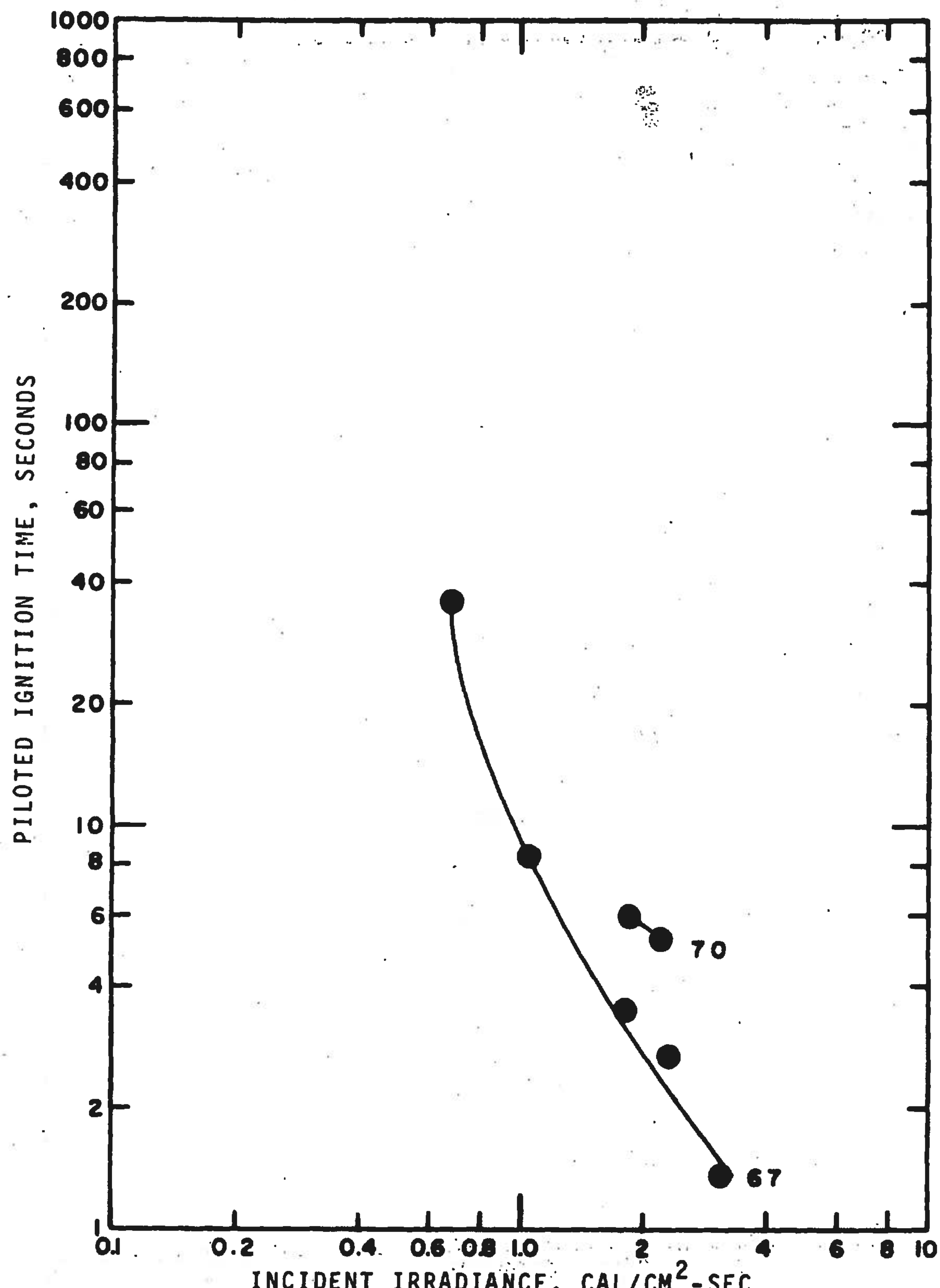

Figure 33. Ignition of IITRI samples Nos. 67 (vinyl-paper fabric) and 70 (dynel-nonwoven synthetic backed fabric).

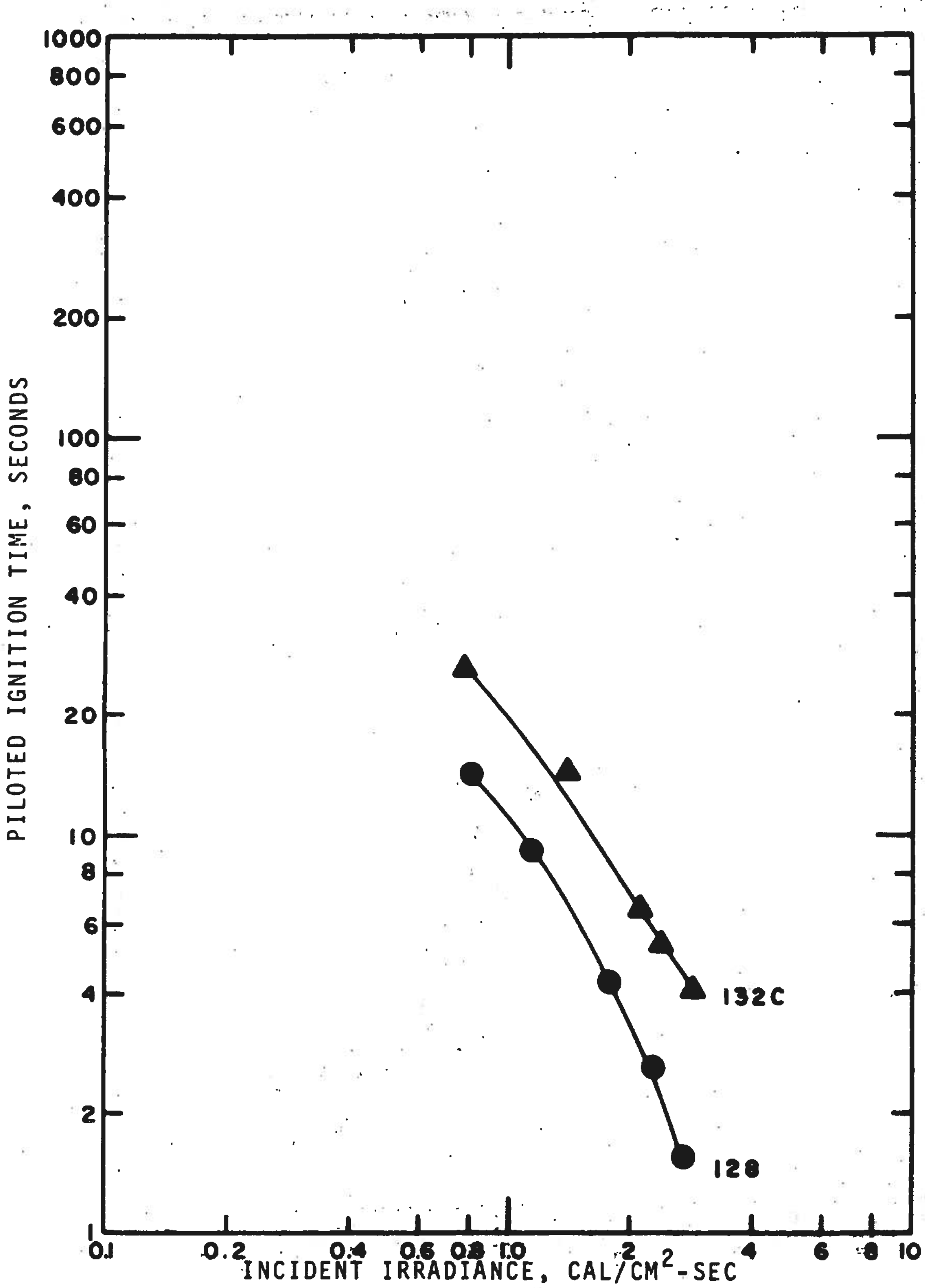

Figure 34. Ignition of IITRI sample No. 128 (vinyl door trim assembly).

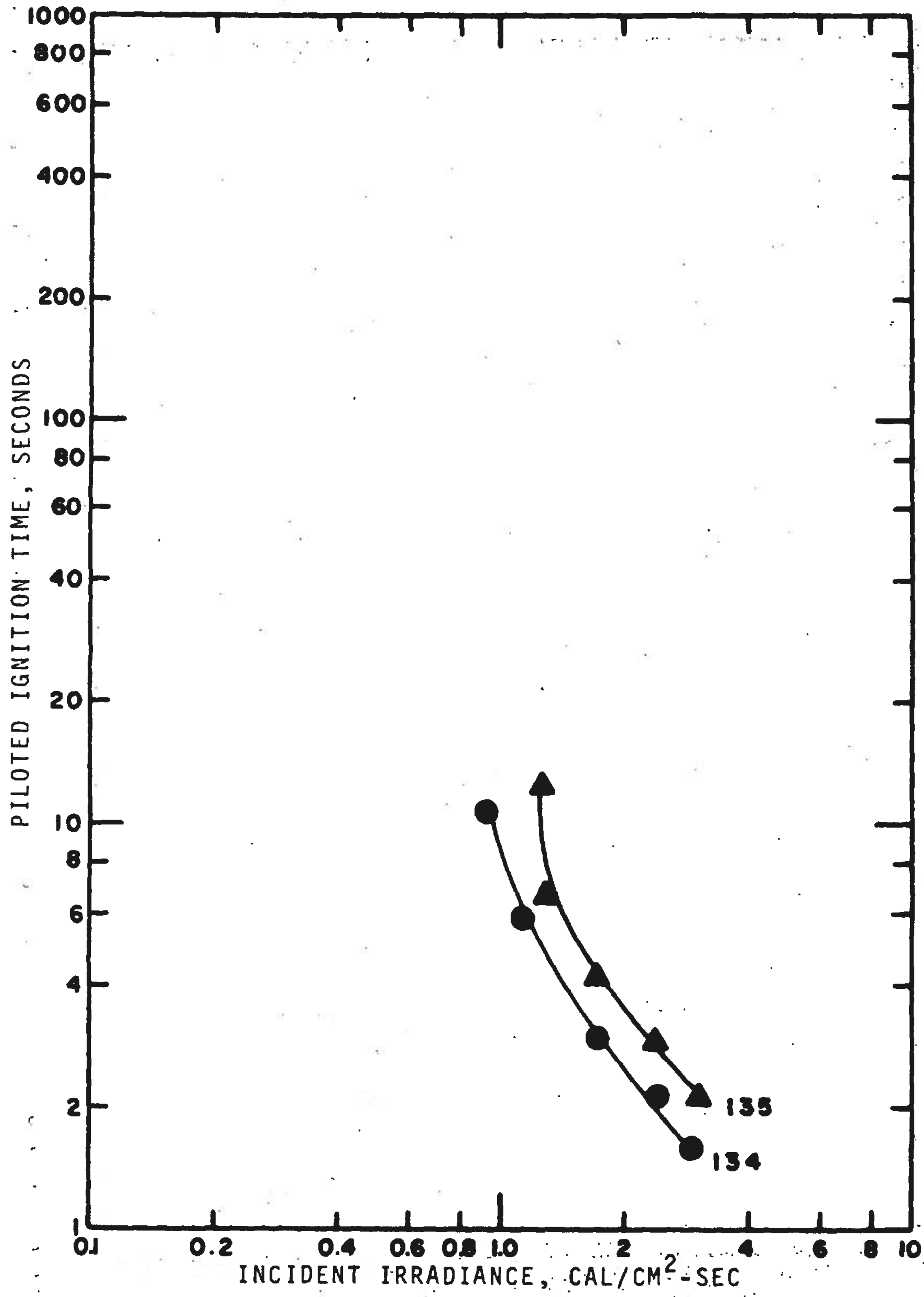

Figure 35. Ignition of IITRI samples No. 134 (vinyl-cotton fabric) and No. 135 (vinyl-elastic fabric).

