TRAFFIC ACCIDENTS

IN ADELAIDE, SOUTH AUSTRALIA

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AUSTRALIAN ROAD RESEARCH BOARD

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TRAFFIC ACCIDENTS IN ADELAIDE, SOUTH AUSTRALIA (1963 – 1964)*

SECTION 1 — SUMMARY

OBJECT OF THE INVESTIGATION

1.1 This project was entirely financed by the Australian Road Research Board. Its object was defined as follows: 'To gather data in Australian conditions basic to the design of roads, traffic organization and vehicles, by the objective study of the medical and engineering aspects of injury-producing accidents.'

METHODS

1.2 The investigating team consisted of a doctor (G. A. Ryan) and a mechanical engineer (A. J. McLean) in a vehicle equipped with a two-way voice radio tuned to the ambulance frequency. Working to a carefully designed statistical plan the team attended in 1963 and 1964 a representative sample comprising 12.3 per cent of those traffic accidents in metropolitan Adelaide to which an ambulance was called. Some few sources of bias were present in the sampling procedure, partly avoidable, partly unavoidable. These are discussed in the body of this report (para. 3.26).

1.3 A rapid but thorough investigation was made at the scene of the accident. The doctor recorded age, sex, height, weight and seated positions of the participants, and the details of their injuries, while the engineer studied the vehicular and environmental aspects. A comprehensive set of photographs was taken. Together the two members determined when possible what particular structures caused the injuries. The victims were then followed to the hospitals, where their injuries and personal particulars were recorded in more detail. Their subsequent progress in hospital was followed until discharge or death. A full necropsy was performed on every victim who died.

1.4 In a similar way the vehicles were followed when necessary to the repair shops, where damage could be studied in detail and at leisure. In many cases an estimate of the cost of repair was obtained.

1.5 A measured sketch plan was made of the scene of every accident. In numerous cases the scene was re-visited to complete the details of the site plan, and most of these sketches were subsequently drawn for the permanent record. Many of them are printed in this report.

1.6 As far as possible, the information obtained on both medical and engineering aspects was recorded in a quantitative way so that subsequent statistical analysis could be performed. Some items could be measured with reasonable accuracy, for example the length and direction of skid marks. Others were estimates of varying precision, such as travelling speed of the vehicles and their speed at impact. Other items again, such as the degree of injury to

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***This work is a report on a project sponsored by the Australian Road Research Board. The project was planned and directed by J. S. Robertson. The work at the scene of the accidents was carried out by A. J. McLean and G. A. Ryan. The opinions and interpretations of the facts obtained in this study, and the recommendations derived from analysis of the data, are those of the authors, and do not necessarily represent the views of the Australian Road Research Board.**

the victim, were recorded as ranked scores according to a predetermined code, which was very similar to and was based on the code used by the Automotive Crash Injury Research organization of Cornell University, U.S.A. In general these estimates and measurements proved satisfactory enough for subsequent quite detailed statistical study, and yet they were simple to obtain, and therefore they would be usable and useful (in our opinion) in the hands of trained but non-professional accident investigators.

RESULTS

The size of the sample

1.7 The unit attended accidents in the Adelaide metropolitan area during two periods, one in 1963 and the other in 1964. Between March 4 and November 5, 1963, 201 accidents out of a total of 1,676 accidents were attended (11.9 per cent), and between February 3 and August 30, 1964, a further 207 accidents were attended out of 1,626 (12.7 per cent). The overall figure of attendance was therefore 408 accidents in 3,302, or 12.3 per cent. This agreed closely with the estimate of 10 to 15 per cent for the possible attendance which was worked out on the basis of the ambulance records during the preliminary planning study. It is considered that this sample was sufficiently large to permit reasonable inferences to be drawn about the total accidents in Adelaide during these two years.

Accidents involving pedestrians

1.8 There were 79 such accidents, involving 82 pedestrians, in the sample of 408 accidents (19.3 per cent), distributed as follows:

63 pedestrians were struck by 61 cars,
7 pedestrians were struck by trucks or buses,
7 pedestrians were struck by motor-cycles,
4 pedestrians were struck by cars with trailer,
1 pedestrian was struck by a pedal cycle.

1.9 There were three main age groups:

(a) chiefly males aged less than 20 years,
(b) chiefly males aged 35 to 64 years, many of whom were affected by alcohol,
(c) males and females older than 65 years.

1.10 Approximately three-quarters of the drivers first saw the pedestrian only when it was too late to avoid the collision. At night no driver saw the pedestrian in the distance.

1.11 Of the 22 pedestrians (37 per cent), who could remember what happened, nearly three-quarters saw the striking vehicle only immediately before impact, or not at all.

1.12 More pedestrians were struck when crossing from the driver's left (46) than from the right (30). Nineteen (41 per cent) of those crossing from the left were obscured by a moving or stationary vehicle, but only four (13 per cent) of those crossing from the right. In 11 of these 23 cases the striking vehicle was overtaking another vehicle.

1.13 Eleven of 76 pedestrians (14.5 per cent) crossing the road were standing in the centre at the time of impact. This is a high proportion of the total, and points to the clear need for more protective measures for pedestrians in this city.

1.14 Thirty-five per cent of the accidents happened within the boundaries of an intersection, 28 per cent were within 20 yards of an intersection and 37 per cent occurred more than 20 yards from an intersection. There were three times as many accidents in the 20 yards 'downstream' from an intersection as in the 20 yards 'upstream'. Those occurring 'downstream' involved more night accidents, and more vehicles which were overtaking or had turned left.

1.15 Eleven (13 per cent) of the 79 accidents occurred at or within 20 yards of pedestrian crossings or signalized intersections.

1.16 Seventy-two of the 79 accidents were on busy roads (5,000 or more vehicles per 12 hours). Nearly half of these were at or near shopping areas. Relatively more old people and children were involved in accidents in the suburbs than in the city proper.

1.17 Responsibility for the accidents was assigned by the unit (not the police) as follows:

Suburban accidents:		
Careless or drunk pedestrian	34	
All reasonable care taken by pedestrian	24	58
City accidents:		
Careless or drunk pedestrian	10	
All reasonable care taken by pedestrian	11	21
Total:		79

1.18 Thus 44 accidents (56 per cent) were due to the carelessness or drunkenness of the pedestrian, but in 35 cases (44 per cent) all reasonable care was taken by the victim and yet the accident occurred. The locations of those accidents due to carelessness or drunkenness cannot be predicted and have little significance for the traffic engineer, but it is disturbing that in almost half the cases all reasonable care was taken by the victim. The locations of these accidents merit very careful study by our traffic engineers, for it seems that more positive measures are needed to protect pedestrians in these and other similar places.

1.19 The injury patterns in the victims have been described in detail. When struck by motorcycles, trucks and buses, and cars, pedestrians suffer injuries to the lower limbs, pelvis, abdomen and thorax, caused mainly by the vehicles. Injuries to the head and upper limbs are caused mainly by striking the road.

1.20 Concussion was the commonest single head injury (56 per cent of cases). Superficial scalp and face injuries each occurred in half the cases. There were only three injuries to the facial skeleton, but eight of the pedestrians suffered fractures of the skull, and of these eight victims five died.

1.21 There were four injuries to the skeleton of the neck in three cases, all fatal.

1.22 The commonest thoracic injury was fracture of the ribs and bony skeleton without internal injury, but nine pedestrians had internal thoracic injuries. In all nine victims the lungs were injured and in three the heart and great vessels, including two instances of rupture of the aorta. Of the nine persons (11 per cent) with fractured ribs, only one was aged less than 55 years.

1.23 Internal abdominal injuries occurred in six cases, all fatal.

1.24 Eleven pedestrians (of whom six died) suffered fracture of the pelvis.

1.25 There were four fractures of the upper arm and seven of the lower arm, but there were 27 skeletal injuries in the lower limbs. Six of these latter fractures were of the femur and 15 of the tibia (four compound). In addition there were two fractures of the fibula and four skeletal injuries of the ankle joint.

1.26 The motions of the pedestrian during the very brief period of the accident have been worked out in detail and our conclusions can be presented with some confidence. Pedestrians are not 'run over' by cars but are 'run under', for when struck by a car the pedestrian is thrown in the air after the initial impact with the bumper and the front of the car; the thorax and head then strike the bonnet and windscreen. He then falls to the road or, if the speed is higher, he rotates about his head and 'somersaults' onto the roof, whence he falls to the road. Impact with the road from this considerable height and speed (for he is now travelling at the speed of the car) produces further injuries.

1.27 Injuries to the head and thorax are most often serious or fatal. Injuries to the lower limbs are most common. There was an average of 2.7 injuries per pedestrian struck by a car.

1.28 Eleven of the 82 pedestrians (13.5 per cent) were killed. Three died at the scene, one was dead on arrival at the hospital, and six died in hospital. Fifty-seven (70 per cent) were admitted to hospital and survived, ten were given casualty treatment only, and five did not need treatment. The total number admitted to hospital was therefore 63 (77 per cent). For the 57 pedestrians who were admitted to hospital and survived, the mean length of stay was 11 days. Twenty-five (44 per cent) stayed seven days or more.

1.29 Analysis of these accidents has shown that there is a statistically significant difference in injury-producing potential for pedestrians between cars with sloping fronts (e.g. Volkwagens) and cars with the conventional square front (e.g. Ford Falcon). Below 20 m.p.h. a Falcon is more likely to produce severe injuries than is a Volkswagen 1200. Between 20 and 25 m.p.h. the injury-producing potential is the same. Above 25 m.p.h. the Volkswagen 1200 will probably cause more severe injuries than the Falcon.

Pedal cyclists

1.30 We attended 44 accidents (11 per cent of the total 408 accidents) involving 44 pedal cyclists. Forty-two accidents occurred in the suburbs and two in the City proper.

1.31 There was a marked peak of incidence in the 10 to 14 year age group, and 26 of the cyclists (more than half) were aged less than 20 years. There were 40 males and four females.

1.32 Almost half of the accidents occurred in the two hours between 4 p.m. and 6 p.m. Because our sample includes a relatively higher proportion of off-peak accidents it is therefore likely that more than half of all injury-producing pedal cycle accidents occur during these two hours. Although we attended many more pedal cycle accidents on Fridays than on other days, this bias could be due to chance.

1.33 Twelve accidents occurred at night and 32 during the day. Only two children (aged less than 15 years) were involved in night accidents. The other 16 children were injured in daytime accidents, often when making a sudden U-turn or a right-turn in front of a following car.

1.34 Most night-time accidents seemed to occur because drivers did not see the cyclists riding steadily along at the side of the road. The visibility of cyclists at night is therefore important, and depends on how well the cyclist contrasts with his background. On a poorly lit road this is first achieved by the tail light on the bicycle, and we therefore recommend large bright tail lights on bicycles. As the vehicle closes with the cyclist the next stage of visibility is when the headlights illuminate him, and during this process there may be a short period when the contrast between the cyclist and the background may be greatly diminished. This can occur under lighting conditions which may be classed as good. Eleven of our 12 night-time pedal cycle accidents occurred in such conditions.

1.35 In four night-time accidents the driver did not see the cyclist at all. Each of these four drivers had obviously been drinking. One cyclist of the 44 had obviously been drinking.

1.36 Of the 40 vehicles which struck cyclists 28 (70 per cent) were proceeding straight ahead, as were 16 cyclists, but 22 cyclists were changing direction at the moment of impact.

1.37 Seventy per cent of the accidents occurred at or near intersections. This may result from the distracting effect of the intersection on the drivers, with the result that they do not notice the cyclist. Fifteen of 23 drivers told us that they did not see the cyclist at an intersection until it was too late. Therefore a cyclist should be taught that he must not assume that a driver has seen him, particularly at an intersection.

1.38 The types of collisions were as follows:

2 pedal cyclists were struck by motor-cycles
3 pedal cyclists were struck by trucks
1 pedal cyclist struck a pedestrian
3 pedal cyclists fell off without a collision
35 pedal cyclists were struck by cars

1.39 When struck by a car the pedal cyclist, like the pedestrian, has no protection from the impacts with the car and subsequently with the road. In most cases (24/35 of our cases) the front of the car struck the side of the bicycle, and in two-thirds of collisions of this kind (14/24) the rider fell on top of the bonnet of the striking car.

1.40 The motions of the cyclist during and after the impact with the car depend on the relative positions of the centre of gravity of the cycle plus rider and the top of the bonnet of the striking car. When seated normally on the cycle the combined centre of gravity for a rider of medium height is near the front of the saddle, and when the rider is leaning forward over the handlebars the centre of gravity shifts forwards about 7 in. In both postures the centre of gravity is about 33 in. above the ground, just below the saddle height of 35 in. This height is nearly the same as that of the top of the bonnet of a car of conventional frontal design. Therefore when struck from the side by the car, the rider and cycle will momentarily be pushed sideways by the car.

1.41 However the rider and cycle do not behave like a rigid body on impact except at very low speeds (less than 10 m.p.h.), for they are readily separated. The post-impact motions of each can be derived by relating the point and direction of impact to the positions of their individual centres of gravity (considering other factors such as rotational inertias, which influence these motions, in a purely qualitative way). The kinematics of the pedal cycle/car collision are therefore as follows.

1.42 An impact from the side at a height of 33 in.—the height of a car bonnet—will strike the rider on the hip and will cause the cycle to be pushed away in front of the car, while the rider will be rotated about his centre of gravity, his head moving towards the car. His legs, being below the top of the bonnet, will be pushed forwards and will thus assist in rotating his trunk towards the car. The distance back from the front of the car that his head will strike is determined by the speed of the car at impact. With increasing speed the rider strikes successively the top of the bonnet, the windscreen, and at still higher speeds he strikes the roof just above the upper edge of the windscreen. The height of the rider's trajectory will also be affected to some extent by his position, i.e. seated or standing on the pedals, and by his stature. After striking the car the rider then falls to the road on either side or behind the car. If the car stops quickly the rider may be projected onto the road in front of the car. Occasionally the cyclist may be thrown diagonally over the bonnet of the car without touching it, landing directly on the road.

1.43 In a minority of cases the centre of gravity of the cycle and rider at the moment of impact is beyond a corner of the front of the car, so that the cycle and rider pivot about the corner of the car and slide down its side to the road. In impacts directly from the cyclist's rear (five cases) the rider again is thrown directly up the car through a distance proportional to the impact speed.

1.44 Like the pedestrian, therefore, the cyclist suffers multiple impacts with the car and the road, and consequently he also suffers multiple injuries. The 35 pedal cyclists struck by cars sustained a total of 98 injuries to all body areas, an average of 2.8 injuries per cyclist. Injuries to the lower limb were most numerous, but were also all minor. Head injuries were almost as numerous as injuries to the lower limb but were mostly moderate or worse. Three cyclists were killed, with six fatal injuries between them (three to the head, one to the thorax and two to the spine).

1.45 In all, there were 29 head injuries among the 44 cyclists, with 28 cases of concussion, 25 soft-tissue injuries of the face, and 15 soft-tissue injuries of the scalp. Nineteen of the 25 soft-tissue facial injuries were caused by the road as were eight of the 15 scalp injuries. The rest were caused by impact with the striking vehicle. There were two fatal neck injuries with transection of the brain stem (one case) and spinal cord (one case). There was one crush fracture of a lumbar vertebral body and one of fractured lumbar transverse processes.

1.46 There were relatively few thoracic injuries but one of them was a fatal transection of the thoracic aorta. The road and the vehicle each caused about half the thoracic injuries.

1.47 Three pelvic fractures were caused by the vehicle striking the cyclist's hip. Thirteen of the 18 upper limb injuries were abrasions or bruises, almost all caused by the road. In addition there were five fractures or dislocations, all of the left arm, although only two of the impacts were from the right. There were two fractures and 47 soft tissue injuries of the lower limb. Twenty-three of the latter were caused by the front of the car.

1.48 Twenty-eight of the 44 cyclists (64 per cent) were admitted to hospital and three were killed. Details of disposal were as follows:

No treatment required	6
Casualty treatment only	7
Admitted, later discharged	28
Dead on arrival at hospital	2
Dead at scene	1

1.49 The lengths of stay of those admitted to hospital were:

24 hours or less	10
1–2 days	7
3–5 days	4
6–10 days	2
11–15 days	3
16–20 days	1
21–25 days	0
26–30 days	0
More than 30 days	1

Motor-cyclists

1.50 There were 66 accidents, or 16 per cent of the total of 408 accidents. The proportion increased from 14 per cent in 1963 to 18 per cent in 1964, although motor-cycles comprised 4.15 per cent of all registered vehicles in 1963 and 3.48 per cent in 1964. It is possible that as motor-cycles become a smaller fraction of the total traffic their risk of accident involvement increases.

1.51 Forty-five of the 66 accidents happened in the daytime, and 24 of the 66 in the two hours between 4 p.m. and 6 p.m. The peak at this time involves motor-cycles much more than motor-scooters. There is also a slight peak between 12 noon and 2 p.m., and the evening peak continues, although diminished, to between 8 p.m. and 9 p.m.

1.52 The daily number of accidents increased from Monday to Thursday, with the Friday total slightly less than Thursday's. We sampled only alternate Saturdays and very few Sundays, so that our figures for those days are too small to be meaningful.

1.53 Because of the dangers associated with skidding and the obvious relationship between reduced skid resistance and wet roads, it was surprising that only one of the 66 accidents occurred during rain and only three on wet roads. Our figures do not show any significant relationship between poor tyres on the motor-cycle and increased incidence of skidding. Light motor-cycles seem to be less susceptible to skidding while braking than the heavier machines or scooters. A lower speed at impact for the less powerful machines may be a factor here.

1.54 There were 67 riders in the 66 accidents, one of which involved two machines. Sixty were males and seven were females. There were seven pillion passengers of whom four were females and 3 were males. Riders aged 16 to 19 years markedly predominated, while from 20 to 34 years the number of riders was evenly distributed with age. There were very few riders aged more than 35 years. Twenty-three riders (38 per cent) were aged less than 20, and 32 (53 per cent) less than 24 years. Forty-three per cent of motor cycle riders but only 30 per cent of scooter riders were aged less than 20 years. Length of driving experience increases with age and most riders had been driving since reaching the legal minimum age of 16 years. We found that most accidents occur in the second to fifth years of driving experience.

1.55 The types of accidents were as follows:

	No. of Cases
Collision between motor-cycle and car	47
Collision between motor-cycle and pedestrian	7
Collision between motor-cycle and truck	4
Collision between motor-cycle and pedal cycle	2

Collision between motor-cycle and train	1
Motor-cycle alone	6
Total	67

Most of the accidents occurred on busy roads.

1.56 Forty of the 67 accidents occurred at intersections, six within the 20 yards before and six within the 20 yards after an intersection, and 14 not at intersections. Fifty-two (79 per cent) of the cycles were travelling straight ahead before the collision, and only five (8 per cent) were changing direction. However, 33 (70 per cent) of the cars involved were changing direction, and 23 of these were turning right.

1.57 There were six single vehicle accidents. Two of these were collisions with fixed objects, and four were falls when the riders lost control. All these machines were proceeding straight ahead.

1.58 In the seven cases when motor-cycles collided with pedestrians the riders all fell off after the collision. Only one of these accidents was at night, and it is possible that an approaching motor-cycle is more noticeable at night, when its headlight is on, than in the daytime. In collisions between motor-cycles and pedal cycles (two cases) the fall to the road rather than the collision itself caused injury to the motor-cyclist.

1.59 The one death among motor-cyclists was after a collision with a diesel railcar at a level crossing. There was no evidence that the cyclist was thrown on to the guard rail in this accident.

1.60 There were 47 collisions between motor-cycles and cars. Almost half the cars (23) were turning right. The disturbing feature of this latter type of accident is that there is little the motor-cyclist can do to avoid such a collision. In 13 cases the car turned right across the path of the motor-cyclist approaching on the same road, and five of these were at light-controlled intersections. At one of these intersections the layout of the lights is confusing, and at another there is a split green phase which possibly contributed to the accident. Split phase operation of lights appears to place unfair demands on a driver, and we believe that in principle it is not desirable to reduce the safety margin of a control device in an attempt to expedite traffic.

1.61 Accidents involving cars turning right were about equally divided between day and night. The motor-cyclists usually saw the car approaching in the distance, but the car drivers seldom noticed the motor-cyclist until just before the collision. Our data do not show that motor-cyclists involved in this particular kind of accident were travelling unusually fast.

1.62 There were ten cases in which a car turned right from a side road into a through road and hit a motor-cyclist travelling towards the intersection along the other road. Seven of these cases were in daylight, and in four of them the car driver's view was obscured by another vehicle. Again there was little the cyclist could do to avoid the collision.

1.63 In seven cases the cars were attempting a 'U' turn from a parked position against the kerb, and six of these were in daylight. It seems likely that the car drivers underestimated the speed of the motor-cycle and also the time needed to complete a 'U' turn, especially as the average speed of the motor-cycles in these particular accidents was high (between 30 and 40 m.p.h.).

1.64 There were eight collisions at intersections in which both the car and the motor-cycle were proceeding straight across. In one case the car driver moved off because the car on his right had also started to move, without realizing that the latter driver had allowed a motor-cyclist to cross from the right—a relatively common predisposing cause of accidents. In two of these cases the motor-cyclists were travelling unreasonably fast, and in another case the car was travelling much too fast. Accidents involving rear end collisions (three) and cars turning left (two) were few.

1.65 There were four collisions with trucks, two of them at light-controlled intersections.

At one of these the truck entered the intersection just at the end of the green phase. The subsequent amber phase was not long enough to allow the truck to clear the intersection before the light changed to red, and simultaneously to green for the motor-cycle.

1.66 It will be clear from the preceding paragraphs that the motor-cyclist is often the 'victim' in accidents. In only 15 of these 67 cases could the motor-cyclist reasonably be expected to have been able, by his own action, to avoid the collision. Because cyclists are so liable to serious injury the duty of car drivers to look out for them is clear, and needs emphasizing.

1.67 There are two main configurations of collisions between cars and motor-cycles and scooters. These are front impacts, where the front of the machine strikes the car first and the rider travels forwards, and side impacts, where the front of the car strikes the side of the machine and the rider travels sideways. Although there are relatively more front impacts for scooters than for motor-cycles the figures are small and the difference is not significant.

1.68 Motor-scooter riders suffer more moderate and greater injuries than motor-cyclists, but the difference does not quite attain statistical significance. The distribution of regional injuries in the two classes of riders is also quite similar, and therefore both groups of riders can be combined when considering injuries.

1.69 In both front and side impacts most injuries are minor. Injuries to the head and lower limbs are most numerous. Severe and very severe lower limb injuries are relatively more common in side impacts than in front impacts, for the riders are directly struck by the car, and there are more severe head injuries in front impacts than in side impacts, when the riders are thrown head first against the car. Neither of these differences reaches statistical significance.

1.70 There were 29 front impacts and 17 side impacts. There are marked differences in the mechanics of these two types of collision. In the 29 front impacts the parts of the car struck by the cycle were as follows (see para. 6.68 for details):

Front of the car	5
Side of the car	20
Rear of the car	4

In four of the five impacts with the front of the car the cycle was at an angle. None of these riders landed on the top of the bonnet, but all bounced off to one or the other side of the car.

1.71 In impacts with the side of the car the cycle either strikes 'head on' and falls to the road, or the front of the machine is jerked violently to one side by the car, rotating the whole machine. In the first type the rider is thrown directly forward over the handlebars into the side of the car. In the second type he is thrown sideways against the side of the car. Rotation occurs when the speeds of the cycle and the car are approximately the same. 'Head on' impacts without rotation seem to occur when the speed of the cycle is high and that of the car is low. This might be expected from the dynamics of the situation, and presumably rotation would also occur when the speed of the car is high and that of the cycle is low. However, we have no cases of this latter type of collision.

1.72 In 'head on' impacts with the mudguard, the rider may be thrown on to or over the bonnet. One rider fractured the shaft of his femur as it was bent over the mudguard or handlebar. When the machine is rotated there may often be concussion from striking the head against the car, and fractures of the small bones of the rider's hand occur as it grips the handgrip which is swung against the side of the car.

1.73 In 'head on' impacts with the doors rotation is less frequent, and the rider receives head and face injuries when he is thrown directly into the side of the car. If rotation occurs concussion and hand injuries are again seen.

1.74 'Head on' impacts with the rear mudguard produce less severe injuries. However, there were only four such cases. Impacts directly on the rear of the car (four cases) produce rather similar patterns of injury, but in two cases there was fracture of the tibia from striking the bumper bar of the car.

