

AUTOMOBILE OCCUPANT INJURIES
from
STRIKING THE WINDSHIELD

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SUMMARY

Facial lacerations resulting from head-to-glass impacts against newer (post-1965) automobile windshields are fewer, less extensive, and less severe than those caused by similar impacts against the pre-1966 windshields. When the thinner laminate of the pre-1966 windshield was impacted by the head, slicing lacerations were typically found. Head impact to the new windshield typically produces abrasions or small lacerations of the forehead which do not require sutures. Only rarely is the post-1965 laminated windshield perforated, and the head-to-glass impact speed required is more than double that required to perforate the pre-1966 thin-laminate windshield. When the thicker windshield laminate is torn by head impact, facial lacerations are sustained, but they tend to be less extensive and less severe than those caused by striking and perforating the old type of laminated windshield.

There is no evidence that the incidence of intercranial or neck injury is increased by striking the new windshield.

Our experience suggests that the frequency of severe, extensive multiple facial lacerations from striking the windshield will decrease markedly as the proportion of cars equipped with the new windshield rises, and that facial injuries incurred by striking the new laminated windshield will not be a significant clinical problem.

GENERAL INTRODUCTION

Facial injuries, especially lacerations, caused by striking automobile windshields are well known to emergency room physicians. The lacerative properties of pre-1966 USA windshields have been well documented both in field studies of actual crashes and in the laboratory.¹⁻⁴ It has been shown that in automobile accidents the head was the body area most frequently injured (70%), with about one-third of these injuries caused by impact on, or contact with, the windshield.^{5,6} When all the body areas were combined, and the average of the driver and his passenger was taken, the windshield was shown to be the leading injury producer. In England about one-third of the head injuries received in automobile crashes were caused by striking the windshield.⁷ This is equivalent to the USA experience.

For many years all automobiles and trucks manufactured in the United States have been equipped with windshields of laminated glass. Prior to 1966 the laminated windshield was made by firmly bonding a 0.015-inch thickness plastic interlayer between two pieces of glass. Studies have shown that a head would penetrate the pre-1966 laminated windshield at head-to-glass speeds above 13 miles per hour.⁴ Severe lacerations to the face were frequently sustained on the jagged edges of glass at the lower margins of the hole. It has been demonstrated in the laboratory and verified in field studies that in head-on crashes the unrestrained occupant moves forward and strikes his knees on the instrument panel, which reduces or stops the forward motion of the lower portion of the body,^{1,4} then the occupant begins to flex forward, arcing downward into the windshield. The head strikes the windshield and continues to bow downward. If the vehicle is equipped with pre-1966 laminate glass, and if the head-to-glass speed is above 13 miles per hour, the head penetrates the glass some 4 to 8 inches beneath the initial impact point (the depth of penetration is dependent upon the head-to-glass impact speed). Shallow penetration of the glass produces typical U-shaped lacerations in the forehead area. Deeper penetration into the windshield produces slicing lacerations about the face. These lacerations are not caused by the flying and broken glass but rather by the rigid glass at the lower margins of the hole. The head frequently bobs up and down as it enters or leaves the windshield hole, producing several distinct series of lacerations.

Beginning with the 1966 models, cars manufactured in North America are equipped with a new type of laminated windshield which has a dou-

ble thickness plastic interlayer (0.030-inch) and balanced adhesion properties between the plastic and the glass. Laboratory tests on this glass indicate that rupture does not occur until a head-to-glass speed of approximately 29 miles per hour has been reached,⁴ a more than twofold increase in penetration resistance.

One frequent cause of interlayer rupture at relatively low head-to-glass velocities in pre-1966 windshields is the high interlayer-to-glass bond strength. The newer windshields incorporate a thicker interlayer, and a lower bond strength between the interlayer and the glass, thus providing much greater energy absorption upon impact by an occupant.

Recent automobile accident investigations presented here indicate that the new laminated windshield markedly reduces the number and severity of facial lacerations caused by head-to-glass impacts. Tears in the laminate from head impact are infrequent. In a few cases where the laminate has been torn (at car impact speeds of 30 mph or higher), the lacerations are similar to those seen when the head struck the thinner laminate windshield, but not as extensive.

When the new windshield is struck, the plastic area below the impact site will bulge outward a variable amount depending upon the head velocity. The inner layer of glass breaks into small particles. There has been some concern that these small slivers of glass would fly about the car and cause injuries, especially to the eyes. Ordinarily, however, a small pile of these glass particles is found on the instrument panel beneath the head impact site. To date our investigations of automobile accidents have found no ocular injury caused by these particles, nor are the particles found scattered about the interior of the car.

The newer windshield appears to be accomplishing its objectives of reducing head penetration and facial lacerations without increasing neck or intercranial injuries. When these injuries were noted, they were minor in extent, and very few neck pain complaints or intracranial injuries were found that could be related to the windshield glass impact alone.

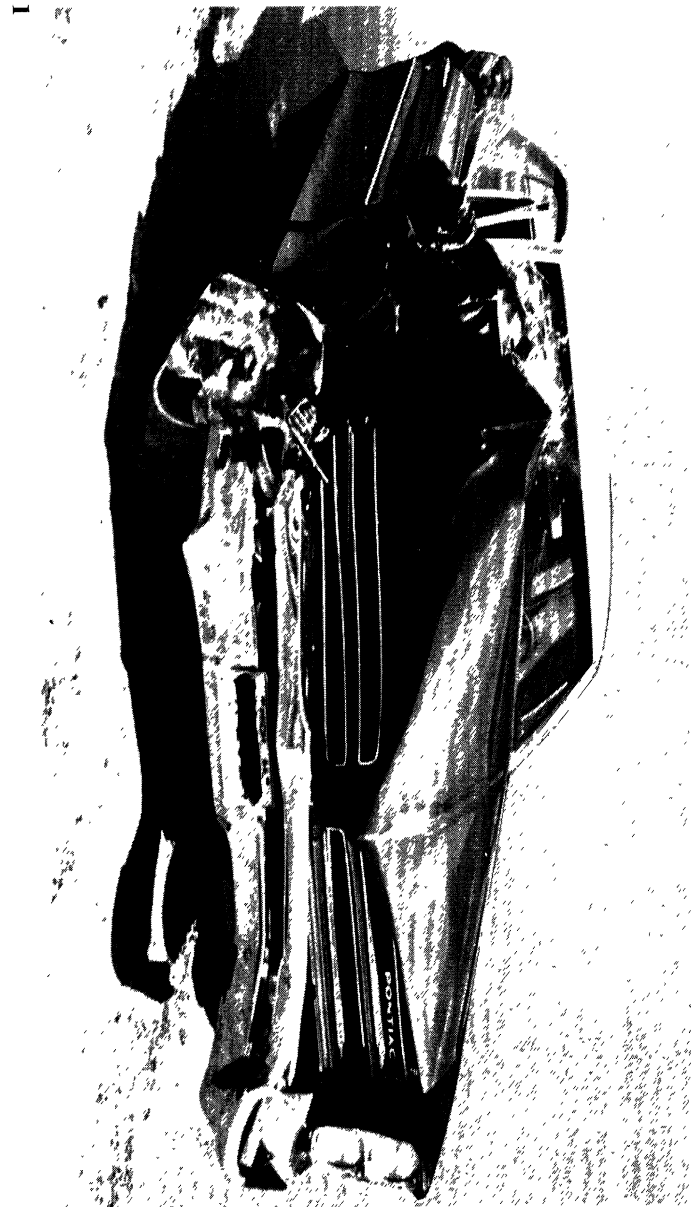
INTRODUCTION TO CASE DESCRIPTIONS

The following case reports involve head impacts to the new, thicker laminated windshield (post-1965 models). Each case description is accompanied by photographs of the car and of the location of the head impact. Where possible, these cases are matched with cases involving pre-1966-model automobiles where car-impact speeds were equivalent to or less than those of the matched vehicle (in most cases). This criterion should afford some assurance that the occupant velocity (and hence the head-to-glass speed) of any pre-1966 case selected did not exceed that of the post-1965 case it matches.

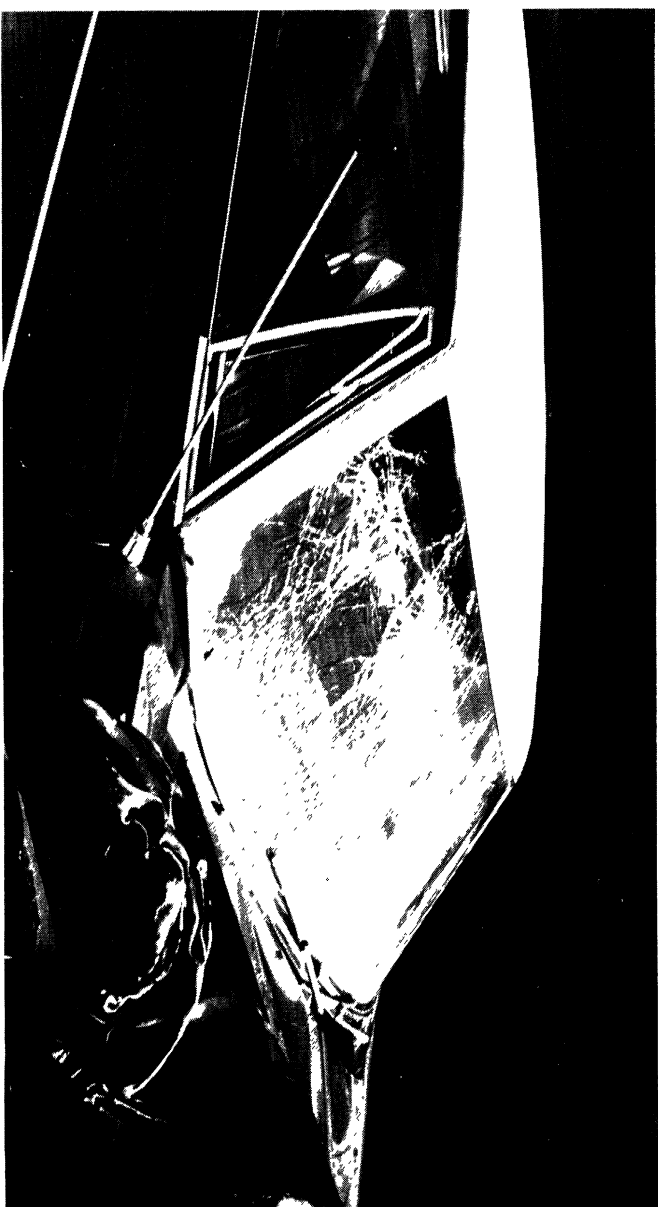
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5. Kihlberg, J. K.: "The Driver and His Right Front Passenger in Automobile Accidents." Cornell Aeronautical Laboratory, Inc., Report No. VJ-1823-R16, 1965.
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1966 Pontiac (Figures 1 and 2). Car-pole accident (impact velocity 25 mph). The left rear passenger (female, 26 years old) struck the right side of the windshield 18 inches from the right "A" pillar and 3 inches below the header. She sustained an abrasion to the right side of her head. She refused medical treatment.
(Case #101/5/2/66)

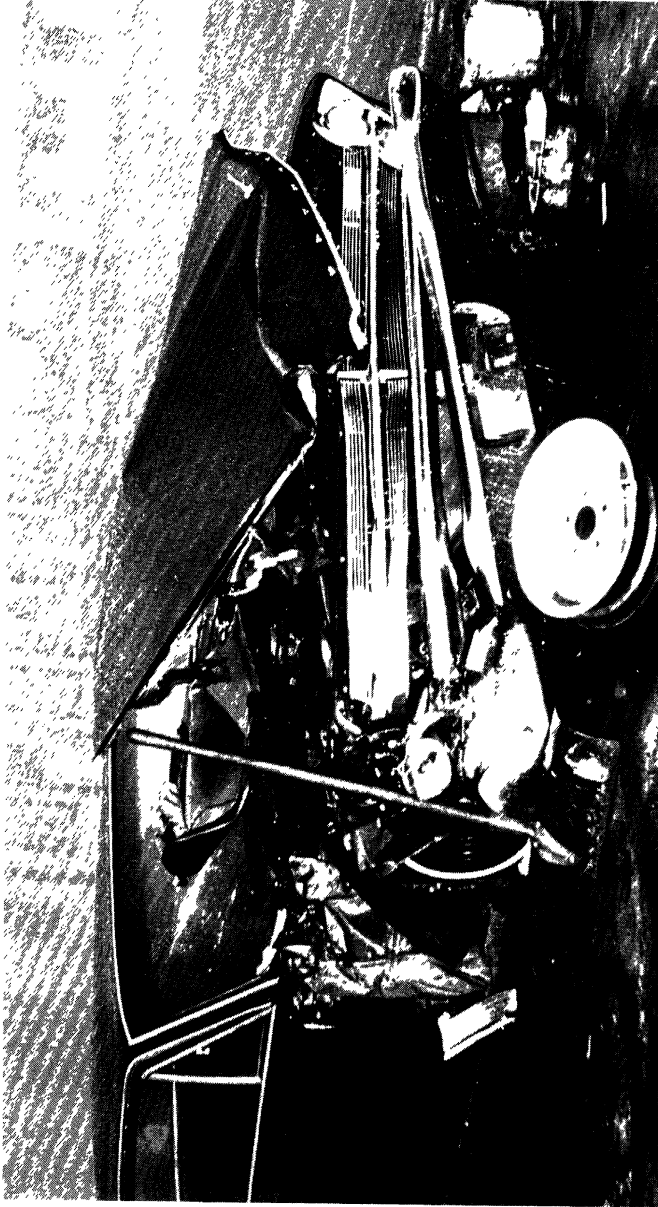


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1967 Plymouth (Figures 3 and 4). Car-
tree accident (impact velocity 25-30
mph). The passenger (male, 22 years
old) struck the windshield, sustaining
a contused nose and a laceration of the
lip. Head impact area was 9 inches
from the right "A" pillar and 12 inches
below the header. The windshield im-
pact area was not bulged outward. Seat
belts were not worn.
(Case #174/11/24/66)