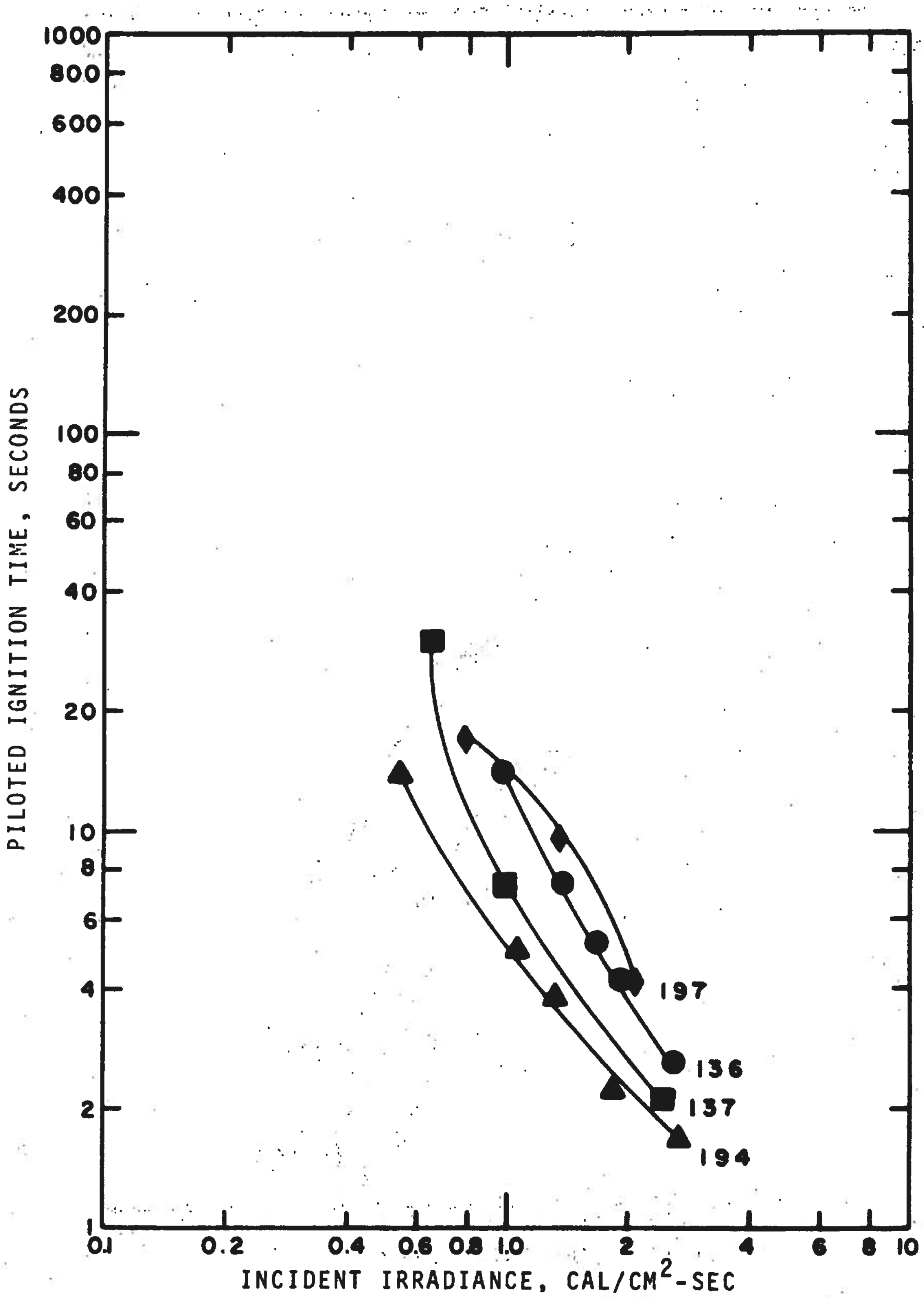

Figure 36. Ignition of IITRI samples Nos. 136 (vinyl-elastic fabric), 137 (vinyl-paper door panel), 194 (jute padding), and 197 (vinyl-cotton fabric).

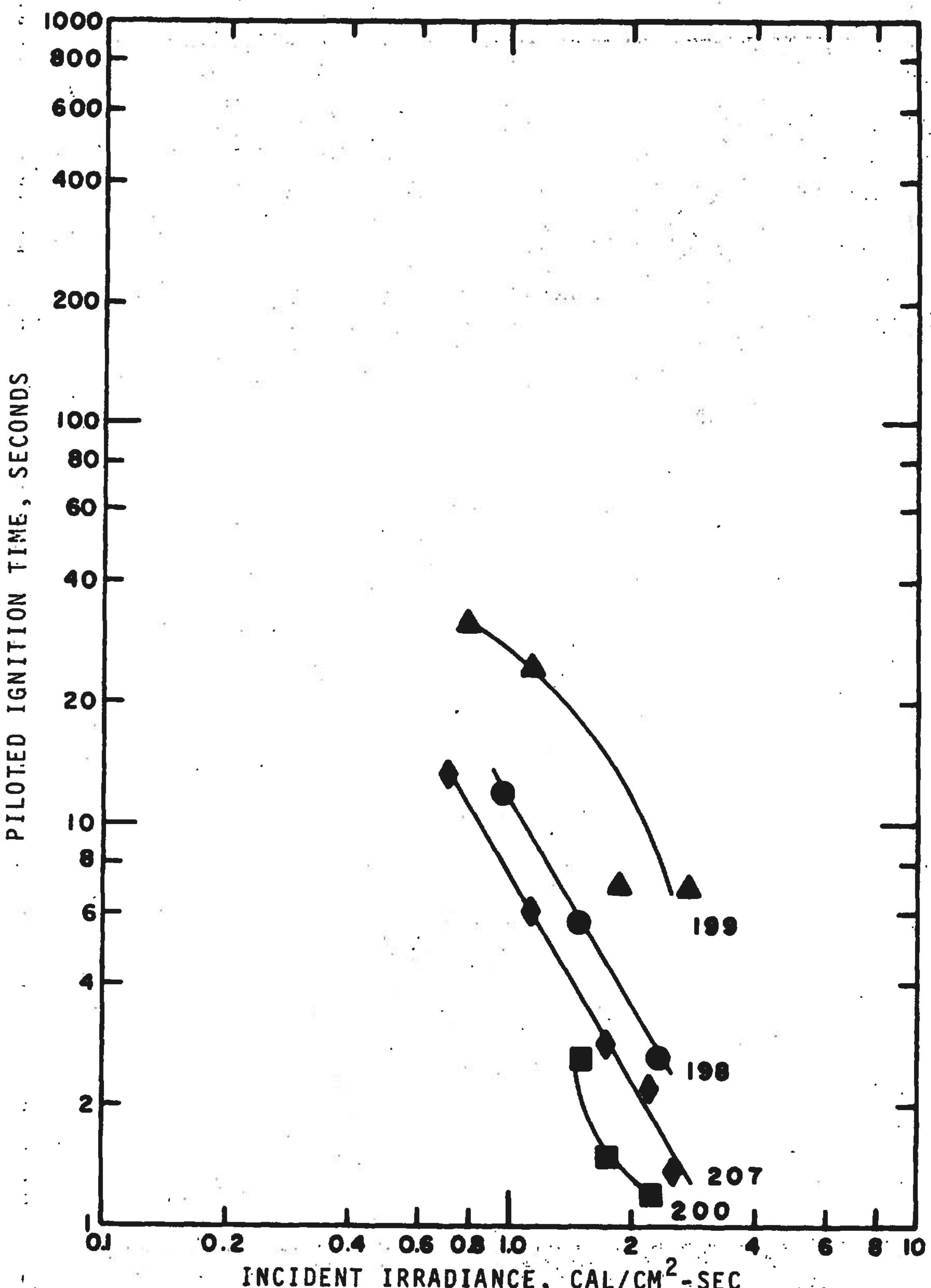

Figure 37. Ignition of IITRI samples Nos. 198 (vinyl-cotton-rayon fabric), 199 (wool-rayon fabric), 200 (leather trim), and 207 (vinyl-urethane-hardboard trim panel).

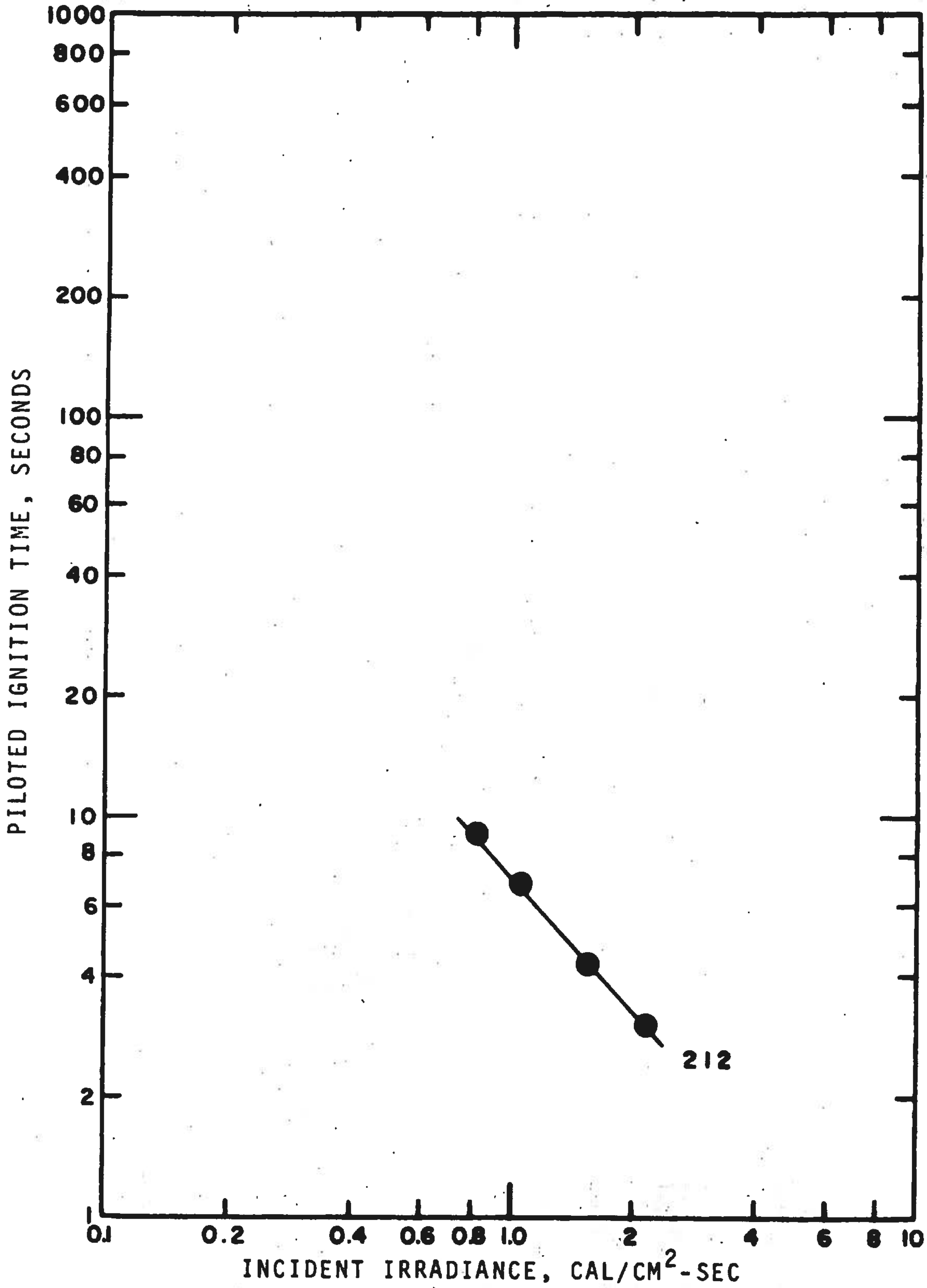

Figure 38. Ignition of IITRI sample No. 212 (vinyl-fiber-hardboard door panel).