1.75 In side impacts (front of car against side of cycle) the legs of the rider are directly exposed to injury from the front of the car, particularly from the bumper bar, which is generally at a level about 6 to 12 in. above the footrest of the cycle. In consequence severe fractures of the lower half of the tibia and fibula are common, as are fractures of the small bones of the hands, for the hands are also one of the first parts of the rider to be struck.

1.76 Rider and motor-cycle do not part company in side impacts so frequently as do pedal cycles and their riders. Motor-cycles are lower and heavier than pedal cycles, and therefore the centre of gravity of the rider and machine is below the top of the front of the bonnet.

1.77 After the impact with the front of the car the rider is projected on to the road and slides along it. This causes abrasions of the bony prominences, concussion, and (in two of our cases) a fractured skull.

1.78 Ninety-six per cent of motor-cyclists were injured to some degree, and 51 per cent sustained moderate or greater injuries. There was one death (previously mentioned): a collision with a train. Regional injuries were head and neck 55 per cent, thorax 13 per cent, abdomen 6 per cent, spine and pelvis none, upper limb 45 per cent and lower limb 90 per cent. The 74 persons received 148 injuries, or 2.0 injuries per person. Striking the road or—rarely—a fixed object, produced 50 per cent of all injuries to motor-cyclists. Next most common was striking the front or sides of the other vehicle, generally a car. The commonest cause of head injury was striking the road, followed by striking the side of the car. For lower limbs the road was the chief cause of injury, but the front of the car caused the more severe injuries.

1.79 Among 39 persons with head injuries there were 27 soft tissue injuries of the face, seven skeletal injuries of the face, 24 concussions, 16 soft tissue scalp injuries and three fractures of the skull. Twelve concussions were caused by striking the road, eight by striking the car, and the cause of four could not be determined. There were no bony injuries of the neck, spine or pelvis.

1.80 Thoracic injuries were few. There were eight soft tissue injuries, five skeletal injuries, and one internal injury—a pneumothorax.

1.81 Among 32 persons with injuries to the upper limb there were 35 soft tissue injuries and seven skeletal injuries, of which five were fractures of the small bones of the hand. By contrast, there were 64 persons with injuries to the lower limb. There were 80 soft tissue injuries and 16 skeletal injuries. Among the latter there were ten fractures of the tibia, five of them compound, and two fractures of the femur.

1.82 Thirteen (17 per cent) of the 74 motor-cyclists did not require any hospital treatment, 27 (36.5 per cent) were treated in a casualty department and allowed to go home, 33 (45 per cent) were admitted and later discharged. One person (previously mentioned) was killed —at the scene of the accident.

1.83 The length of hospital stay of the 33 persons admitted was:

	No. of Cases
0-1 days	10
1-2 days	2
3-5 days	7
6-10 days	3
11-15 days	0
16-20 days	2
21-25 days	4
26-30 days	2
More than 30 days	3
Total	33

Helmets

1.84 Twenty-two of the 74 persons in this survey were wearing crash helmets. More motor-scooter riders (13/35) were wearing helmets than motor-cyclists (9/39). Thirty per cent of those aged less than 20 years wore them, and 56 per cent of those between 20 and 35 years. None of the 14 riders aged more than 35 years wore a helmet.

1.85 The proportion of moderate and greater head injuries in those wearing helmets was not different from that in the group not wearing them. Among the helmet wearers the proportion of those with injuries to both the head and body was reduced slightly but not significantly. Among motor-cyclists wearing helmets there was a slight excess of cases with no head injury; there were no cases of scalp injury; and there were more 'concussion only' cases than expected, but not significantly so. Our data also do not suggest that helmet wearers in our sample had sustained more severe impacts than those not wearing them, for there were proportionately similar numbers of fractures of the face and skull in the two groups. Average estimated impact speeds for both helmet wearers and those not wearing them were the same (16 m.p.h.).

1.86 To attain an impact speed of 20 m.p.h. a rider's head, considered as a free body weighing 10 lb., would have to fall free for a distance of 14 ft., and would therefore have 140 ft-lb of energy. The British Standard for motor-cyclists' helmets (B.S. 2001: 1960) uses a striker of 10 lb mass falling through 9 ft, i.e. an energy content of 90 ft-lb, and the helmet under test must not allow a force greater than 5,000 lb to be developed on the head block holding the helmet. This value of 90 ft-lb is only two-thirds of the force developed in most of the impacts in our survey.

1.87 Australian helmets meet the Australian Standard E33—1959, which is identical with B.S. 2001: 1956. The point of impact on the helmet in the test rig used seems to be towards the top of the front of the helmet, but in our accidents most of the impacts were near the bottom edge of the helmet, and only three of the 13 were on the crown or at the angle at which the test impact is delivered. There is no protective padding at the sides of the helmet near the lower edge where it is most needed, nor does the suspension harness keep the helmet away from the head in impacts in this position.

1.88 Although analyses of figures from large populations of motor-cyclists have shown that helmets save lives, our small series has shown that their efficiency in preventing some of the effects of impacts to the head could be improved.

1.89 We suggest that official consideration be given to requiring that all helmets for motor-cyclists meet the B.S. 1869: 1960—Protective Helmets for Racing Motor-Cyclists. This specifies an enveloping helmet which covers the forehead, ears and occiput, there is a strong webbing suspension and the helmet is completely lined throughout with energy-absorbing material. In addition the shock absorption test should include impacts normal to the shell of the helmet and centred on the headband region.

Accidents involving trucks

1.90 In this section we include all heavy vehicles and some light commercial vehicles. A vehicle weighing up to the arbitrary limit of 2 tons tare weight we classify as a 'light truck', and over this as a 'heavy truck'. There were 27 light trucks and 35 heavy trucks in our survey, and there were 59 accidents involving trucks, comprising 14.4 per cent of the total accidents. There were 34 collisions with cars, 8 multiple vehicle collisions and 7 collisions with pedestrians. Other types of collision were infrequent. Only one-sixth of truck accidents occurred in the central city area.

1.91 There were 62 trucks with 85 occupants involved in the 59 accidents. There were two periods of peak incidence, one between 3 and 4 p.m. and the other between 6 and 7 p.m. This is different from the time distributions for other types of accidents where there is usually only a single peak, between 4 and 6 p.m. It is possible that the bias in our sample towards a greater proportion of off-peak accidents may have contributed to this difference.

1.92 The daily incidence is constant from Monday to Wednesday, but falls on Thursday and Friday. Our data are not adequate to allow conclusions about Saturday and Sunday.

1.93 The age distribution of truck drivers ranged from 17 to 66 years, with peaks at 20 to 29 years and 35 to 39 years. There were 24 passengers whose ages ranged from 5 to 69 years.

1.94 Collisions between trucks and pedestrians, pedal cyclists and motor-cyclists have been described previously. Because the trays of many trucks are close to the level of the head of a motor-cyclist as he is seated on his machine the rider may strike his head on the edge of the tray. Crash barriers below the tray at the rear and the sides would reduce the injury potential in this type of collision. There was one collision between two trucks—a heavy truck and a heavy utility. Both drivers were ejected through doors which came open. We believe that door latches on trucks should be designed to obviate this happening.

1.95 The eight multiple-vehicle collisions were naturally complex. Two were the familiar type of chain collision, but in one case the truck driver was reversing without having a clear view to the rear, and in another, which occurred at a railway level crossing, the truck driver probably mistook the sound of the horn on the railcar for that of a vehicle behind him, and he may also have mistaken the headlight of the railcar for a light of some other kind. It is possible that too much is being expected of motorists at these rail crossings.

1.96 Almost 80 per cent of all collisions between a car and a truck happened at intersections. In some of these truck accidents environmental features were to blame, and in some cases drivers did not stop at stop signs. However, cars and trucks yielded right of way to each other with equal frequency, and we found no evidence that truck drivers, being in the heavier vehicle, are less likely to yield right of way than car drivers.

1.97 There were five cases in which trucks turned right across the path of cars. In two of these the truck turned right from the slow lane of a dual highway and collided with a car travelling in the fast lane in the same direction. In two other cases the truck turned right despite the fact that a car was approaching fast from the opposite direction, the truck drivers probably misjudging the time needed to complete the turn.

1.98 One truck driver was probably under the influence of alcohol, and one car driver who collided with a parked truck had a blood alcohol content of more than 0.08 per cent.

1.99 The injuries of the 85 occupants were as follows: no injury 66, minor injury 15, moderate injury 4, severe injury or worse nil. None of the occupants of trucks which collided with pedestrians, pedal cyclists or motor-cyclists was injured at all. The four persons with moderate injuries all received concussion, but one of these was in a fall from the tray to the road. All other injuries to truck occupants were minor abrasions, bruises and lacerations to the face, scalp and limbs. In those accidents where cars and trucks collided, the occupants of the cars received much more severe injuries than those of the trucks; in fact 35 per cent of the car occupants received moderate or greater injury, as against 1.8 per cent of truck occupants. It is clear that the heavier the vehicle the safer are its occupants in a collision.

Car accidents: general considerations

1.100 Because 80 per cent of motor vehicles are cars, collisions between two cars are the commonest type of car accident. Usually there is only one impact, and both cars come to rest without striking anything else, but in some cases there is a subsequent collision with a third vehicle or with a fixed object. Although collisions are of almost endless variety, they can be categorized into types. Thus in our series there were 108 collisions between two cars without subsequent collision; 32 cases in which there was a subsequent collision, usually with another vehicle, less frequently with a utility pole or other object; 31 single car accidents, including eight collisions with a utility pole, eight cases of rollover only and six collisions with trees; and 13 collisions with parked vehicles.

1.101 The time distribution of 210 accidents (all car-car collisions, all single car accidents and most collisions between cars and trucks) showed a peak about 6 p.m. which gradually fell off to 11 p.m., but the total accidents were almost evenly divided between day (110) and night (100). There was a marked preponderance on Saturday. In 155 of the 210 accidents (74 per cent) an intersection played a significant part. Only 27 occurred on wet roads.

1.102 Five-sixths of drivers were men. The commonest age group of drivers involved in these car accidents was 20 to 24 years, and half were aged less than 35 years. There is a secondary peak at 35 to 39 years, with a subsequent gradual decline. About one-tenth of all drivers had obviously been drinking. When it is recalled that we could make no chemical tests for alcohol consumption, but had to rely on our general impression—which will detect only relatively gross impairment—the true proportion of drinkers is likely to be significantly higher.

1.103 Most front seat passengers were aged 15 to 19 years, and 60 per cent of rear seat passengers were aged less than 20 years, with a peak at 10 to 14 years. We obtained data on the length of driving experience for 265 drivers, and the figures suggest that the rate of accident occurrence falls off rapidly with increasing experience after the first ten years. Thirty-one per cent of the accidents happened to drivers who had been driving less than six years.

1.104 The most common configuration in car to car collisions was for the front of one car to strike the side of another. The 90° grid on which Adelaide streets are laid out, with the consequent large number of right-angled intersections, helps to account for the predominance of the front-to-side configuration. This also has the important consequence that car occupants are injured as often by the sides of the interior of the car as by the front.

1.105 Seventy-nine per cent of the 151 drivers for whom the information was available did not see the other vehicle until it was too late to avoid the collision (see para. 10.5 on 'critical speeds at intersections').

1.106 Forty-four of the 408 accidents (10.8 per cent) were essentially single-car accidents, including 13 collisions with parked vehicles. In two cases the driver collapsed at the wheel and the car swerved off the road into a tree. In two cases there seemed to have been a deliberate attempt to crash the car. In two further cases the driver's attention was distracted and he lost control, and finally there were two cases in which trailers broke loose from their towing vehicle. These last two cases draw attention to the need for specifications of the strength of the safety chains on towing attachments and for their method of attachment to both the trailer and the towing vehicle.

1.107 Apart from the specific causes listed in the preceding paragraph, the effect of alcohol is the most noteworthy feature of the single vehicle accident. Over one-third (16 of 44) of these drivers had obviously been drinking, and the number actually affected by alcohol could have been greater than this.

1.108 Most single car accidents occur at night (27 of 44). Single car rollovers are equally common by day and by night, but collisions with poles, trees and parked cars are more common at night (21 cases at night, nine by day).

1.109 A collision with a utility pole can result in severe damage to the vehicle and severe injury to the occupants. Poles can be modified to minimize the damage to a vehicle which hits one, and the value of introducing such modified poles could be considered.

1.110 There were 12 single car rollovers. In these accidents speeds were much higher than the average for the whole series. The average travelling speed was 35 to 40 m.p.h., and the speed at rollover slightly less—about 35 m.p.h. The averages for all cars in our survey were a travelling speed of 27 m.p.h. and 21 m.p.h. at impact. Nine of the 12 drivers were aged less than 25, with driving experience ranging from four months to nine years with an average of three years. Thus youth and inexperience combine in many cases with alcohol to produce a particularly dangerous combination; and there are yet other factors. Half of the vehicles involved were manufactured before 1955, and five of the 12 vehicles had independent rear suspensions of the swing-axle type. Although the condition of the tyres on these vehicles was generally good, tyre pressures were low in two of six cases, and dangerously so in one of these.

Car accidents: the car

1.111 More than one-third (38.5 per cent) of all cars in the accidents of this survey were produced by the General Motors Corporation (Holden cars). The Ford Motor Company, with

17 per cent of the total, and the British Motor Corporation, with 16 per cent, were the next largest group. 7.4 per cent were Volkswagens.

1.112 The effects of vehicle type and of design changes in particular types of vehicle on injury production are not exactly proportional to the number of these vehicles on the roads, but on the number of such models that are actually involved in accidents. These two proportions are not the same, for some makes of vehicles are over-represented and some are under-represented in accidents. We found that Volkswagens made up 7.4 per cent of all cars in our survey, but only 4.9 per cent of the total metropolitan vehicle population, Ford vehicles 13.9 and 18.1 per cent respectively, and Holdens 38.5 and 39.6 per cent respectively. Thus Holdens appear in accidents about as often as would be expected from their frequency in the vehicle population, while Volkswagens are over-represented and Fords are under-represented. These differences are highly significant statistically, but they do not imply by themselves that Volkswagens are intrinsically more dangerous and Fords intrinsically safer than Holdens. It may be that one particular type of driver, e.g. a young driver, favours the Volkswagen, so that its accident involvement may be more a reflection of the type of driver than of the characteristics of the car.

1.113 It follows from the high proportion of Holdens in our vehicle population, and their appearance in accidents to a corresponding proportion, that even slight improvements in the design of the Holden (such as the new door latches fitted to the 1965 HD model) will eventually (as the improved vehicles replace the old) have an important effect on the injuries received by road users in about a third of all the cars that are involved in accidents. Similarly, improvements in the design of Volkswagens, such as improved door latches or steering column, would be potentially much more effective than the percentage of Volkswagens on our roads would indicate.

1.114 Most of the cars in this survey were manufactured in the years 1960 and 1962. There was a marked scarcity of vehicles manufactured in 1961. This was a time of temporary economic recession in Australia, which may have affected the number of new cars registered in that year. Total vehicles on the register in 1961 were greater than in 1960, but there may have been many more older cars retained in use in 1961 than in 1960.

1.115 Over one-third (148 of 408) of the accidents covered by our survey were primarily collisions between two cars, and to facilitate the description of these collisions we have developed a simple numerical code. We also refer to the particular car we are considering as the 'case car'. The *alignment* of the other car to the case car is described by allocating it to one of twelve positions which are set at 30° intervals to the long axis of the case car, proceeding clockwise from the front around the car as seen from above. The *point of impact* is similarly described by one of twelve positions clockwise around the car (see para. 9.12 for details). Any impact with a second car can now be described by two sets of figures, one indicating the alignment of the other vehicle and the other the point of impact on the case car. It should be noted that these two sets of figures do not necessarily give the point of impact on the other car, nor do they necessarily give the direction of the impact.

1.116 This notation, which allows for 12 possible angles between the cars and for 12 possible points of impact on the case car, gives 144 possible combinations. Some of these are unlikely (such as two cars reversing into each other), while others are common. Therefore when we allocated each of the 296 cars in these 148 accidents to one or other of these 144 categories, only 56 categories were required, and of these only 20 categories contained five or more cases. In fact these 20 categories contained 225 of the total 296 individual cases. The most frequent point of impact is the centre front of the case car, and the least frequent is its left rear corner. The other vehicle is most likely to be aligned at right angles to the case car, either on the left or the right. In other words, right-angled end-to-side collisions against the passenger compartment are most frequent in Adelaide. Most of these are intersection accidents, and possibly reflect the influence of our rectangular grid of streets.

1.117 The sides of the passenger compartment probably deform more easily than any other part of the structure of a car, and our findings therefore suggest that they deserve close attention by designers so that they may be made as strong as possible. The interior sides of the passenger compartment, generally the doors, could easily be made safer on many cars. The arm rest in particular often produces injuries to the occupant who is thrown against it.

1.118 Our traffic engineers also should note the frequency of right-angled end-to-side collisions, for in many locations it is possible to control the angles at which vehicles approach each other, for example by suitably designed traffic islands. However, careful and detailed analysis of the effects of impact geometry on overall vehicle damage and on average severity of injury did not show any significant effects, for the uncontrolled variables such as vehicle weights and speeds, and age, sex and seated position, were such that the variation within categories was greater than that between categories. More data are therefore needed to answer this important question.

1.119 We found, as might have been expected, that the likelihood of a subsequent collision was greatest in rear impacts (at an angle), much less for right-angled impacts on the sides and very small for frontal impacts. Subsequent rollover is rare in both frontal and rear impacts, but occurs in almost one-third of side impacts.

1.120 Injuries to car occupants are almost always caused by striking some part of the interior of the car. As far as we could, we related each injury to the structure which causes it. We also noted the damage to the interior of the car, and tried to determine if this was caused by the deformation of the vehicle body on impact or by an occupant being thrown against it. Four components deserve special mention: these are the steering wheel, the instrument panel, the rear vision mirror and the front seat. Our sample comprised 390 cars of the total of 553 cars (excluding 20 cars which were parked and unoccupied and 143 which struck pedestrians, pedal cyclists or motor cyclists).

Steering wheel

1.121 One hundred and twelve of the 390 cars (28.7 per cent) had the steering wheel damaged by an occupant, usually but not always the driver. In 62 cases the wheel was only slightly damaged, but it was severely damaged in 50 cases. Sometimes the spokes failed, allowing the occupant to strike the more solid hub. This impact is reduced in severity by a 'dished' design. Three spokes seem more effective in this regard than two-spoked designs, and it is to be regretted that some late model cars have changed to two-spoked wheels.

1.122 It is probable that the wheel of a Volkswagen is more likely to be damaged by an occupant being thrown against it than is the case with any of the models of the Holden, but the damage to the wheel is not often severe. Severe injuries were only occasionally produced by the wheel, and then only when the occupant struck the hub.

1.123 A significant hazard is produced if the steering column is pushed back into the passenger compartment, usually by an impact on the front of the car. This is particularly dangerous in the Volkswagen; in one of our cases the steering column of a Volkswagen was forced back almost 10 in. into the compartment, which was not otherwise significantly encroached on and was therefore 'survivable', with the result that the driver fractured his neck with transection of the spinal cord. The attention of the makers should be drawn to the possibility of significant improvement in this design feature.

Instrument panel

1.124 One hundred and thirty-six of these 390 cars (35 per cent) had instrument panels damaged by occupant contact. In 100 of these the damage was minor, but in 36 it was severe. Considering only Holdens and Volkswagens (the two models which occurred most frequently in our survey), there were 44 cases of minor damage and 17 of severe damage. The former caused mostly superficial injuries, but there was one case of bilateral fractures of the patellae, and one of bilateral fractures of the lower legs on a home-made parcel shelf below the panel. In the 17 cases with severe damage to the panel there were two cases with no injuries, 13 superficial injuries, two fractures of the midshaft of the femur and one of dislocation of the hip.

1.125 Minor injuries could be minimized, and more serious injuries reduced in severity, if the instrument panel were designed to present a smooth projection-free surface to the occupants, and to deform readily when struck. In some models 'crash padding' has been installed on the panel, but in many cases we found that it is not located where the occupants most frequently hit the panel, and in others it consists of only a thin layer of sponge rubber, which can absorb a negligible amount of the force of the impact of the occupant with the panel. Much more attention should be given by designers to making panels more 'crash worthy'.

Rear vision mirror

1.126 In 50 cases (12.8 per cent) an occupant hit the rear vision mirror, in 9 cases without damage to the mirror. In the other 41 cases the damage to the mirror varied from a bent standard to shattered glass, with or without a fractured standard which left a jagged end exposed. An occupant is more likely to hit the mirror in a Volkswagen than in a Holden, for he is closer to it. The injuries produced are mostly concussions and lacerations around the eyes and forehead. Design attention should be given to making mirrors safer, particularly to ensure that the glass when broken does not expose sharp edges and that the inertia of the whole assembly is low.

Front seats

1.127 In 25 cases (6.4 per cent) these were directly damaged in the collision, but in 66 cases (16.9 per cent) they were damaged by inertia forces of the seat itself and/or the occupants. In the latter class, failure of the seat mountings was much more frequent in the separate 'bucket' seats of the Volkswagen than in the bench seat of the Holden. Failure of the seat mountings will tend to force the occupants forward against the instrument panel. With a bench seat the occupant may become jammed, and the mass of the seat added to that of the occupant may aggravate his injuries.

Glass

1.128 Annealed plate glass is found only in older types of cars, and is therefore infrequent. Its lacerative potential is obvious. Laminated glass fractures in a similar manner to untreated plate glass, leaving jagged edges which will produce severe lacerations if the screen is penetrated by the occupant. Tempered glass is stronger than laminated glass, and there is a greater risk of concussion if the occupant strikes it. However, the risk of serious laceration is greatly reduced, except from jagged edges which remain in the frame when the screen is broken. Therefore the method of mounting a tempered glass screen determines its lacerative potential.

1.129 We attended one accident at night in which a car fitted with a tinted windshield drove into the back of another car which was stationary waiting to turn right. Had the driver been able to see a little more clearly his accident might not have occurred. The practice of tinting windshields is an undesirable method of reducing day-time glare, because the filter cannot be removed at night, as sunglasses can be.

Seat belts and mounting points

1.130 It is important that seat belt mounting points should be an integral part of the basic body frame of the car. We attended one accident in which the load on the belt caused the welds at the top of the centre post to fail, allowing the post, mounting point and belt to come forward. It is therefore necessary that the manufacturer should make the mounting points sufficiently strong.

1.131 We regret the reluctance of most Australian manufacturers to fit seat belts as original equipment in all cars. Legislation to this end was passed by a former government of this state, but has not been proclaimed. Proclamation of this bill would be the most effective single action that the government could take to reduce the frequency and severity of injuries and fatalities in road traffic accidents. There is evidence from Wisconsin, U.S.A., that because legislation ensures that many more cars have belts in them, twice as many people will be wearing belts than would be the case without legislation.

Door locks

1.132 8.6 per cent of all car doors (including cars which struck pedestrians) in this survey came open in the accident. There is now abundant evidence that ejection greatly increases the risk of serious to fatal injury (see para. 11.56). Over the years, therefore, improvements have been made to door locks to prevent their coming open. The earliest of these was some form of longitudinal restraint to prevent the two halves of the lock separating from each other. We found that 5.5 per cent of locks with longitudinal restraint came open in the accident, whereas 11.1 per cent of those without longitudinal restraint came open. For Holden cars, which are by far the most frequent make on our roads, the lock failed in 8.9 per cent of doors without longitudinal restraint in their locks and in 4.8 per cent of doors with improved locks. This result is in close agreement with a similar analysis based on General Motors cars in the U.S.A. For the Volkswagen 1200 sedan, which has only two doors, 11.0 per cent of doors came open in the accident.

1.133 We emphasize the extreme importance of this feature of the detail design of the passenger car, for an effective doorlock is a safety feature which is built into the car and is operating all the time. It is not dependent for its efficiency on the common sense and continued co-operation of the occupant, as is the case with the seat belt. If the doorlocks of all new cars can be improved to the point where it is no longer the lock but the door itself which fails, many lives will be saved and much suffering avoided.

Roadworthiness

1.134 Generally in this report we are more concerned with the 'crashworthiness' of vehicles than with their roadworthiness, for estimation of the latter is complicated by the often extensive collision damage. Also we lacked the authority and the time to conduct detailed 'autopsies' on the vehicles involved. We encountered only two cases — both single vehicle accidents — in which deficient roadworthiness was of more than minor causal importance, and it is therefore possible that a programme of compulsory inspection of vehicles might do little to reduce metropolitan traffic accidents. More information, derived from a detailed inspection of a properly chosen sample of some hundreds of vehicles involved in accidents, is required before an authoritative statement could be made on the likely benefits that would accrue from such a programme, and at what cost.