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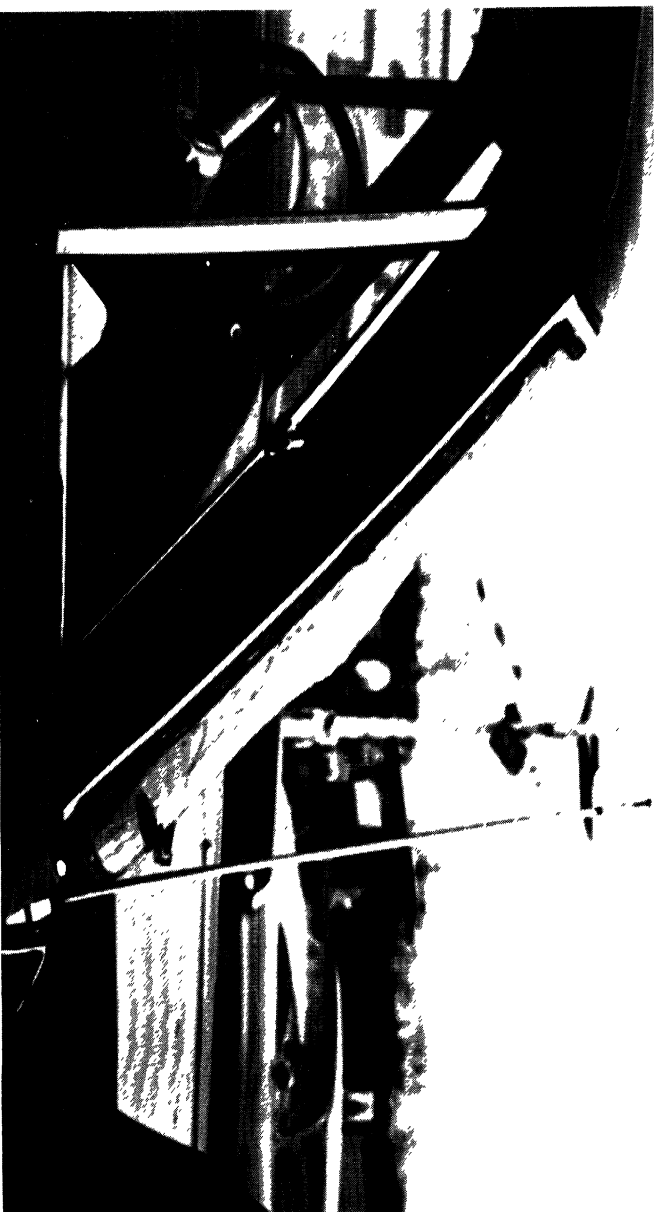


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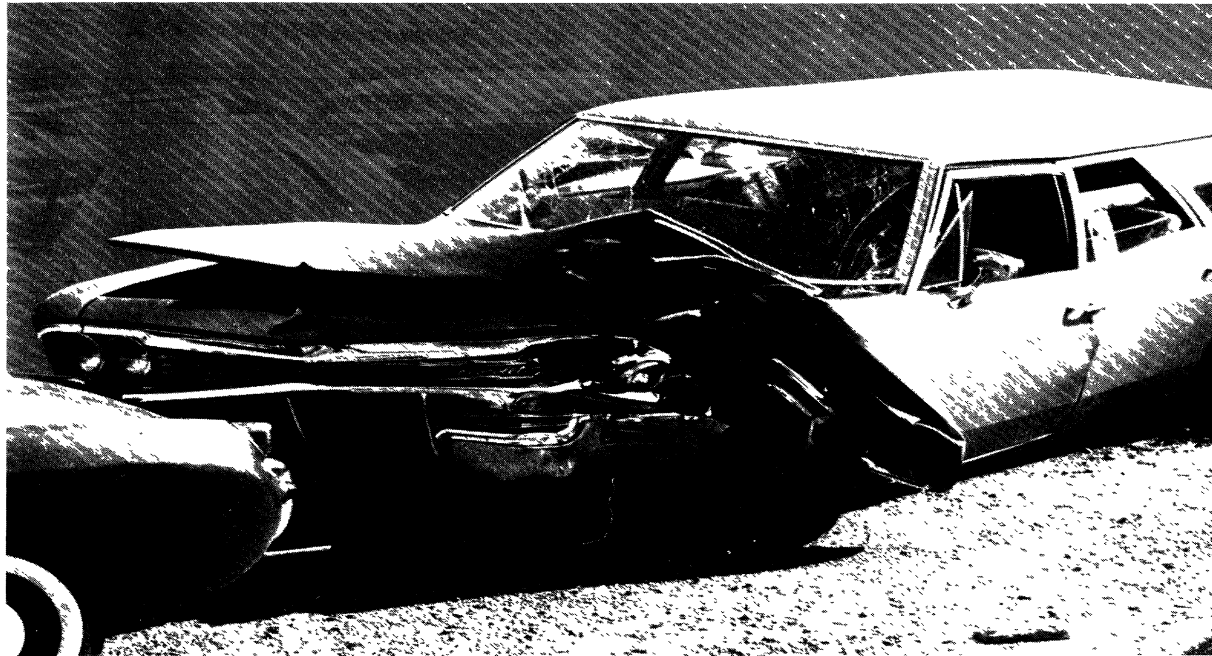
1966 Rambler (Figures 5 and 6). Car-tree accident (impact velocity 25 mph). The passenger (male, 19 years old) struck the windshield 7 inches below the header and 5 inches from the right "A" pillar. The windshield was bulged outward. He sustained extensive facial abrasions and multiple small lacerations to the forehead, some of which required sutures. Seat belts were not worn.
(Case #165/11/15/66)



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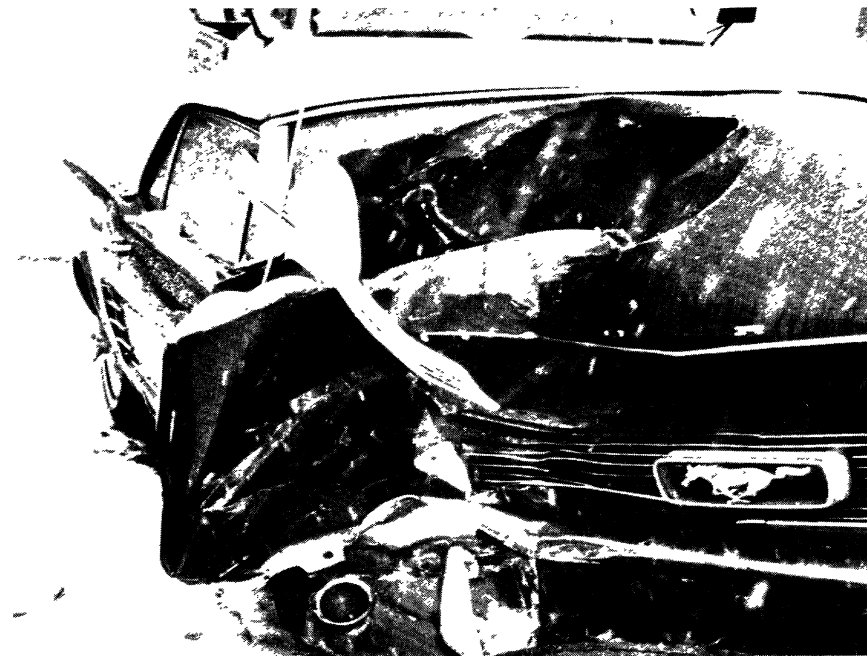
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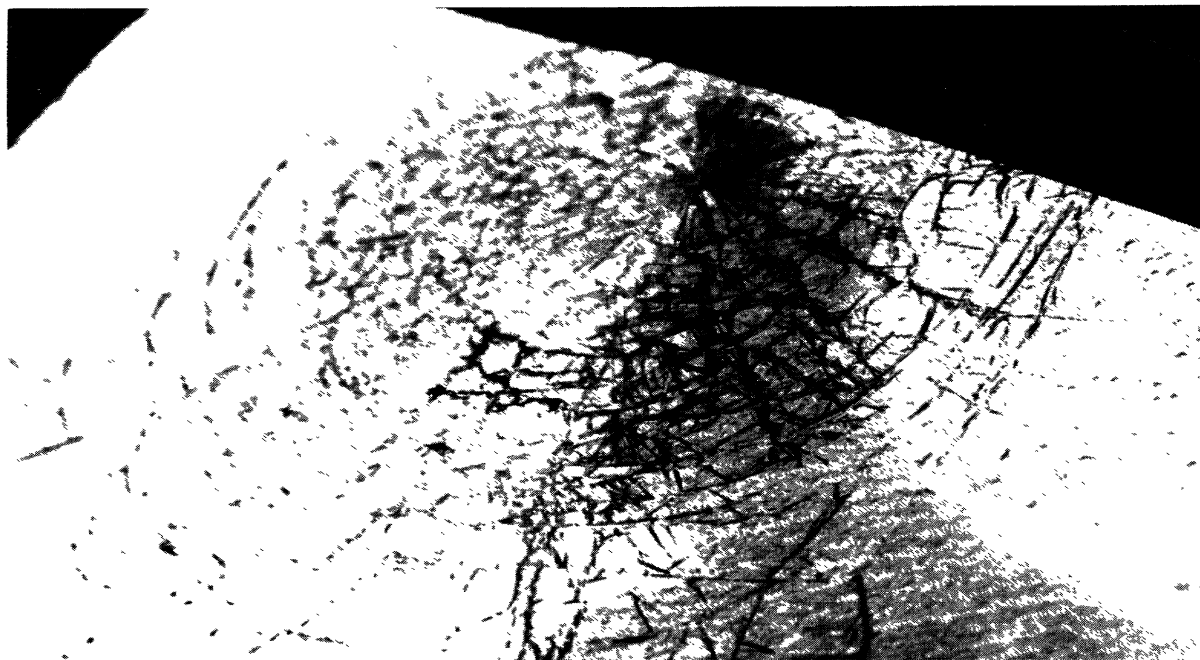
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1966 Chevrolet (Figures 7 and 8). This station wagon left the roadway, went into a ditch, and struck a tree (impact velocity 25-30 mph). The front passenger (male, 14 years old) struck the windshield 10 inches from the right "A" pillar 9 inches below the header. He bulged the windshield outward at the point of impact. He had a mild concussion (unconscious for a short period of time) but no facial or scalp lacerations. Seat belts were not worn.
(Case #124/6/27/64)

1966 Mustang (Figures 9 and 10). Car-tree accident (impact velocity 25 mph). The driver (male, 40 years old, 6 feet 1 inch, 180 pounds) struck the windshield 3 inches below the header and 10 inches from the left "A" pillar. He sustained minor abrasions to his forehead at the hairline.
(Case #190/2/24/67)



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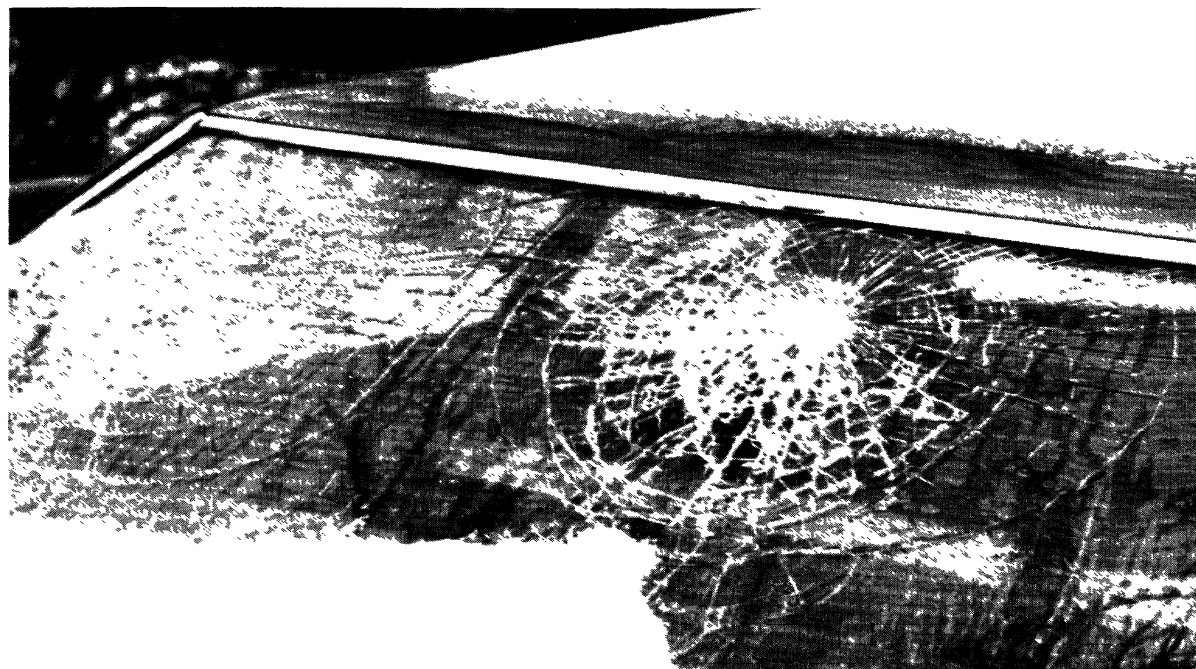
1965 Mustang (Figures 11 and 12). This vehicle hit the rear of a parked car (impact velocity 20 mph). The passenger (female, 23 years old) struck the windshield 7 inches from the right "A" pillar and 3 inches below the header. She sustained a 5-cm laceration to her forehead. Seat belts were not worn. (Case #199/2/18/67)

1966 Chevrolet (Figures 13 and 14). Car-pole accident (impact velocity 30 mph). Three distinct windshield impact sites were found. The driver (male, 41 years old) sustained small forehead lacerations from impact to the windshield just to the left of the rear view mirror. The passenger (female, 40 years old), struck her head on the windshield 8 inches below the header and 11 inches from the right "A" pillar. She sustained small cuts and scratches to the right side of her face. Adjacent to the right "A" pillar was an impact site not typical of a head impact. Here, the laminate was torn, with blood and tissue on the glass, and the area was markedly bulged forward. This may have been produced by the rear right passenger who sustained a laceration of the hand. Seat belts were not worn.