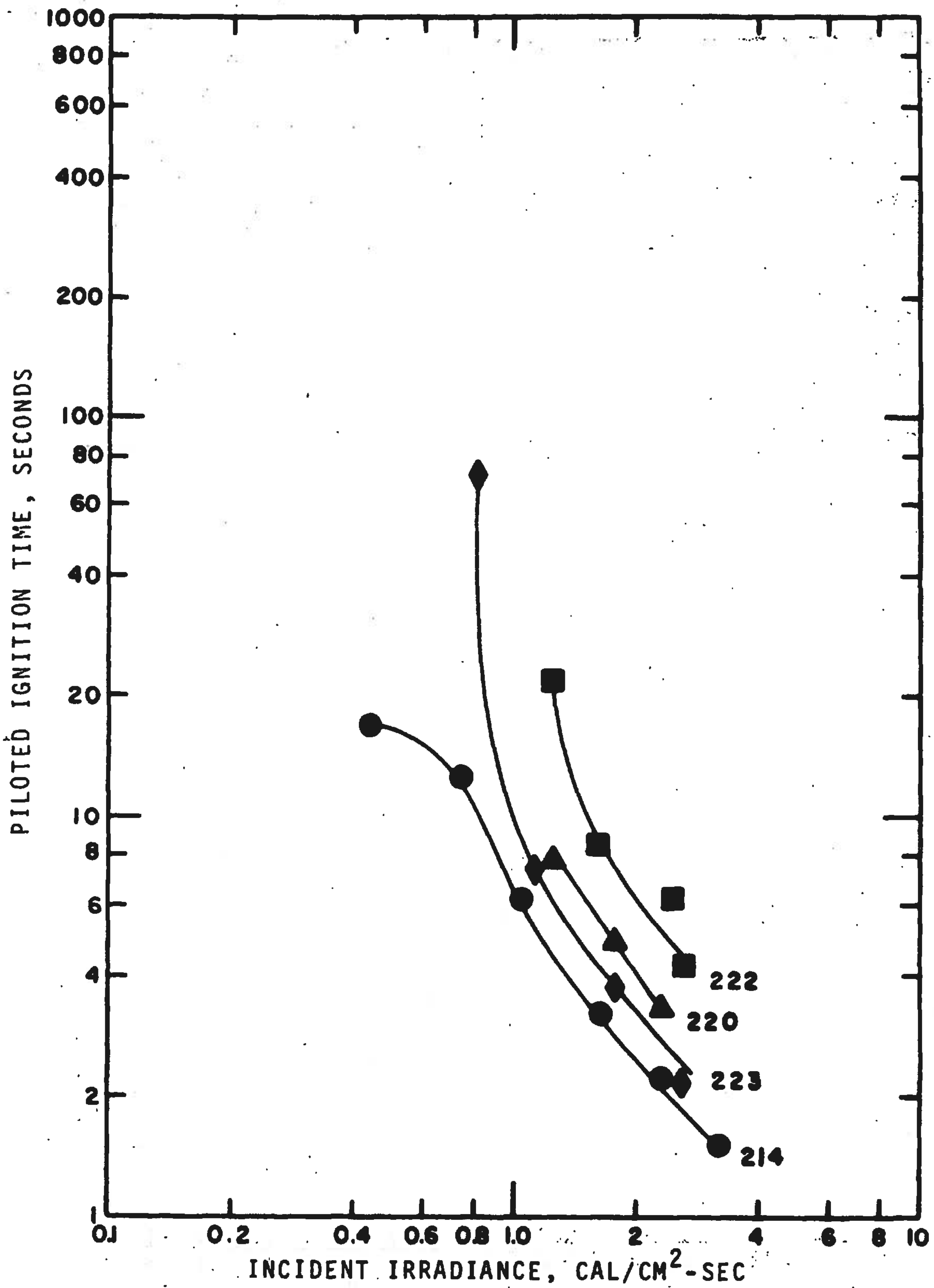

Figure 39. Ignition of IITRI samples Nos. 214 (vinyl fabric), 220 (loop pile carpet), 222 (floor mat underlayer, tar over fiber), and 223 (wheel cover, plastic over cardboard).

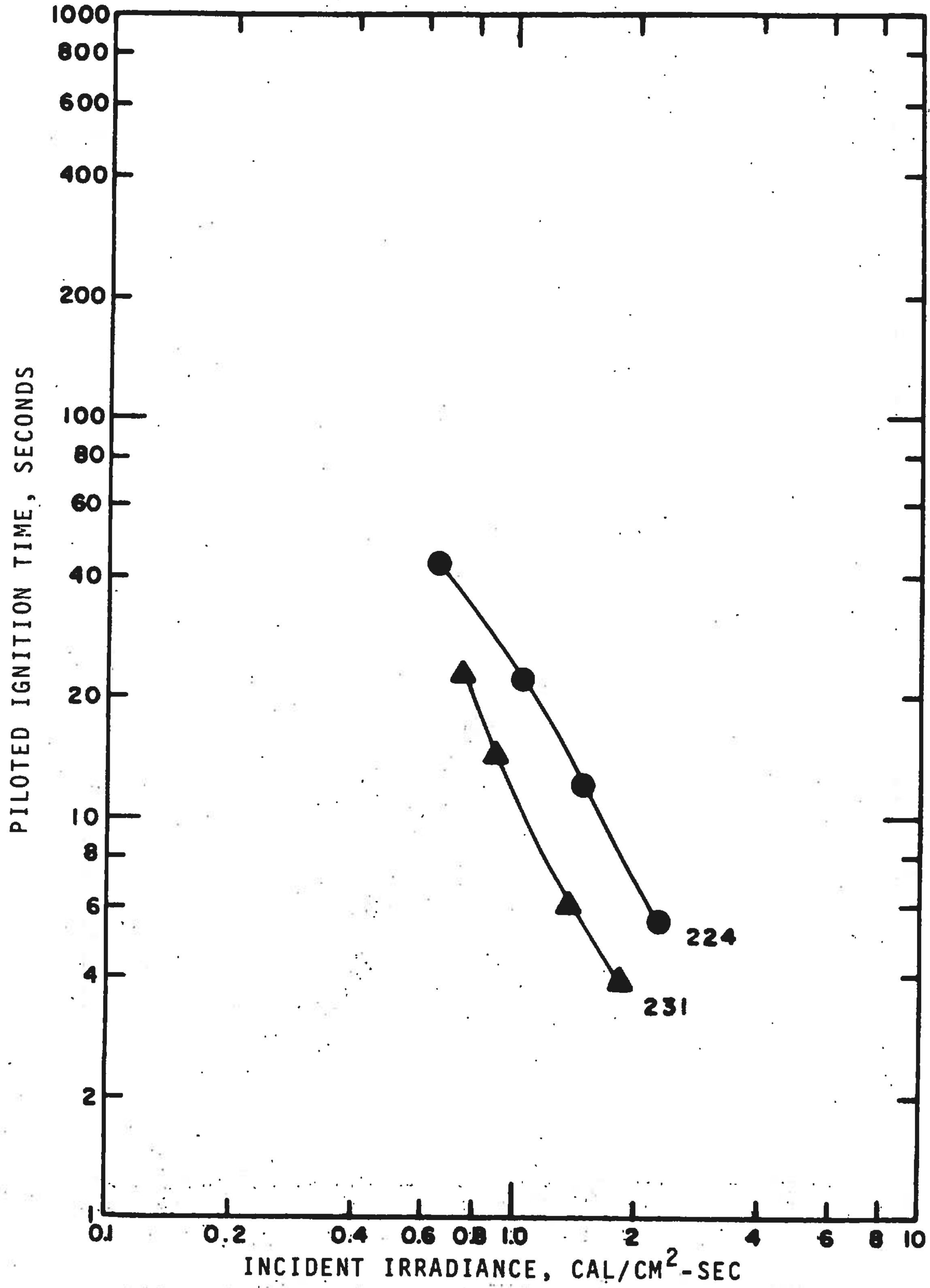

Figure 40. Ignition of IITRI samples No. 224 (plastic floor covering) and No. 231 (liner, 4 layers).