Cost of repair

1.135 In the second year of this survey we tried to find out the actual cost of repair for each vehicle, and we present the cost of repair for 86 passenger cars. This sample was small, and was in no way properly representative, but some useful findings emerged. Thus there was a wide range of repair costs for the same degree of damage; for moderate damage the cost of repair varied between limits of £15 and £450, mainly as a result of similar variations in the market value of the vehicles concerned. We tried to minimize the effect of variations of this kind by dividing the cost of repair by the current market value of the vehicle, with some allowance for the general condition of each vehicle. For minor damage the value of this index averaged 0.05; for moderate damage it averaged 0.24; for severe damage 0.62 and for very severe damage it was 1.00 (i.e. a complete 'write off').

TABLE 1.1

INDICES OF REPAIR VERSUS MEDIAN VALVES OF OVERALL DAMAGE INDEX

Overall Damage Index		(Cost of Repair/Market Value) x 20
Scale	Median values	
Minor	1.5	1.0
Moderate	5.0	4.8
Severe	11.0	12.4
Extremely severe	22.5	20.0

1.136 These indices of repair are approximately in the ratios 1:5:12:20 from minor through to extremely severe, and we were gratified to find that they are in good agreement with the median values for each range of our overall damage index (see para. 3.47), as TABLE 1.1 shows. We thus obtained another indication that our simple vehicle damage scale was realistic and useful.

Time taken to complete repairs

1.137 This is subject to extraneous circumstances far more than is the cost. We obtained a few figures on this aspect for a total of 41 cars. Minor damage averaged 2 days to repair, moderate damage averaged more than 2 weeks, severe damage 3½ weeks and extremely severe damage (one case) required more than two months.

Car accidents: environment

1.138 We estimated as accurately as we could the travelling speeds (before evasive action) and the impact speeds of all vehicles involved in our accidents; and also the speeds of vehicles which rolled over without impact, and of motor-cycles at the moment when the rider fell. Although the ranges of speeds were considerable the means were quite low: a travelling speed of 27.0 m.p.h. and 20.5 m.p.h. at impact. However, the mean speeds for the 17 fatal accidents were higher: 36 m.p.h. and 31 m.p.h. Thus — if our estimates are accurate — most accidents occur at speeds well within the official speed limit of 35 m.p.h. Although the estimation of the speed of a vehicle after the event is most difficult, and the statements of drivers and witnesses are unreliable, other clues are useful, particularly skid marks due to braking. Our final estimates of speeds were generally much higher than those of the drivers concerned, but even so our mean values are low when compared to the speeds of traffic streams on many metropolitan roads, and we conclude that even slow speeds can still be dangerous in a metropolitan area — particularly at intersections.

1.139 We therefore made a special study of critical speeds* at intersections, by returning to 34 intersections at which we had attended accidents. With a radar speedmeter we recorded the approach and crossing speeds for 451 vehicles. We also measured the relevant sight distances, and were able to establish a minimum stopping distance from a given speed on the particular surface. We then calculated the critical speeds at these intersections.

1.140 Details of the calculation are given in para. 10.10 to 10.20. The results were surprising and disturbing, for in no case was the critical speed greater than 37 m.p.h., and in one case it was less than 11 m.p.h. The actual speeds of the 451 vehicles we observed varied between 50 and 0 m.p.h., and of them 363 (81 per cent) were exceeding the critical speed. Thus only 19 per cent of these drivers could hope to avoid all vehicles approaching from the right at these intersections. It is very easy in Adelaide to drive dangerously fast without exceeding the official limit of 35 m.p.h.

1.141 This study also suggested that the 'give way to the vehicle on the right' rule may be unsatisfactory in this city, for at the speeds at which vehicles are actually driven only one driver in seven could hope to obey the rule in every case. This important matter needs much further impartial and careful study, for perhaps a major and minor road system of determining right of way might be more in line with present driver behaviour. As a starting point, many more observations should be made at a larger and carefully representative sample of intersections.

1.142 We also made a special study of accidents at one particular signalized intersection (Gepps Cross), because we attended more accidents there (6) than at any other place. In fact a total of 433 accidents were reported from this intersection during the 4-year period 1961-64, and the property damage from the 143 accidents in 1964 alone has been estimated

*The maximum approach speed which will at any point enable the driver to avoid a collision, either by continuing on with undiminished speed or by stopping, is taken to be the meaning of the term 'critical speed'. The present application considers only the possibility of a collision with a vehicle approaching the intersection at a steady speed from the right of the case vehicle. It is also restricted to two roads which intersect at right angles.

This same assumption applies wherever the term 'critical speed' is used in this report.

at £A15,000. We found that the phasing of the lights allowed a conflict of two traffic streams, each of which had a green light, and the alignment of their paths is such that there is often a third car which obscures the other two cars from each other. Over these four years this particular feature of the phasing of the lights accounted for one quarter of the 433 accidents — 110 in all — but these included half of the personal injury accidents and half the total property damage. It is indeed unfortunate that this state of affairs was allowed to persist for so long.

1.143 Considerable emphasis is often placed on the relationship between skidding and accidents, especially skidding due to braking. It is well known that the effective braking force is less when the wheel is locked and sliding than when it is braked just short of locking. Although brakes which automatically achieve this latter end are standard on large commercial aircraft they are not found on cars, and few drivers are capable of the necessary degree of control to brake in this way during a 'panic stop'. Most will brake so hard that they will skid. We found that of the 623 vehicles for which this information was recorded 180 skidded when braking. All were on bitumen roads.

1.144 We therefore made a special study of skidding on this type of surface, recognizing that the term 'bitumen surface' includes surfaces varying from the machine-made 'hot mix' to the poorly maintained macadam-based surface found in many suburban side streets. We found by performing locked-wheel skids in our own vehicle at accident scenes that there can be great variations in the skid resistance of a clean dry bitumen surface. Our tests gave stopping distances, from 30 m.p.h., varying from 11 to 22 yd. A stopping distance of 22 yd from 30 m.p.h. on clean dry bitumen (at 80 F) is most surprising. The poor skid resistance of the particular surface on which this latter stopping distance was found is apparently due to the large aggregate being coated with bitumen which is melted by the heat generated by the tyre sliding over it. The resulting skid mark is a molten tar mark and not an abraded rubber mark, and the vehicle in fact slides on molten tar. We understand this surface is a base course for the final layer of hot mix, and because there is often a delay of some months before the final layer is applied, we suggest that signs should be displayed to warn motorists of the slippery surface.

1.145 The white paint used for road markings has a much lower skid resistance than that of a bitumen road surface, and it can initiate a skid in much the same way as a patch of oil may do so. The skid may then continue on the bitumen surface. Similarly, the skid resistance of a dry road surface will be reduced if it is covered with a layer of loose material. Although only 16 of our 623 vehicles were on such a surface, ten of them skidded on the loose material. Some of these cases could have been avoided if the regular road maintenance had included removing the loose material with a street sweeping machine.

1.146 Exactly one eighth of our accidents occurred on wet roads. Seventy-five vehicles were travelling on wet roads at the time of their accidents, but only 10 of these were recorded as having skidded. In 16 cases we were unable to determine whether skidding had occurred. Considering only verified cases, we found just as many instances of skidding on loose material as on wet roads. It must be remembered that the Adelaide rainfall is only some 21 in. annually, mostly in short sharp falls.

1.147 Temperature effects on skidding are not critical in Adelaide. Ice formation on the road surface is unknown, and indeed the softening of road tars in midsummer may be more of a problem. However, we did not investigate accidents during the hottest months.

1.148 The condition of the tyres of the vehicle is often considered to be related to the risk of skidding, and we therefore carefully examined tyres of vehicles involved in our accidents, classifying them into two classes, either 'good' or 'worn'. We regarded a tyre as good if it had a well-defined tread pattern with the tread at least 1/10 in. deep, and if even one tyre could not be classed as good we placed that vehicle in the 'worn' class. More vehicles with good tyres (94) skidded than did those with worn tyres (67), even on wet roads, though on wet roads the numbers were very small (7 and 3). However, we do not know how many of the vehicles were braking, nor can we assume that other conditions such as the skid resistance of the surfaces on which the accidents occurred were similar. Indeed, we have already shown that the skid resistance of even dry clean bitumen can vary by as much as 100 per cent. For vehicles which did not skid, there were almost equal numbers with good tyres as with worn tyres. We found no evidence therefore that worn tyres played a major role in the causation of our metropolitan accidents.

1.149 Skid marks on the road convey much more information than merely to indicate that the vehicle has skidded. Assuming that the coefficient of friction between a skidding tyre and a uniform road surface is independent of both the weight and speed of the vehicle, it was possible, by relating the length of the test skids in our own vehicle to those of vehicles involved in accidents, to calculate the speed lost by that vehicle in the skid. This was particularly valuable in pedestrian accidents where little energy is lost by the vehicle in the actual collision. Skidding in collisions between vehicles usually permitted only an estimate of the difference between travelling and impact speeds.

1.150 Skid marks often define very clearly the position of the wheels on impact, and under certain conditions the angle of deflection of the marks may help determine the momentum of each vehicle on impact. Skid marks also often clearly show the path of a car after the impact, and if the marks for the front and rear wheels are separate — as they are when the vehicle is sliding sideways or spinning — it is possible to determine the position of the car at any point along the skid marks, if the track and wheelbase of the car are known. In this way it is often possible to determine the exact behaviour of a car at the moment when an occupant was ejected.

1.151 Accidents at intersections are very common in Adelaide, where the rectangular layout is such that there are very many intersections between wide straight roads. Thus for car-to-car collisions 70.5 per cent occurred at intersections, 5.5 per cent within the 20 yd. after an intersection, 2.2 per cent within the 20 yd. before an intersection and 21.8 per cent not at intersections. 17 car accidents occurred at intersections controlled by stop signs, and 25 at traffic lights, i.e. 42 of the total of 129 accidents at intersections. Three cases occurring at stop signs were of no special significance, for they involved stationary vehicles which were struck by other cars which had been involved in previous collisions. However, nine vehicles that had stopped, as required, at a stop sign were struck by vehicles approaching on the intersecting road — five from the right and four from the left. In this kind of collision a third vehicle may create a 'blind spot' for the driver moving off from the stop sign, and sometimes drivers seem not to appreciate that if they move off suddenly an approaching car may not be able to stop in time.

1.152 In 11 accidents of these 25 we are certain that one vehicle did not stop at the stop sign, and one of these resulted in the death of a passenger in the offending car. In two more cases we suspect but cannot be sure that the driver did not obey the sign.

1.153 In some instances stop signs and other warning signs are difficult to see, either because they are obscured by foliage, or by poles and the like which have been placed in front of them by some other public agency. We also found some unnecessary signs.

1.154 Thirty-seven of the total 408 accidents were at traffic lights. There were two main groups: in one group (16 cases) both vehicles were proceeding straight across the intersection, and in the other (15 cases) one vehicle was turning right. Other kinds of accident were few. The commonest feature of the first group was a collision during or at the end of the amber phase of the lights. An all-red phase seems to be the only way to minimize this type of happening, and a judgement would have to be made in some way between the benefit resulting from a diminution in accidents and the cost of a diminution in traffic flow; or to put it crudely, how many accidents are tolerable for a given vehicle flow?

1.155 There were two cases in which a driver mistook a green 'turn left' arrow for the green light for 'straight ahead', but only one case of the afternoon sun shining directly into the traffic lights making it difficult to decide which light was illuminated.

1.156 In the second group a vehicle turned right across the path of another vehicle approaching from the other direction. This is the typical motor-cycle accident, and five of these 15 accidents involved a motor-cycle. In some cases the layout of the intersection and/or the mode of operation of the lights seemed to be confusing. We mention some specific instances.

Car accidents: occupants

1.157 There were 1,029 car occupants seated in the 542 cars involved in our survey, i.e. 1.9 persons per car. There were 228 occupants of cars which collided with pedestrians, pedal cycles and motor-cycles, and of these 221 were not injured at all, one of the remainder[1] received severe injuries, and none was killed. Of the 801 occupants of cars which collided with cars, trucks, fixed objects or rolled over, 63 per cent were injured (minor 42 per cent, moderate 16 per cent, severe 4 per cent, very severe and fatal 1 per cent). There were only two deaths in car occupants: one was a 13-year-old boy who was thrown against a tree from the tray of a truck when it rolled over on a bend, and the other was a 27-year-old woman occupying the left front seat of a Morris Minor which was struck on its left front door by a large car.

1.158 Regional injuries were: head and neck 70 per cent, thorax 19 per cent, abdomen 4 per cent, spine and pelvis 2 per cent, upper limb 31 per cent and lower limb 52 per cent. Most of the limb injuries were minor, as were about two thirds of the head injuries. However, 26 per cent of head injuries were of moderate to fatal degree, as were 6 per cent of thoracic injuries, 1 per cent of abdominal injuries, 2 per cent of injuries to the spine and pelvis, 4 per cent of upper limb injuries and 3 per cent of lower limb injuries, so that head injuries made up almost half of the injuries that warranted admission to hospital or caused death.

1.159 75 per cent of those with head injuries had soft tissue injuries of the face, and 5 per cent had fractures of the face. About half (120/265) of the soft tissue facial injuries were lacerations, and many of these victims were women, to whom the cosmetic effects are especially important. 34 per cent were concussed, and 19 percent had lacerations of the scalp. There were two skull fractures (0.06 per cent).

1.160 Certain structures inside the car cause characteristic lacerations: thus sunvisor hinges cause a 'U' shaped laceration of the scalp at or above the hairline, and the rear vision mirror, which is usually struck by the forehead, nose and upper cheek, produces a series of small lacerations as the glass shatters. When a car occupant strikes a tempered glass windscreen with force sufficient to break it, he usually receives small shallow lacerations. If his head then travels downwards he receives lacerations to the lower surface of the chin. On the other hand, impact with a laminated glass windscreen produces severe lacerations when the glass is penetrated by the head. In all, there were 48 cases when the occupant's head struck the windscreen (43 tempered, 5 laminated).

1.161 There were 15 neck injuries. Of these eight were soft tissue strains, five of which were due to impacts from the rear of the car. There were two injuries of the spine. In one of these (previously described) a 35-year old man driving a Volkswagen struck another car head on, the steering column was driven up in front of him almost 10 in., and he suffered a fracture-dislocation of the cervical spine with transection of the spinal cord and consequent permanent quadriplegia, when his head struck the header area.

1.162 The commonest thoracic injuries were superficial abrasions and bruises (67 per cent). 41 per cent of injuries to the thorax were skeletal injuries, of which more than half were fractures of the ribs, and in five of these 25 cases there was evidence of damage to the underlying lung.

1.163 There were three internal abdominal injuries and two of these victims died. One had lacerations of the spleen and left kidney, and the other a laceration of the left kidney and avulsion of the left renal artery from the aorta. In the third case there was contusion of the left kidney. There were six cases with fractures of the pelvis and two of fractures of lumbar transverse processes.

1.164 In the upper limb superficial injuries predominated, but there were 15 fractures. Only one of these resulted from a blow (from the tray of a truck) on the protruding elbow of a driver. Superficial injuries also predominated in the lower limb, usually abrasions and bruises from striking the lower edge of the instrument panel or the edge of the parcel shelf. However there were 13 fractures in 11 persons (hip 1, femur 3, patella 4, tibia 3, foot 2).

1.165 Proceeding to analyse the cause of injury to car occupants, we found that for **all** injuries the instrument panel caused most injuries, followed in order of frequency by the door and frame, the windscreen and frame, the header area, the steering wheel and column, ejection, and the front seat. However, if only injuries of moderate or greater severity are considered, the order of causation changes markedly, for the door was easily the most important cause of moderate or greater injury (51 injuries), followed by the windscreen (24 injuries), the instrument panel (18 injuries), the header area (17 injuries), ejection (16 injuries), and the steering column (11 injuries).

1.166 The direction of impact has a considerable bearing on what areas of the car interior cause injury to each part of the body, and the seated position of the occupant also influences injury production. Thus in front impacts passengers are injured more often than drivers, in impacts on the right side drivers are injured more often than passengers, and in impacts on the left side front seat passengers are injured more often than drivers. The occupant's body in fact strikes those parts of the interior of the car which lie closest to it in the direction of the impact. In frontal impacts the heads of both driver and front seat passenger strike the header area, but the driver also strikes the steering wheel and therefore does not strike the windscreen as often as the front seat passenger. The driver's chest strikes the steering wheel, the passenger's chest strikes the instrument panel. The legs of both strike the instrument panel.

1.167 In impacts from the right side the driver is injured in all body areas by the door, but the front seat passenger strikes the header area and the instrument panel with his head and thorax, and the steering wheel with his upper limbs, while his lower limbs also strike the instrument panel.

1.168 In impacts from the left side the front seat passenger is injured in all body areas by the door, and ejection becomes a cause of injury for the head and both upper and lower limbs. Drivers are thrown to the left and forwards, usually clear of the steering wheel, to strike their heads on the left side of the windscreen and the header area. They may also strike the left door. The instrument panel is still the main cause of injury to the lower limbs.

1.169 Rear seat passengers in frontal impacts strike their knees on the front seat, and possibly their heads on the top of the back of the front seat. In side impacts they strike the doors rather as do front seat occupants.

1.170 The degree of injury also varies according to seated position. Thus front seat passengers are injured significantly more often than drivers, and rear seat passengers less often than either of the other two classes. Because almost two thirds of front seat passengers are women, and the commonest injuries are to the head and legs, women are exposed to the risk of injury more than men are, and the injuries they receive may well be more serious, both abolutely and also cosmetically.

1.171 There is, as expected, a significant correlation between injury severity and vehicle damage. The regression lines have the same slope, but the line for front seat passengers is above that for drivers, which in turn is above that for rear seat passengers.

Ejection

1.172 Thirty-five of the 1,029 car occupants in all the accidents in our series were ejected (3.4 per cent). The proportion of moderate and worse injuries was significantly greater in those ejected (16 of 34 cases) than in those not ejected (155 of 987 cases). Only one of the 34 persons ejected was not injured at all, while almost half had moderate or worse injuries. (In one person ejected the degree of injury was not recorded.) Those ejected received severe to fatal injuries more than four times as often as those not ejected.

1.173 In our series ejection was associated with spinning of the car rather than with

1.189 It is likely that the severity of injuries received by pedestrians could be reduced by appropriate redesign of the frontal shapes of cars. We believe that vehicle designers should bear the pedestrian in mind, as well as the car occupant, when considering the safety features of their vehicles.

PEDAL CYCLISTS

1.190 Educational programmes directed at car drivers should include the advice to be especially watchful for pedal cyclists between 4 p.m. and 6 p.m., when half the cyclists' accidents occur, and to be aware that a youthful rider may make a sudden 'U' turn in front of the car.

1.191 Similarly, pedal cyclists should be warned of the danger of sudden 'U' turns, and they should also be warned that drivers are likely not to notice them at intersections.

1.192 Because one third of pedal cycle accidents occur at night, and often involve cyclists riding steadily along at the side of the road, cycles should carry lights which are larger and brighter than those commonly used at present.

1.193 Head injuries are common in pedal cyclists struck by cars, and there is a case for urging them to wear protective helmets of suitable design.

1.194 Pedal cyclists are very vulnerable to serious injury, and many of them are children in whom such injuries are particularly distressing. We believe that there is a case for a serious study of the practicability of removing pedal cyclists from the roadway altogether, on to the footpath if special cycle tracks are not possible. Pedestrians might suffer some inconvenience if this were done, but young lives would be saved.

MOTOR-CYCLISTS

1.195 Because almost two thirds of motor-cycle accidents occur at intersections, educational programmes directed at motor cyclists should warn them to take special care at such places, and should indicate that many motor-cycle accidents involve collisions with cars that are changing direction.

1.196 Programmes aimed at drivers should emphasise the risk to motor cyclists when car drivers pull out from the kerb or start a 'U' turn. Unless the driver looks carefully to his rear before attempting these manoeuvres he may not notice an approaching motor cyclist. In one half of all collisions between a motor cycle and a car, the car was turning right. Drivers need to ensure that the road is clear of motor cycles, as well as other large vehicles, before turning right.

Helmets

1.197 In most of the head impacts suffered by motor cyclists in this survey, greater forces were developed on the head than the present helmets are designed to withstand. Moreover only a minority of impacts occur on the crown of the helmet where there is protective padding, and most impacts are on the lower sides where there is no padding. The efficiency of the helmet at present specified by Standard E33-1959 — and required by law to be worn by all motor cyclists in Victoria — is not as great as it could be. Official consideration should be given to requiring that all helmets sold for use by motor cyclists meet British Standard B.S. 1869:1960 — Protective Helmets for Racing Motor Cyclists —

which specifies an enveloping helmet covering the forehead, ears and occiput, a strong webbing suspension and a complete lining with energy-absorbing material.

TRUCKS

Doorlatches

1.198 Truck occupants may be ejected through the doors, and their injuries thereby aggravated. Trucks should therefore be fitted with doorlatches designed to prevent unlatching in an accident, just as for cars.

Crash barriers

1.199 A study should be made of the benefits and costs that would result from requiring the installation of crash barriers of suitable design below the tray at the rear and at the sides of trucks.

CARS

Seat belts

1.200 Few car occupants in our survey wore belts, but the benefits of seat belts were confirmed. The case for requiring belts as original fittings of cars is strong.

Injury-producing structures in cars

1.201 Our findings, which we believe are important, on the injury-producing potential of the internal components of cars, are set out in para 11.26 to 11.38. We believe they should be carefully studied by vehicle manufacturers, for here is a body of facts which will be of undoubted value in designing for safety. We hope also that these findings will be studied by those authorities concerned with design standards of vehicles and vehicle components.

Windshield injuries

1.202 Further investigation of the injury-producing potential of laminated and tempered glass windshields appears to be worthwhile. This might be approached by a comparison of injury data from this series (in which tempered glass windshields greatly predominate) with matched examples from the Cornell data (which contains entirely laminated windshields).

Trailers

1.203 The strength and condition of safety chains, and their methods of attachment both to the trailer and to the towing vehicle, should be specified to prevent accidents caused by trailers breaking loose.

HIGHWAY ENGINEERING

Utility poles

1.204 A cost-benefit analysis of collisions with utility poles would be worthwhile, to determine whether these poles — at least in places where pedestrians are few — should be so constructed as to minimise the damage to a vehicle (and to its occupants) on striking the pole.

Speed at intersections

1.205 The relation between actual speed at intersections and a safe speed of approach (which we call the 'critical speed') is recommended for special study. An examination of 38 intersections showed that 84 per cent of drivers were exceeding this critical speed. If this speed is confirmed as being impractically low the validity of the 'give way to the right' rule is called in question. We estimate that a single team working with a radar speed meter could get very valuable information in two months.

1.206 Our methods for calculating these critical approach speeds at intersections differ from those commonly employed by traffic engineers. In addition to an 'on the spot' study of actual approach speeds at a carefully chosen, adequately large and representative sample of intersections, we suggest that there is a need for the re-examination of the general case — the whole question of how to calculate a 'safe approach speed' for an intersection. This should obviously be incorporated into the 'on the spot' study.

Accident records at light-controlled intersections

1.207 Better methods are needed for checking the 'before and after' accident records at complex intersections at which lights have been installed. In one particular instance we found that a most unsatisfactory situation had been allowed to persist for some years.

Slippery bitumen surfaces

1.208 The poor skid resistance of certain base course bitumen surfaces should be recognized. If it is not practicable to cover the base course with the final course promptly, signs should be displayed to warn drivers of the slippery surface.

GENERAL

Collision theory

1.209 An analysis in greater depth should be made of the engineering data obtained in this survey, to bring the material into better order and to try to make some progress towards the understanding in quantitative terms of what happens in collisions between cars, and to advance the rather rudimentary existing 'collision theory'.

Alcohol

1.210 There is a need for accurate information about the customary distribution of alcohol levels in the driving population, and studies should be set up to obtain it — if possible in two capital cities to provide a cross-check. It cannot be doubted, from the data available from our police forces and our pathologists, that Australia has a drinking driver problem. What is not known accurately is the size of the problem, and it is important to obtain this information as a baseline for studying secular trends, and particularly the effects of changes in legislation against driving while under the influence of alcohol.

Continuing surveillance

1.211 A mobile unit concerned with the analysis of individual accidents or groups of accidents, and not concerned in any way with enforcement, should be a permanent feature of the highway scene in each capital city. Traffic accidents are a serious endemic disease which needs continuing surveillance. Such a unit — among other things — would help to study particular 'black spots' where accidents are frequent, so that remedial measures can be taken without delay.