(Case #194/1/22/67)



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14

1964 Dodge (Figures 15 and 16). Car-tree accident (impact velocity 25 mph). The driver (male, 57 years old) struck the center of the windshield, sustaining a long, undermined, flap-like laceration to the right cheek and lacerations to the chin, upper lip, left cheek, and back of the head. The passenger (female, 55 years old) struck the windshield 13 inches from the right "A" pillar and 6 inches below the header. She sustained lacerations of the scalp and both arms, and a frontal bone fracture. Seat belts were not worn.
(Case #69/6/15/66)



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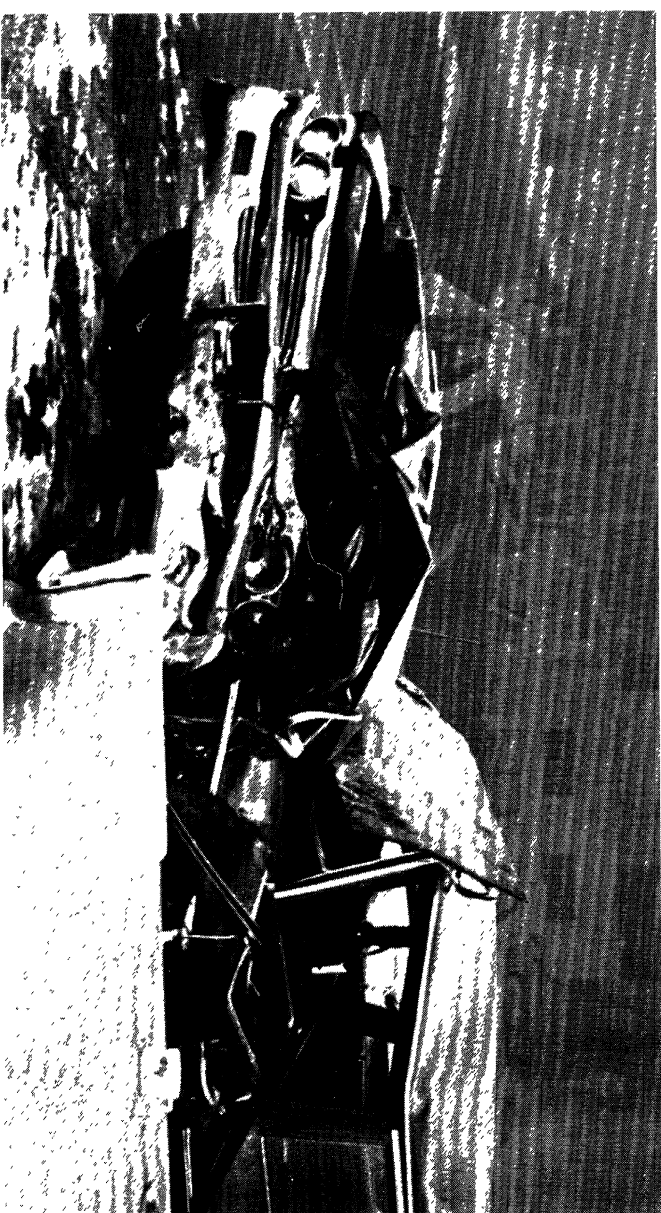


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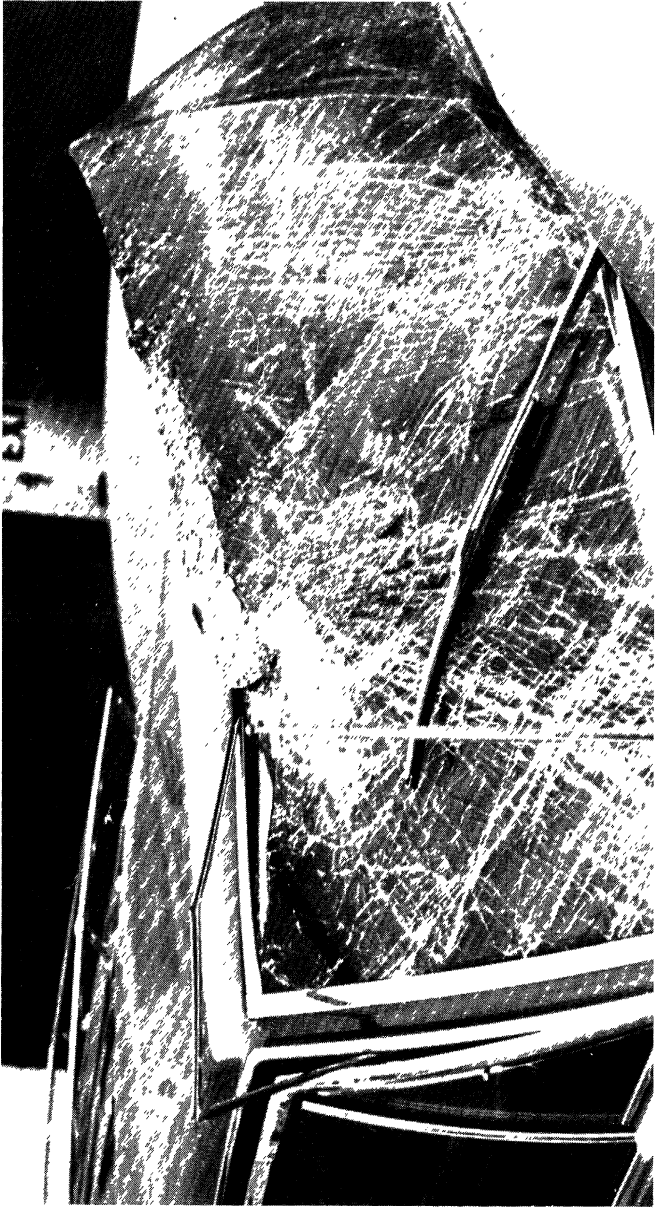
1966 Ford Station Wagon, 1966 Chevrolet Station Wagon (Figures 17, 18, 19). A head-on collision with approximately a 50 percent overlap between the two vehicles (impact velocity 45-50 mph). Both windshields were cracked throughout (matted) and partially out of the frame due to frame distortion. The passenger in the Chevrolet (female, 40 years old) struck the windshield 12 inches to the right of the "A" pillar and 7 inches below the header. She sustained a small laceration at the bridge of her nose. The passenger in the other car (female, 33 years old) sustained a 7-cm laceration of the left ear and adjacent areas, and a 6-cm laceration in the center of the forehead. In the latter case no typical head impact area could be found on the matted windshield, but the lacerations were typical of glass impact. The laminate was intact in both windshields. Seat belts were not worn. (Case #8/2/20/66)



17



18



1966 Falcon (Figures 20 and 21). This car was turning left when it was struck in the right side by a 1965 Chevrolet (impact velocity 20-25 mph). After impact, the car spun out; the driver (female, 44 years old) struck the right side of the windshield 14 inches from the right "A" pillar and 5 inches below the header. She sustained a small laceration to the left scalp area.

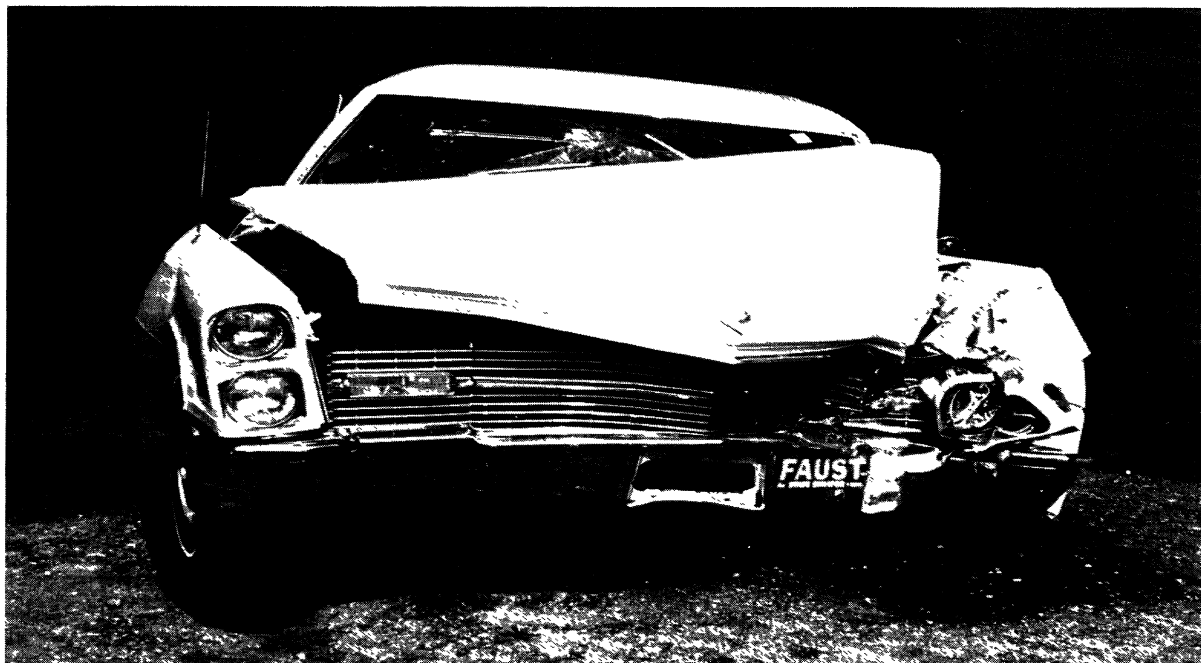
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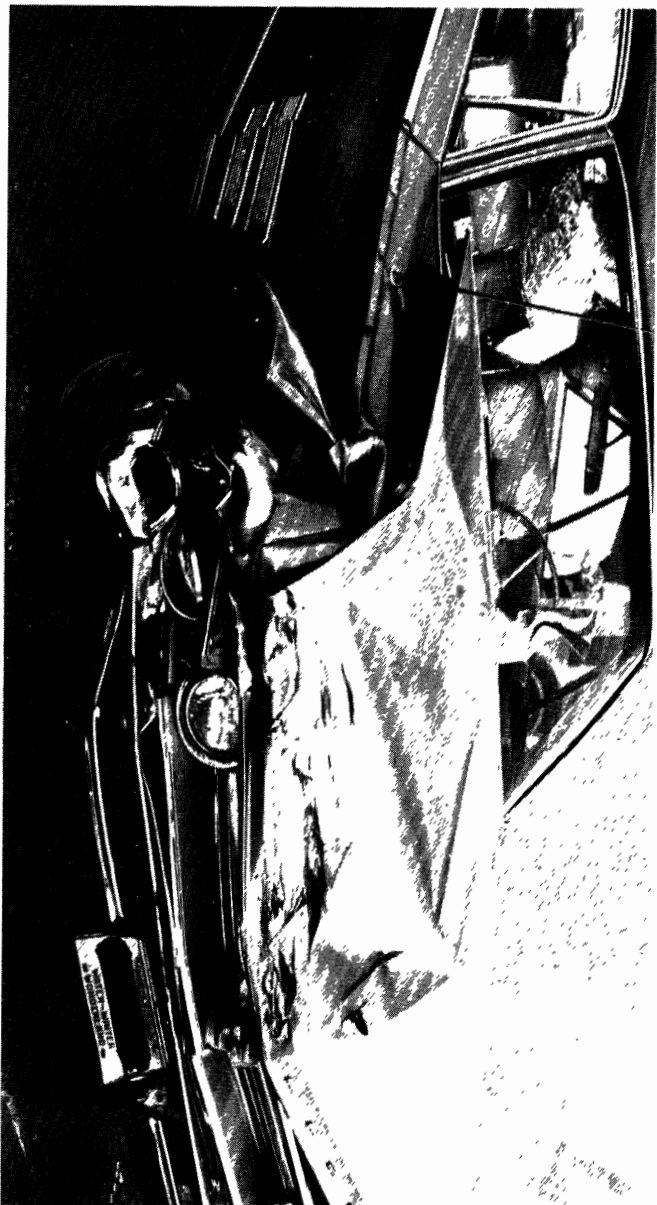
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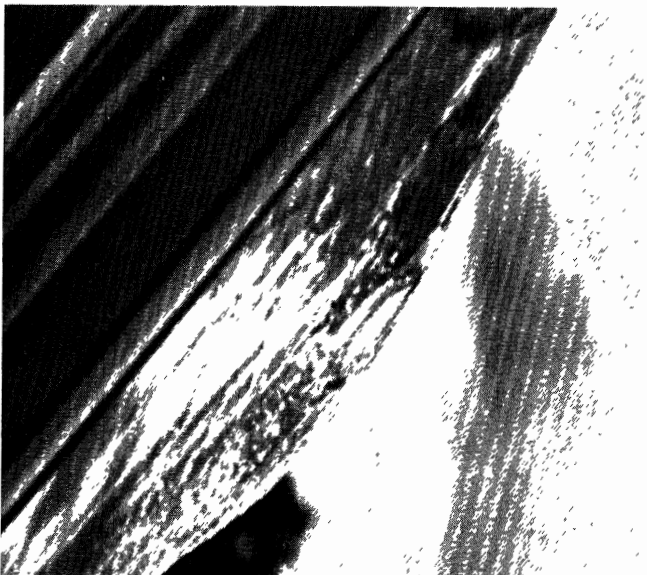
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1966 Cadillac (Figures 22 and 23). This vehicle, after being struck in the rear fender, hit a guard rail (impact velocity 25-30 mph). The passenger (male, 64 years old) sustained a laceration of his left elbow and forearm. He struck the windshield with his head but did not have any injuries from this impact. The windshield was fractured (matted) in many areas from frame distortion. Seat belts were not worn.
(Case #127/7/1/66)

1966 Chrysler (Figures 24, 25, 26). This vehicle was struck by another that had turned in front of it (impact velocity 35 mph). The front passenger (male, 24 years old) struck the windshield, 6 inches from the left "A" pillar and 5 inches below the header, markedly bulging it outward. He sustained minor superficial lacerations to the right side of his forehead. Seat belts were not worn. (Case #145/9/5/66)