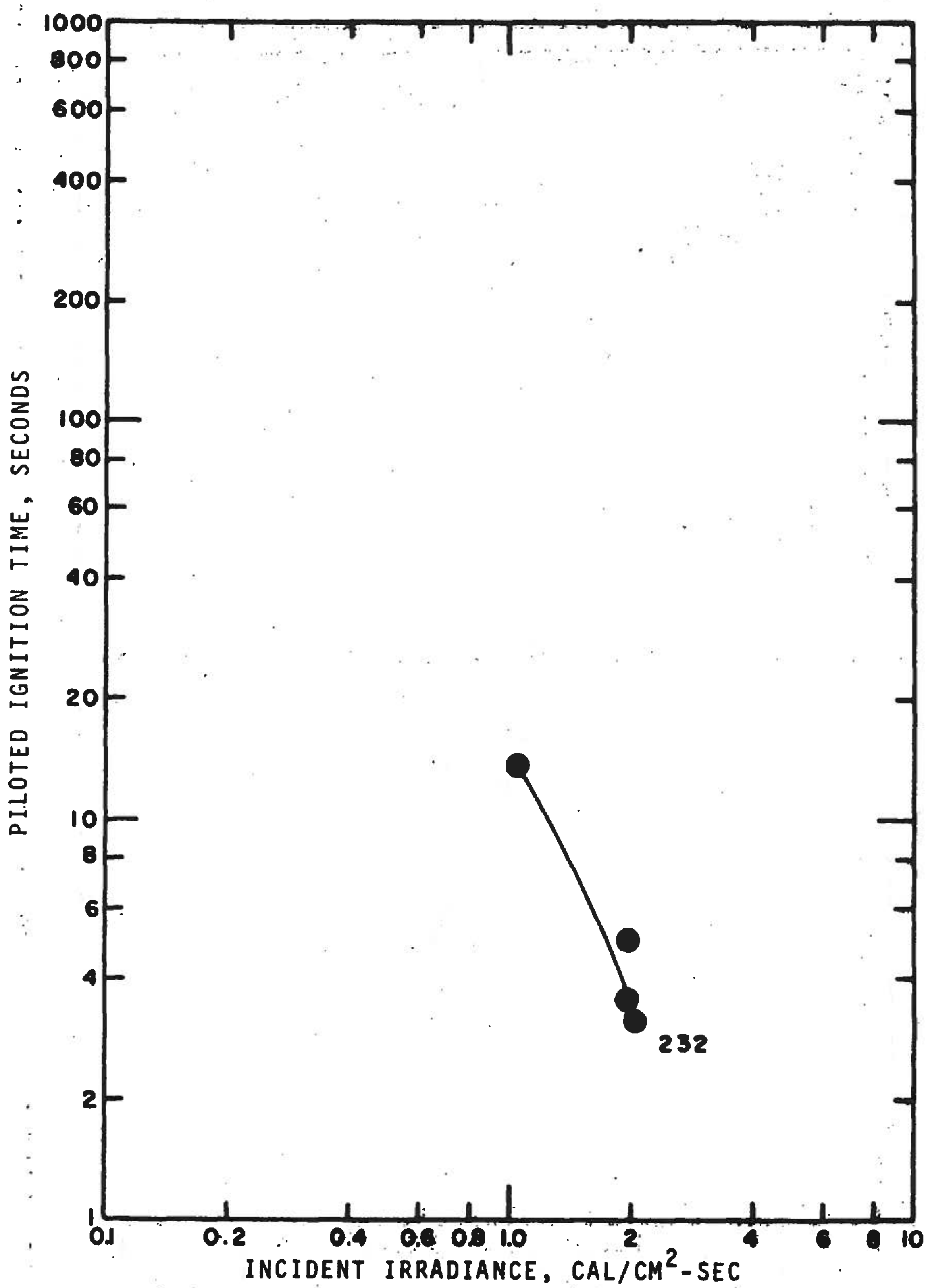

Figure 41. Ignition of IITRI sample No. 232 (unknown woven fabric).

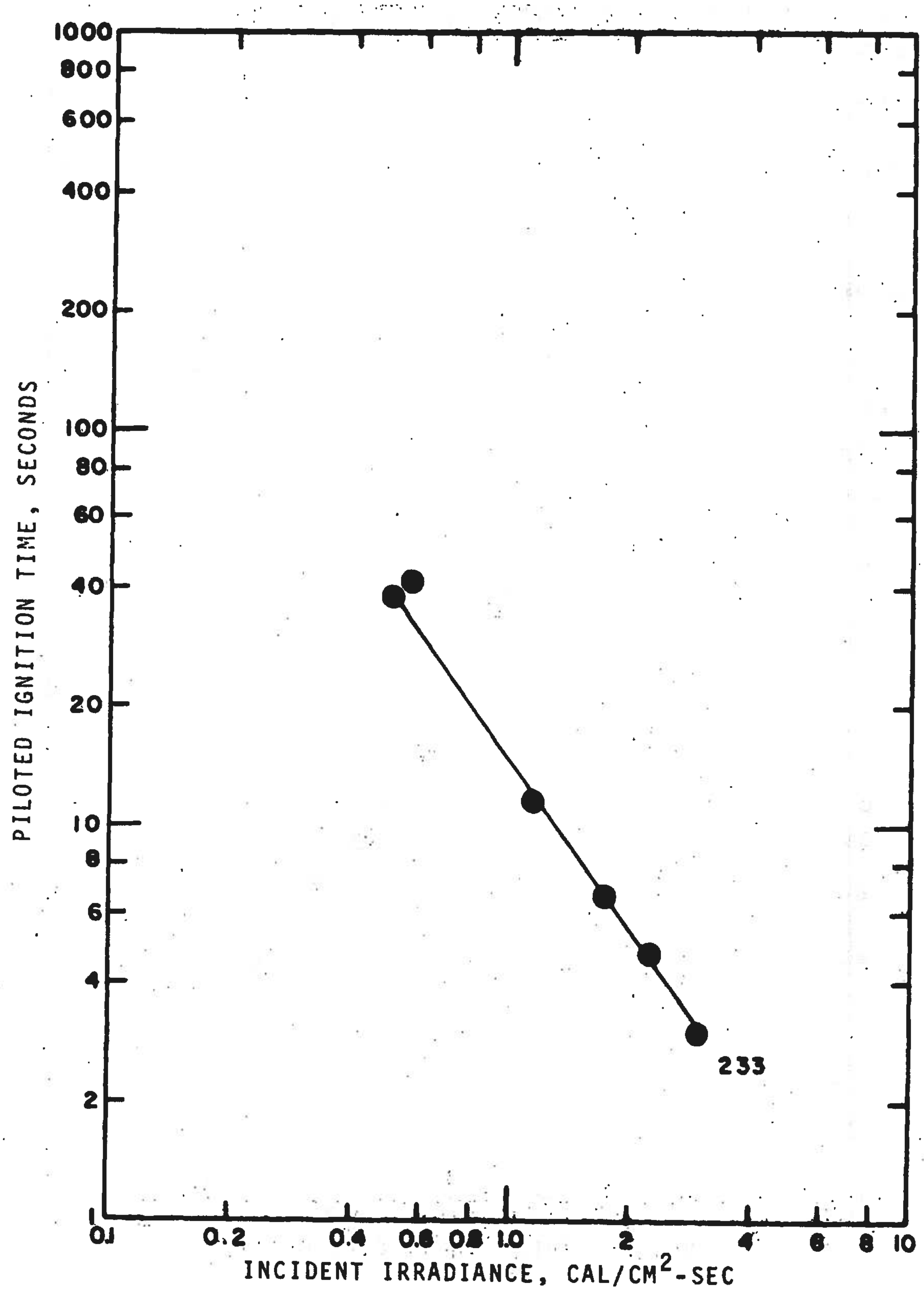

Figure 42. Ignition of IITRI sample No. 233 (unknown woven fabric).

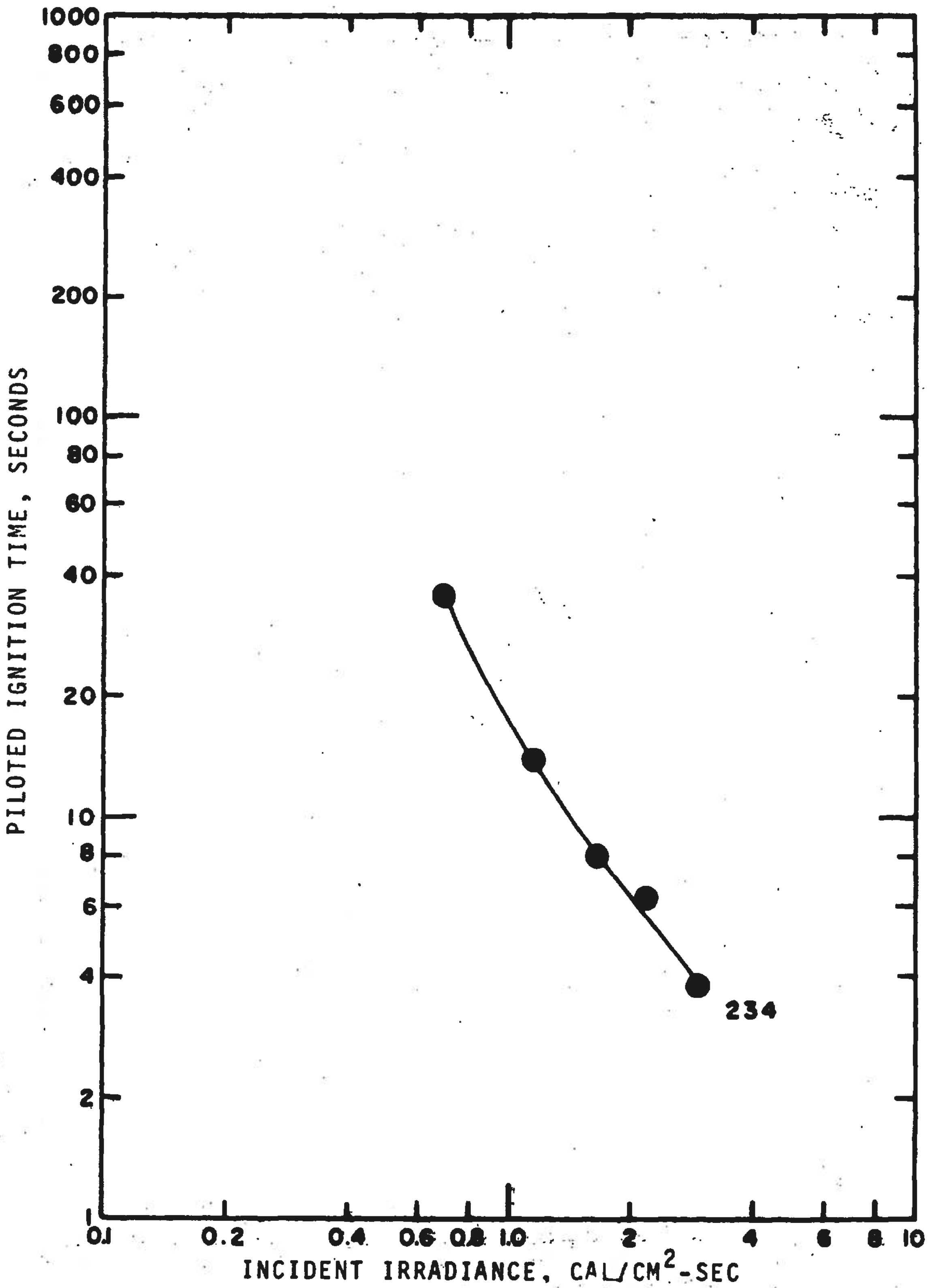

Figure 43. Ignition of IITRI sample No. 234 (unknown woven fabric).