Country accidents

1.212 There is still a serious gap in knowledge created by the lack of good information about rural accidents. Further thought should therefore be given to setting up a detailed study in the country.

SECTION 2 — INTRODUCTION

2.1 This report deals with research on traffic accidents and injuries conducted by the Traffic Accident Research Unit of the Department of Pathology of the University of Adelaide, South Australia. Its aim is to give a general picture of the field of work covered, and it is hoped that more detailed study of particular aspects of the large mass of data obtained may be undertaken later.

2.2 The object of our investigation was defined as follows: 'to gather data in Australian conditions basic to the design of roads, traffic organization and vehicles, by the objective study of the medical and engineering aspects of injury-producing accidents'. The criterion for an accident to be admitted to our study was that it was one to which an ambulance was called.

2.3 This was a broad directive, and we have done our best to preserve a proper balance between the medical and the engineering aspects. We include in the latter the detailed study of the performance of vehicles, the nature of the forces involved in collisions, and environmental features.

2.4 This Department first became interested in these problems in 1959, when it was arranged through the courtesy of the Adelaide City Coroner, Mr. T. E. Cleland, that all persons killed in traffic accidents in metropolitan Adelaide (population 600,000) would be submitted to a full post-mortem examination, and that these necropsies, which number rather more than 100 annually, would be conducted by the pathologists of this Department. In very large cities a necropsy rate approaching 100 per cent is, for various reasons, not often or usually achieved for victims of traffic accidents, but we have a virtually complete sample covering more than five years. Some of the results of our post-mortem work have already been published (Hodge, Ref. 1) and a further report is being prepared.

2.5 Each of these deaths is naturally a personal tragedy, but the necropsies in themselves become somewhat routine, and the injuries for different classes of participants tend to fall into rather distinct patterns. For example, head injuries are very common in all classes of victims, as are fractures of the lower limb in pedestrians struck by cars. Internal injuries are of greater variety, but they too have their patterns. Although the pathologist is often able to make an informed guess about the general mechanism of production of any particular injury he cannot be certain of it, and it is obvious that accurate and detailed knowledge is mandatory as a basis for any programme aimed at preventing or minimizing injuries.

2.6 In order to try to obtain more information about the circumstances of these fatal accidents, we arranged through the courtesy of the Commissioner of Police (Brigadier J. G. McKinna) and the head of his Traffic Division (Inspector J. A. Vogelsang, later succeeded by Inspector R. A. Wilson) to be given a copy of the police accident report form for each case. Although much useful information can be obtained from these forms, it is not possible to determine the exact cause of each particular injury accurately (the form of course is not designed for this purpose). It is easy however to determine from the police reports the day of the week and the time of day at which the accident causing the fatality occurred. There is a significant excess of deaths on Saturdays (TABLE 2.1 A)*. When we consider the time of

*** All Tables with numbers marked 'A' are printed in Appendix A to this Report.**

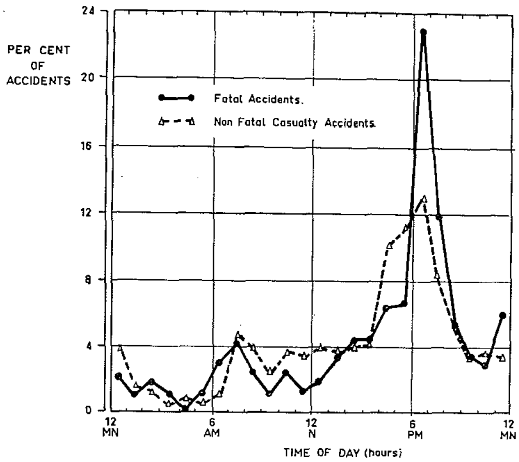


Fig. 2.1—Hourly distribution of accidents in Adelaide (1962)

day at which the accident occurred, we see from *Fig. 2.1* (compiled from 1962 figures) that the single hour between 6 p.m. and 7 p.m. contributes 23 per cent of the deaths but only 13 per cent of non-fatal casualty accidents. The time distribution of fatal accidents is in fact significantly different from that of non-fatal casualty accidents, and the reasons for this difference certainly merit further study.

2.7 Fatal accidents, though distressingly frequent, comprise only a small proportion of the total of injury-producing accidents. For this reason, and to gain information in much greater depth, a submission was made in April, 1962, by one of us (J.S.R.) to the Australian Road Research Board through its Human Factors Committee for an 'on-the-spot' study to be made in Adelaide, and the Board gave its approval in May, 1962. The staff (Dr. G. A. Ryan and Mr. A. J. McLean) were appointed late in 1962, and work on the roads began in January, 1963, and proceeded steadily until August, 1964, when 434 accidents had been investigated in detail.

2.8 An intensive and extended on-the-spot investigation of this kind had never been made in Australia before. We therefore encountered many difficulties in determining the details of how we would operate, and we made many mistakes both in planning and execution. We discuss these frankly in the appropriate places in our narrative, because we believe this will be helpful to others who may wish to set up similar studies elsewhere; and such studies will surely be needed.

2.9 The three major components of the transportation system — the roads, the vehicles and the people — interact with each other in a very complex way. At every accident we had to take notice of all three major components, together with their sub-components. Therefore, we used the well-tried epidemiological approach, which studies the interactions of the *agent* (the vehicle), the *host* (the human participant) and the *environment*. We did this not only because of our predominantly medical background, but because this method of study lends itself well to this work. Fundamentally the study of a large number of accidents is not so different from the study of infectious disease as is commonly supposed. Haddon et al. (Ref. 2) have recently re-emphasized this similarity. The environment includes the physical environment and also the social environment within which the whole system operates.

2.10 We made no systematic study of the social environment of our accidents, because we did not have a trained social worker attached to our unit. However, a later study similar to ours carried out in Brisbane had a social worker in the team, and most interesting and valuable information on the social background of their participants has been obtained (Jamieson and Tweddell — personal communication).

THE CHOICE OF ACCIDENTS FOR STUDY

3.1 Our fundamental aim was to ensure that as far as possible our sample was as fully representative of Adelaide metropolitan accidents as our resources would permit, so that useful and valid predictions could be made from the sample about the totality of Adelaide accidents. However, we failed to attain this object in some respects which will be made clear later in this chapter.

3.2 We have already explained that we used an 'ambulance definition' for admission to our study. We considered using a 'police definition', but we found on enquiry that the ambulance commonly reaches the scene before the police, and it was important that we should be on the spot as quickly as possible.

3.3 There is a single centralized radio-controlled ambulance service in Adelaide, conducted by the St. John Ambulance Brigade, Inc., and all calls are received at the central switchboard. At the start of a working period we notified the switchboard operator that the unit was on duty, and thereafter he called us by radio whenever a traffic accident was notified. Excellent and friendly co-operation by the switchboard operators, directed by Mr. C. Scolyer, ensured that nearly all such calls were relayed to us.

3.4 We also considered, initially, that the use of an ambulance definition might produce a considerable bias in our sample towards more spectacular and severe accidents, but this fear has not been borne out. In Adelaide it seems that when any participant in an accident is injured to even the slightest degree, and sometimes when nobody has been injured at all, the ambulance is summoned at once. That is, 'ambulance accidents' in our series include fatal accidents, injury-producing accidents, and some accidents involving property-damage only. It is likely that the readiness with which an ambulance is called will vary from city to city. Here we merely report our own experience.

3.5 Having decided to use an ambulance definition we turned our attention to the detailed planning of our sample to try to ensure the best possible cover of accidents both in space and time. We therefore obtained through the courtesy of Mr. H. G. Berry, at that time Transport Manager of the St. John Ambulance Brigade, their records of the 1,172 accidents reported to the Ambulance Brigade during the 6-month period between January and June, 1962. These accidents were plotted on a map of the city which we divided arbitrarily into five regions defined in relation to certain main roads. The number of accidents in each region were counted, and are tabulated in TABLES 3.1A and 3.2A, subdivided by areas, days of the week and times of day. An analysis of these figures showed that the regions did not differ significantly in their patterns of accidents according to the time of day, nor were there significant differences in these patterns between the warm weather period of January to March and the cooler months of April to June. The arbitrary regional boundaries therefore were of no significance and could be disregarded.

3.6 A possible source of bias must be recognized here, for the ambulance records did not show the type of vehicles concerned, so that it is possible that more trucks and heavy vehicles were involved in accidents in the industrial areas during the daytime.

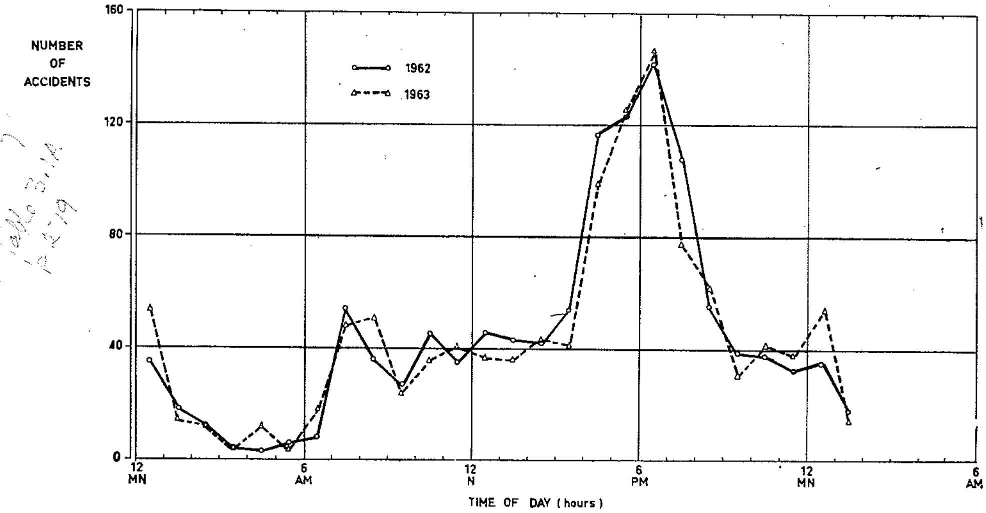


Fig. 3.1—Hourly distribution of accidents reported to the ambulance authorities (Adelaide)

3.7 When Adelaide metropolitan accidents, regardless of where they occurred, are plotted according to their time of occurrence, the interesting distribution shown in *Fig. 3.1* is obtained. This figure includes accidents occurring in 1962 and 1963, and shows that there is some stability in the distribution between the years. From a low point in the early hours of the morning a small peak occurs between 7 a.m. and 9 a.m. corresponding to the morning flow of vehicles. After this there is a small drop, followed by a very slow rise until 4 p.m. Thereafter a very large and steep rise occurs, reaching a peak between 6 p.m. and 7 p.m., after which there is a precipitous fall.

3.8 Various speculations may be made concerning the reasons for the very high evening peak compared with the modest morning peak. It may be supposed that the ebb tide of homeward-bound vehicles would not be very different in volume from the morning inflow. Traffic flow figures, obtained from the Department of Highways and Local Government, show however that the evening peak flow is rather higher than the morning peak, but that the latter is more prolonged. It is also likely that the effects of fatigue would make a significant contribution to the evening peak, but we are not aware of any measurements of this parameter having been made on a sample of drivers in Adelaide, although many studies of the effects of fatigue on driving performance have been reported from elsewhere (Crawford, Ref. 4, gives a short review). The effect of darkness must also be kept in mind, for during the winter months the evening peak is in darkness, but not the morning peak. However, it appears from a study of the quarterly figures of the distribution of accidents according to the time of day that the effect of darkness on the evening peak is relatively slight (see TABLE 3.3A). It was found that in 1961 the peak incidence occurred between 6 p.m. and 7 p.m. in the darker months, but between 5 p.m. and 6 p.m. in the lighter months; whereas in 1963 the evening peak is between 6 p.m. and 7 p.m. in all four quarters of the year. Even so, statistical analyses (χ^2) of the quarterly totals for 1963 show no significant differences in the patterns of distribution of accidents.

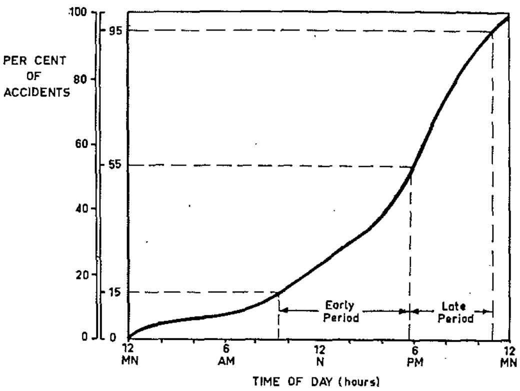


Fig. 3.2—Cumulative graph of accidents by time of day (Adelaide)

3.9 Again, the effects of drinking alcohol may be expected to contribute to the height of the evening peak, and it may be significant that hotels close in this city at 6 p.m. However, no valid data exist for Adelaide of the distribution of alcohol in the average driving population. It is true that we know that significant and often large amounts of alcohol are present in a substantial proportion of drivers, riders and pedestrians who are killed (Hodge, Ref. 1), and it is tempting to extrapolate this knowledge to the driving population at large. However, this is not permissible, for the time distribution of fatalities is not quite the same as that for non-fatal casualty accidents, nor can we assume that those killed are a representative sample of the road users at risk. Indeed it is to be hoped, and it is likely, that they are not. It is probable, however, that alcohol makes a contribution to the evening peak, but because we lack the power to sample for alcohol by testing the blood or breath of a randomly chosen group of drivers not involved in accidents, as well as of those who are involved, we cannot say how great this contribution is.

3.10 When the total accidents according to the time of day are plotted as a cumulative graph (*Fig. 3.2*) a sigmoid curve results, with the steepest slope at the time of maximum occurrence of accidents. We selected two periods, each including 40 per cent of the total daily expectation, as our working periods. The early period was from 10 a.m. to 5.45 p.m. and the late period was from 5.45 p.m. to 11 p.m. The period to be worked on any one day was decided at random by reference to a table of random numbers.

3.11 To allow for days off duty for recreation, and to permit the necessary large amount of office work to be done, days on duty were decided according to the following plan:

(a) alternate Saturdays were off duty,
(b) after a short initial period no Sunday accidents were studied,
(c) one weekday was off duty and this day was cycled through the weeks, i.e., Monday in the first week, Tuesday in the third week, etc.

3.12 A typical working cycle is shown in TABLE 3.4A and tables summarizing our total experience are set out in TABLE 3.5A, together with the numbers of accidents attended in each period. From this it can be seen that although there seems to be a deficient number of early periods on Thursday, this may be ascribed to chance, for the value of χ^2 is not significant.

3.13 It will be noted that we based our two working periods on the *total* expectations of the occurrence of accidents according to the time of day, summed up over a period of six months. Regrettably we did not study the hourly distribution of accidents for each day of the week separately. When we were very near the end of our work we made a further study of the ambulance statistics, and we realized, to our dismay, that there is a high incidence of accidents between midnight on Saturday and 2 a.m. on Sunday, and to a lesser extent between midnight on Friday and 2 a.m. on Saturday

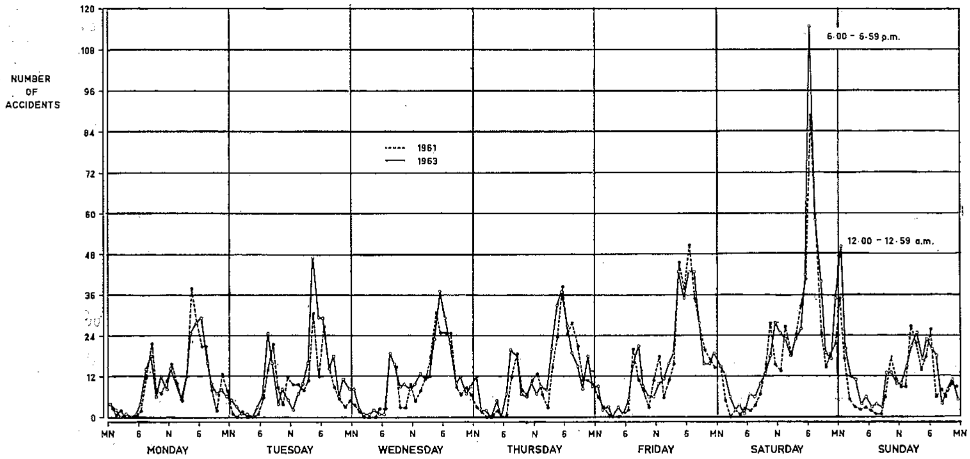


Fig. 3.3—Accidents by time of day by day of week (Adelaide)

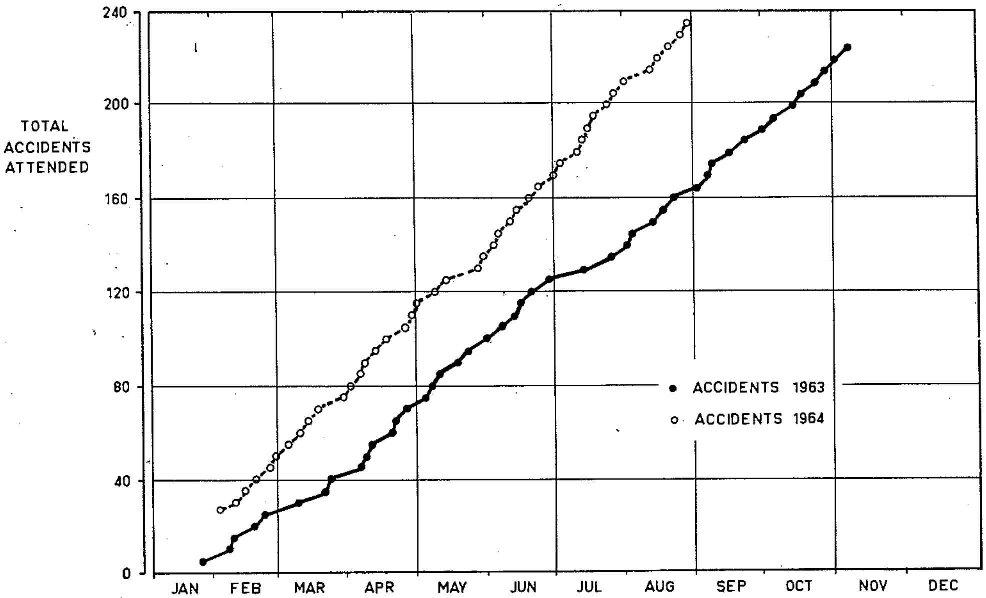
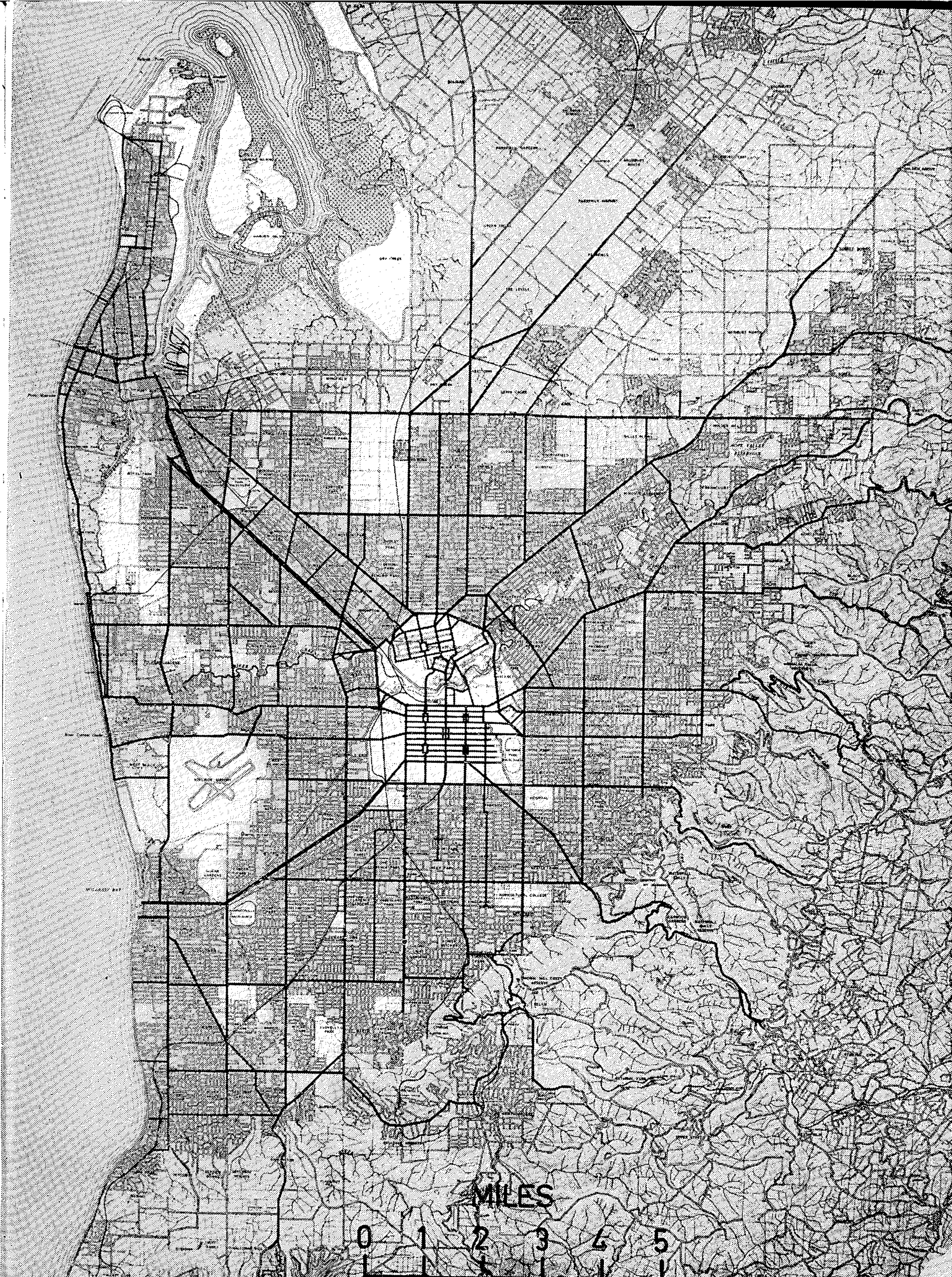


Fig. 3.4—Cumulative plot of attendance at accidents

(*Fig. 3.3*). We had covered none of these accidents. In retrospect, we should have been aware of this gap in our sample, for this Department performs many post-mortems at weekends on people killed during the previous night.

3.14 From the beginning we were reluctant to accept limitations to our plan, but they were made necessary because we had only a single team to cover both the work on the roads and the necessary office work. As it was, a great deal of night duty, often in cold and wet weather, was necessary, and meals had to be taken at odd hours. Furthermore, we had to face two years of

Fig. 3.5—Map of Adelaide showing 'busy' roads ⟶


MILES
0 1 2 3 4 5

work on this basis. Even so, in the light of the knowledge and experience we now have, it is clear that we could have devised a better sampling plan, and we urge others who may be contemplating a similar investigation to be extremely careful in their planning.

THE NUMBER OF ACCIDENTS ATTENDED

3.15 During the period March 4 to November 5, 1963, we attended 201 accidents. In this period 1,476 other accidents were attended by ambulances. Thus we attended 201 out of a total of 1,676 accidents, or 11.9 per cent. Between November 4, 1963, and February 2, 1964, we were off the roads and engaged on the task of writing our Second Interim Report. We resumed work on the roads on February 3, 1964, and between that date and August 30, 1964, we attended a further 207 accidents out of a total of 1,626 for the period; i.e., 12.7 per cent. The overall figure of our attendance therefore is 408 accidents in 3,302 or 12.3 per cent. This is within the range of 10 to 15 per cent which we estimated as possible in our original planning study, and in our opinion it represents a satisfactory proportion. A cumulative plot of our attendances is shown in *Fig. 3.4*.

THE CHOICE OF REGIONS TO STUDY

3.16 The topography of Adelaide (latitude 35° south) lends itself well to a study of this kind, for the city is relatively small (population 600,000) and lies on a flat compact coastal plain between the sea and the Adelaide Hills, which rise to the east quite steeply out of the plain to a height of just over 2,000 ft. The city centre was laid out at its foundation in 1836, and was designed to be surrounded by a belt of open parklands which have for the most part been preserved. Beyond the parklands the suburbs have spread over the years on the plain between the hills and the sea, and the flat terrain (almost all of it less than 250 ft above sea level and with no real hills in the city area) has permitted an essentially rectangular grid of streets to be developed. There are therefore very many intersections, and we have found that accidents at intersections predominate in our study, and that single-vehicle accidents have been relatively few. Similar studies in other Australian cities are likely to show some difference from ours, depending on (among other things) the relative number of hilly winding roads and intersections.