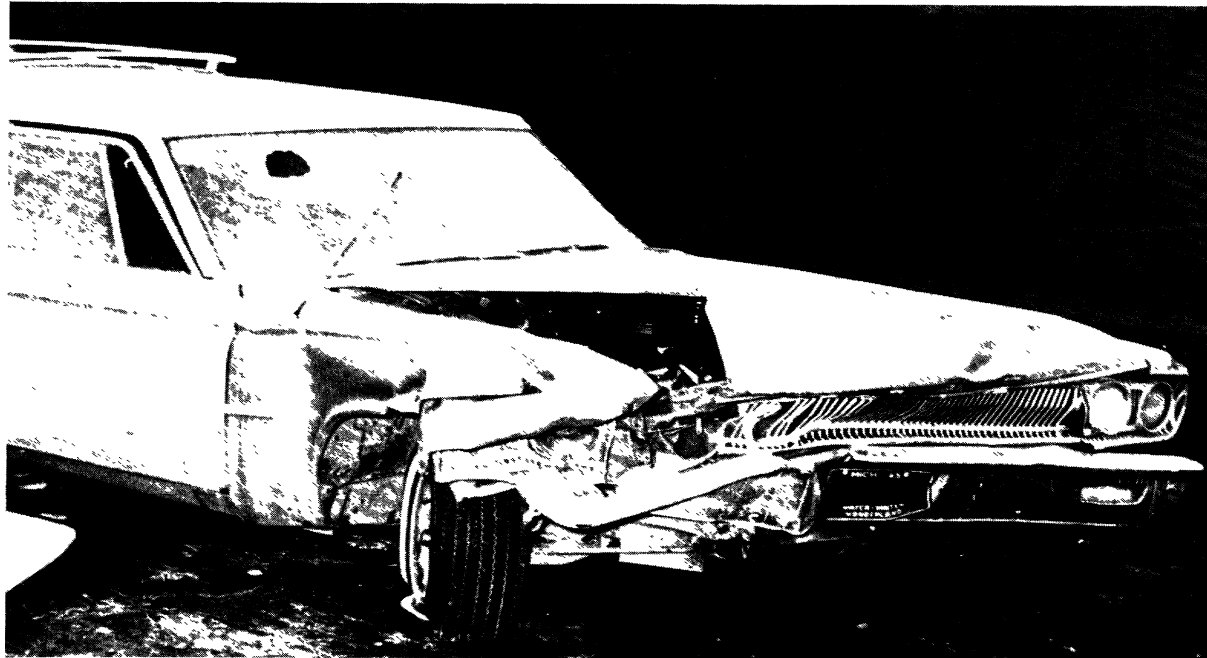
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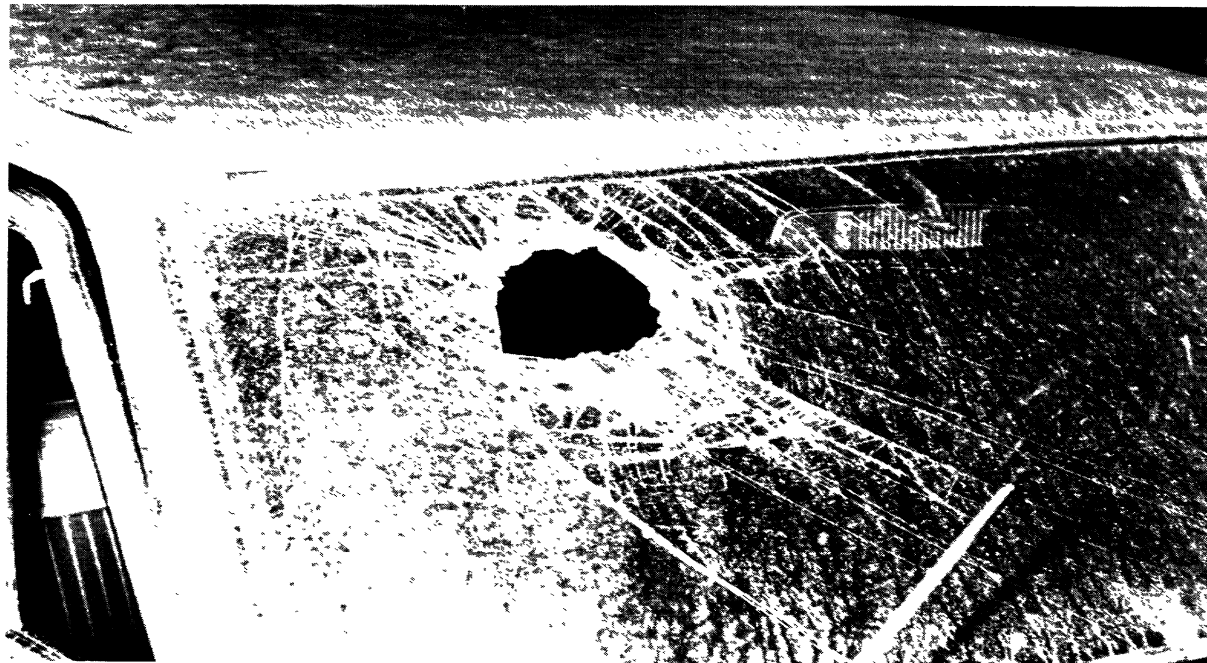
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1965 Dodge (Figures 27 and 28). This vehicle turned in front of another at an intersection and was struck (impact velocity 30-35 mph). The front center passenger (female, 35 years old) contacted the windshield 9 inches from the right "A" pillar and 4 inches below the header. She sustained a laceration of the forehead. Seat belts were not worn. (Case #80/12/2/65)

1966 Chevrolet (Figures 29 and 30). Car-tree accident (impact velocity 20-25 mph). The driver (male, 5 feet 9 inches, 160 pounds) lost control of this car when he reached over to close the right door window while driving. He struck the windshield to the right of the rear-view mirror, markedly bulging it outward. He sustained a 5-cm laceration to his right cheek.

(Case #151/9/17/66)



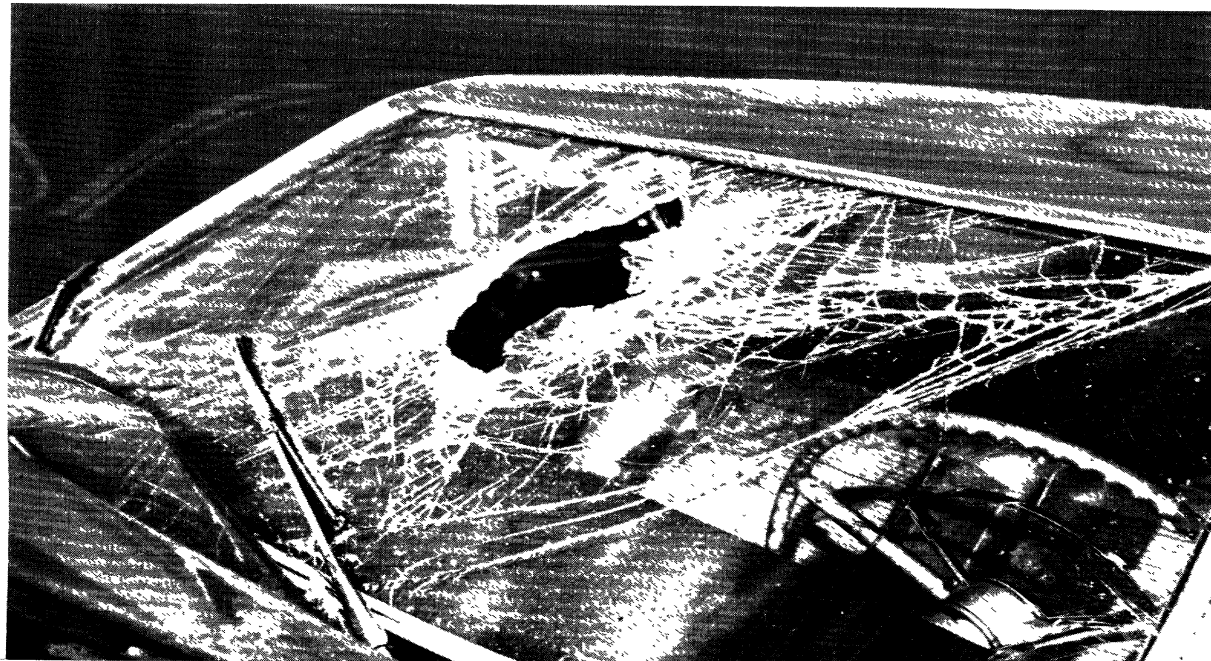
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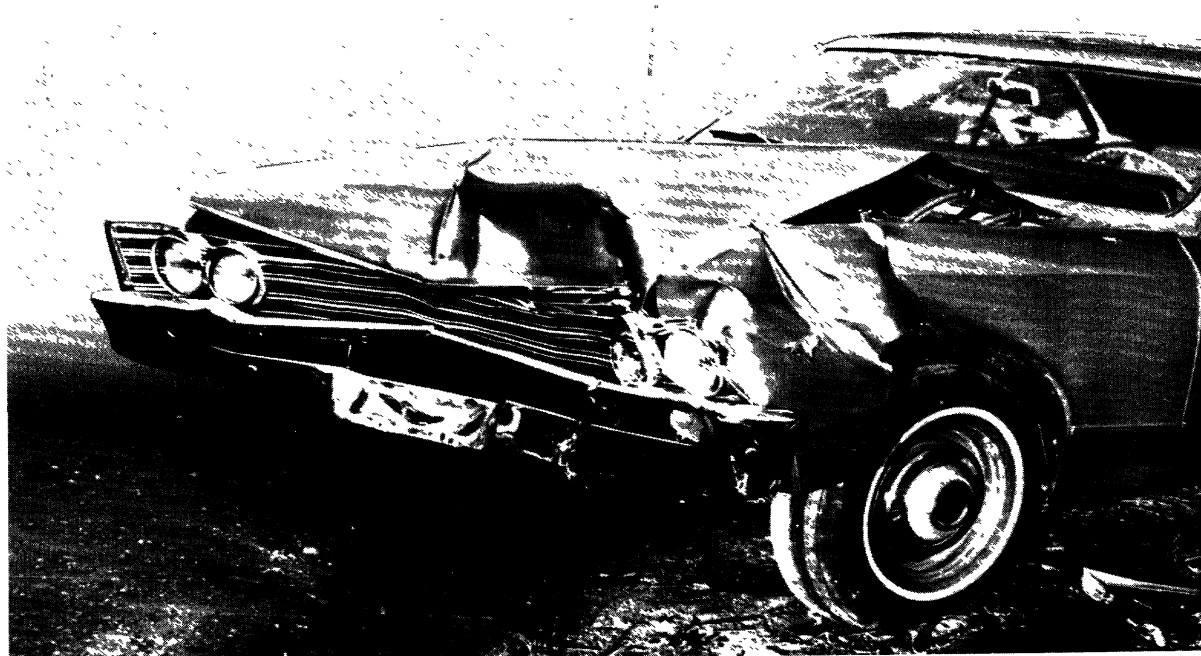
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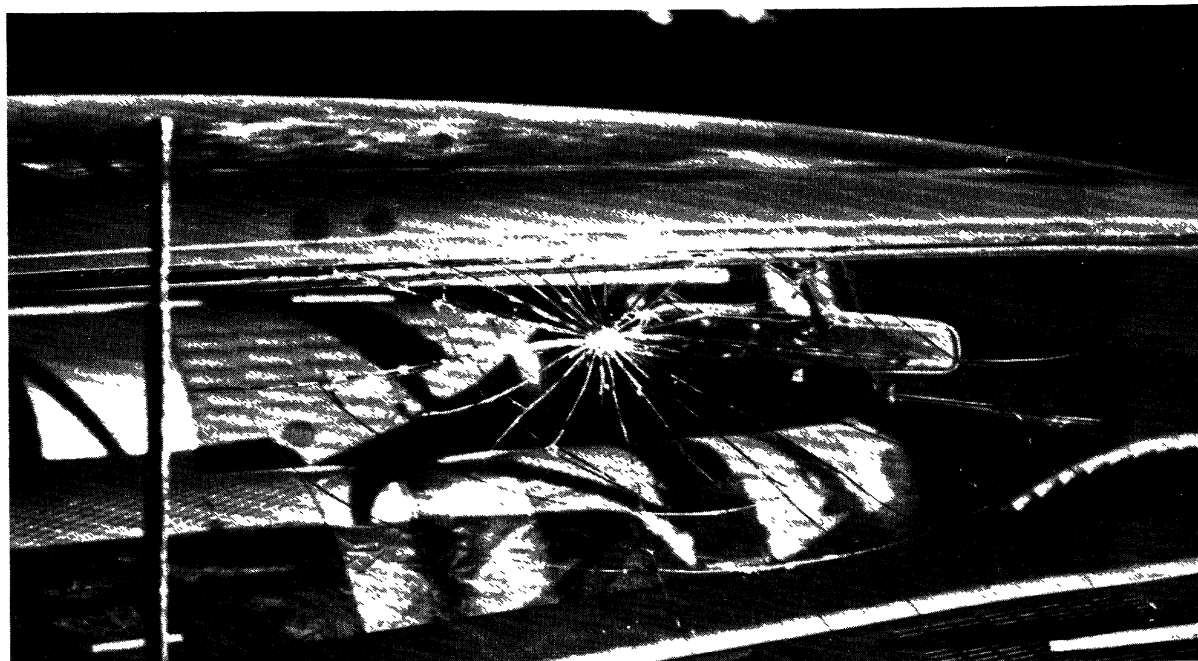
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1965 Chevrolet (Figures 31 and 32). A head-on collision with the front corner of a van truck (impact velocity 35 mph). The driver (male, 54 years old) struck the center of the windshield and sustained multiple facial lacerations and a frontal bone skull fracture involving the frontal sinus. Seat belts were not worn. See figure 79.
(Case #222/5/14/67)