TABLE 1

BURNING RATES OF FABRIC SAMPLES

Material	Comments*	Burning Rate**, in/min			Average
N-1	Lengthwise, Normal	1.37	1.61	1.58	1.52
N-1	Lengthwise, Inverted	1.70	1.62	1.55	1.62
N-1	Crosswise, Normal	1.59	2.69	2.34	2.21
N-1	Crosswise, Inverted	2.60	2.90	2.71	2.74
N-2	Lengthwise, Normal	1.51	1.58	1.58	1.55
N-2	Lengthwise, Inverted	1.55	1.68	1.60	1.61
N-2	Crosswise, Normal	5.65	4.92	4.25	4.94
N-2	Crosswise, Inverted	3.52	3.05	5.39	3.98
N-3	Lengthwise, Normal	2.26	1.84	1.70	1.93
N-3	Lengthwise, Inverted	1.61	1.75	1.87	1.74
N-4	Lengthwise, Normal	2.41	2.48	2.62	2.50
N-4	Lengthwise, Inverted	3.04	2.94	2.84	2.90
N-4	Crosswise, Normal	2.43	2.53	2.43	2.46
N-4	Crosswise, Inverted	2.60	2.65	2.42	2.56
N-5	Lengthwise, Normal	1.14	1.04	1.06	1.08
N-5	Lengthwise, Inverted	1.87	1.93	1.83	1.87
N-5	Crosswise, Normal	1.84	1.73	2.64	2.07
N-5	Crosswise, Inverted	3.26	3.38	3.05	3.23
N-6	Lengthwise, Normal	1.07	1.06	1.07	1.07
N-6	Lengthwise, Inverted	1.84	1.97	1.99	1.93
N-6	Crosswise, Normal	3.70	2.12	2.72	2.84
N-6	Crosswise, Inverted	3.20	2.75	3.76	3.23
N-7	Lengthwise, Normal	1.10	1.13	1.01	1.08
N-7	Lengthwise, Inverted	1.83	1.88	1.90	1.87
N-7	Crosswise, Normal	2.21	2.61	2.62	2.48
N-7	Crosswise, Inverted	2.89	3.12	2.55	2.86

*The pattern orientation lists first the direction of the decorative pattern or (in the case of vinyls) the direction of the backing fabric and then the orientation of the surface. Normal refers to the normally exposed side of the fabric up and inverted means the normally exposed side down.

**A dash signifies that the sample would not burn sufficiently to determine a burning rate.

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min			Average
N-8	Lengthwise, Normal	1.32	0.73	1.04	1.03
N-8	Lengthwise, Inverted	2.12	2.05	2.12	2.10
N-8	Crosswise, Normal	1.68	2.03	1.73	1.81
N-8	Crosswise, Inverted	2.82	2.62	2.72	2.72
N-9	Lengthwise, Normal	1.36	1.33	1.58	1.42
N-9	Lengthwise, Inverted	2.02	2.14	2.09	2.08
N-9	Crosswise, Normal	1.42	1.38	1.36	1.39
N-9	Crosswise, Inverted	1.50	1.43	1.48	1.47
N-10	Lengthwise, Normal	1.08	1.11	1.18	1.12
N-10	Lengthwise, Inverted	2.04	2.23	2.42	2.23
N-11	Lengthwise, Normal	1.17	1.04	1.01	1.07
N-11	Lengthwise, Inverted	1.35	1.46	1.39	1.40
N-11	Crosswise, Normal	1.13	1.02	1.15	1.10
N-11	Crosswise, Inverted	1.30	1.41		1.35
N-12	Lengthwise, Normal	1.21	1.12	1.22	1.18
N-12	Lengthwise, Inverted	2.28	2.38	2.31	2.32
N-12	Crosswise, Normal	3.88	2.88	2.82	3.19
N-12	Crosswise, Inverted	3.70	2.80	2.97	3.15
N-13	Lengthwise, Normal	1.93	2.18	2.11	2.07
N-13	Lengthwise, Inverted	2.06	2.02	1.86	1.98
N-13	Crosswise, Normal	1.59	1.47	1.75	1.60
N-13	Crosswise, Inverted	1.55	1.35	1.50	1.46
N-14	Lengthwise, Normal	1.94	1.86	1.95	1.92
N-14	Lengthwise, Inverted	1.72	2.08	1.88	1.92
N-14	Crosswise, Normal	1.69	1.63	1.75	1.69
N-14	Crosswise, Inverted	1.61	1.52	1.61	1.58
N-15	Lengthwise, Normal	4.68	3.78	5.15	4.54
N-15	Lengthwise, Inverted	2.66	2.78	2.47	2.64
N-15	Crosswise, Normal	3.10	--	--	--
N-15	Crosswise, Inverted	4.08	4.54	4.40	4.34
N-16	Lengthwise, Normal	4.37	3.02	3.23	3.54
N-16	Lengthwise, Inverted	2.61	3.26	3.24	3.04
N-16	Crosswise, Normal	2.33	3.29	3.89	3.17
N-16	Crosswise, Inverted	3.48	4.17	3.62	3.76

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min			Average
N-17	Lengthwise, Normal	2.76	4.11	3.88	3.58
N-17	Lengthwise, Inverted	5.24	3.98	4.33	4.52
N-17	Crosswise, Normal	0.97	1.27	1.51	1.23
N-17	Crosswise, Inverted	5.24	5.02	5.44	5.24
N-18	Lengthwise, Normal	4.25	5.17	4.80	4.74
N-18	Lengthwise, Inverted	3.24	3.45	2.84	3.18
N-18	Crosswise, Normal	--	--	3.33	3.33
N-18	Crosswise, Inverted	3.34	4.32	3.51	3.72
N-19	Lengthwise, Normal	4.15	4.70	5.11	4.65
N-19	Lengthwise, Inverted	3.13	3.92	3.43	3.49
N-19	Crosswise, Normal	3.54	2.38	3.78	3.23
N-19	Crosswise, Inverted	4.90	4.38	4.33	4.54
N-20	Lengthwise, Normal	3.79	2.12	2.76	2.89
N-20	Lengthwise, Inverted	5.35	5.20	5.50	5.35
N-20	Crosswise, Normal	2.80	2.54	--	2.67
N-20	Crosswise, Inverted	5.02	4.84	4.46	4.78
N-21	Lengthwise, Normal	4.36	3.96	5.15	4.50
N-21	Lengthwise, Inverted	2.96	3.44	3.80	3.40
N-21	Crosswise, Normal	--	3.24	--	3.24
N-21	Crosswise, Inverted	4.90	4.42	5.50	4.95
N-22	Lengthwise, Normal	4.20	4.30	4.16	4.21
N-22	Lengthwise, Inverted	2.78	3.29	3.92	3.33
N-22	Crosswise, Normal	3.41	3.88	3.20	3.49
N-22	Crosswise, Inverted	5.47	5.35	5.55	5.45
N-23	Lengthwise, Normal	3.38	4.17	5.00	4.18
N-23	Lengthwise, Inverted	3.61	3.93	3.69	3.74
N-23	Crosswise, Normal	4.00	2.82	3.37	3.39
N-23	Crosswise, Inverted	4.60	5.75	4.63	4.99
N-24	Lengthwise, Normal Angle = -30°	--	--	--	
N-24	Lengthwise, Normal Angle = -15°	--	--	--	
N-24	Lengthwise, Normal Angle = 0°	--	--	--	
N-24	Lengthwise, Normal Angle = +15°	4.86	4.89	4.62	4.79

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min					Average
N-24	Lengthwise, Normal Angle = 30°	9.18	9.89	9.57			9.55
N-24	Lengthwise, Normal Angle = 45°	12.86	13.04	13.24			13.05
N-24	Lengthwise, Normal Angle = 60°	14.52	13.43	14.52			14.16
N-24	Lengthwise, Normal Angle = 75°	13.04	15.52	16.67			15.08
N-25	Lengthwise, Normal Angle = -30°	1.10	1.11	1.10	1.11	1.10	
		1.09	1.12	1.12	1.11	1.11	
		1.11	1.10	1.10	1.10	1.09	
		1.09	1.11	1.11	1.10	1.10	
		1.10	1.10	1.10	1.10	1.10	
		1.10	1.11	1.11	1.10	1.10	1.10
N-25	Lengthwise, Normal Angle = -15°	1.16	1.16	1.23	1.18	1.19	
		1.17	1.18	1.16	1.20	1.17	
		1.20	1.18	1.19	1.17	1.19	
		1.17	1.16	1.19	1.17	1.17	
		1.20	1.18	1.20	1.17	1.16	
		1.20	1.16	1.20	1.17		1.18
N-25	Lengthwise, Normal Angle = 0°	2.66	2.18	2.76	2.56	2.64	
		2.53	2.58	2.51	2.39	2.57	
		2.67	2.57	2.49	2.33	2.54	
		2.64	2.49	2.51	2.58	2.56	
		2.49	2.56	2.60	2.55	2.65	
		2.60	2.51	2.72	2.49	2.53	2.55
N-25	Lengthwise, Normal Angle = 15°	10.64	11.24	12.66	11.11		
		12.66	12.05	11.90	11.49		
		12.05	11.90	12.50	12.20		
		12.50	11.24	12.50	12.05		
		11.49	11.36	12.05	11.90		
		12.66	12.05	12.50	11.49		
		11.36	11.11	12.35	11.36		
		12.66	11.90				11.90
N-25	Lengthwise, Normal Angle = 30°	16.67	14.93	16.67	17.54		
		16.95	18.18	17.57	16.67		
		17.24	16.67	16.67	17.57		
		16.67	18.18	14.93	16.67		
		18.18	16.95	14.93	17.57		
		16.67	17.24	17.57	17.24		
		16.67	16.67	14.93	17.57		
		17.24	16.95				16.87

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min					Average
N-25	Lengthwise, Normal	24.39	22.73	20.41	22.22		
	Angle = 45°	23.26	21.74	22.73	23.26		
		20.41	19.23	23.81	22.73		
		23.26	21.28	23.26	19.23		
		22.73	23.81	21.28	23.26		
		23.26	21.74	20.41	22.73		
		23.26	24.39	22.22	22.73		
		22.73	21.74				22.34
N-25	Lengthwise, Normal	27.78	23.81	27.78	23.81		
	Angle = 60°	24.39	24.39	26.32	27.03		
		25.64	24.39	24.39	24.39		
		27.03	25.64	26.32	24.39		
		27.03	24.39	23.81	23.81		
		27.78	24.39	26.32	25.64		
		25.00	25.00	25.64	23.81		
		27.03	24.39				25.38
N-25	Lengthwise, Normal	32.14	31.03	31.03	26.47		
	Angle = 75°	32 14	26.67	27.59	28.13		
		30.00	34.64	27.27	33.31		
		28.13	27.27	27.27	33.31		
		29.03	26.47	28.13	28.13		
		29.03	32.14	30.00	31.03		
		31.03	28.13	28.13	31.03		
		29.03	28.13				29.53
N-26	Lengthwise, Normal	1.58	1.45	1.38	1.52	1.64	
	Angle = -30°	1.44	1.42	1.43	1.41	1.56	
		1.54	1.48	1.51	1.52	1.53	
		1.54	1.45	1.45	1.50	1.45	
		1.44	1.45	1.49	1.49	1.52	
		1.67	1.47	1.44	1.46	1.44	1.49
N-26	Lengthwise, Normal	2.27	2.41	2.37	1.68	2.15	
	Angle = -15°	2.05	2.09	2.30	2.39	2.14	
		2.00	2.59	2.42	2.82	1.96	
		2.74	2.47	2.20	2.60	2.12	
		3.14	3.21	2.66	3.20	2.31	
		2.19	1.89	1.92	2.52	2.00	2.37