3.17 The only real barrier to direct travel from any part of the city of Adelaide to any other is the shallow and narrow River Torrens which winds in a generally westerly direction from the hills to the sea through the centre of the metropolitan area. It is crossed by bridges in several places. These features are shown in the map (*Fig. 3.5*) on which the busy roads are also indicated. An indication of the relative traffic volumes on these main roads can be gained from a map compiled by the Department of Highways and Local Government and shown in *Fig. 3.6*.

3.18 Despite the fact that our study covered only two years (1963 and 1964), traffic flow increased significantly during this period. Counts made at ten intersections in the metropolitan area showed an increase of about 10 per cent between early 1963 and late 1964. (TABLE 3.6A). Motor vehicle registrations in the metropolitan area in January, 1963, were 188,000 and by August, 1964, were 203,500, an increase of 8.3 per cent and 15,500 in total. This increase accounts, partly at least, for the greater rate at which we collected accidents in 1964 than in 1963. There were also more accidents per day in 1964 than in 1963.

Fig. 3.6—Relative traffic volumes in Adelaide →


ADELAIDE
METROPOLITAN ARE
TRAFFIC FLOWS
AS AT OCTOBER 1966

METHODS OF REGIONAL SAMPLING

3.19 We have used three different methods of regional sampling during our work. The modifications to our procedure have been introduced in the light of experience, but have not in themselves produced any systematic bias in our sample, other than that inherent in the original plan.

3.20 We decided that the first 25 accidents would be regarded as a trial sample, not to be included in the definitive sample. The unit thus worked between January 22 and March 3 mostly during the evening peak hours, when accidents are most common, to establish operating procedures.

3.21 We then decided, when we began our definitive sample (at accident No. 0026), that the unit would work either north of the river or south of the river, and either early or late, both the region and the working period being decided at random. Obviously four possible combinations resulted:

north — early
north — late
south — early
south — late

For the first 24 working periods (March 4 to April 5, 1963) we operated in this way. A large number of blank periods (with no accidents) were encountered.

3.22 We therefore gave further thought to the probability of an accident occurring in the region covered during the working period, for we knew, from the ambulance data, the distribution of the total accidents both in time and space. If accidents were random events in the continuum of space and time it might be presumed that they could be described by a Poisson distribution, provided that the expectation of occurrence remained constant. From this the probability of occurrence of at least one accident in the region and the period could be predicted with some confidence. However, the expectation does not remain constant but varies very markedly from hour to hour and less markedly from day to day. Therefore a modified Poisson distribution or a negative binomial distribution might be expected to fit the data better.* Even so, a simple Poisson distribution gave a quite good fit to the observed ambulance data. Because our object was merely to obtain an approximate estimation of the probability of at least one accident occurring, rather than to determine the best mathematical description of the distribution of ambulance accidents, we used the simple Poisson probabilities. These calculations are set out in TABLES 3.7A and 3.8A and they showed clearly enough that many working periods were very likely to be blank, so that some means of increasing the expectation of encountering an accident had to be sought.

3.23 It was found in the following arrangement: the unit stationed itself, at the start of the working period, at a central point near the river, and went to the first accident reported, whether it was north or south of the river. Thereafter for the rest of the period it remained in the region in which the first accident occurred. In this way the occurrence of the first accident reported was used as the random event which determined the region to be worked, and a significantly increased 'catch' resulted. The unit operated in this way from Saturday, April 6 to July 20, 1963.

3.24 Even so, the vagaries of chance continued to be brought home to us. For example, the first accident would direct the unit to the north, whereupon no more accidents would occur in the north, but several in the south which could easily have been reached. We came to realize, therefore,

* The problem of fitting theoretical distributions to observed data on accidents has been much studied. A useful general discussion is that of Fitzpatrick (Ref. 5).

that the city was small enough to be covered in its entirety.

3.25 We thus simplified our plan still further. We attended the first accident reported in the working period anywhere in the city, and thereafter went to the next accident reported, regardless again of its location. We were careful however to observe priority in accident reports. If two accidents were reported almost simultaneously we always went to the first one reported, even if we believed that the second was more spectacular and more severe. Again, while still working on one accident, another reported during our attendance at the first had to be disregarded. This introduced still another possible bias into our work, for during the slacker periods we could attend most of the accidents that occurred, but during the peak hours many accidents were missed. Our sample of peak-hour accidents is therefore proportionally smaller than of off-peak hours, but it was as unbiased as we could make it, and we consider that it was adequately representative. The record of our attendance between February 3 and August 28, 1964, tabulated by hour of day and day of week, is set out in TABLE 3.9A.

3.26 At this point we may conveniently summarize the sources of bias in our sample. They are:

(a) Apart from the short initial period, no Sunday accidents were attended. In Sunday accidents commercial vehicles are likely to be under-represented. There are fewer Sunday than weekday accidents, except between midnight and 2 a.m.

(b) We sampled only half the Saturdays.

(c) Accidents reported before 10 a.m. and after 11 p.m. were not attended, and we entirely missed the important weekend peaks late at night.

(d) We attended proportionally fewer peak-hour accidents than those in off-peak hours, especially at weekends.

Fig. 3.7— The vehicle, with A. J. McLean photographing skid marks

THE VEHICLE AND ITS EQUIPMENT

3.27 A standard Ford Falcon Station Wagon was used. It was fitted with a roof platform equipped with an extendable ladder to provide a high vantage point for photography (*Fig. 3.7*). The vehicle had a two-way voice radio tuned to the ambulance frequency (call-sign 'Car 99') and a flashing amber light to act as a warning at night accidents. It was painted yellow and was plainly marked 'Australian Road Research Board — Traffic Accident Unit'. The crew wore white dustcoats or white raincoats for safety at night. Extra insurance against personal injury was arranged for them.

3.28 Photographs at the scene were taken with good 35 mm cameras, one loaded with black and white film and the other with high-speed colour film. Each camera was used with an electronic flash unit powerful enough to give good illumination at night. Other equipment consisted of a measuring wheel to measure the length of skid marks, a simple protractor to measure angles of divergence of skid marks, and various other items, such as a sling psychrometer, surface thermometer and a first aid kit. Skid resistance of road surfaces was measured by locked-wheel skids with our own vehicle at the scene.

3.29 We found it imperative, as have the few other teams who have made 'on-the-spot' studies overseas, to get to the scene as quickly as possible and in any case in less than about 20 minutes. The information obtainable about the motions of the vehicles, their initial positions, speeds, trajectories and final positions decays quickly, particularly in busy peak-hour traffic on major roads, when the vehicles have to be cleared quickly from the scene to allow traffic to proceed. The two members of the team therefore had to get into action immediately after arriving at the scene.

3.30 The engineer's first concern was to record the general circumstances of the accident. This was done by photographing the scene, showing the positions of the vehicles in relation to each other and the general road layout. A great advantage of this method of recording information is that a series of photographs shows virtually everything, not only those things which are obviously important at the time. In the confusion at the scene of an accident it is only too easy to forget to check whether all the street lights are on, or the positions of parked vehicles, to mention only two examples. This information can be obtained later if a comprehensive set of photographs is available for reference.

3.31 The positions of vehicles and skid marks were then marked with chalk on the road surface. This enabled us to leave the detailed drawing of a plan of the accident until after the scene had been cleared.

3.32 While the engineer photographed the scene and the vehicles, the doctor found the injured and assisted the ambulance men when required, or, if we arrived before the ambulance, rendered first aid as necessary. The doctor interviewed those participants who had not been taken to hospital and recorded their injuries (if any) and their age, sex, height, weight, seated position, and their account of the accident. He also interviewed any eye witnesses who had remained at the scene. No names were recorded except for those admitted to hospital, and their names were removed from the records after they had been discharged.

3.33 Co-operation from the public was commendably good: 95 per cent of our involuntary subjects co-operated fully. Most of them were quite willing to talk about their accident, once it had been explained that we did not belong either to the police or the newspapers.

3.34 We had neither the equipment nor the authority to enable us to estimate blood alcohol levels in drivers and pedestrians. We did record whether or not a participant had been drinking, basing our decision on the smell of his breath and general behaviour. Towards the end of the survey we were able to use a simple breath alcohol indicator ('Alco Test'). The results we obtained from this indicator suggest that our estimation 'had been drinking' was conservative; therefore, we have not detected all the drivers and pedestrians who were affected by alcohol. This should be remembered whenever the effect of alcohol is discussed elsewhere in this Report.

3.35 The make, model and registration number of each vehicle were noted, and also the name of the towing service which removed the vehicle from the scene. If possible the vehicle was inspected for damage at the scene, but very often circumstances such as heavy traffic prevented this, and the vehicle would then be inspected at the depot of the towing service or at a crash repair shop. Here again the amount of accurate information available decreased with time, except for certain details of damage which could only be determined after the vehicle had been partially dismantled. Inspection of the interior of the vehicle was guided by the known injuries the occupants received. We tried to assign a cause to each injury (*Fig. 3.8*), but did so only when the relationship was readily demonstrated. We were also particularly concerned with damage to the interior of the vehicle caused by occupant's contact but which was not associated with injury to the occupant. Whereas the 'crashworthiness' of a vehicle becomes immediately apparent after an accident, its 'roadworthiness' is much more difficult to assess because many components can be damaged in the accident. There are certain checks than can be made however, and the results of these will be discussed in a subsequent section of this report.

Fig. 3.8—A. J. McLean (left) and G. A. Ryan at case 0229

3.36 Environmental features were also recorded, whenever possible in a quantitative form, e.g. ambient temperature and humidity, and road surface temperature. At a given speed, stopping distance has been found to depend mainly on the properties of the road surface, in the case of a skidding vehicle. We therefore recorded the type of surface and carried out skid tests with our own vehicle. This enabled us to check our estimate of the travelling and impact speeds of the vehicles involved in the accident. It should be noted that our speed estimates, based on statements from drivers, damage to the vehicles and motions of the vehicles, were commonly higher than the driver's own estimate of his speed. Even so we suspect that our estimates may still be conservative.

FOLLOW-UP STUDIES

3.37 After as much as possible had been recorded at the scene the unit followed the injured to the hospitals. Here the medical member had free access, being well known to the medical staff. In the Casualty Department he was able to record the injuries in more detail, and to determine the height, weight, age, sex and seated position of the injured. The X-ray Department provided films of fractures, etc., which were copied. With the permission of the subjects, photographs were taken of the more significant injuries. Thereafter the patients were followed up for details of the results of treatment, length of hospital stay, and the like. No difficulty of any sort was placed in our way, and we would like to express our gratitude to the Boards, the Superintendents and Staff of the Royal Adelaide Hospital, the Queen Elizabeth Hospital and the Adelaide Children's Hospital, who needed no persuasion about the usefulness of our task and who eased our work in every possible way.

3.38 In a similar way the engineer followed the vehicles to the repair shops, where mechanical damage could be inspected at leisure and in more detail. He was also able, in a good proportion of cases, to obtain an estimate of the cost of repair, a parameter which is of use in checking the assessment of the degree of damage to the vehicle. For similar degrees of damage to similar models of vehicles these costs are likely to show a considerable variability (though not more so, and for similar reasons, than the costs of medical treatment for comparable injuries) but on average they are likely to provide a reasonable estimate, by extrapolating from our sample, of the overall cost to the community of the repair of vehicles involved in personal injury accidents in Adelaide.

3.39 In fatal cases the team, including the engineer, attended the necropsies and recorded and photographed the injuries.

3.40 In many cases the team returned later to the scene of the accident to make more detailed measurements and observations of the roads and their fixtures and furnishings, and it was our constant endeavour to make as great a contribution as possible to the traffic and highway engineering side of the work, for we realized that this is one of the basic factors in the accident situation.

DEFINITIONS AND CRITERIA OF CLASSIFICATION

General

3.41 The following definitions were used. *An injury-producing traffic accident*: one which involves a vehicle, occurs on a public road, and to which an ambulance is called.

Type of vehicle: vehicles were divided into the following categories:

(a) *Car*: including car-type station sedans, vans, utilities.
(b) *Light truck*: including forward control vans, small buses, jeep-type vehicles.
(c) *Heavy truck*: Over 2 tons tare weight, bus, semi-trailer.
(d) *Car with trailer.*
(e) *Three wheeled car* or motor-cycle with sidecar.
(f) *Motor-cycle*: including motor-scooters and motor-assisted cycles.
(g) *Pedal cycle.*

Ratings of injury severity

3.42 Although exact details of each injury in each of the participants in the whole sample of 408 accidents were recorded, and it is intended that a subsequent medical dissertation will be written on this aspect, we also used for statistical purposes a simple system of ranking injuries according to severity.

3.43 In this system injury is divided into six grades, which correspond approximately to the classification used by the Automotive Crash Injury Research Unit of Cornell University in the U.S.A. (Ref. 6). These grades are:

Nil:	no injury
Minor:	bruises, abrasions, lacerations, 'dazed' — no loss of consciousness.
Moderate:	fractures of nose, hands, feet, concussion less than 10 minutes, large lacerations, dislocations.
Severe:	fractures of limbs, injury not endangering life.
Very severe:	injury endangering life.
Fatal:	death within 30 days from any cause after involvement in a vehicular accident.

3.44 The body is divided into six areas:

- Head and neck, excluding spine
- Thorax
- Abdomen
- Spine and pelvis
- Upper limb
- Lower limb

3.45 Each body area is assessed for injury and the injury graded according to the above scheme, the degree of injury being judged relative to the region affected rather than to the whole body.

Rating of vehicle damage

3.46 In a similar way we assessed and graded damage to the vehicles involved in the accidents. This is done on a simple five point scale as follows:

Nil:	no damage.
Minor:	from scratches to dents or deformation of the body of the vehicle — no structural damage.
Moderate:	crumpling of the body of the vehicle — little or no structural damage.
Severe:	structural damage, together with extensive damage to the body of the vehicle.
Extremely severe:	extensive structural damage; general demolition of the vehicle.

3.47 For cars the above scale is applied separately to the front, the passenger compartment and the rear sections of each vehicle. From these separate ratings an overall damage rating is obtained by taking the simple arithmetic sum of the numerical rat-

Fig. 3.9—Minor overall damage

Fig. 3.10—Moderate overall damage

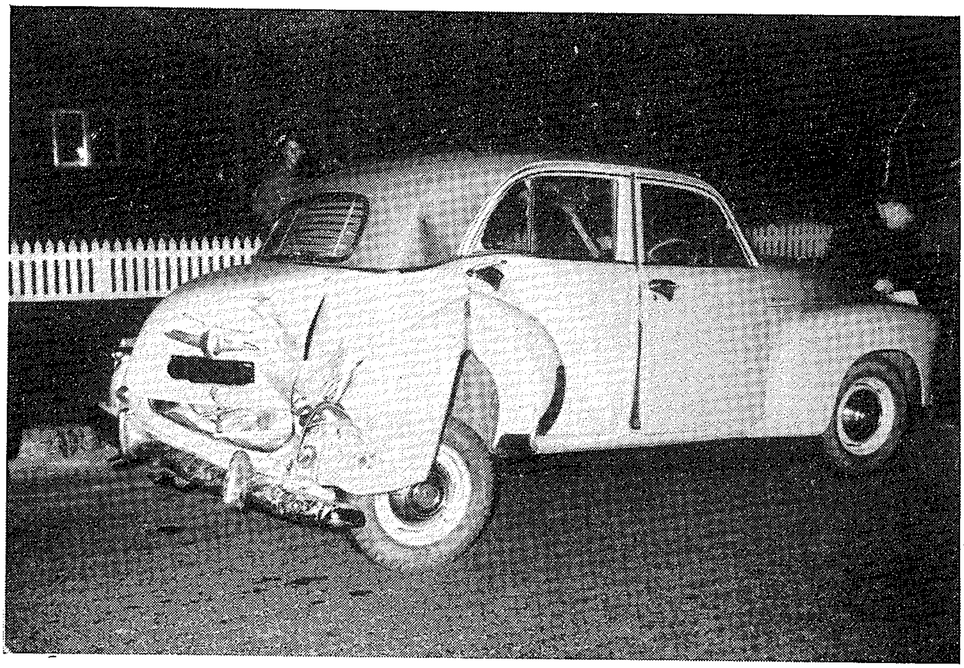


Fig. 3.11—Severe overall damage

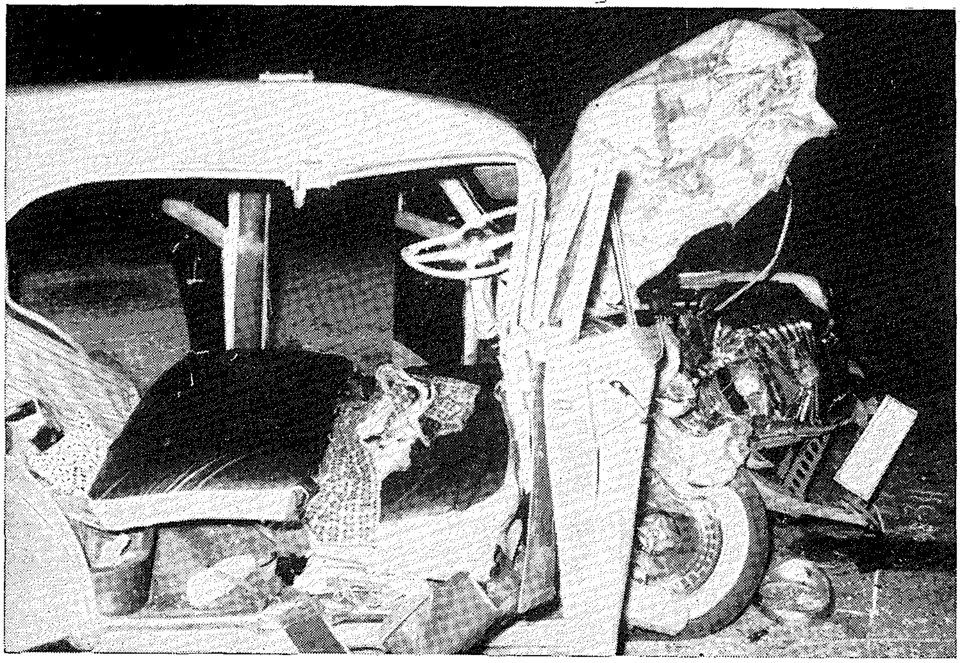


Fig. 3.12—Extremely severe overall damage

ings given to these three sections, viz:

Degree of damage	*Numerical rating*
Nil	0
Minor	1
Moderate	3
Severe	7
Extremely severe	10

These overall damage ratings are then classified as follows:

Degree of overall damage	*Numerical rating*
Nil	0
Minor	1 - 2
Moderate	3 - 7
Severe	8 - 14
Extremely severe	15 - 30

Note that no attempt is made to give a greater weight to the passenger compartment than to the ratings for the front or rear sections of the car (Moreland, Ref. 7). These damage ratings are illustrated in *Fig. 3.9* to *3.12*.

3.48 For vehicles other than cars, including cycles and motor-cycles, only an overall damage rating was used, along the lines of the scale given in para. 3.46.

Rating of accident severity

3.49 In the early part of the work we attempted to record a general assessment of the severity of the accident, in addition to the detailed ratings of vehicle damage and injury severity. This concept was applied only to accidents involving cars, and excluded collisions with motor-cyclists, pedal cyclists and pedestrians. The degrees used were minor, moderate, severe and very severe, and they were assessed by a study of the damage to the vehicles together with their motions during the accident, and excluded the injuries to the occupants. However, it was found that the subjective element involved in this particular rating was so large that its usefulness was very limited, and we gradually discontinued it altogether.

Data codes

3.50 Two codes were developed to enable the data to be recorded in a form suitable for machine sorting. One was the accident circumstance and vehicle data code and the other was the circumstances and injury code. These are attached in Appendix D.

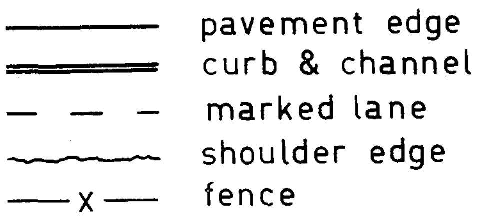
Statistical significance

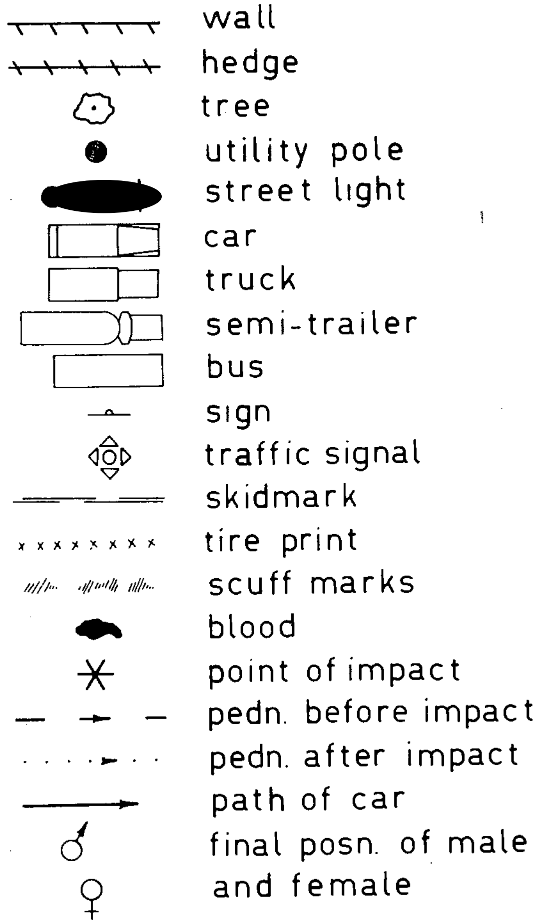
3.51 The following symbols, unless specifically defined otherwise, are used to designate levels of statistical significance:

N.S. = Not significant
* = Significant at 5% level
** = Significant at 1% level
*** = Significant at 0.1% level

3.52 The following symbols have been used in all site plans:

LEGEND





THE PEDESTRIAN'S COMPLAINT

In spite of all order, justice, and decorum, we, the greater number of the queen's loyal subjects, for no reason in the world than because we want money, do not share alike in the division of her majesty's high road. The horses and slaves of the rich take up the whole street; while we peripatetics are very glad to watch an opportunity to whisk across a passage, very thankful that we are not run over for interrupting the machine, that carries in it a person neither more handsome, wise, or valiant than the meanest of us. For this reason, were I to propose a tax, it should certainly be upon coaches and chairs: for no man living can assign a reason why one man should have half a street to carry him at his ease, and perhaps only in pursuit of pleasures, when as good a man as himself wants room for his own person to pass upon the most necessary and urgent occasion . . . It is to me most miraculous, so unreasonable an usurpation as this I am speaking of, should so long have been tolerated. We hang a poor fellow for taking any trifle from us on the road, and bear with the rich for robbing us of the road itself . . . The overseers of the highway and constables have so little skill or power to rectify this matter, that you may often see the equipage of a fellow whom all the town knows to deserve hanging, make a stop that shall interrupt the lord high chancellor and all the judges in their way to Westminster.

(Sir Richard Steele, Equipages: *The Tatler,* 11 March, 1709/10.)

PEDESTRIAN ACCIDENTS

4.1 An accident involving a pedestrian (hereafter called a 'pedestrian accident') is perhaps the simplest kind of traffic accident: a naked and relatively uncomplicated encounter between man and the machine. All cities swarm with pedestrians, who wish to and need to cross streets thickly populated with moving vehicles. It is noteworthy that almost all the pedestrian accidents in our sample occurred on roads classified as 'busy' in respect of vehicular movement (see *Fig. 4.10* and para. 4.52).

4.2 Drivers tend to regard pedestrians, naturally enough from their point of view, as a hindrance to the free passage of their vehicles, while the pedestrians accept the hazard of moving vehicles as an inevitable impediment to their freedom to cross streets wherever, whenever and in whatever manner they wish. The degree of acceptance of this risk by pedestrians varies. Some take foolish risks, through youth or age, absence of mind, drunkenness, or for a variety of other reasons. Some of these factors are brought out in our discussion.