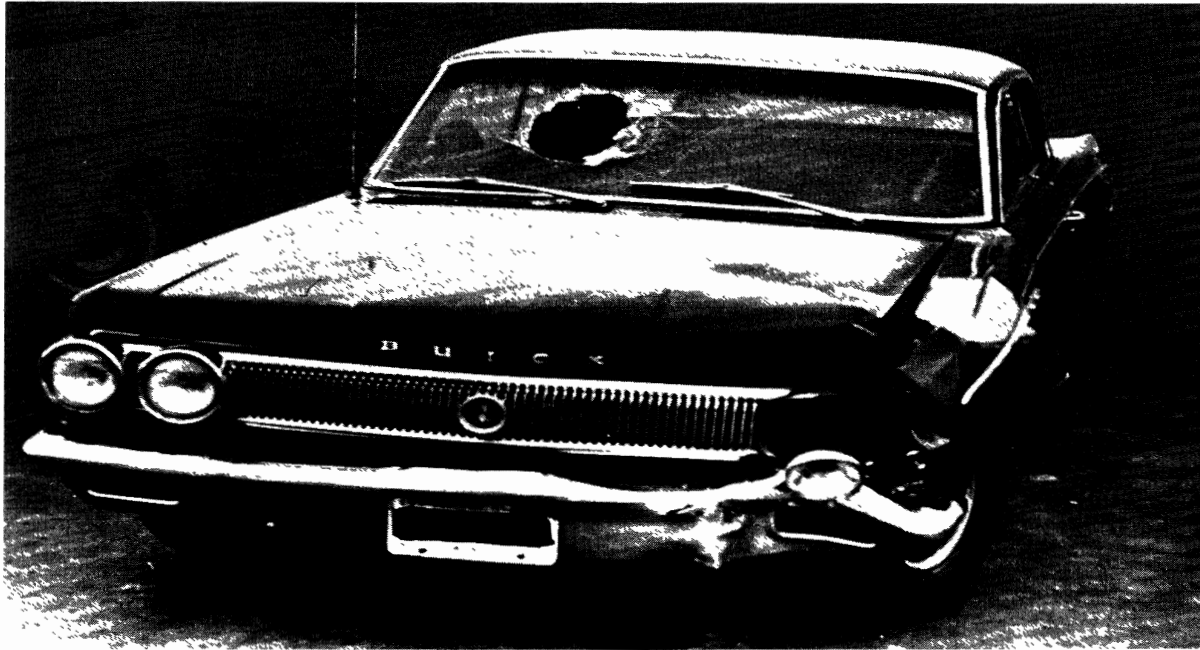
1967 Chevrolet (Figures 33 and 34). An intersection collision (impact velocity 25 mph). The front right passenger (female, 24 years old) struck the windshield 17 inches from the right "A" pillar and 4 inches below the header. She sustained a bruised forehead. Seat belts were not worn.
(Case #156/10/6/66)



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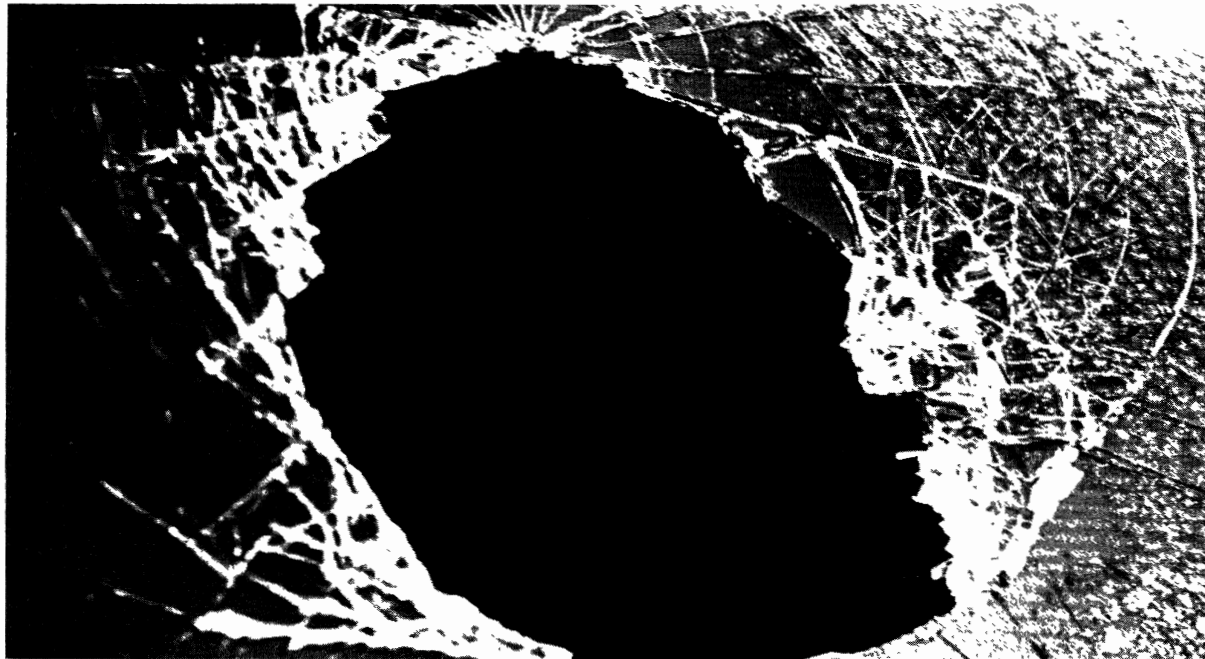


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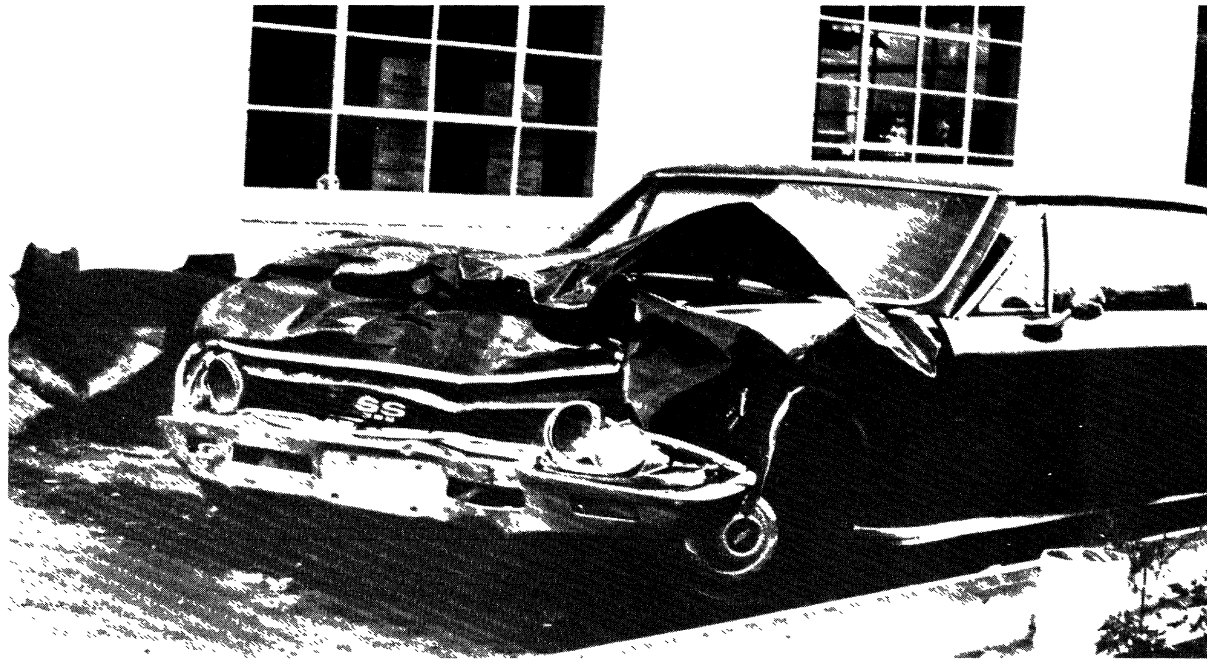
1963 Buick (Figures 35 and 36). Car-tree accident (impact velocity 15 mph). The driver (male, 25 years old) struck the windshield on the passenger's side. He sustained lacerations of the forehead, right cheek, tip of nose, and of the right ear and preauricular area. Seat belts were not worn.
(Case #44/12/18/66)



36

1966 Chevrolet (Figures 37 and 38). An intersection collision (impact velocity 45 mph). The windshield of the Chevrolet had a head impact imprint 8 inches below the header and 9 inches from the left "A" pillar. The driver (male, 20 years old) sustained a 6.5-cm laceration on the back of his head. He flexed over the steering wheel to contact the windshield (hair found on the inner glass). There was only a slight outward bulge at the impact site. Seat belts were not worn.

(Case #37/10/7/66)



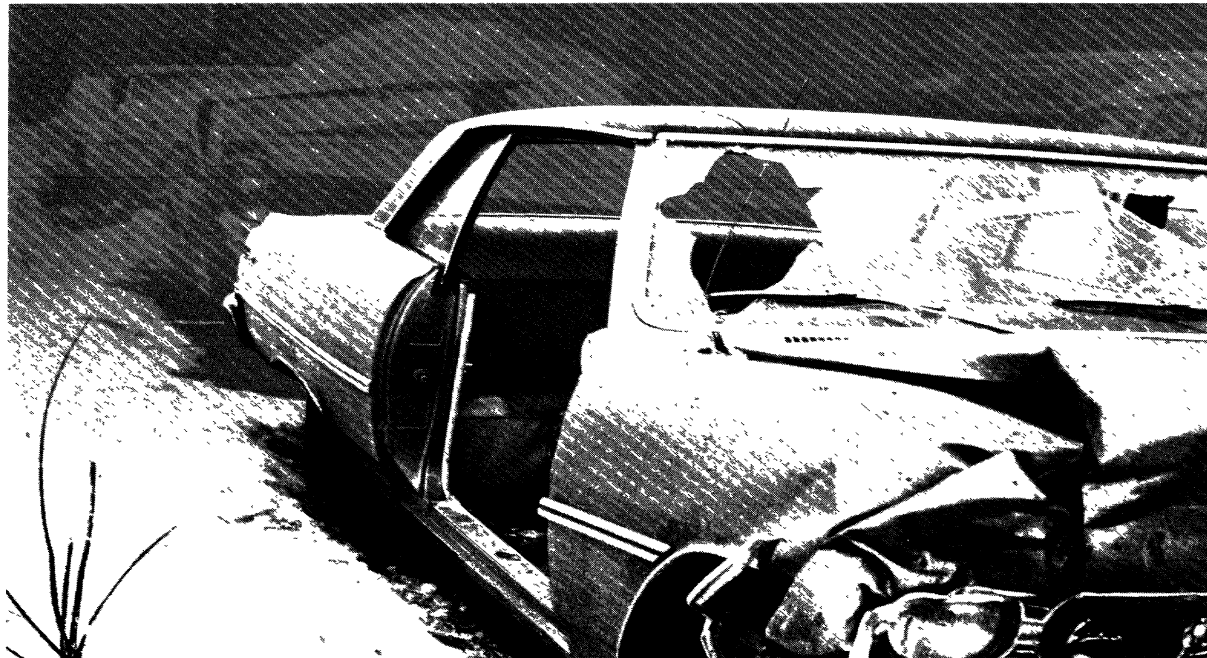
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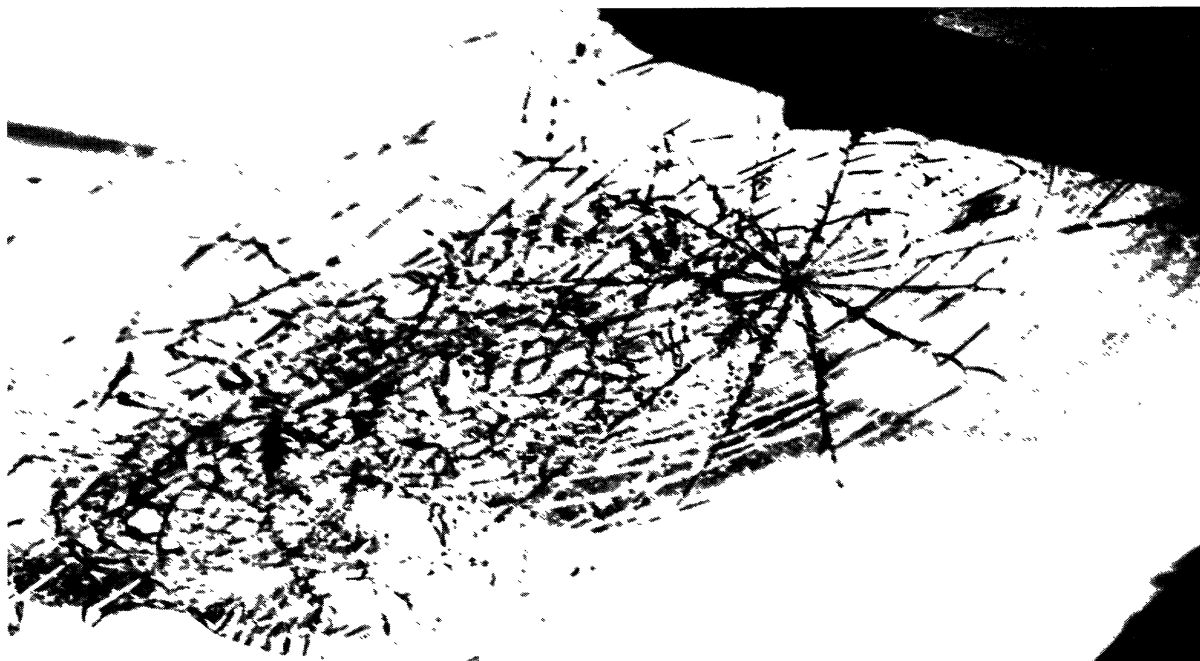
1965 Chevrolet (Figures 39 and 40). A head-on, car-to-car collision (impact velocity 20-25 mph). The driver (male, 49 years old) struck the windshield 14 inches from the left "A" pillar and 3 inches below the header. He sustained multiple lacerations of the forehead and chin. The passenger (female, 46 years old) struck the windshield 5 inches from the right "A" pillar and 4 inches below the header. She sustained a 5-cm laceration of the left forehead, a 5-cm laceration behind the left ear, and a 3-cm laceration behind the right ear. Seat belts were not worn.