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min					Average
N-26	Lengthwise, Normal	5.15	5.49	4.05	4.85	4.10	
	Angle = 0°	5.52	4.46	4.41	4.78	3.31	
		4.26	3.32	3.33	5.32	4.59	
		4.20	3.95	4.78	4.03	5.18	
		4.76	4.61	3.83	5.03	5.29	
		3.70	3.44	4.20	4.15	4.65	4.42
N-26	Lengthwise, Normal	11.84	12.16	12.68	12.50		
	Angle = 15°	11.25	11.11	12.00	13.43		
		12.16	12.68	11.11	12.68		
		12.86	12.68	12.33	12.86		
		11.84	12.50	13.24	14.75		
		13.04	10.34	12.50	11.11		
		11.39	11.84	13.24	12.33		
		12.68	13.24				12.35
N-26	Lengthwise, Normal	19.15	19.57	16.07	15.79		
	Angle = 30°	18.00	14.75	17.65	17.65		
		16.98	14.52	17.65	17.31		
		16.07	17.65	18.75	18.75		
		23.08	19.57	19.15	16.07		
		18.00	16.36	17.31	16.98		
		15.25	20.00	16.98	18.37		
		18.75	18.00				17.67
N-26	Lengthwise, Normal	31.03	28.13	32.14	30.00		
	Angle = 45°	28.13	27.27	34.62	28.13		
		32.14	26.47	36.00	30.00		
		28.13	31.03	31.03	27.27		
		32.14	34.62	30.00	32.14		
		28.13	31.03	28.13	25.00		
		29.03	31.03	33.33	31.03		
		28.13	34.62				30.33
N-26	Lengthwise, Normal	33.33	34.62	32.14	32.14		
	Angle = 60°	37.50	28.13	26.47	28.13		
		31.03	31.03	29.03	33.33		
		32.14	31.03	28.13	29.03		
		31.03	32.14	37.50	31.03		
		34.62	39.13	37.50	31.03		
		32.14	28.13	33.33	31.03		
		30.00	33.33				31.97

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min					Average
N-26	Lengthwise, Normal	31.03	33.33	29.03	34.78		
	Angle = 75°	38.10	30.77	33.33	31.03		
		34.62	29.03	30.00	31.03		
		31.03	33.33	34.62	32.14		
		29.03	32.14	29.03	29.03		
		33.33	31.03	30.00	27.27		
		30.00	34.62	32.14	32.14		
		29.03					31.59
N-27	Lengthwise, Normal	3.30	3.20	4.44	8.00	9.33	
		2.80	4.00	2.97	5.45	3.33	
		1.58	2.78	3.17	3.24	3.01	
		4.15	2.02	1.52	1.36	3.65	
		1.89	3.29	4.64	3.03	3.00	
		2.97	2.31	2.56	1.62	3.76	
		1.93	2.65	4.09	6.67	2.23	3.43
S-1	Lengthwise, Normal						
S-1	Lengthwise, Inverted	5.67	6.25	4.41			5.44
S-1	Crosswise, Normal		7.90	9.79			8.84
S-1	Crosswise, Inverted	10.50	6.68	6.82			8.00
S-2	Lengthwise, Normal	5.36	4.33	7.29			5.66
S-2	Crosswise, Normal	7.27	9.00	11.22			9.16
S-3	Lengthwise, Normal	3.74	3.52	3.66			3.64
S-3	Lengthwise, Inverted	3.96	3.68	3.90			3.85
S-3	Crosswise, Normal	9.90	8.33	9.70			9.30
S-3	Crosswise, Inverted	7.93	8.85	7.81			8.20
S-4	Lengthwise, Normal	2.50	2.46	2.53			2.50
S-4	Lengthwise, Inverted	2.40	2.40	2.48			2.43
S-4	Crosswise, Normal	2.66	2.85	2.79			2.77
S-4	Crosswise, Inverted	3.47	3.08	3.26			3.27
V-1	Lengthwise, Normal	2.27	2.07	2.05			2.13
V-1	Lengthwise, Inverted	2.08	2.16	2.09			2.11
V-1	Crosswise, Normal	1.98	1.97	2.09			2.01
V-1	Crosswise, Inverted	2.17	2.55	2.34			2.35
V-2	Lengthwise, Normal	3.68	3.42	3.39			3.50
V-2	Lengthwise, Inverted	6.06	5.91	5.52			5.83
V-2	Crosswise, Normal	3.26	3.27	3.40			3.30
V-2	Crosswise, Inverted	5.65	6.17	5.81			5.88

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min			
					Average
V-3	Lengthwise, Normal	2.81	2.54	2.38	2.58
V-3	Lengthwise, Inverted	2.31	2.28	2.26	2.28
V-3	Crosswise, Normal	2.22	2.19	2.36	2.26
V-3	Crosswise, Inverted	2.40	2.38	2.44	2.41
V-4	Lengthwise, Normal	2.08	2.00	1.09	1.99
V-4	Lengthwise, Inverted	2.08	1.80	1.72	1.87
V-4	Crosswise, Normal	3.55	2.91	2.71	3.06
V-4	Crosswise, Inverted	2.34	2.34	2.18	2.28
V-5	Lengthwise, Normal	4.19	4.53	4.10	4.27
V-5	Lengthwise, Inverted	3.35	4.19	4.41	3.98
V-5	Crosswise, Normal	3.69	3.97	3.62	3.76
V-5	Crosswise, Inverted	3.34	3.26	3.72	3.44
V-6	Lengthwise, Normal	2.71	3.81	3.78	3.43
V-6	Lengthwise, Inverted	5.18	7.00	7.35	6.50
V-6	Crosswise, Normal	3.57	3.40	3.43	3.46
V-6	Crosswise, Inverted	5.69	5.18	6.58	5.81
V-7	Lengthwise, Normal	3.14	3.16		3.15
V-7	Lengthwise, Inverted	4.96	4.96		4.96
V-7	Crosswise, Normal	3.09	3.40	3.47	3.32
V-7	Crosswise, Inverted	3.40	4.28	4.14	3.94
V-8	Lengthwise, Normal	4.14	4.00	4.77	4.30
V-8	Lengthwise, Inverted	8.20	6.58	7.15	7.31
V-8	Crosswise, Normal	4.56	4.68		4.62
V-8	Crosswise, Inverted	6.95			6.95
V-9	Lengthwise, Normal	2.50	3.33		2.92
V-9	Lengthwise, Inverted	4.63	5.00		4.81
V-9	Crosswise, Normal	2.41	2.45	3.45	2.77
V-9	Crosswise, Inverted	4.03	3.57	4.66	4.08
V-10	Lengthwise, Normal	2.71			2.71
V-10	Lengthwise, Inverted	3.76			3.76
V-10	Crosswise, Normal	2.82	2.81	2.89	2.84
V-10	Crosswise, Inverted	3.57	3.03	3.45	3.50

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min					
							Average
V-11	Lengthwise, Normal	4.20	4.55				4.38
V-11	Lengthwise, Inverted	5.95	5.88				5.92
V-11	Crosswise, Normal	3.10	3.67	3.82			3.53
V-11	Crosswise, Inverted	5.95	5.74	5.74			5.81
V-12	Lengthwise, Normal	4.03					4.03
V-12	Lengthwise, Inverted	7.05					7.05
V-12	Crosswise, Normal	4.39	5.29				4.84
V-12	Crosswise, Inverted	6.34	5.27	4.65			5.42
V-13	Lengthwise, Normal Angle = -30°	--	--	--			
V-13	Lengthwise, Normal Angle = -15°	--	--	--			
V-13	Lengthwise, Normal Angle = 0°	3.75	4.19	3.82	4.33	3.98	
		4.10	3.27	3.64	3.89	3.68	
		3.66	3.64	3.91	2.40	3.73	
		3.94	3.92	3.83	3.23	3.58	
		3.63	3.23	4.08	3.97	3.73	
		2.72	3.33	3.56	3.74	3.69	3.67
V-13	Lengthwise, Normal Angle = 15°	12.35	11.76	11.36	11.11		
		11.63	11.76	12.05	11.49		
		11.90	10.87	11.49	11.90		
		11.24	11.49	11.49	11.49		
		10.87	10.75	11.63	12.35		
		12.20	11.11	10.75	11.36		
		11.49	11.49	11.36	10.99		
		10.87	11.76				11.48
V-13	Lengthwise, Normal Angle = 30°	20.93	20.45	18.37	19.15		
		19.57	20.00	18.37	21.43		
		18.75	18.37	18.75	18.75		
		18.75	18.37	18.75	18.75		
		20.45	18.75	20.45	19.57		
		20.93	18.75	18.37	18.37		
		18.75	18.37	20.45	19.15		
		20.45	19.15				19.32

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min				
						Average
V-13	Lengthwise, Normal Angle = 45°	26.47	32.14	27.27	25.00	
		27.59	26.47	25.71	30.00	
		28.13	29.63	32.14	24.24	
		25.00	27.27	28.13	27.27	
		25.71	25.71	26.47	27.27	
		30.00	29.03	30.00	32.14	
		27.27	28.13	30.00	27.27	
		26.47	29.03			27.90
V-13	Lengthwise, Normal Angle = 60°	27.27	28.13	29.03	28.13	
		29.03	30.00	32.14	31.03	
		31.03	29.03	29.03	23.68	
		28.13	25.71	29.03	31.03	
		32.14	29.03	30.00	30.00	
		32.14	29.03	29.03	30.00	
		33.33	30.00	32.14	31.03	
		31.03	29.03			29.65
V-13	Lengthwise, Normal Angle = 75°	29.03	30.00	32.14	34.62	
		34.62	30.00	36.00	34.62	
		33.33	33.33	34.62	31.03	
		29.03	36.00	34.62	36.00	
		30.00	32.14	31.03	29.03	
		31.03	37.50	36.00	36.00	
		34.62	31.03	31.03	37.50	
		29.03	31.03			32.87
V-14	Lengthwise, Inverted Angle = -30°	--	--	--		
V-14	Lengthwise, Inverted Angle = -15°	--	--	--		
V-14	Lengthwise, Inverted Angle = 0°	--	--	--		
V-14	Lengthwise, Inverted Angle = 15°	1.43	1.51	1.70	1.50	
		1.94	1.71	1.39	1.49	
		1.59	1.90	1.62	1.48	
		1.49	1.44	1.78	1.57	
		1.54	1.64	1.51	1.45	
		1.78	1.54	1.50	1.59	
		1.52	1.46	1.45	1.48	
		1.64	1.42			1.57

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min					Average
V-14	Lengthwise, Inverted	10.11	10.47	9.68	10.71		
	Angle = 30°	10.11	10.47	11.11	9.57		
		10.47	8.65	9.09	9.68		
		10.23	10.11	10.84	10.71		
		10.11	10.11	10.00	10.34		
		10.23	8.82	9.18	10.47		
		10.23	10.23	9.78	9.78		
		10.84	10.84				10.10
V-14	Lengthwise, Inverted	16.36	16.67	18.00	16.98		
	Angle = 45°	19.57	16.07	26.47	18.00		
		20.45	17.31	26.47	37.50		
		17.31	15.79	25.71	16.67		
		25.00	15.25	15.25	15.52		
		19.57	17.31	16.67	16.98		
		19.15	19.57	15.52	17.31		
		36.00	18.37				19.76
V-14	Lengthwise, Inverted	23.08	20.00	20.93	23.08		
	Angle = 60°	18.00	19.15	27.27	29.03		
		25.00	21.95	37.50	20.45		
		37.50	33.33	29.03	22.50		
		23.68	20.45	27.27	26.47		
		20.00	23.68	20.93	30.00		
		23.08	21.95	29.03	30.00		
		37.50	24.32				25.54
V-14	Lengthwise, Inverted	40.91	36.00	40.91	23.68		
	Angle = 75°	39.13	40.91	25.00	25.00		
		23.08	29.03	39.13	52.94		
		40.91	33.33	37.50	26.47		
		29.03	30.00	39.13	34.62		
		32.14	40.91	40.91	39.13		
		33.33	33.33	47.37	33.33		
		26.47	39.13				35.09
V-15	Lengthwise, Normal	5.36	5.71	5.77	6.19	5.66	
		6.00	6.00	6.59	6.19	5.41	
		6.67	6.59	6.00	6.25	6.00	
		6.59	6.06	5.56	7.06	5.41	6.05