4.3 Accidents to pedestrians are very common, and they are also — for the pedestrian is entirely unprotected by an enclosing vehicle that can absorb energy in a crash — particularly lethal. Our findings show that three quarters of all pedestrians involved in accidents need hospitalization

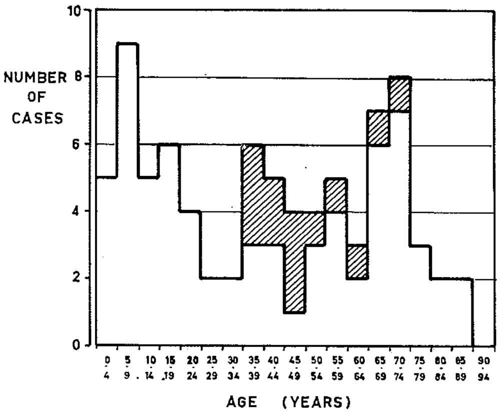


Fig. 4.1—Pedestrians (all accidents)

and that a disturbingly large proportion of them are killed. The special methods taken for their protection, which vary in stringency in different cities, are therefore amply justified. The pedestrian, has, or ought to have, as much right to use the city as the driver. Although some of our findings may apply only to this city, in general they highlight the whole problem of accidents involving pedestrians.

WHAT KINDS OF PEOPLE ARE INVOLVED IN PEDESTRIAN ACCIDENTS?

4.4 In an effort to characterize the person who is involved in a pedestrian accident we have analysed the age distribution of the 82 pedestrians involved in the 79 pedestrian accidents we attended. *Fig. 4.1* shows the age distribution of all pedestrians. There are three distinct peaks. The first is in the age interval from 5 to 9 years. There is a second smaller peak between 35 and 39 years which then merges into a third peak at 70 to 74 years which is almost as high as the first peak. The youngest pedestrian was aged 3 years, and the oldest 86 years. The theoretical lower limit of age for pedestrians is the age at which the child first walks. It seems that by age 3 a child is mobile enough to run on to a roadway. At the other end of the scale there is no real limit, for some people remain comparatively mobile until they are very old indeed. Whether they are still agile and alert enough to cope with modern traffic while crossing roads is sometimes rather doubtful.

4.5 The age distribution of male pedestrians involved is shown in *Fig. 4.2*. There is a marked peak at age 5 to 9 years, which

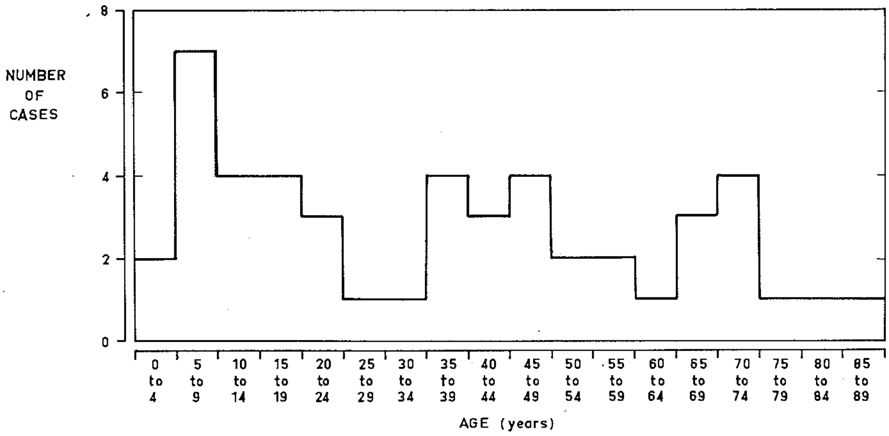


Fig. 4.2—Ages of male pedestrians

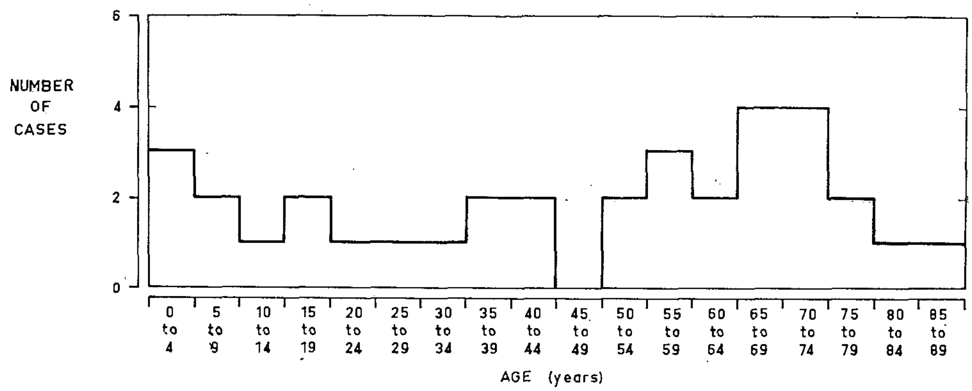


Fig. 4.3—Ages of female pedestrians

is succeeded by a gradual fall to a minimum between 25 and 34 years. There is another rise between the ages 35 and 49 years. A third peak occurs in the age group 70 to 74 years. This figure is rather different from that showing the age distribution for females (*Fig. 4.3*). There are only two real peaks in this graph. The first is in the age group 0 to 4, and the second is between 55 and 74 years. Between these two groups the graph is almost flat. If we compare the actual figures, we find that for ages less than 50 there are twice as many males as females involved. For the years over 49 there are more females than males.

4.6 The population of metropolitan Adelaide contains more females than males over the age of 50. If we compare the ratios of males to females, aged less than 50 and greater than 49, in our group of involved pedestrians with the same ratios for metropolitan Adelaide, we get results shown in TABLE 4.1. The figures in this table indicate that the proportion of male pedestrians under 50 years involved in accidents in our sample is greater than the proportion of males in the general population. The proportion of males to females aged 50 years and more is approximately the same for the general population and for the accident sample.

4.7 *Fig. 4.1* is a graph of the ages of those pedestrians who had obviously consumed alcohol before their accident, as indicated by the smell of their breath and their general appearance and behaviour. Between the ages of 35 and 64, 11 of the 28 pedestrians involved showed the presence of alcohol. That is, 40 per cent of the pedestrians in this age group were affected by alcohol. There were only two female pedestrians who had obviously consumed alcohol. They were both in this age group.

TABLE 4.1

MALE:FEMALE RATIOS

	Age Less Than 50 Years	Age 50 Years and Greater
T.A.R.U.* pedestrians Males:females	2.20:1	0.79:1
Metropolitan Adelaide population Males:females	1.03:1	0.88:1

*T.A.R.U. = Traffic Accident Research Unit.

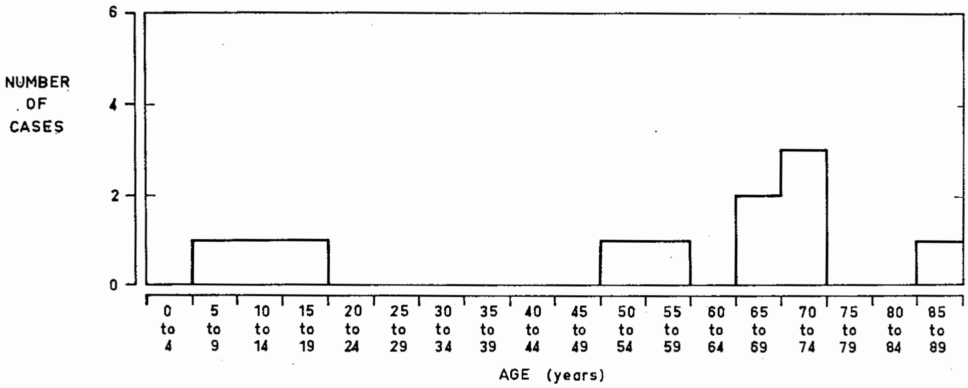


Fig. 4.4—Ages of pedestrians killed

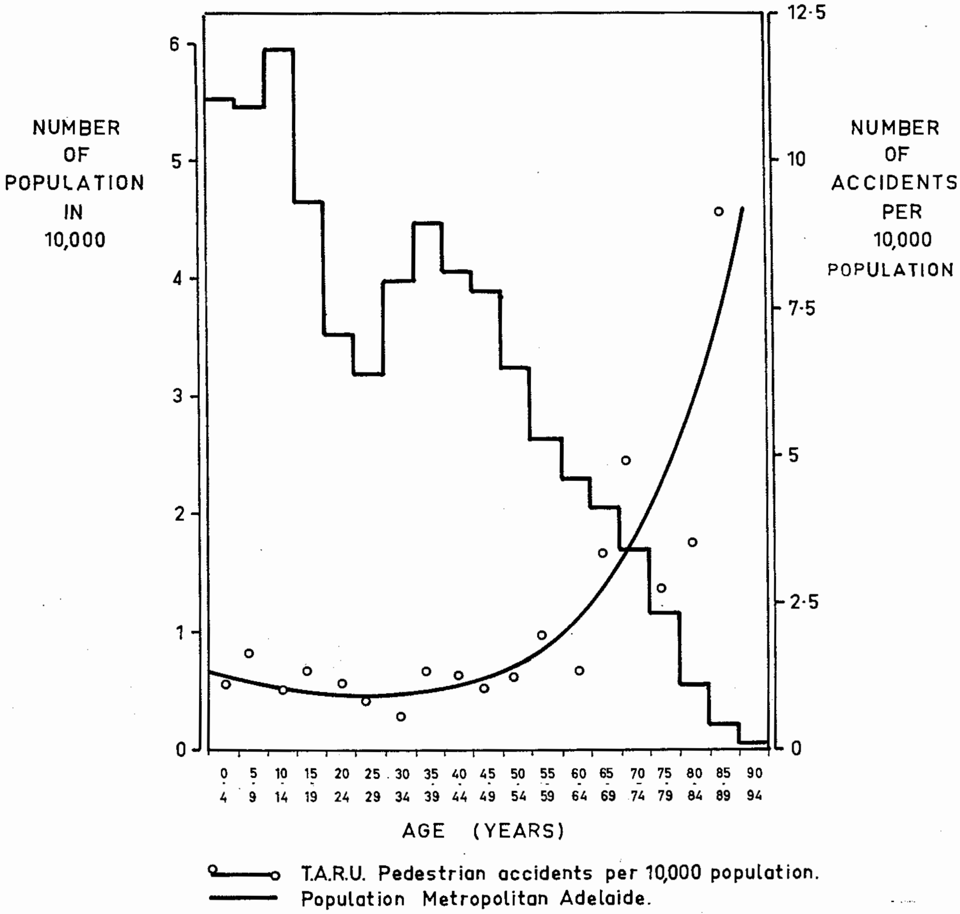


Fig. 4.5—Accident frequency by age of pedestrian

4.8 Haddon et al. (Ref. 8), in a study of 50 fatally injured adult pedestrians in Manhattan, found two discrete groups. One consisted of the elderly who had been drinking little or not at all, and the other of the middle aged who had been drinking heavily. These correspond with the two older age groups in our study.

4.9 In *Fig. 4.1* the three peaks at different ages correspond to circumstances in which coordination and awareness of surroundings are impaired or not fully developed. In childhood and youth there is lack of experience in assessment of risks. In the age group 35 to 64, in which people should have accumulated experience in risk-taking and its results, the faculties are dimmed by alcohol in almost half the cases. Over the age of 65 the processes of degeneration cause a slowing of both mind and body, increasing the risks involved in crossing roads.

4.10 The age distribution of pedestrians killed is shown in *Fig. 4.4*. The 11 deaths are clustered about the extremes of age 5 to 19 years and 50 to 89 years. There were six males and five females killed, and the graph is roughly the same shape as that for all pedestrians. Of the six pedestrians over 12 years of age who survived less than 12 hours, one had alcohol present in the blood at necropsy (0.150 mg per cent). One male aged 6 was not examined post mortem. The other four survived from 3 to 18 days.

4.11 There are thus three main groups of persons involved in pedestrian accidents:

(a) young males less than 20 years old,

(b) males aged 35 to 64 affected by alcohol,

(c) males and females older than 64 years — females outnumbering males.

4.12 *Fig. 4.5* shows the age distribution of the population of metropolitan Adelaide. Superimposed on this is a curve showing the ratio between the number of pedestrian accidents in our sample and the number of the population in each age group. The curve has a slight negative slope to its minimum value at about 25 years, followed

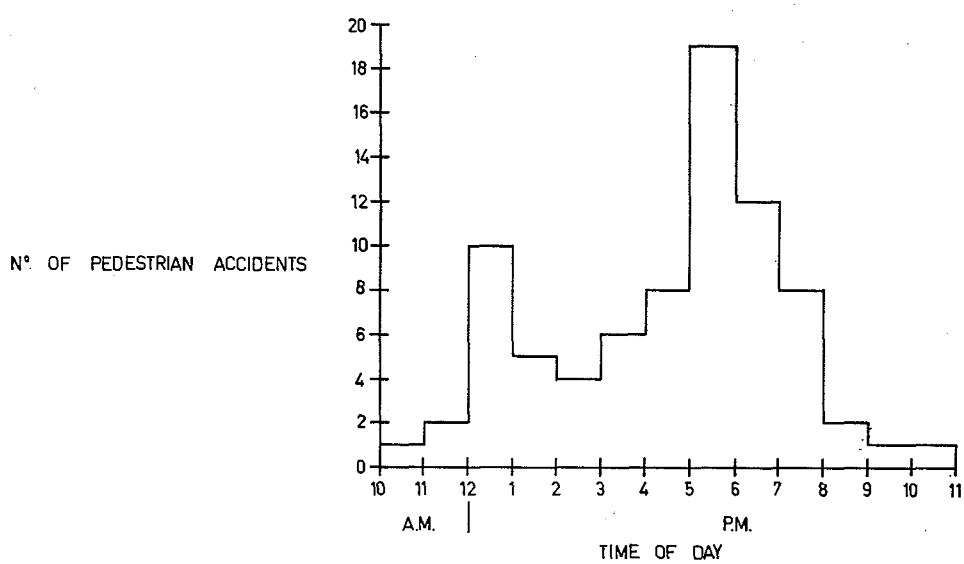


Fig. 4.6—Pedestrian accidents attended by time of day

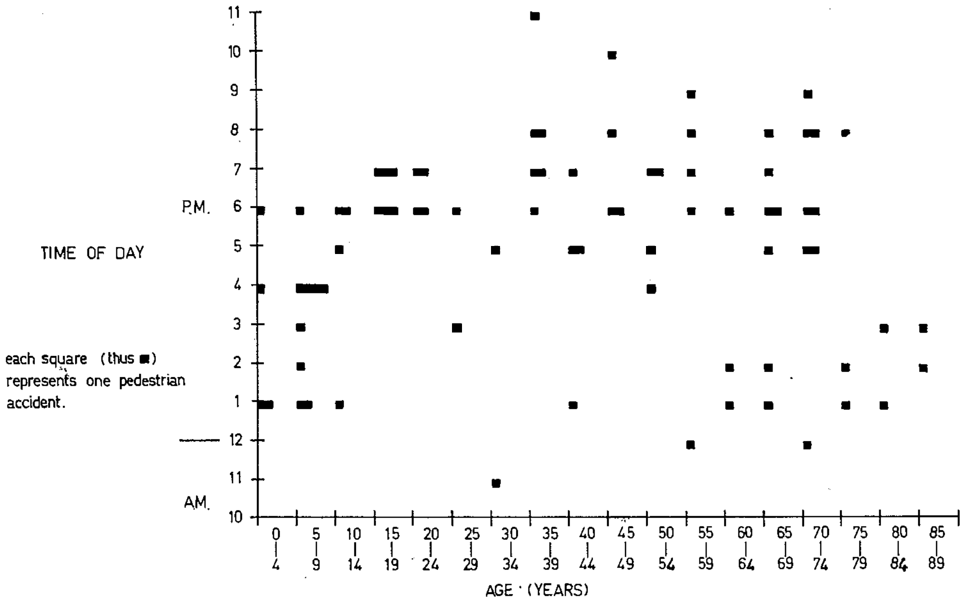


Fig. 4.7—Pedestrian accidents by age by time of day

by a positive slope which increases rapidly beyond 60 years. This means that the risk of being involved in a pedestrian accident first falls slightly to a minimum in the years 20 to 29, then increases rapidly with increasing age. The shape of this curve is similar to the J-shaped curve cited by Haddon et al. (Ref. 8) as representing the age-specific death rates of pedestrians in Manhattan and the U.S.A. Logically, therefore, measures designed to influence pedestrian behaviour should be aimed specifically at these three groups which make up the majority of pedestrians involved in accidents.

THE TIME DISTRIBUTION OF THE PEDESTRIAN ACCIDENTS

4.13 The time distribution of pedestrian accidents is shown in *Fig. 4.6*. The graph extends from 10 a.m. to 11 p.m., for this was the period during which we collected accidents. It can be seen that there are two peaks, one between 12 noon and 1 p.m. and the second between 5 p.m. and 6 p.m. The graph does not truly represent the pattern of accidents in time, for we were able to attend relatively more of the accidents occurring in the off-peak periods than in the peaks themselves.

4.14 A diagram has been drawn up to show the number of persons in each 5-year age group and the times when they had their accidents. There are distinct patterns (*Fig. 4.7*). Up to age 14 the accidents are evenly spread between 12 midday and 6 p.m. There are none later than 6 p.m. Between 15 and 29 years the accidents are spread from 11 a.m. to 11 p.m. with a concentration from 4 p.m. to 8 p.m. Between ages 60 and 89 there are two concentrations, the first between 12 midday and 3 p.m. and the second between 4 p.m. and 5 p.m.

4.15 In general, young people under 10 years and those older than 70 years were involved in accidents between 12 noon and 4 p.m. The accidents of most of the other pedestrians occurred between 4 p.m.

and 8 p.m. These groupings probably reflect the patterns of activity of the age groups concerned. Children are on the roads at lunch time and when going home from school; older people are on the roads when they are doing their shopping, and returning home from work.

WHAT WERE THE PEDESTRIANS AND THE DRIVERS DOING WHEN THE ACCIDENTS OCCURRED?

4.16 In an effort to analyse what the participants were doing immediately before the impact we devised a method of correlating the movements and some of the actions of pedestrians and motor vehicle drivers. In the three cases where there were two pedestrians involved we have considered only the elder of the two. Therefore there are 79 cases, not 82.

The driver's view

4.17 As a starting point we considered that, if the pedestrian or the driver had seen each other in time for effective and appropriate evasive action, there would have been no collision. Since there *was* a collision, one or both parties did not see the other, or seeing too late — could not avoid collision, or — seeing danger in time — did the wrong thing.

4.18 Considering the driver of the vehicle first, the extreme case is where he does not see the pedestrian at all before impact, and the impact itself is the first intimation to him that something has happened, e.g.

● **Case 0234***

A 59-year old pedestrian was struck by a Volkswagen travelling about 40 to 50 m.p.h. on an unlit road. The driver of the car did not see the pedestrian at all. He merely heard a bump, and then stopped and turned around to see what had happened. The pedestrian struck the left front mudguard of the car and dented the left front corner of the roof. He was killed, suffering extensive injuries to the thorax, spine, abdomen and legs.

4.19 The next case is where the driver sees the pedestrian for the first time a short distance away, but the pedestrian is so close that the driver is unable to brake or take any avoiding action before impact, e.g.,

● **Case 0276**

A 70-year old female pedestrian on a marked pedestrian crossing, at night, was struck by a Volkswagen at approximately 30 m.p.h. The driver of the car says that the pedestrian appeared from his left, apparently coming from in front of another car which was slightly ahead of him and on his left side. The pedestrian suffered compound fractures of right and left tibiae.

4.20 Next follows a group where the pedestrian is seen for longer periods of time and the driver is able to brake for varying distances before impact, e.g.

● **Case 0200**

A 49-year old male pedestrian came wandering out of a hotel across a main road. The 20-year old male driver of the car, a Ford Prefect, saw this pedestrian, braked, swerved to his right and just brushed the pedestrian with the left front head light and left side of the car. The pedestrian sustained concussion and a small abrasion to the left side of his head. The pedestrian was drunk.

4.21 Finally there is the case where the driver first sees the pedestrian at a considerable distance. In this case the driver believes the pedestrian will not cross the road, and when the pedestrian continues walking the driver brakes, but too late to avoid striking the pedestrian, e.g.

● **Case 0177**

A Holden FJ was travelling in the centre lane of a three-lane divided highway. The driver saw a pedestrian starting to cross the road, from the left, at an intersection. The pedestrian looked in the direction of the car and continued walking. The driver slowed. The pedestrian kept walking. Then

*Summaries of all accidents recorded can be obtained from the Australian Road Research Board on request.

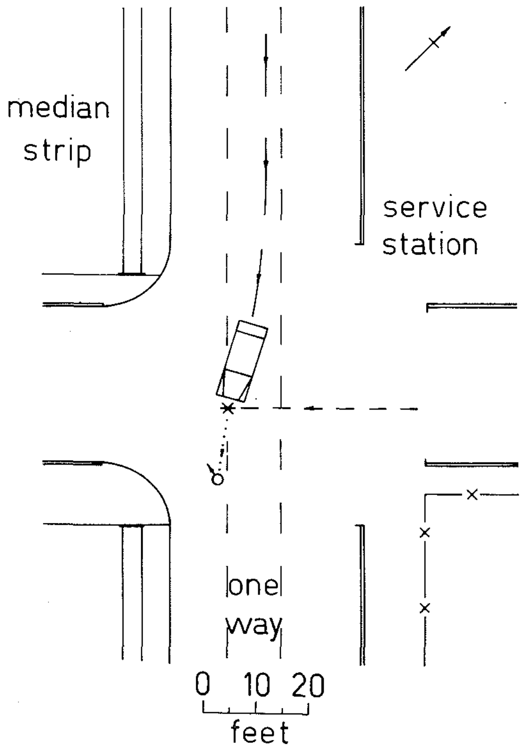


Fig. 4.8—Case 0177

the pedestrian 'started' as if seeing the car for the first time, and hurried across the road. The driver of the car had begun braking by this time, and swerved to his right and braked harder as the pedestrian hurried in front of him. The pedestrian was struck by the centre of the front of the car and was thrown forwards as the car stopped. The pedestrian said he did not see the car until he was out in the middle of the road; then he did not know whether to jump upwards or forwards. The pedestrian was 84, very fit, and had a corneal opacity of his left eye. He sustained abrasions to the left forehead, the back of the left hand, and a bruise to the right calf (see *Fig. 4.8*).

4.22 The 79 pedestrian accidents have been divided into classes according to the distance at which the driver first saw the pedestrian — using the following notation for the four classes:

In the distance — The driver sees the pedestrian at a considerable distance.

Close — The driver, on seeing the pedestrian, brakes immediately, but strikes the pedestrian. This includes cases where impact occurred before the driver could brake.

Not at all — The driver does not see the pedestrian at all before impact.

Not known — The driver or rider concussed — unable to say what happened — incomplete record of the accident.

4.23 The accidents were assigned to these classes after study of the drivers' accounts of the accidents, which were written down after each accident. In the earlier cases where the notes are incomplete, the accidents are classed as *not recorded.*

4.24 A further subdivision of these classes is obtained by dividing them according to whether the driver did or did not brake before impact.

4.25 There are therefore four operational classes which are measures of the relative positions of the vehicle and the pedestrian when first seen by the driver. These definitions take into account the closing speed of the vehicle and the pedestrian relative to each other. The four classes are:

(a) in the distance
(b) close — braked before impact
(c) close — did not brake before impact
(d) not at all

4.26 The actual numbers of cases are shown in TABLE 4.2.

4.27 Ignoring the 'not knowns', the numbers in each group are shown in TABLE 4.3.

4.28 In 24 (39.4 per cent) of these cases (more than one third), the driver saw the pedestrian only immediately before impact (no evasive action possible) or he did not see the pedestrian at all. Only in 14 (22.9

TABLE 4.2

NUMBERS OF CASES

Driver Saw Pedestrian	Braked Before Impact	Did not Brake Before Impact	Not Known if Braked Before Impact	Total
In the distance	11	3	—	14
Close	23	11	1	35
Not at all	—	13	—	13
Not known	2	3	12	17
	36	30	13	79

per cent) of these cases did the driver have an opportunity to take adequate evasive action.