(Case #5/3/5/67)

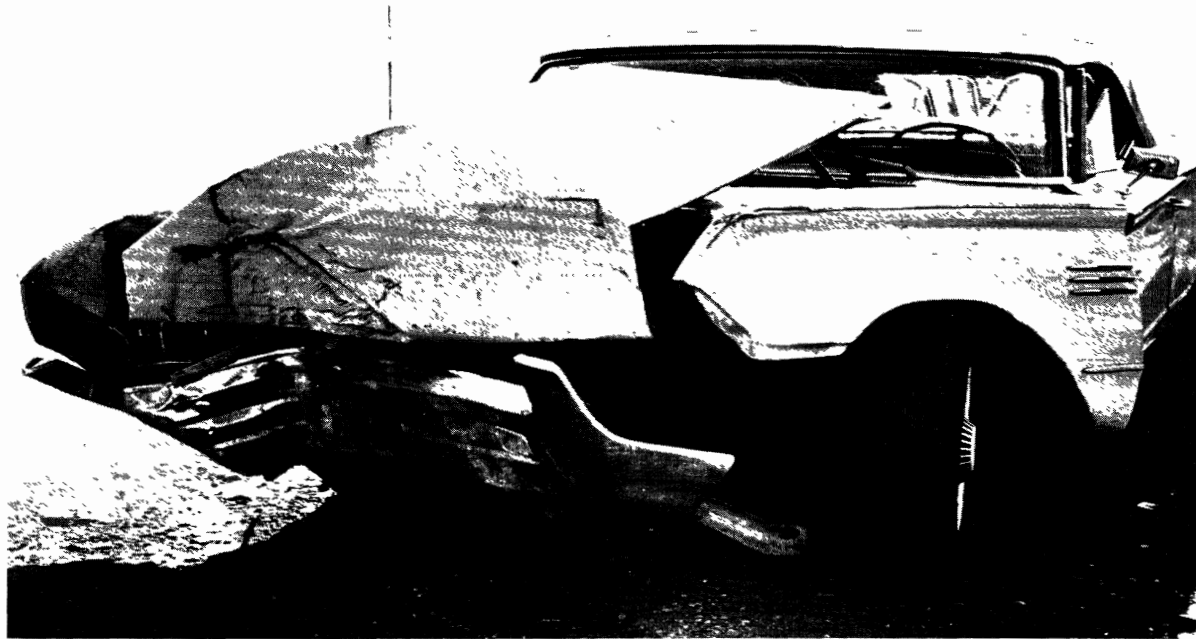
1966 Chrysler (Figures 41 and 42). A 1961 Ford Van turning left was struck by an oncoming Chrysler (impact velocity 40-45 mph). The driver of the Chrysler was not injured. His passenger (female, 33 years old) struck her forehead on the windshield 18 inches from the "A" pillar and 9 inches below the header. The windshield impact area was bulged outward; the laminate was not perforated. The attending physician stated that her forehead was "chewed up." After removing small glass particles from the multiple small lacerations, the area was bandaged and the patient sent home. No sutures were required to close the wounds. Seat belts were not worn. (Case #50/12/18/66)



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1964 Mercury (Figures 43 and 44). This vehicle struck a guard rail (glancing impact at 40-50 mph). The passenger (female, 11 years old) struck the windshield 29 inches from the left "A" pillar and 11 inches below the header. She sustained a long laceration at the hairline. Seat belts were not worn.
(Case #167/10/9/66)

1966 Oldsmobile, 1966 Ford (Figures 45, 46, 47 and 48). The Ford went out of control, crossed an expressway median, and struck the Oldsmobile in the side (glancing impact at 50 mph). Because of frame deformation, especially at the "A" pillar, the windshield of the Oldsmobile was matted; the left half of the windshield had fallen rearward into the occupant area. The driver sustained lacerations of the lower lip and hand from side window glass. No injuries were sustained from windshield glass. Seat belts were not worn. The passenger in the Ford (male, 26 years old) struck the windshield 3 inches below the header and 3 inches from the "A" pillar. The laminate was perforated. He sustained a cervical sprain. The driver of the Ford (male, 28 years old) struck his right elbow against the windshield just to the right of the mirror; a minor elbow-forearm laceration was sustained from this impact. Seat belts were not worn.

(Case #203/3/10/67)



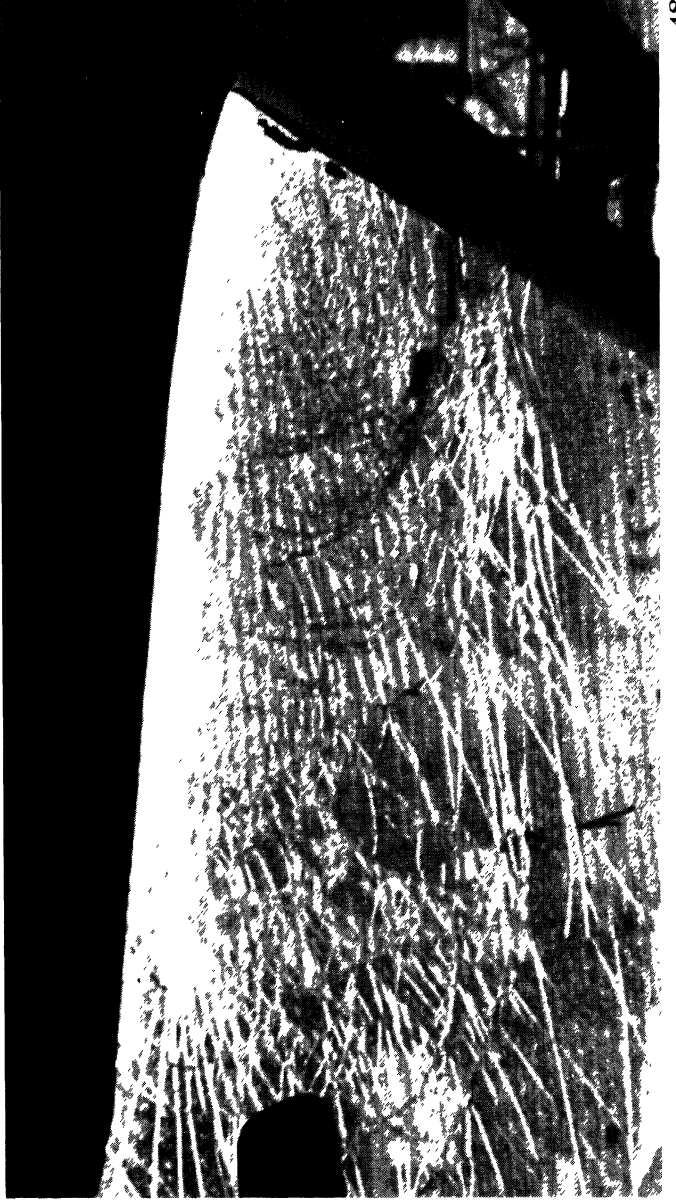
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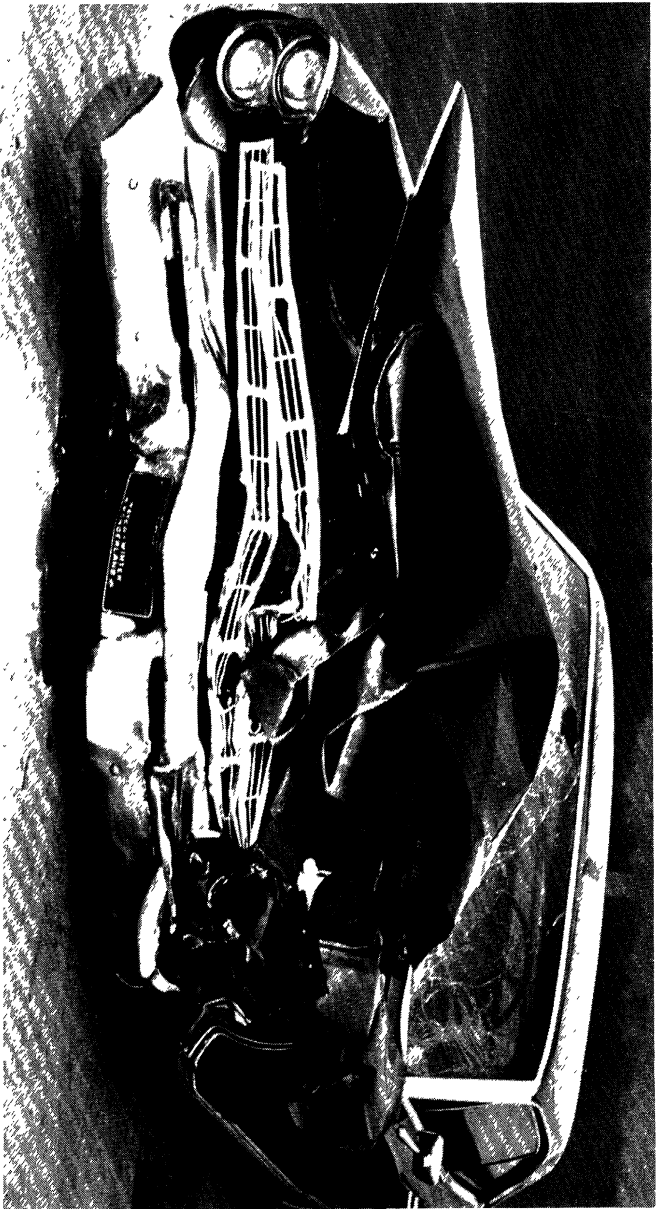


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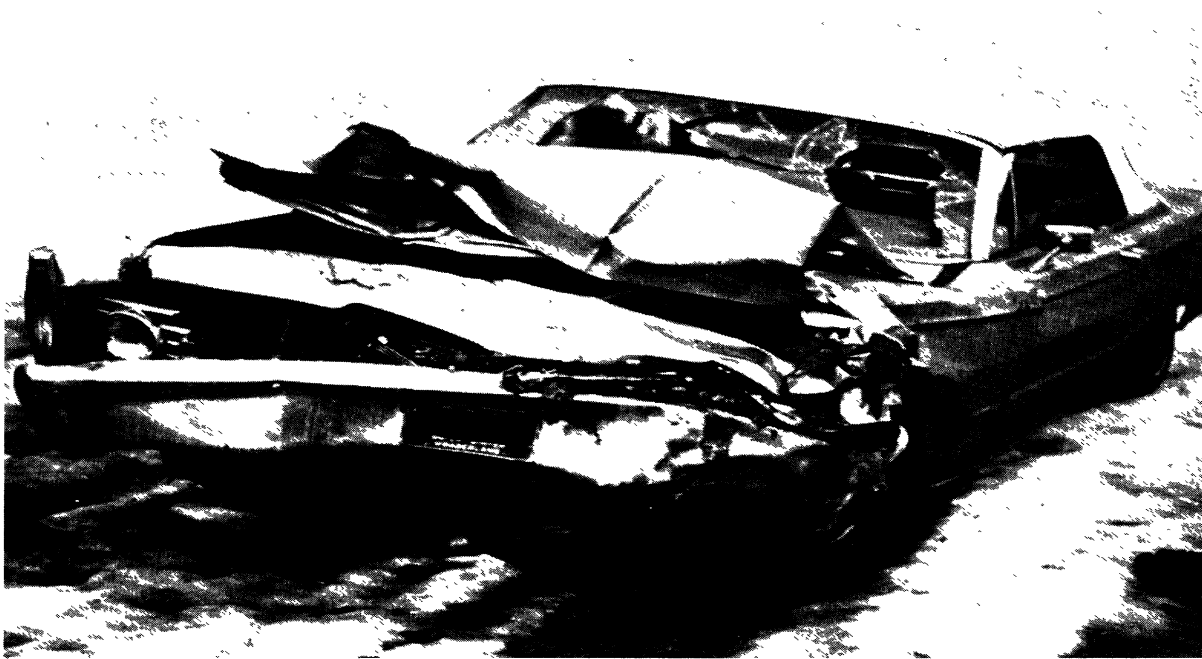
1967 Ford (Figures 49 and 50). A head-on, car-to-car collision (impact velocity 30 mph). The front passenger (female, 45 years old) struck the center of the windshield bulging it outward and tearing the laminate. She sustained abrasions of the forehead from this impact. Seat belts were not worn. (Case #206/5/10/67)



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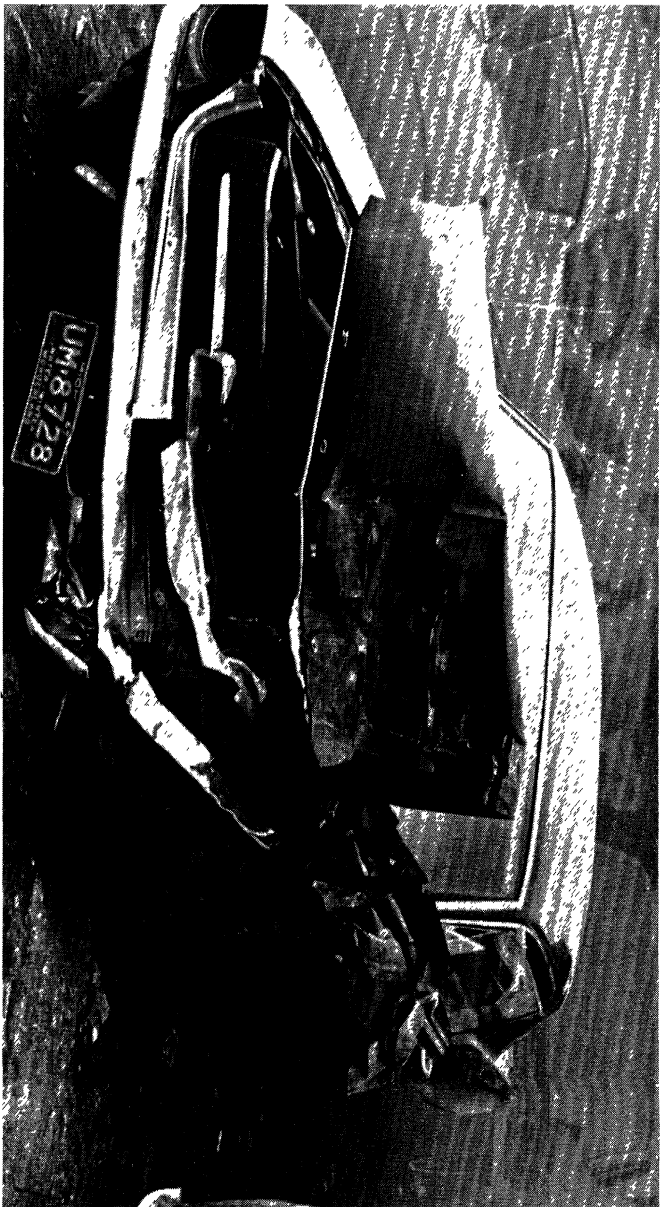


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1965 Mercury (Figures 51 and 52). A head-on, car-to-car collision (impact velocity 35 mph). The driver (male, 34 years old) struck the windshield above the steering wheel and sustained a large vertical scalp laceration and a laceration to the forehead. The passenger (female, 31 years old) struck the windshield, sustaining minor lacerations and abrasions about the face. Seat belts were not worn.