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min			
					Average
C-1	Lengthwise, Normal	--	--	--	
C-1	Lengthwise, Inverted	0.54	0.40	0.63	0.53
C-1	Crosswise, Normal	--	--	--	
C-1	Crosswise, Inverted	0.39	0.44	0.41	0.41
C-2	Lengthwise, Normal	--	--	--	
C-2	Lengthwise, Inverted	--	--	--	
C-2	Crosswise, Normal	--	--	--	
C-2	Crosswise, Inverted	--	--	--	
C-3	Lengthwise, Normal	0.34	0.45	--	0.40
C-3	Lengthwise, Inverted	--	--		
C-3	Crosswise, Normal	--	--	--	
C-3	Crosswise, Inverted	0.33	--	0.33	0.33
C-4	Lengthwise, Normal	--	--	--	
C-4	Lengthwise, Inverted	--	--	--	
C-4	Crosswise, Normal	0.55	--	0.34	0.45
C-4	Crosswise, Inverted	--	--	--	
C-5	Lengthwise, Normal	--	--	--	
C-5	Lengthwise, Inverted	--	--	--	
C-6	Lengthwise, Normal	--	--	--	
C-6	Lengthwise, Inverted	--	0.45	0.52	0.48
C-6	Crosswise, Normal	--	--	--	
C-6	Crosswise, Inverted	0.73	0.48	0.49	0.57
C-7	Lengthwise, Normal	--	--	--	
C-7	Lengthwise, Inverted	--	0.42	--	0.42
C-7	Crosswise, Normal	--	--		
C-7	Crosswise, Inverted	--	--	--	
C-8	Lengthwise, Normal	--	0.52	0.52	0.52
C-8	Lengthwise, Inverted	--	--	--	
C-8	Crosswise, Normal	0.58	0.57	--	0.58
C-8	Crosswise, Inverted	--	--	--	
C-9	Lengthwise, Normal	0.68	--	--	0.68
C-9	Lengthwise, Inverted	0.57	0.55	0.48	0.53
C-9	Crosswise, Normal	0.74	0.65	--	0.70
C-9	Crosswise, Inverted	0.53	0.47	0.52	0.51

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min					Average
F-1		8.20	8.62	8.47	9.26	8.47	
		8.62	8.93	8.93	8.77	8.47	
		8.40	9.01	8.33	9.26	8.48	
		8.40	8.33	8.33	9.26	8.06	
		8.06	7.94	8.00	8.00	8.07	
		8.48	9.09	8.62			8.53
F-1	Two sheets Angle = -30°	2.81	3.10	3.26	3.16	3.11	
		2.83	2.79	2.81	2.81	3.00	
		2.93	2.90	2.86	3.11	2.89	
		3.13	2.99	2.83	3.00	2.95	
		3.03	2.97	2.82	3.02	2.92	
		2.93	2.76	2.86	2.74	2.79	2.94
F-1	Two sheets Angle = -15°	3.10	3.16	3.34	3.53	3.53	
		3.37	3.60	3.60	3.20	3.30	
		3.34	3.71	3.41	3.23	3.30	
		3.41	3.18	3.30	3.47	3.43	
		3.28	3.51	3.51	3.53	3.25	
		3.30	3.36	3.41	3.11	3.11	3.37
F-1	Two sheets Angle = 0°	5.27	5.22	5.31	6.32	5.89	
		5.77	5.13	4.96	5.13	4.62	
		4.58	5.18	4.69	5.13	5.31	
		5.18	4.48	4.80	4.77	5.56	
		4.69	4.77	5.05	5.18	4.32	
		5.66	6.25	5.09	5.83	5.61	5.20
F-1	Two sheets Angle = 15°	12.50	11.12	14.29	14.64		
		14.29	11.12	12.50	13.34		
		12.25	14.64	11.77	13.34		
		14.29	13.34	12.00	13.64		
		11.54	15.00	13.05	13.05		
		14.64	13.96	15.00	13.05		
		14.64	14.29	13.05	12.25		
		15.00	13.64				13.38
F-1	Two sheets Angle = 30°	22.23	23.08	22.23	23.08		
		22.23	24.00	27.28	26.09		
		27.28	28.58	30.00	25.00		
		27.28	24.00	30.00	26.09		
		26.09	24.00	25.00	24.00		
		25.00	24.00	28.58	25.00		
		28.58	27.28	27.28	26.09		
		25.00	28.58				25.77

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min					
							Average
F-1	Two sheets Angle = 45°	33.34	33.34	33.34	35.30		
		31.58	35.30	33.34	35.30		
		33.34	37.50	31.58	31.58		
		33.34	33.34	33.34	33.34		
		37.50	31.58	33.34	35.30		
		35.30	35.30	33.34	35.30		
		35.30	35.30	31.58	30.00		
		31.58	30.00				33.63
F-1	Two sheets Angle = 60°	40.00	40.00	42.86	40.00		
		46.16	40.00	40.00	46.16		
		46.16	42.86	40.00	46.16		
		46.16	46.16	46.16	42.86		
		46.16	40.00	42.86	46.16		
		40.00	40.00	42.86	40.00		
		42.86	40.00	40.00	42.86		
		40.00	46.16				42.72
F-1	Two sheets Angle = 75°	46.16	50.00	42.86	46.16		
		42.86	42.86	46.16	46.16		
		46.16	46.16	50.00	50.00		
		42.86	46.16	46.16	50.00		
		50.00	50.00	46.16	50.00		
		46.16	54.55	50.00	42.86		
		46.16	46.16	46.16	42.86		
		42.86	42.86				46.59
F-2		6.52	6.45	6.32	6.52	6.45	6.45
F-2	Two sheets	3.03	3.03	3.23	3.14	2.96	
		2.99	3.29	3.07	2.92	3.05	
		3.09	3.07	3.09	2.94	3.27	
		3.16	3.29	3.13			3.10
F-2	Three sheets	2.91	2.84	2.82	2.90	2.84	2.86
F-3		6.85	7.25	6.66	6.75	7.35	6.95
F-4		8.82	8.10	7.69	8.95	8.11	8.34
F-4	Two sheets	5.26	5.34	5.22	5.30	5.19	5.24
F-4	Three sheets	3.97	4.03	4.05	4.05	4.03	4.03
F-5		9.09	7.70	8.93	7.70	7.94	8.26

TABLE 1 -- Continued

Material	Comments	Burning Rate, in/min					Average
F-6		10.71	10.53	10.71	10.00		
		10.53					10.49
F-7		11.76	11.54	11.32	11.45		
		11.32					11.50
CT-1	Parallel to warp	2.68	2.57	2.86	2.68	3.09	
		2.92	2.89	2.52	2.54	3.07	
		3.15	3.05	2.84	3.52	3.07	
		3.01	2.82	3.18	2.69	3.39	
		3.23	3.20	3.45	3.27	2.68	
		3.28	2.81	3.35	3.51	2.92	
		2.88	3.07	3.01	3.52		3.02
CT-1	Perpendicular to warp	3.66	3.82	3.78	3.44		3.68
CT-2	Parallel to warp	4.70	4.80	4.78			4.76
CT-2	Perpendicular to warp	4.67	4.71	4.25	4.78		4.61
CT-3	Parallel to warp	4.54	5.13	4.56			4.75
CT-3	Perpendicular to warp	4.71	5.40	4.67			4.93
CT-4	Parallel to warp	5.55	5.13	5.00			5.22
CT-4	Perpendicular to warp	5.29	4.93	5.75			5.33
CT-5	Parallel to warp	6.14	5.81	6.10			6.02
CT-5	Perpendicular to warp	6.14	6.33	6.70			6.39
CT-6	Parallel to warp	5.65	6.29	5.81	5.59		5.84
CT-6	Perpendicular to warp	5.62	5.81	6.53	5.75		5.93
CT-7	Parallel to warp	5.70	5.92	5.84			5.82
CT-7	Perpendicular to warp	6.06	6.37	5.95			6.13
P-1	Lengthwise, Normal	--	--	--			
P-2	Lengthwise, Normal	--	--	--			

TABLE 2

SUMMARY OF BURNING RATES OF SEAT MATERIALS USED IN AUTOMOBILE INTERIOR FIRE TESTS

Interior Fire Test Number	Automobile	Material	Average Burning Rate in/min
3	1968 Buick Wildcat	White vinyl	3.15
4	1970 Ford Mustang	White vinyl	2.88
5	1970 Plymouth Road Runner	Blue vinyl (seat)	3.07
5	1970 Plymouth Road Runner	Blue vinyl (seat edge)	4.68
6	1968 Pontiac	White vinyl	2.89
7	1970 Chevrolet Impala	Blue vinyl (seat)	3.13
7	1970 Chevrolet Impala	Blue vinyl (seat edge)	4.45
9	Unknown	Urethane foam, 1/2" thick	15.04
10	Unknown	Latex foam, 1/2"thick	2.87
11	Chevrolet Impala	Green vinyl	3.71
12	1969 Dodge Charger	Black vinyl	3.10
13	1968 Rambler	Black vinyl	4.19
13	1968 Rambler	Black fabric	--
14	1968 Plymouth	Blue fabric	1.51
14	1968 Plymouth	Blue vinyl	3.70
15	General Motors	Green vinyl	4.58
15	General Motors	Green fabric	2.31
16	1969 Ford	Vinyl	4.67
17	1969 Chevrolet Impala	Foam	1.55
17	1969 Chevrolet Impala	Green fabric	2.20
17	1969 Chevrolet Impala	Green vinyl	4.32
18	General Motors	Fabric	2.82
18	General Motors	Foam	2.82
18	General Motors	Vinyl	2.74

TABLE 2 -- Continued

Interior Fire Test Number	Automobile	Material	Average Burning Rate in/min
19	1967 Dodge	Foam	3.30
19	1967 Dodge	Vinyl	2.68
19	1967 Dodge	Cotton backing	4.93
19	1967 Dodge	Fabric	8.24
20	Bucket seat	Fabric	--
20	Bucket seat	Black Fabric	2.37
24	GM truck	Fabric	5.00
25	Unknown	Vinyl	2.82
25	Unknown	Fabric	--
26	1967 Ford Torino	Vinyl A	4.49
26	1967 Ford Torino	Vinyl B	3.04
27	1969 Pontiac	Fabric	1.28
27	1969 Pontiac	Vinyl	3.41
29	1969 Chevrolet Chevelle	Vinyl A	2.50
29	1969 Chevrolet Chevelle	Vinyl B	4.27
31	1969 Chevrolet Chevelle	Fabric	4.18
31	1969 Chevrolet Chevelle	Vinyl	4.00
31	1969 Chevrolet Chevelle	Carpet, nylon & viscose face, jute bk	0.43
32	1971 Buick	Vinyl, fbr mtrx bk	--
32	1971 Buick	Vinyl, cloth back	--
33	1970 Oldsmobile Cutlass	Vinyl headliner	6.59
33	1970 Oldsmobile Cutlass	Vinyl, fbr matx bk	--
33	1970 Oldsmobile Cutlass	Fabric	2.12