The pedestrian's view

4.29 Similarly, we can suppose that if pedestrians saw the vehicle in time they would take avoiding action. Thus we can divide these accidents into those in which pedestrians saw the vehicle:

(a) in the distance
(b) close
(c) not at all
(d) not known whether pedestrian saw the vehicle, i.e. he was concussed
(e) not recorded if pedestrian saw the vehicle

4.30 In the first case the pedestrian often stated that he saw the vehicle in the distance, but thought he had time to cross in front of it. He did not, as in

● **Case 0129**

A 70-year old male pedestrian was struck by a Holden Station Sedan. The driver saw the pedestrian in the centre of the road, coming from her right. She sounded her horn and the pedestrian ran across in front of the car. She braked and swerved, striking the pedestrian with the left front corner of the car. The speed at impact was 21 to 30 m.p.h. The pedestrian said he saw the car in the distance but thought he had plenty of time to cross. He suffered abrasions to his nose and left knee.

TABLE 4.3

DRIVER'S VIEW OF THE PEDESTRIAN

Driver saw pedestrian	No.	%
In the distance	14	22.9
Close, braked before impact	23	37.7
Close, did not brake before impact	11	18.1
Not at all	13	21.3
	61	100.0

4.31 The next class includes those who saw the vehicle only just before it hit them, e.g.

● **Case 0231**

Collision between a pedestrian and an Austin A70. The speed of the car was 30 to 35 m.p.h. The driver saw the pedestrian on the left side of the road looking away from him. As she started to cross the road he sounded his horn, and then when he was very close she jumped out in front of him. He braked, swerved to the left and struck her with the right head light. The pedestrian said she looked both ways, did not see any traffic approaching, and suddenly saw this car nearly on top of her. The pedestrian, aged 37, suffered a comminuted pertrochanteric fracture of the right femur, i.e. hip, which was compound from within through a small laceration in the right groin. She also had fractures of the right superior and inferior pubic rami and a fracture of the body of the left pubis (i.e. fractures of the right side of the pelvis). She also had an abras-

TABLE 4.4

PEDESTRIAN'S VIEW OF THE STRIKING VEHICLE

Pedestrian First Saw the Striking Vehicle	Pedestrian Crossing from		Total
	Left	Right	
In the distance	3	4	7
Close	8	3	11
Not at all	4	1	5
	15	8	23

ion to the left knee, and a bruise of the bridge of her nose.

4.32 There are a few cases where the pedestrian stated that he did not see the striking vehicle at all, e.g.

● **Case 0381**

A 57-year old woman crossing a wide road with a narrow median strip, looked both ways, did not see any traffic, and was struck by a Ford Falcon coming from her right. She said she did not know where it came from. The driver of the car said the pedestrian stepped straight out without looking. The pedestrian sustained fractures of the right side of the pelvis and a bruise to the right calf.

4.33 Large numbers of pedestrians were concussed and remember nothing at all about their accident.

4.34 Using the above classification, we have the following tabulation of distances at which pedestrians first saw the striking vehicle:

Pedestrian saw the vehicle	in the distance	7
	close	11
	not at all	5
	not known	46
	not recorded	10
Total		79

4.35 Of the 23 pedestrians about whom we have definite information, 11, or slightly less than half, first saw the striking vehicle immediately before impact. Five of 23 did not see the striking vehicle at all before the impact. From eyewitnesses' accounts of the accidents two of the pedestrians who are classed as 'not known' were seen to 'start' just before the impact, as if they were seeing the vehicle for the first time, but later they could not remember anything about the accident at all.

4.36 Therefore 11 + 2, or 13 of 25 pedestrians first saw the vehicle that struck them just before impact, i.e. when it was too late to take evasive action. Another five did not see the vehicle at all. Thus, a total of 18 out of 25 pedestrians were not in a position to avoid a collision when, if at all, they first became aware of danger. This means that three-quarters of these 25 pedestrians either did not look before entering the roadway, or if they did look, did not see the striking vehicle in time.

Pedestrian movements

4.37 Of these 18 pedestrians one was walking on the road with his back to the traffic when he suddenly heard a car behind him, and one was walking on the footpath when a car with a trailer backed into him from a parking area. Eliminating these two cases, the other 16, together with seven who saw the striking vehicle in the distance, were crossing the road from either the right or the left — according to TABLE 4.4 (the two pedestrians seen to 'start' before impact are included in 'close'). In this table the terms 'from the right' and 'from the left' refer to the direction of movement of the pedestrian as seen by the driver of the striking vehicle.

TABLE 4.5

OBSTRUCTIONS TO VISION

	Pedestrian Crossing from		Total
	Left	Right	
Pedestrian crossing with back to traffic	2	2	4
Masked by stationary vehicle	13	2	15
Masked by moving vehicle	6	2	8
No obstruction to vision	25	24	49
	46	30	76

4.38 Of those crossing from the left 12 of 15 did not see the vehicle until it was too late. Of those crossing from the right four of eight did not see the vehicle until it was too late. Of those who first saw the striking vehicle in the distance, almost equal numbers were crossing from the right (4) and the left (3), while of those who first saw the vehicle when close or not at all, three times as many were crossing from the left (12) as from the right (4). Thus it would seem that a greater proportion of pedestrians crossing from the left side of the road failed to see the striking vehicle.

Obstructions to vision

4.39 In an effort to find a reason (or reasons) why this should be so, we examined the movements of the 76 pedestrians who were crossing the road at the time of impact, and looked for possible causes of obstruction to their vision. Forty-six were crossing from the left and 30 from the right. TABLE 4.5 shows the number of pedestrians who were walking with their backs to the traffic as they crossed the road. It also shows the number of pedestrians masked by moving and stationary vehicles from the drivers and vice versa.

4.40 The table shows that there were four persons walking across the road who were struck from behind, and there were 23 cases where the pedestrian was masked from the driver by a moving or stationary vehicle, e.g.,

● Case 0317

A 33-year old female pedestrian ran between stationary cars in the two left traffic lanes and was struck by a 1958 Ford Zephyr travelling down the outside lane. The pedestrian suffered a fracture of the right superior pubic ramus (pelvis) and a fracture of the mid-shaft of the right tibia (lower leg). (See *Fig. 4.9.*)

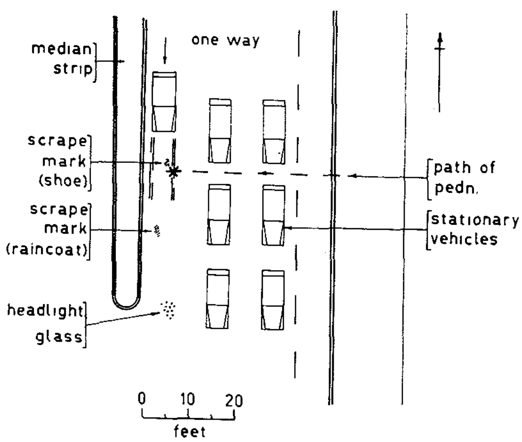


Fig. 4.9—Case 0317

4.41 In 19 of these 23 cases the pedestrian was coming from the left side of the road, and in only four cases was the pedestrian coming from the right, i.e. 41 per cent of the 46 pedestrians coming from the left were obscured by a moving or stationary vehicle, and only 13 per cent of pedestrians crossing from the right. Where there was no obstruction to vision the numbers of pedestrians struck, who were coming from the right and the left, were approximately equal.

TABLE 4.6

VEHICLE MOVEMENTS

Vehicle	Pedestrian Crossing from		Total
	Left	Right	
Proceeding straight ahead	10	4	14
Proceeding straight ahead overtaking	9	2	11
Turning left	2	—	2
	21	6	27

TABLE 4.7

PEDESTRIAN ACCIDENTS WITH NO OBSTRUCTION TO VISION

Driver First Saw Pedestrian	Pedestrian Coming from		Total
	Left	Right	
In the distance	7	3	10
Close	9	11	20
Not at all	2	4	6
Not known	7	6	13
	25	24	49

Vehicle movements

4.42 TABLE 4.6 shows the movements of the vehicles which were involved in the 27 cases where there was some obscuration of vision (23 cases where a vehicle obscured vision and four cases where the pedestrian had his back to the traffic).

4.43 In almost half (9 of 21) of the cases where the pedestrian was crossing from the left the striking vehicle was overtaking, e.g.

● **Case 0356**

A Holden FB sedan travelling at 35 m.p.h. moved into the centre of the road to pass a car travelling in the same direction. The driver suddenly saw in his headlights three females standing in the centre of the road, facing to his right. A 13-year old girl was struck by the right front headlight and thrown to the right. She suffered head injuries and a fractured right arm and died 12 hours later. The second woman, aged 23, was standing behind and to the left. She was struck by the centre of the bonnet, and suffered concussion, fractures of the face and right leg. The third pedestrian escaped injury. The driver did not brake before the impact.

4.44 Two of the six pedestrians coming from the right were struck by overtaking vehicles. In 11 of the 27 cases where vision was obscured, the pedestrian was struck by a vehicle which was overtaking. Over three quarters of these pedestrians were coming from the left. Assuming that equal numbers of pedestrians cross from the right side of the road as from the left, which appears reasonable, it seems that pedestrians crossing from the left are struck more often than pedestrians crossing from the right. This may be because pedestrians crossing from the left are masked by moving or stationary vehicles more often than those coming from the right. Furthermore, vehicles which strike these pedestrians are often overtaking other vehicles. The overtaken car screens the pedestrian crossing from the left in front of it from the overtaking car.

4.45 However, there were 49 cases (of 76) where there was no obstruction to vision, but a collision resulted. Twenty-five pedestrians were coming from the left and 24 from the right. These 49 cases in which there was no obstruction to vision can be subdivided as in TABLE 4.7.

Fig. 4.10—79 pedestrian accidents (Traffic Accident Research Unit survey, 1963-64) →

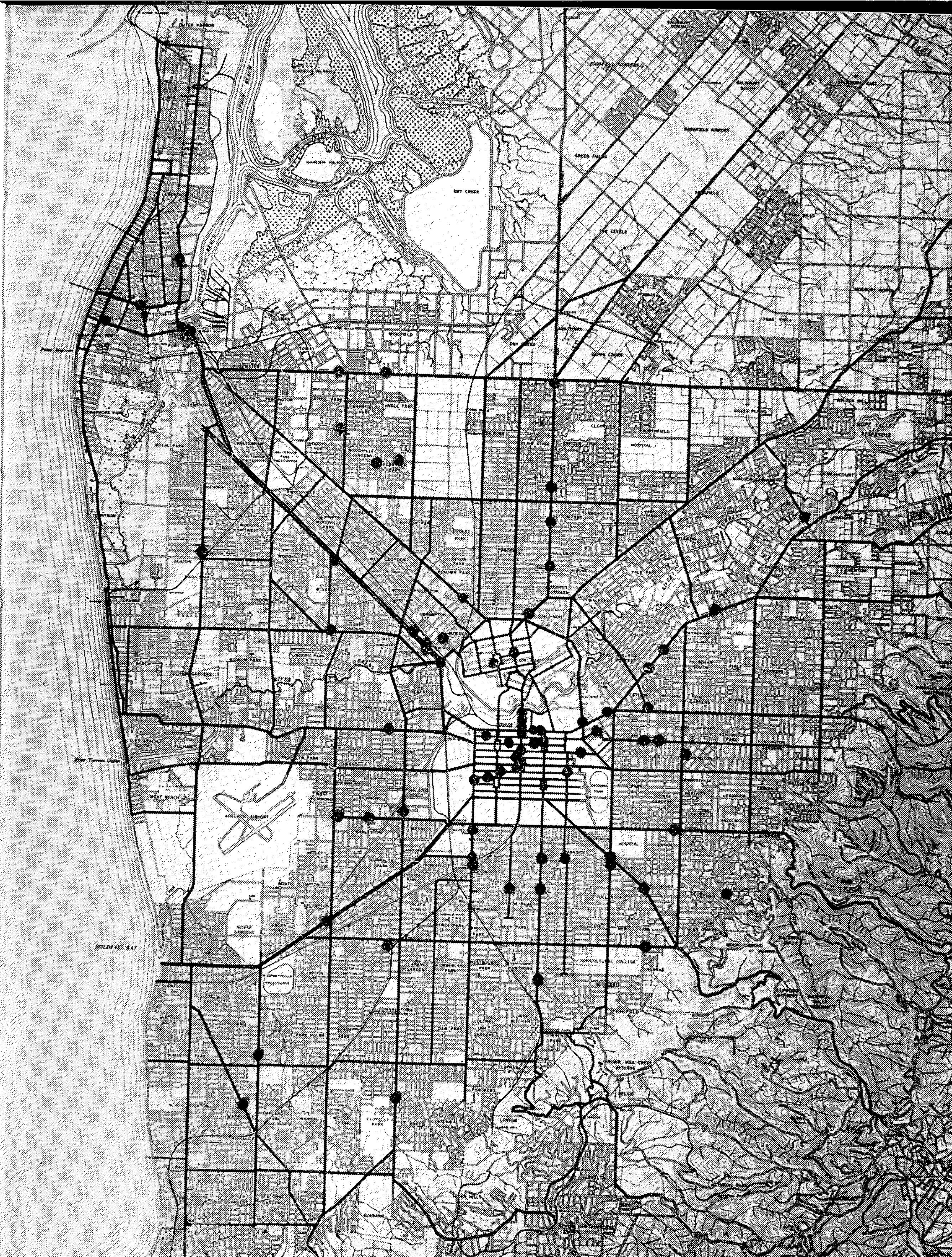


TABLE 4.8

VEHICLE MOVEMENTS

Vehicle Motion	Pedestrian Coming from		Total
	Left	Right	
Proceeding straight ahead	7	7	14
Proceeding straight ahead overtaking	1	4	5
Turning right	2	3	5
Turning left	1	1	2
	11	15	26

4.46 There are 13 cases in which we do not know if the driver saw the pedestrian. In six cases the driver did not see the pedestrian at all, and in 20 cases he saw the pedestrian close to him, just before the impact. These cases are more or less evenly divided between pedestrians coming from the right and the left. However, pedestrians coming from the right are seen in the distance only half (3 cases) as often as pedestrians coming from the left (7 cases).

4.47 Thus, in 26 of 49 cases the driver did not see the pedestrian until it was too late to avoid a collision, even though there was no obstruction to vision. Nineteen of these 26 cases occurred at night. This points to the difficulty drivers have in seeing pedestrians at night.

4.48 We can set out what the vehicles were doing in these 26 accidents in TABLE 4.8.

4.49 It seems that where there is no obstruction to vision, vehicles overtaking and vehicles turning right hit pedestrians coming from the right more often than they hit pedestrians coming from the left. Vehicles travelling straight ahead seem to hit pedestrians coming from the right and left equally often. However, our figures are still very small and this point needs further study.

4.50 It therefore seems likely that the greater number of pedestrians in our sample who were hit coming from the left were involved because they were obscured from the driver for one reason or another, since when there is no obstruction to vision pedestrians crossing from the right and the left are hit equally often.

Pedestrians standing in the centre of the road

4.51 It is a common sight to see pedestrians standing in the centre of a busy road, with their backs to one stream of traffic, waiting for a gap in the other stream to complete their crossing. There is a considerable risk attached to this procedure, as shown by the fact that 11 of the 76 pedestrians struck while crossing the road were thus 'stranded in the middle'. Six of these

TABLE 4.9

LOCATION OF PEDESTRIAN ACCIDENTS

Locality of Accident		No. of Accidents	% of Total
Suburban:	Shopping	34	43.0
	Residential	16	20.3
	School	4	5.1
	Industrial	5	6.3
City:	Commercial	18	22.8
	Residential	2	2.5
		79	100.0

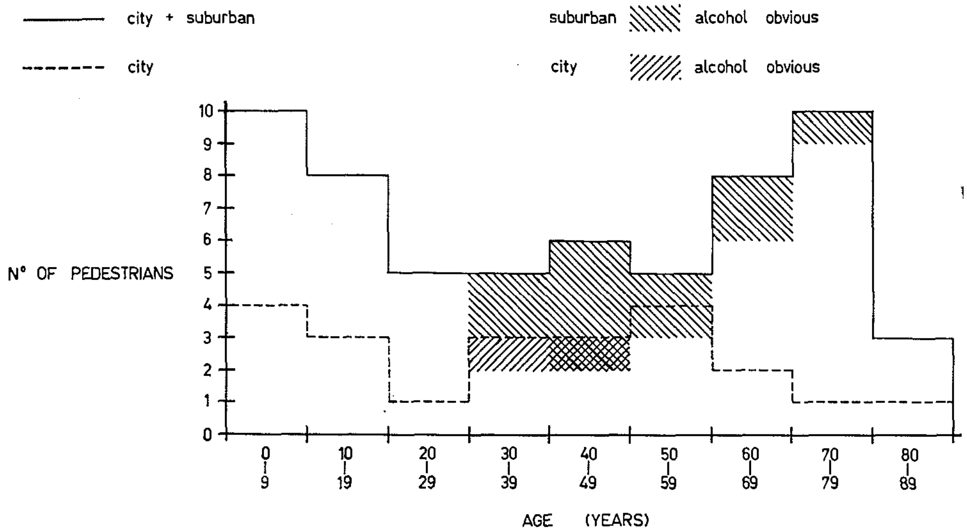


Fig. 4.11—Effect of environment on age distribution in pedestrian accidents

pedestrians were crossing from the left and five from the right. It is clear that many of these particular accidents would not have occurred, had there been a pedestrian refuge of some kind in the centre of the road.

THE EFFECT OF THE ENVIRONMENT

4.52 The locations of our pedestrian accidents are shown in *Fig. 4.10.* Almost all occurred on busy roads. In fact 72 of a total of 79 occurred on roads carrying more than 5,000 vehicles in 12 hours; the remainder occurred on minor side streets.

4.53 Almost half of the pedestrian accidents occurred very close to a shop or in a shopping area, as is shown by TABLE 4.9. A 15 m.p.h. speed limit past schools and the frequent use of traffic monitors on school crossings may have limited the number of pedestrian accidents near schools. Accidents involving children occurred mainly away from schools and during weekends.

4.54 The age distribution of pedestrians involved in accidents, as shown in *Fig. 4.1,* refers to the whole metropolitan area. When subdivided into City and suburban accidents there are marked differences between the two age distributions (*Fig. 4.11*).

4.55 The ages of pedestrians involved in accidents in the suburbs are distributed in a similar form to that shown in *Fig. 4.1.* There are three main groups: children, middle-aged males who had consumed alcohol shortly before their accident, and elderly people. By comparison the City distribution has a smaller proportion of children and elderly people. There are also only two City pedestrians who had been drinking; the other 11 cases all occurred in the suburbs. This variation between the two distributions may be a reflection of the fact that children and elderly folk are mainly walking across roads in the vicinity of their homes, which are in the suburbs. Most of the pedestrians in the City are transients who are there on business, and are therefore generally people between the ages of 20 and 60 years.

4.56 Pedestrian accidents in the City account for one quarter of all pedestrian accidents in the metropolitan area, whereas only one fifth of the remaining types of metropolitan traffic accidents occurred in the City. Although this difference is not statistically significant ($\chi^2 = 2.46$) and may be due to chance, it is a result that could be explained by the large numbers of pedestrians and vehicles on the City streets. It may point to a need for greater pedestrian protection in the City area, even to the detriment of vehicular traffic flow. The City of Adelaide has many wide streets without medians or pedestrian refuges. One third of the pedestrian accidents we attended in the City might have been avoided had a median or refuge been provided.

Pedestrian accidents at and near intersections

4.57 The definition of an 'intersection accident' has caused us some difficulty. After consideration we decided that only those accidents which were influenced by the presence of an intersection would be called intersection accidents. This excludes cases where a pedestrian-vehicle collision occurred where two roads intersected, but one of the roads could have been ignored without affecting the course of the accident. Using this definition we found that there were 20 accidents at intersections and 59 accidents not at intersections, i.e. there were 20 accidents (25 per cent) where the intersection played a part in the production of the accident. However, this does not tell us how many accidents took place within the boundaries of an intersection, regardless of whether the intersection had anything to do with the accident.

4.58 Also, it has been pointed out by the Road Research Laboratory in England (Ref. 9) that the area on either side of a pedestrian crossing is more dangerous than the crossing itself. It seemed likely that this would apply to intersections, for drivers of vehicles will be concentrating on the intersection and its traffic and they possibly will fail to observe pedestrians crossing close to the intersection. Therefore we examined all the pedestrian accidents and divided them into four groups:

(a) At an intersection: the impact point was within the extensions of the property alignments of the roads at the intersection.
(b) Within 20 yards of an intersection: before the vehicle reached the intersection, or 'upstream'.
(c) Within 20 yards of an intersection: after the vehicle had passed the intersection, or 'downstream'.
(d) Not at an intersection: more than 20 yards from the boundaries of an intersection.

4.59 The 79 accidents were distributed as follows:

At an intersection	28	35.5%
Within 20 yards before an intersection	5	6.3%
Within 20 yards after an intersection	17	21.6%
Not at an intersection	29	36.6%
Total	79	100.0%

TABLE 4.10

INTERSECTIONS AND PEDESTRIAN ACCIDENTS

Pedestrians Crossing from the	At an Intersection	Within 20 Yd of an Intersection		Not at an Intersection	Total*
		Before	After		
Right	12	3	6	9	30
Left	16	2	11	17	46
	28	5	17	26	79

*(3 not crossing)

TABLE 4.11

DISTRIBUTION OF PEDESTRIAN ACCIDENTS BY DAY AND NIGHT

	At Intersection	Within 20 Yd of Intersection		Not at Intersection	Total
		Before	After		
Day	15	3	7	20	45
Night	13	2	10	9	34
	28	5	17	29	79

4.60 Slightly more than one third happened at intersections, 22 (27.9 per cent) happened within 20 yards of intersections and the rest, slightly more than one third, happened more than 20 yards from an intersection. The most important finding here seems to be that there were three times as many pedestrians struck when crossing just past an intersection than just before an intersection.

4.61 This may suggest that more people cross the road just 'downstream' from an intersection than 'upstream' from it; but on two-way roads a pedestrian crossing at a point some distance from the intersection will be 'upstream' relative to one line of traffic and 'downstream' relative to the other. Therefore it seems reasonable to assume that on the average as many pedestrians cross 'upstream' from an intersection as 'downstream', and the fact that three times as many pedestrians are struck within the 20 yards beyond an intersection as are struck within the 20 yards before an intersection means that vehicles are more likely to strike pedestrians beyond the intersection than before it; and conversely, from the pedestrian's point of view, his greatest danger lies in the car approaching from the intersection.

4.62 The directions in which the pedestrians were crossing the road are shown in TABLE 4.10. There were twice as many pedestrians coming from the left as from the right, of those crossing after and not at an intersection. The numbers are more nearly equal for those crossing before or at an intersection.

4.63 If we consider the distribution of these accidents by day and night we get the results shown in TABLE 4.11.

4.64 There are relatively more pedestrian accidents at night within the 20 yards past an intersection than there are in any of the other three positions. This is more clearly shown by the proportion of day to night accidents in each situation (see TABLE 4.12).

4.65 There are only slightly more pedestrian accidents in the daytime than at night, at and before intersections, compared with more than twice as many day accidents as night accidents more than 20 yards from an intersection. There are more night accidents than day accidents within 20 yards after an intersection. This is completely the reverse of the other groups, and possibly means that the usual difficulties in seeing pedestrians at night are accentuated

TABLE 4.12

PROPORTION OF DAY TO NIGHT ACCIDENTS

	At an Intersection	Within 20 Yd of an Intersection		Not at an Intersection
		Before	After	
Day:Night	1.3:1	1.5:1	0.7:1	2.2:1

TABLE 4.13

MOVEMENTS OF VEHICLES INVOLVED IN INTERSECTION ACCIDENTS

	At Inter-section	Within 20 Yd of Intersection		Not at Intersection	Total
		Before	After		
Proceeding straight ahead	16	2	8	22	49
Proceeding straight ahead, overtaking	5	3	5	6	18
Turning right	6	0	0	0	6
Turning left	0	0	4	0	4
Not known	1	0	0	1	2
Total	28	5	17	29	79

TABLE 4.14

COMPARISON OF VEHICLE MOVEMENTS BY DAY AND NIGHT

	Vehicle Proceeding Straight Ahead	Overtaking	Entering Traffic Lane	Turning Right	Turning Left	Not Recorded	Total
Day	31	9	1	3	2	0	46
Night	18	9	0	3	2	1	33
	49	18	1	6	4	1	79

TABLE 4.15

EFFECT OF REDUCED VISIBILITY AT NIGHT

	Driver Saw Pedestrian				
	In the distance	Close	Not at all	Not recorded	Total
Day	14	16	5	11	46
Night	0	19	8	6	33
	14	35	13	17	79

TABLE 4.16

TYPE OF LIGHTING IN NIGHT ACCIDENTS

Driver Saw Pedestrian	Type of lighting					
	Nil	Fluorescent	Sodium vapour	Mercury vapour	Incandescent	Total
In the distance	0	0	0	0	0	0
Close	1	0	11	5	2	19
Not at all	1	1	1	3	2	8
Not recorded	0	0	3	3	0	6
	2	1	15	11	4	33

in the area just past the usually brighter lighting of an intersection.