(Case #207/2/11/67)

1967 Mustang (Figures 53 and 54). A head-on, car-to-car collision (impact velocity 35 mph). The driver of the Mustang (male, 18 years old, 5 feet 10 inches, 155 pounds), struck the rear-view mirror and slid off of it into the windshield. He sustained a 2-cm, U-shaped laceration above the left eyelid. Seat belts were not worn.
(Case #211/3/26/67)



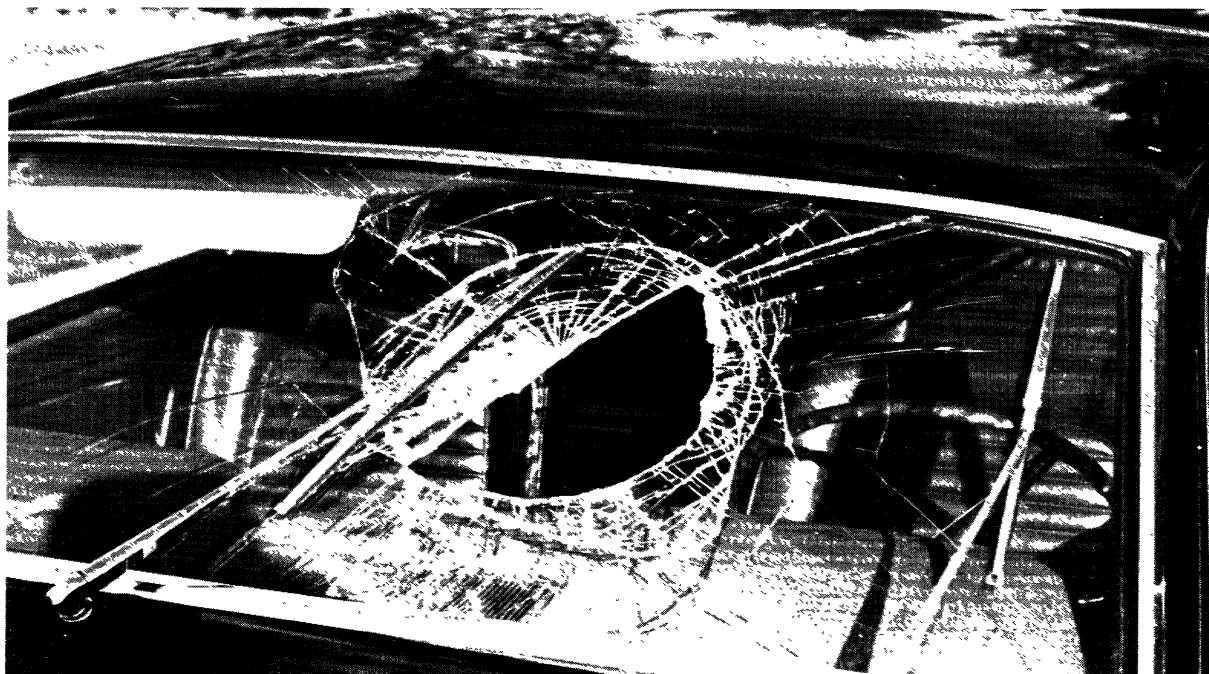
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1965 Mustang (Figures 55 and 56). This vehicle struck the right front of another that turned in front of it (impact velocity 25 mph). The passenger (female, 23 years old, 5 feet 5 inches, 125 pounds) struck the windshield 18 inches from the left "A" pillar and 9 inches below the header. She sustained a 5-cm laceration on the top of the left side of her head. Seat belts were not worn. (Case #73/10/18/65)

1967 Barracuda (Figures 57 and 58). This vehicle went off the roadway, rolled and flipped over several times. The driver (male, 40 years old) struck the windshield just to the left of the rear-view mirror, and sustained multiple lacerations and abrasions of his forehead and face, one of which required sutures. The matted windshield is partially separated from the molding in the header area. No seat belts were worn.

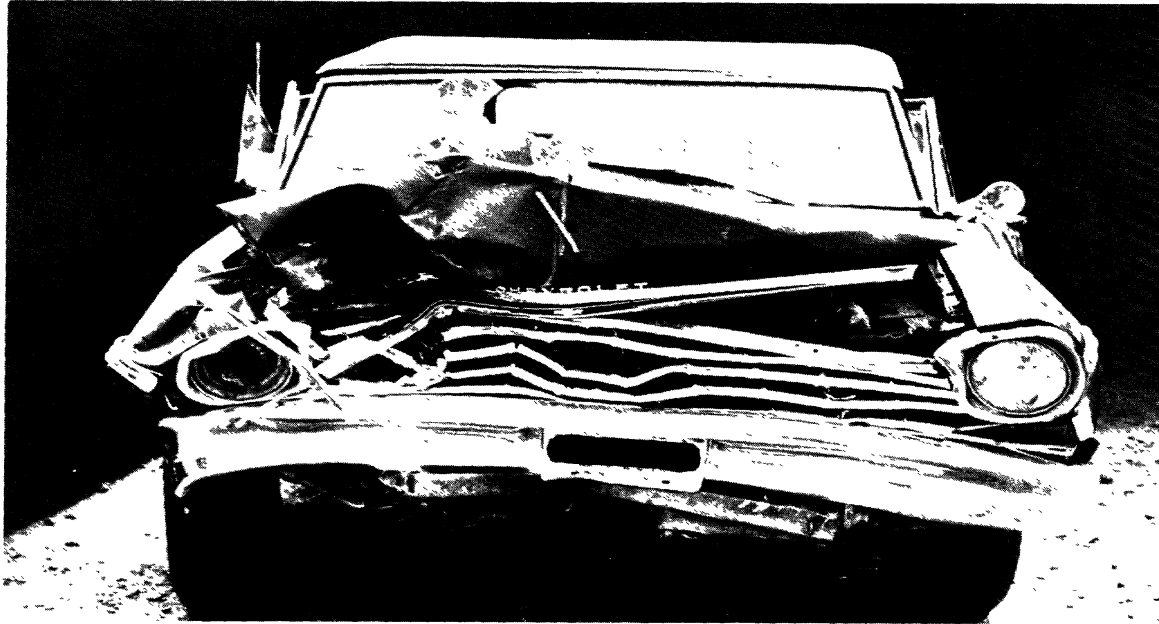
(Case #216/4/18/67)



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1963 Chevy II (Figures 59 and 60). A head-on, car-to-car collision (impact velocity 30 mph). The passenger (female, 24 years old) struck the windshield 11 inches from the right "A" pillar and 12 inches below the header. An adjacent windshield imprint was produced by the rear-view mirror striking the glass. She sustained a 20-cm laceration to the scalp. Seat belts were not worn.

(Case #128/7/23/66)

1967 Chevrolet (Figures 61 and 62). An intersection type collision (impact velocity 30 mph). The driver (male, 52 years old), struck the windshield 7 inches below the header and 8 inches from the left "A" pillar. The laminate was perforated. He sustained a scalp laceration above the left eyebrow. No seat belts were worn.
(Case #219/5/5/67)



61



62

1963 Chevrolet (Figures 63 and 64). A head-on, car-to-car collision (impact velocity 10 mph). The passenger (female, 18 years old) struck the windshield to the right of center, sustaining multiple lacerations of the forehead, right zygoma, and other smaller facial lacerations. Seat belts were not worn. (Case #47/12/28/64)



63



64

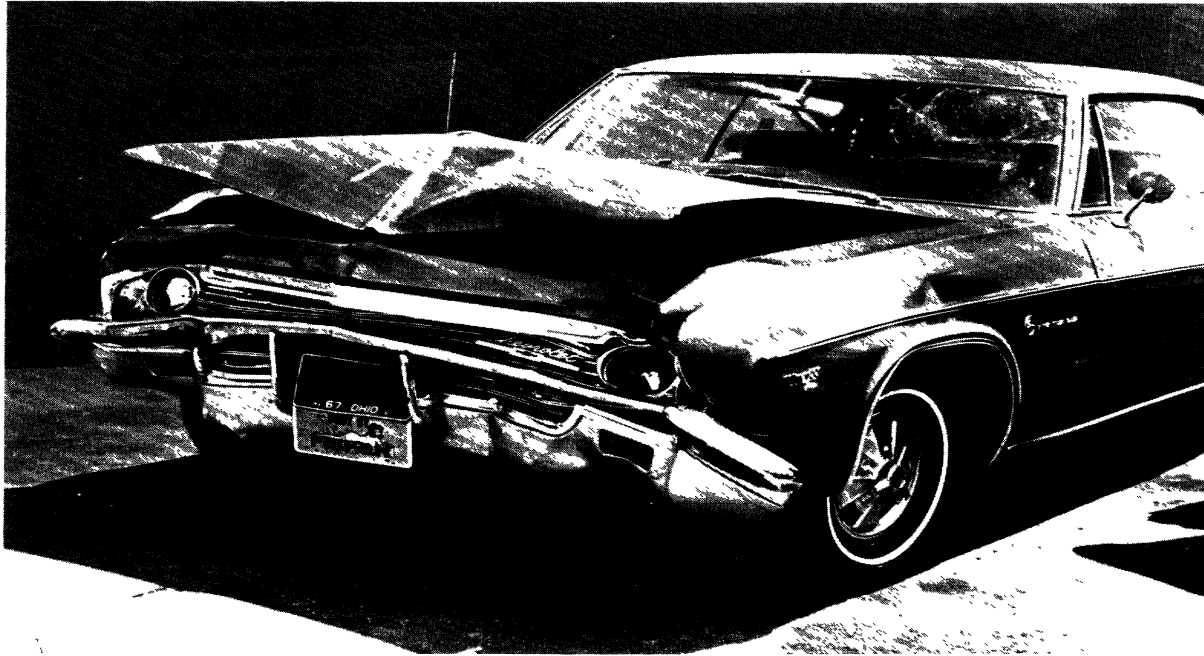
1966 Ford Van (Figures 65 and 66). This van was involved in an intersection collision (impact velocity 30-35 mph). The windshield was broken out completely and was found cracked, but intact, in the rear of the van (it had been placed there by the wrecker crew). The driver was ejected through the windshield opening. He sustained multiple lacerations to the face and ears; it is not known whether his facial injuries were due to ejection or windshield impact. (Case #157/10/7/66)



65



66



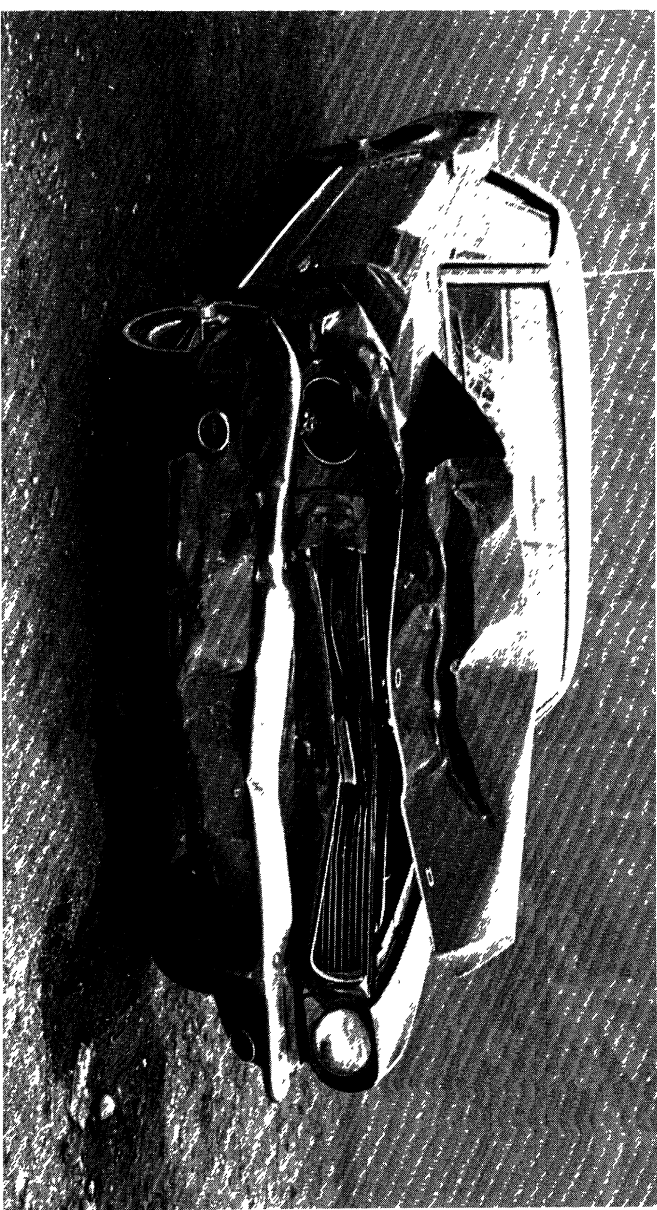
67



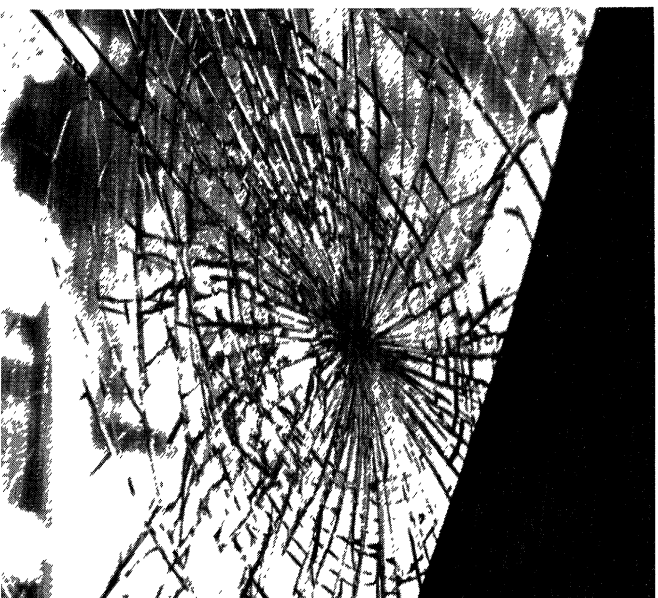
68).