TABLE 3

SUMMARY OF BURNING RATES OF ANGLED SAMPLES

Material	Angle	Number of Tests	Inches per Minute Average	Inches per Minute Maximum	Inches per Minute Minimum	Standard Deviation S	Standard Deviation / Average x 100 %
N-24	-30°	3					
N-24	-15°	3					
N-24	0°	3					
N-24	15°	3	4.79	4.89	4.62		
N-24	30°	3	9.55	9.89	9.18		
N-24	45°	3	13.05	13.24	12.86		
N-24	60°	3	14.16	14.52	13.43		
N-24	75°	3	15.08	16.67	13.04		
N-25	-30°	30	1.10	1.12	1.09	0.01	0.8
N-25	-15°	29	1.18	1.23	1.16	0.02	1.4
N-25	0°	30	2.55	2.76	2.33	0.11	4.3
N-25	15°	30	11.90	12.66	10.64	0.18	1.5
N-25	30°	30	16.87	18.18	14.93	0.91	5.4
N-25	45°	30	22.34	24.39	19.23	1.36	6.1
N-25	60°	30	25.38	27.78	23.81	1.36	5.4
N-25	75°	30	29.53	34.64	26.47	2.25	7.6
N-26	-30°	30	1.49	1.67	1.38	0.06	4.0
N-26	-15°	30	2.37	3.21	1.68	0.41	17.3
N-26	0°	30	4.42	5.52	3.31	0.65	14.7
N-26	15°	30	12.35	14.75	11.11	0.88	7.1
N-26	30°	30	17.67	23.08	14.52	1.76	10.0
N-26	45°	30	30.33	34.62	26.47	2.69	8.9
N-26	60°	30	31.97	39.13	26.47	3.11	9.7
N-26	75°	29	31.59	34.78	27.27	2.44	7.7

TABLE 3 -- Continued

Material	Angle	Number of Tests	Inches per Minute Average	Inches per Minute Maximum	Inches per Minute Minimum	Standard Deviation S	Standard Deviation / Average x 100 %
V-13	-30°	3					
V-13	-15°	3					
V-13	0°	30	3.67	4.33	2.40	1.29	35.2
V-13	15°	30	11.48	12.35	10.87	0.45	3.9
V-13	30°	30	19.32	20.93	18.37	1.25	6.5
V-13	45°	30	27.90	32.14	24.24	2.14	7.7
V-13	60°	30	29.65	33.33	25.71	1.99	6.7
V-13	75°	30	32.87	37.50	29.03	2.72	8.3
V-14	-30°	3					
V-14	-15°	3					
V-14	0°	3					
V-14	15°	30	1.57	1.94	1.39	0.13	8.3
V-14	30°	30	10.10	11.11	8.65	0.60	5.8
V-14	45°	30	19.76	37.50	15.25	5.64	28.7
V-14	60°	30	25.54	37.50	18.00	5.53	21.6
V-14	75°	30	35.09	52.94	23.08	7.20	20.5
F-1	2 sheets, -30°	30	2.94	3.26	2.79	0.15	5.1
F-1	2 sheets, -15°	30	3.37	3.71	3.10	0.17	5.1
F-1	2 sheets, 0°	30	5.20	6.32	4.32	0.51	9.8
F-1	2 sheets, 15°	30	13.38	15.00	11.12	1.18	8.8
F-1	2 sheets, 30°	30	25.77	30.00	22.23	2.28	8.9
F-1	2 sheets, 45°	30	33.63	37.50	30.00	1.92	5.7
F-1	2 sheets, 60°	30	42.72	46.16	40.00	2.72	6.4
F-1	2 sheets, 75°	30	46.59	54.55	42.86	3.04	6.5

TABLE 4

TIME DEPENDENCE OF LIGHT ATTENUATION COEFFICIENTS

Run	Time	b ($in^{-1} x 10^2$)
7	2	0
	4	0.16
	6	0.73
	8	1.74
	9	2.25
	10	2.76
	12	2.50
	14	3.98
	18	3.98
8	1	1.44
	2	3.72
	3	8.08
	4	10.0
	6	13.7
	8	11.9
10	1/2	1.5
	3/4	3.62
	1	2.76
12	1	0.17
	2	5.43
	3	8.20
	4	7.69
	5	7.24
	6	7.34
	7	6.39
	8	5.67
	9	6.49
	10	6.96
	11	6.55
	12	7.37
	13	7.37
13	3	1.32
	4	2.42
	5	0.61
	6	2.95
	7	3.62
	8	4.36
	9	7.24
	10	8.36
	11	15.65
	12	19.20
	13	24.3
14	2	0.17
	3	0.56
	4	0.96
	5	0.96
	6	0.94
	7	0.72
	8	0.78
	9	1.57
	10	1.18
	11	1.85
	12	2.30
	13	1.19
	14	3.82
	15	3.76
15	1	0.94
	2	6.31
	2.7	10.3
	3	7.5
	4	5.47
	5	3.19
	6	4.32
	7	10.4
	8	15.5
	9	44.8
	10	56.1
16	1	0.58
	2	3.04
	3	6.44
	4	10.8
	5	15.7
	6	13.4
	7	10.9
	8	8.57
	9	10.8
	10	16.4
	11	17.8
	12	17.8
	13	22.8
	14	22.0
	15	25.7
17	1	0.52
	2	6.24
	3	6.55
	4	6.67
	5	5.97
	6	5.45
	7	4.58
	8	4.47
	9	4.58
	10	6.29
	11	6.83
	12	6.46
	13	6.10
	14	5.18
	15	4.60

TABLE 4 -- Continued

Run	Time	b ($in^{-1}x10^2$)
18	2	0.83
	3	0.98
	4	0.87
	5	0.68
	6	0.89
	7	1.48
	7.9	2.64
	9	3.70
	10	4.46
19	4	0.17
	5	0.37
	6	0.40
	7	1.03
	8	1.05
	9	1.25
	11	1.48
	13	1.48
20	6	0.20
	7	0.34
	8	0.68
	9	0.86
	10	0.86
	11	1.21
	12	1.42
	13	2.04
	14	3.11
	14.3	3.83
	15	2.71
22	5	5.06
	5.5	12.6
	6	4.39
	7	6.68
	8	5.88
	9	5.25
	10	5.05
	11	4.84
	12	4.87

Run	Time	b ($in^{-1}x10^2$)
23	1	1.93
	2	16.0
	3	20.0
	4	29.8
	5	11.3
	6	9.09
	7	7.78
	8	6.76
	9	6.19
	10	5.00
	11	4.58
	12	4.14
	13	4.04
25	½	1.43
	1	8.33
	2	15.9
	3	15.4
	4	21.5
	5	17.7
	6	16.2
	7	14.2
	8	12.8
	8½	11.6
26	1	0.62
	2	6.18
	3	10.9
	4	10.4
	6	7.84
	8	9.51
	10	8.95
	12	6.65
	14	6.30
	15½	6.14

Run	Time	b ($in^{-1}x10^2$)
28	½	9.4
	1	19.5
	2	22.4
	4	13.4
	6	12.0
	8	8.35
	10	6.30
	12	3.92
	14	4.14
	16	3.18
	16.9	2.18
29	1	0.61
	2	1.44
	3	1.94
	4	3.48
	5	5.65
	5½	6.23
30	¼	1.36
	½	6.30
	1	14.9
	1½	10.9
	2	10.7
	3	10.7
	4	13.7
	5	16.3
	6	25.7
	7	14.6
	8	14.3
	9½	9.37

4. Guard or retaining rails on many older bridges should be improved.

5. Methods utilized by law enforcement officials for speed estimates should be evaluated and perhaps improved.

INTERVIEW: Surviving Passenger of Vehicle
November 7, 1970

Q. Mr. XXX, could you review the series of events relating to your automobile accident on November 1, 1970? A. Well, XXX and I were driving to Henryetta and he decided to take a short-cut on the old highway. We had been to a basketball game and it was around midnight when we had the wreck. I guess we were going about fifty to sixty miles per hour when we came onto the bridge. I didn't know it was there and didn't know what was going on. I didn't feel anything until we landed on our top. When I woke up my head was under water and I was coughing water out. I got my head above the water and I remember the horn was blowing. My left leg was caught but I don't know where. It must have been between the seat and the top of the car. It took me about ten minutes to get my leg loose and get out. I hollered at XXX but never did hear a sound. I found his arm hanging out the door and tried to pull him loose. I saw the lights of a house and so I ran up there to get help. They didn't have a phone, but the man went into Bryan to call and his son took me back to the creek.

Q. How did you get out of the car? A. I don't know, it must have been through the door.

Q. On your side? A. Yes. You know I don't even know whether I was in the front or back seat when we landed.

Q. Where were you riding just before the car ran off the bridge? A. I was in the front seat on the right side.

Q. Were either of you wearing seat belts? A. No, the car didn't have any.

Q. Exactly how were you trapped in the car? A. This leg was caught (left) somewhere. I scratched up my thigh pretty bad getting loose. I think I got loose a little bit just before I got my head above the water, then it took me a while to get it the rest of the way loose.

The passenger was able to free his left leg and pull his head above the water; however, he was unable to remove the driver. The driver was pronounced dead from drowning by an attending physician. No autopsy was performed. The deceased had no fractures or lacerations.

G. PRE-CRASH FACTORS:

Vehicle Factors: No evidence of mechanical malfunctions was noted.

Environmental Factors: The site of this accident is extremely hazardous. The two lane road has no signs of any type to inform motorists of hazardous situations. The bridge is narrow and accepts only one lane of traffic and the approach on both sides requires manipulating a sharp curve in the road approximately one hundred yards before entering the bridge. The bridge was constructed perpendicular to the creek and requires a turning maneuver of approximately fifty (50) degrees for entry. The rails on the approaches and along the bridge are of small angle iron and were broken off with no apparent retaining ability. Darkness contributed to this accident, particularly since no warning signs were present.

Human Factors: The driver of the vehicle had been drinking heavily and had not slept in approximately forty hours. He had fallen asleep in two bars prior to the accident. The driver did not apply his brakes and made no attempt to turn. He proceeded straight ahead in the direction of travel. Neither of the occupants were wearing seat belts since the vehicle was not equipped. The survivor estimates a speed of fifty miles per hour at impact. This was certainly an overestimate.

H. OPINIONS AND OBSERVATIONS:

1. The vehicle was traveling no more than 28-30 mph when it struck the bridge rail. This estimated speed was derived from mathematical computations.

2. The victim would have escaped if he had not been trapped in the vehicle.

3. This type of bridge has been observed throughout Oklahoma and is extremely hazardous. All single lane bridges and bridges requiring difficult maneuvers should be eliminated or at least equipped with appropriate danger signs.

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