1966 Chevrolet (Figures 67 and 68). This vehicle struck another in the rear (impact velocity 20 mph). The driver (male, 29 years old) hit the windshield 3 inches below the header and 8 inches from the left "A" pillar. The impact site was bulged outward. He sustained abrasions of the face and had mild neck pain. Seat belts were not worn.
(Case #228/7/2/67)

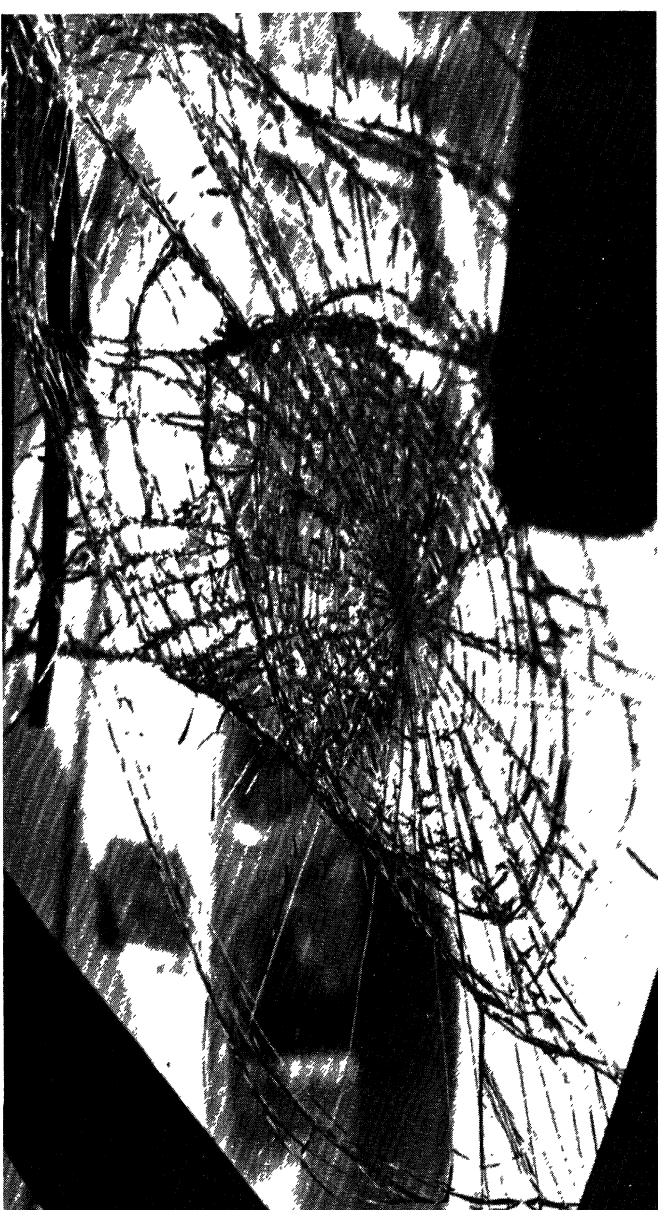
1966 Mustang (Figures 69, 70 and 71). The driver of this car fell asleep and hit two parked cars (impact velocity 25 mph). The passenger (male, 24 years old) struck the windshield 7 inches below the header and 12 inches from the right "A" pillar. The windshield at the impact area was noticeably bulged outward. He sustained small lacerations to his forehead and the top of his head. The driver (male, 29 years old) struck the windshield 8 inches below the header and 12 inches from the left "A" pillar. He sustained small forehead lacerations. Both refused medical treatment. No seat belts were worn. (Case #223/5/20/67)



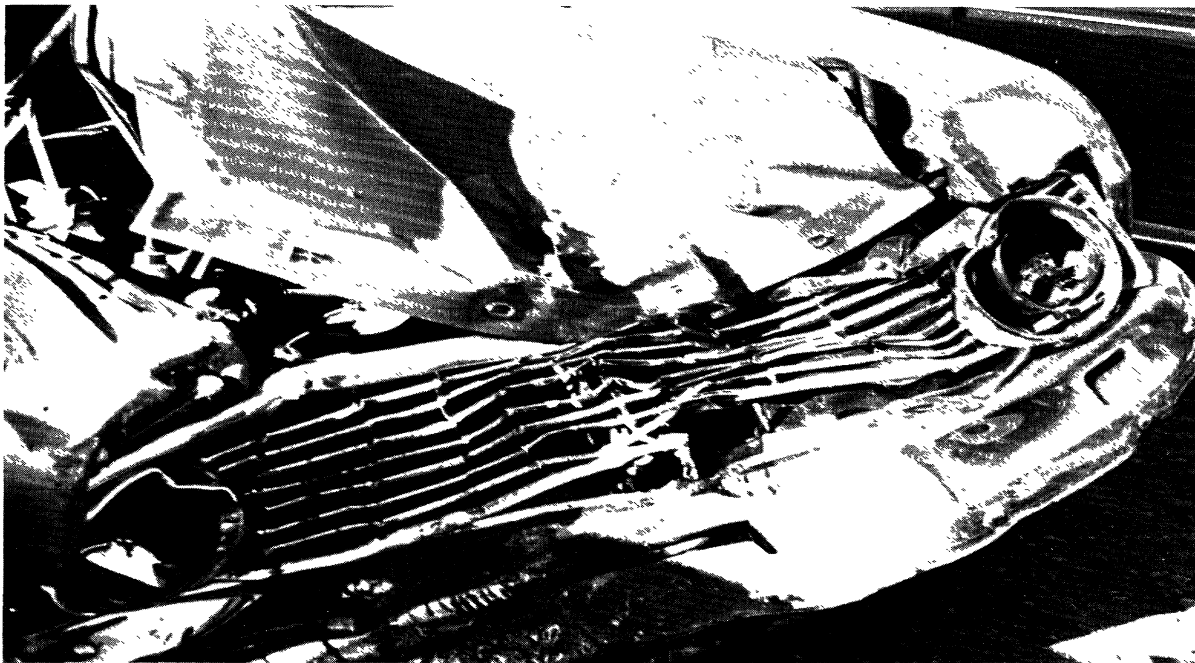
69



70

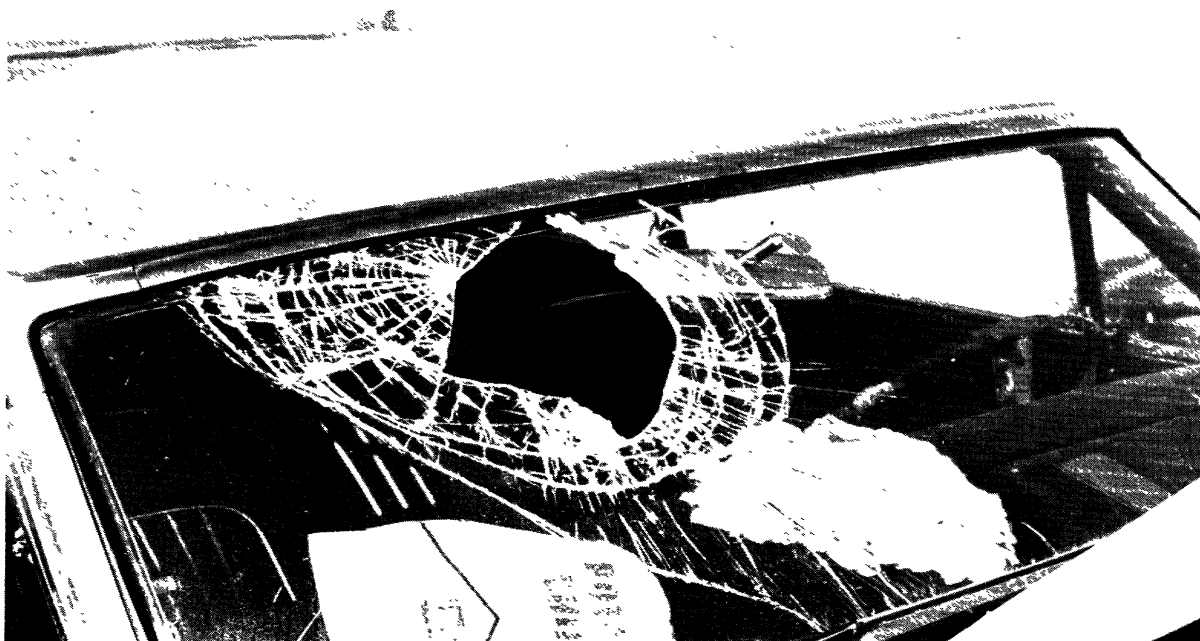


71



72

1964 Falcon (**Figures 72 and 73**). A head-on, car-to-car accident (impact velocity 30 mph). The passenger (female, 19 years old) struck the windshield 14 inches from the right "A" pillar and 5 inches below the header. She sustained multiple lacerations of the left cheek and a mandibular fracture. Seat belts were not worn.
(Case #68/5/24/66)



73

1967 Camaro (Figures 74 and 75). An intersection collision (impact velocity 35 mph). The driver (male, 16 years old, 5 feet 7 inches, 200 pounds) struck the windshield 6 inches below the header and 7 inches from the left "A" pillar. The impact area was bulged outward. He sustained forehead abrasions near the hairline. The passenger (male, 18 years old, 6 feet, 155 pounds) struck the windshield 7 inches below the header and 19 inches from the right "A" pillar. He sustained abrasions about the hairline. No seat belts were used by either occupant.
(Case #2927/6/11/67)



74



75



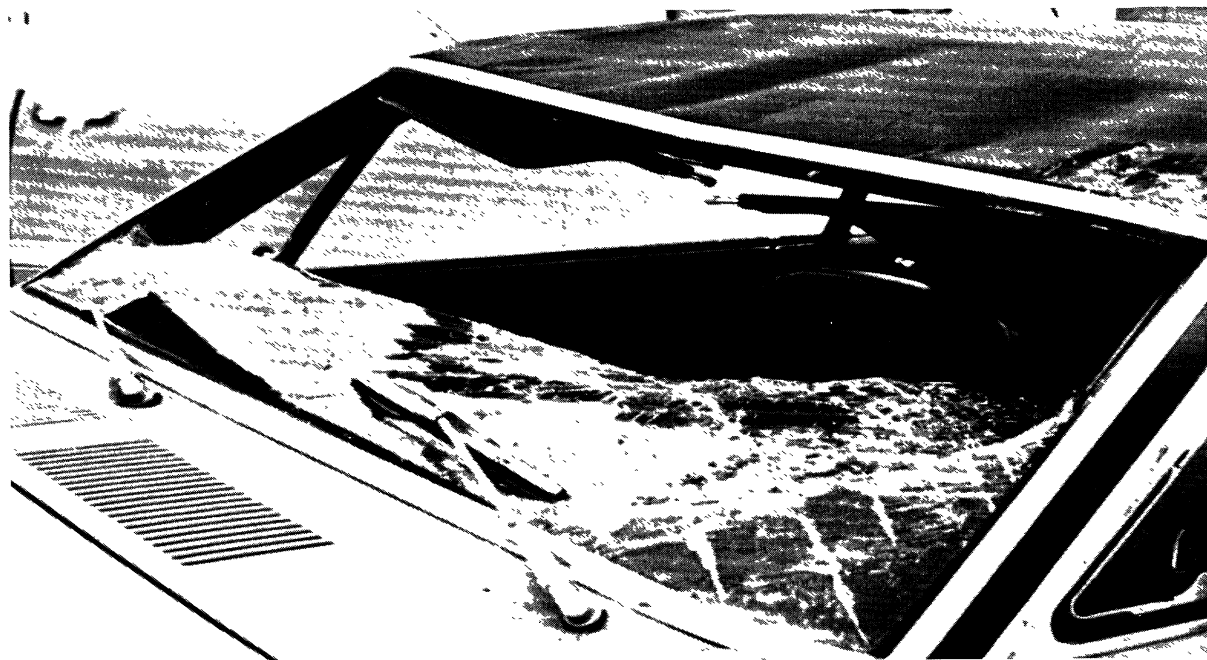
76



77

1966 Chevrolet (Figures 76 and 77). This vehicle struck a railroad signal standard (impact velocity 40-45 mph). The windshield was matted; there was a separation of the windshield from the left "A" pillar and the left side of the header. The head impact area was just below the header, above the steering wheel. The driver (male, 25 years old) was subsequently ejected. In addition to other injuries, he sustained facial lacerations and a brain concussion. It is not known whether these injuries were sustained in the car or as a result of ejection. Seat belts were not worn. (Case #94/3/18/66)

1967 Mustang (Figure 78). This vehicle was forced off the road and flipped over in the snow. The matted windshield fell into the occupant area. No injuries were sustained from the windshield glass. Seat belts were worn. (Pre-1966 windshields usually shattered in rollover accidents, leaving sharp glass edges as potential injury areas.)
(Case #191/2/1/67)



78)

1967 Dodge Van (Figure 79). This van was struck by a car that turned in front of it (impact velocity 35 mph). The entire windshield of the van "popped out" of its frame. The passenger in the van sustained a laceration of the nose from the windshield glass. See figures 31 and 32.
(Case #222/5/14/67)



79)