4.66 The movements of the vehicles involved are shown in TABLE 4.13.

4.67 All the six accidents involving vehicles turning right took place at intersections, while the four accidents involving vehicles turning left took place within 20 yards after an intersection. There were also relatively more vehicles involved while overtaking within 20 yards after an intersection. In three of the four accidents involving left turns the pedestrian was crossing from the left side of the road, i.e. the vehicle was coming from behind the pedestrian.

4.68 The area within 20 yards 'downstream' from an intersection thus seems to have more accidents than the 20 yards 'upstream' from an intersection. The 'downstream' accidents include more night accidents and also involve more vehicles which are overtaking and turning left.

Vehicle movements in pedestrian accidents by day and by night

4.69 Comparing movements of vehicles involved in pedestrian accidents by day and by night there seem to be relatively more vehicles involved while overtaking at night than in the day time as shown in TABLE 4.14.

4.70 TABLE 4.15 shows how the reduced visibility at night affects the ability of drivers to see pedestrians before impact.

4.71 No driver saw a pedestrian in the distance before impact at night. More drivers at night than in the day did not see the pedestrian at all. These factors may have some influence on the higher proportion of pedestrian accidents involving vehicles overtaking at night than in the day. The poor visibility increases the chances of the pedestrian not being seen as he steps from in front of the overtaken vehicle.

Street lighting

4.72 We recorded the type of street lighting at each night-time accident, and compared this with the distances at which the driver saw the pedestrian, as shown in TABLE 4.16.

4.73 The numbers in each group are not large enough to justify drawing conclusions from these data. In a study of the possible influence of street lighting, the details of each street lamp and its position in relation to the accident scene must also be included. Even then other variables, such as lighting from cars approaching the scene, and other sources, will need to be taken into consideration when making an evaluation of the role of street lighting in pedestrian accidents.

Travelling speed and speed at impact

4.74 Drivers' statements of their speed both before and at impact were treated with scepticism. By comparing the length of a skid mark with that of a test skid from a known speed in our station waggon we could estimate the true speed of the striking vehicle. If there were no skid marks we had to rely on witnesses (if any), the amount of damage to the car, and our impression of the veracity of the driver. Speeds were grouped at 10 m.p.h. intervals because we thought our estimates would be no more accurate than this. There is a 35 m.p.h.

TABLE 4.17

SPEED OF VEHICLES (M.P.H.)

	1-10	11-20	21-30	31-40	41-50	Reversing	Not Recorded	Total
Travelling Speed	6	13	23	23	3	1	10	79
Impact Speed	13	22	21	12	3	1	7	79

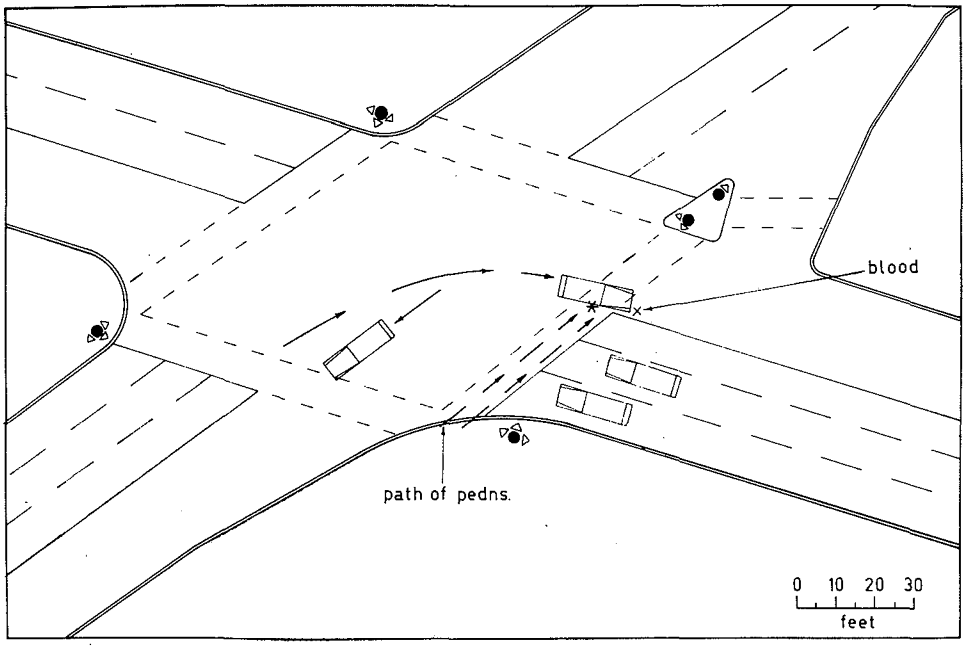


Fig. 4.12—Case 0165

speed limit throughout the metropolitan area.

4.75 The travelling speed and impact speed of all vehicles in the 79 pedestrian accidents are shown in TABLE 4.17. The peak of travelling speeds lies between the groups 21 to 30 m.p.h. and 31 to 40 m.p.h. However, at impact the peak is 10 m.p.h. lower, lying between the groups 11 to 20 m.p.h. and 21 to 30 m.p.h. This indicates that most vehicles slowed by an average of 10 m.p.h. before impact.

PEDESTRIAN CROSSINGS

4.76 Seven of the 79 accidents happened at or within 20 yards of a controlled pedestrian crossing. Only one of these crossings was entirely for the convenience of pedestrians. The accident at this crossing, which consisted of pedestrian-operated traffic lights, involved a boy who ran onto the crossing into the side of a car which had come from his right. Both the boy and the driver claimed to have had the green light.

4.77 There were three accidents at light-controlled intersections. One of these was caused by a driver who did not stop for the red light and hit, on the far side of the intersection, a boy crossing with the green light. Another accident (case 0165) involved a car turning right after slowing to allow a car to go by in the opposite direction (*Fig. 4.12*). The driver of the car did not see two women crossing the road with the 'walk' sign until it was too late to avoid a collision. The pedestrians were concussed and unable to remember whether they had seen the car. The third accident involved a pedestrian running across the road in a rainstorm. The driver of the car which hit this pedestrian claimed that he was travelling with the green light. The pedestrian was concussed. The first of these three accidents happened at midday, the second at night, and the third late in the afternoon.

4.78 There were also three accidents within 20 yards of light-controlled intersections.

These were all night-time accidents involving female pedestrians who were struck by vehicles leaving the intersection. In one case the vehicle was a bus which had come straight across the intersection and hit the pedestrian who was running across the road from the right. Another case was very similar, although the vehicle was a car and the pedestrian was crossing from the left in heavy rain. The remaining case also happened in heavy rain. The pedestrian, running across the road from the left, was struck by a van which had turned left at the intersection.

4.79 Four of these seven accidents were at night, and three happened in rain storms. These storms are not common in Adelaide, and the occurrence of three of these seven accidents at such times suggests that pedestrians choose to risk their lives rather than get wet.

4.80 At the time of this survey uncontrolled pedestrian crossing ('zebra' crossings) were not common in Adelaide. Some local authorities did provide unauthorized pedestrian crossings which were simply indicated by two parallel broken lines, 3 yards apart, painted across the road. *The pedestrian had no legal right of way on these unauthorized crossings.*

4.81 We attended three accidents in which the pedestrian was using such an unauthorized crossing. One of these was at night in the rain. We do not know the full story of this accident, because the driver of the car refused to offer any information and left the scene before the police arrived. The other two accidents each involved a pedestrian who was crossing from the left in front of a slowly moving vehicle and was struck by a car overtaking this vehicle at the crossing. Both these accidents happened in fine weather, one at night, the other late in the afternoon. One additional case involved a car which passed a vehicle that had stopped for pedestrians on the unauthorized crossing, and then struck a pedestrian who was crossing from the left a few yards along the road beyond the marked crossing.

4.82 Apart from the one case for which our information is incomplete, each accident on or near an unauthorized pedestrian crossing involved a car which was passing another vehicle that had slowed down to allow a pedestrian to cross the road. This suggests that these crossings, at which the driver is not legally required to stop, both confuse the motorist and give the pedestrian a false sense of security. The result may well be that such pedestrian crossings introduce additional hazards without removing those already present.

4.83 When initiating a programme for the protection of pedestrians it might seem reasonable to rely on accidents to indicate the most useful locations for pedestrian crossings. Our survey has shown that not all pedestrian accidents are relevant to the provision of a crossing. For example, a small child who has run onto the road and been hit by a car most probably would not have been influenced by the presence of a pedestrian crossing. A pedestrian who has had too much to drink and wanders carelessly across the road is unlikely to make use of a pedestrian crossing. Over half of the pedestrian accidents in our survey but outside the central City area are in this category. This is a sufficient proportion to give the impression that any pedestrian accident depends mainly on chance and not on the characteristics of the particular location. What then of the remaining accidents that cannot be attributed to carelessness on the part of the pedestrian?

4.84 We have separated suburban accidents from City accidents in this analysis because the Highways and Local Government Department has recently completed a series of counts of pedestrian and vehicular

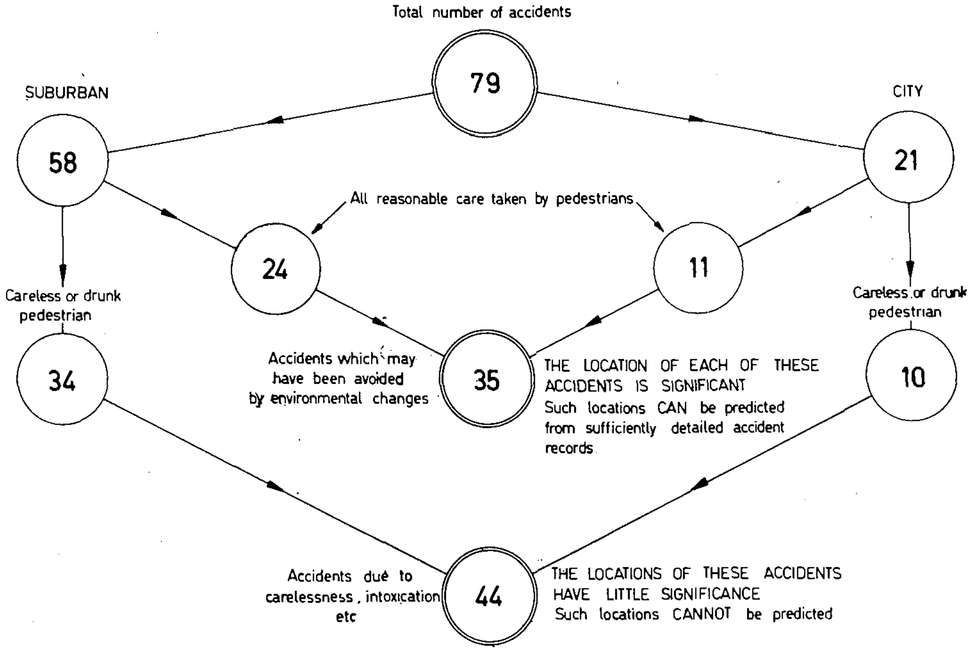


Fig. 4.13—Injury-producing pedestrian accidents (a 12 per cent sample of Adelaide accidents over 2 periods, 1963 and 1964)

traffic in the suburbs of Adelaide (the Adelaide City Council is responsible for traffic management in the City proper). Traffic conditions are among the many factors that must be considered before deciding whether or not to install a pedestrian crossing at any given location. We have also assigned responsibility for each pedestrian accident, as shown in *Fig. 4.13*.

4.85 Twenty-four of the 58 suburban accidents and 11 of the 21 City accidents involved pedestrians who were taking care and yet were struck and injured by a vehicle. At 14 of the 24 suburban locations the flow of vehicles is such that few pedestrians would be likely to go out of their way to cross the road at a marked crossing. At the remaining ten locations the volume of pedestrians and vehicular traffic is sufficient to suggest that a pedestrian crossing may be desirable. Of course, this does not necessarily mean that if crossings were in fact installed at these ten places we could expect a reduction in accidents of up to one sixth (10 cases in 58). This would be the maximum reduction possible. In practice it would probably be less, for many other factors are involved.

4.86 In fact the occurrence of accidents — or their absence — though very important is not the only criterion for the provision of pedestrian crossings. Ease, convenience and absence of anxiety for the pedestrian are also important. Just as it seems to be particularly dangerous to cross the road near but not at traffic lights (see para. 4.78) or an intersection (see para. 4.61), so it is likely to be more dangerous near but not on a pedestrian crossing. Under conditions of low traffic flows pedestrian behaviour may result in a pedestrian crossing introducing more hazards than it replaces, for pedestrians seem to study their own convenience rather than safety when crossing roads, and therefore are reluctant to walk even a short distance to the actual crossing unless heavy traffic makes it easier to use the crossing.

4.87 The above discussion is not to be taken as adverse criticism of the provision of pedestrian crossings, but rather as a warning that such a measure cannot be expected to be a 'cure-all' for this problem of pedestrian accidents. But the frequency of such accidents and the associated high injury and fatality rates do mean that even small reductions, such as would result from the installation of crossings, are very significant.

WHAT KIND OF ACCIDENTS DO PEDESTRIANS HAVE?

4.87 There were 82 pedestrians involved in 79 accidents. Of these:

- 63 were struck by cars
- 7 were struck by trucks and buses
- 7 were struck by motor cycles
- 1 was struck by a pedal cycle
- 4 were struck by cars with trailer.

4.88 In these accidents, pedestrians are injured in two ways. Firstly, by direct impact(s) with the striking vehicle, and secondly, by subsequent impacts with the road surface. The severity of the injuries will depend mainly on the shape and speed of the striking vehicle at impact, since these determine the number and severity of the multiple impacts which follow the initial impact. We now consider each group of accidents separately.

Pedestrians and cars with trailer

4.89 In two of the accidents involving cars with trailers the pedestrians were struck by the trailers. In the first, a 3-year old girl ran out from behind a truck into the right side of a trailer drawn by a utility travelling in the opposite direction at 11 to 20 m.p.h. (see *Fig. 4.14*). She sustained concussion, and abrasions to the back and arms. In the other case, a 22-year old man

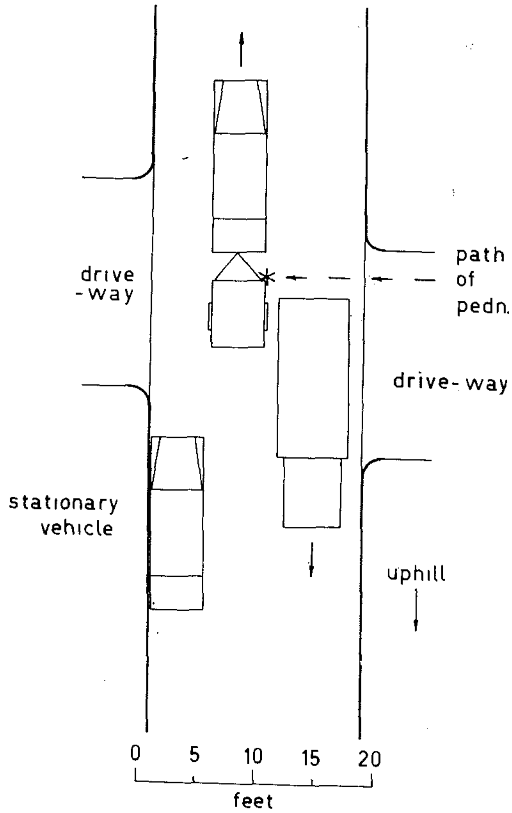


Fig. 4.14—Case 0092

was backing a car and a trailer piled high with empty packing cases out of a parking area and knocked down an 88-year old man, who passed completely under the trailer and halfway down the car. The pedestrian sustained many abrasions from the road surface and the under-parts of the car and trailer, but was otherwise unhurt. In another case, a 3-year old girl ran across the road from the right, was struck by the front of a Holden FJ utility drawing a trailer and passed under both utility and trailer, suffering a few abrasions on the way. In the fourth case, another 3-year old girl ran out from between parked cars into the left head light of a Ford Zephyr towing a trailer at 11 to 20 m.p.h. She sustained lacerations of the face and concussion. It

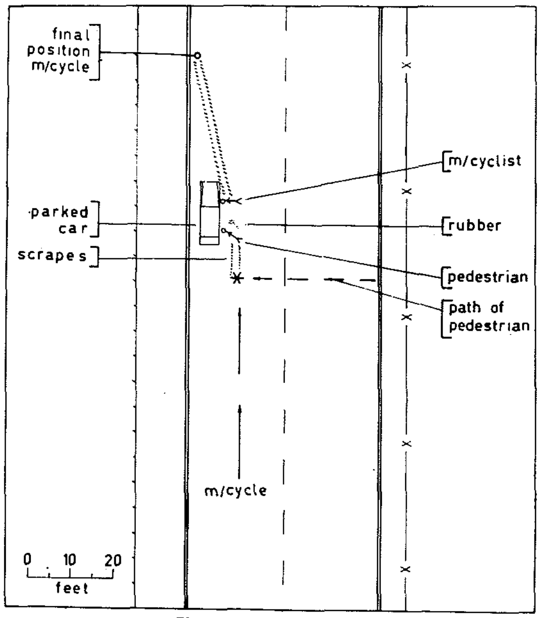


Fig. 4.15—Case 0424

seems remarkable that the three 3-year old girls should all run on to the road, all striking cars drawing a trailer.

Pedestrians and pedal cycles

4.90 There was only one collision between a pedestrian and a pedal cycle, i.e.

● **Case 0167**

A 60-year old woman walking from the right side of the road, diagonally, with her back to the traffic, was struck from behind by a pedal cycle ridden by a 16-year old boy who rode out of a gateway and turned on to the road without looking. The pedestrian suffered concussion and abrasions and a laceration to the right side of her head from contact with the road. She had a bruise on her right buttock which might have been caused by the bicycle.

Pedestrians and motor cycles

4.91 Six of the seven collisions took place in daylight, the other at night. All happened more than 20 yards from an intersection. Six of the pedestrians were coming from the left and one came from the right. One pedestrian was masked by a moving vehicle and one by a stationary vehicle.

4.92 There were five males and two females involved. One 73-year old woman died of complications. She received fractured ribs and an oblique fracture of the left tibia. Five of the seven pedestrians suffered concussion and abrasions and bruises to the head; one received fractured ribs. Abrasions to the arms and legs nearly always occurred.

4.93 There were three fractures of the lower leg. Two of these were oblique, involving the ankle region. These indicate that the main fracturing force resulted from torsion combined with bending and compression of the tibia by the body weight. In both of these cases the pedestrian and the motor-cycle were upright at impact. In the third case the motor-cycle was sliding on its left side and the under surface of the engine, gearbox and frame struck the left lower leg of the pedestrian, producing transverse fractures of the type associated with direct impacts.

4.94 From this it would seem that when a motor-cycle strikes a pedestrian, the front wheel goes to one or other side of the pedestrian's body. The headlight and handlebar strike the pedestrian at about buttock level, producing the torque which may produce an oblique fracture of the lower leg if the foot is fixed on the road. The foot may be fixed by body weight or perhaps by the front wheel of the motor-cycle passing over it at the same time as the handlebars strike the buttocks.

4.95 After the impact with the front of the motor-cycle, the pedestrian falls to the road, almost invariably striking his head and sustaining concussion, abrasions and lacerations as he rolls down the road. The motor-cycle rider falls with the machine, generally sustaining abrasions to his bony prominences. In one case (see *Fig. 4.15*) the motor-cyclist braked and skidded before impact. The motor-cycle struck the pedestrian while sliding on its side, and the motor-cyclist, who was wearing a helmet, almost simultaneously fell off and struck his head on the side of a parked car. He suffered concussion.

4.96 In summary: pedestrians struck by motor-cycles suffer bruises to the upper thigh and buttocks and fractures of the lower legs caused by the machine, and head injuries caused by impacts with the road. The rider of the motor-cycle generally suffers minor injuries from his fall to the road.

4.97 The vertical number plate on the front mudguard, required by law in South Australia, seemed not to cause anything more than minor injuries, for it bends out of the way if struck with any force.

4.98 There seems to be no obvious explanation for the failure of pedestrians to see motor-cycles. Presumably, if they did see the motor-cycle there would not have been an accident. It may be that the motor-cycle is smaller and therefore harder to see than a car, and when seen is closer. All except one accident happened in daylight, and only in two cases was there any obvious obstruction to vision. In one other case, the pedestrian was crossing the road diagonally with his back to the motor-cycle that struck him. Unfortunately, most of the pedestrians were concussed and were unable to remember whether they saw the motor-cycle before impact.

Pedestrians and trucks

4.99 We have included heavy utilities, trucks of all sizes, buses and vans in the category 'trucks'.

4.100 There were four male and three female pedestrians involved in accidents with trucks. They ranged from a boy of 5 to a woman of 85. There were two rather unusual cases.

● **Case 0187**

A man of 28 was seen to walk on to the road from the right of a Fargo utility. As the utility approached the man suddenly seemed to hunch himself down and charged into the front of the utility with his left shoulder. The driver of the utility braked and swerved to try to avoid a collision. Speed at impact was 11 to 20 m.p.h. The pedestrian struck the right front corner and headlight of the utility and was thrown forwards onto the road. He suffered concussion and fractured ribs on the left side, together with a haemo-pneumo-thorax. He was very depressed, and on psychiatric investigation was found to be psychotic.

● **Case 0237**

An inebriated 61-year old male staggered into the left side of a fire engine, which was travelling very slowly at the time. One of the crew leaned out and pushed him off; whereupon he fell down, dislocating his right shoulder and sustaining concussion.

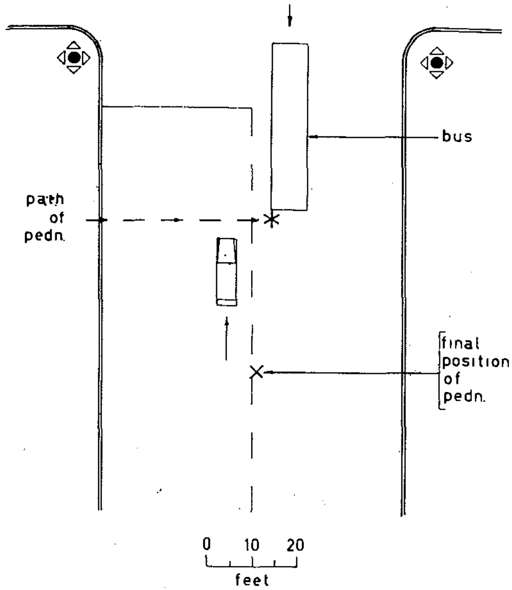


Fig. 4.16—Case 0389

4.101 Other accidents:
Two pedestrians were looking to the left as they stepped into the road, and were struck by buses coming from their right.
One pedestrian ran across in front of cars coming from her right and was struck by a bus coming from her left (*Fig. 4.16*). A small boy ran diagonally onto the road from in front of a parked truck, with his back to the Land Rover which hit him.
A Commer van turning left at traffic lights in heavy rain struck a woman coming from the left, just past the corner.
In these cases it seems that none of the pedestrians looked in the direction from which the vehicle was coming. Presumably, if they had looked, they would have seen the vehicles, which are all fairly large, and perhaps would not have tried to cross the road just then.

4.102 The injuries received were rather more severe than those sustained by pedestrians struck by motor-cycles, e.g.,

● **Case 0126**
An 85-year old woman died of cerebral complications 3 days after she was struck by a Volkswagen Kombi-Van. Her other injuries were fractured right ribs, a compound fracture of the right forearm and a disruption of an inter-vertebral disc in her cervical spine.
This was the only death among the seven pedestrians struck by trucks.

4.103 All these seven pedestrians suffered concussion, mainly through striking the road. One received a fractured skull from the front of a Commer van. Three pedestrians received fractured ribs, one with damage to the lung. These three were struck respectively by a Leyland bus, a Fargo utility and a Volkswagen Kombi-Van, at speeds between 11 and 30 m.p.h., and these injuries were directly caused by the fronts of the vehicles.

4.104 Three of the five injuries to the lower limbs were caused by the striking vehicles. The door hinge on a Volkswagen van lacerated the thigh of an 85-year old woman, the bumper and grille on a Commer van produced bruises on the calf and hip in a 69-year old woman, and a 55-year old woman had her left femur fractured when struck by a Leyland bus.

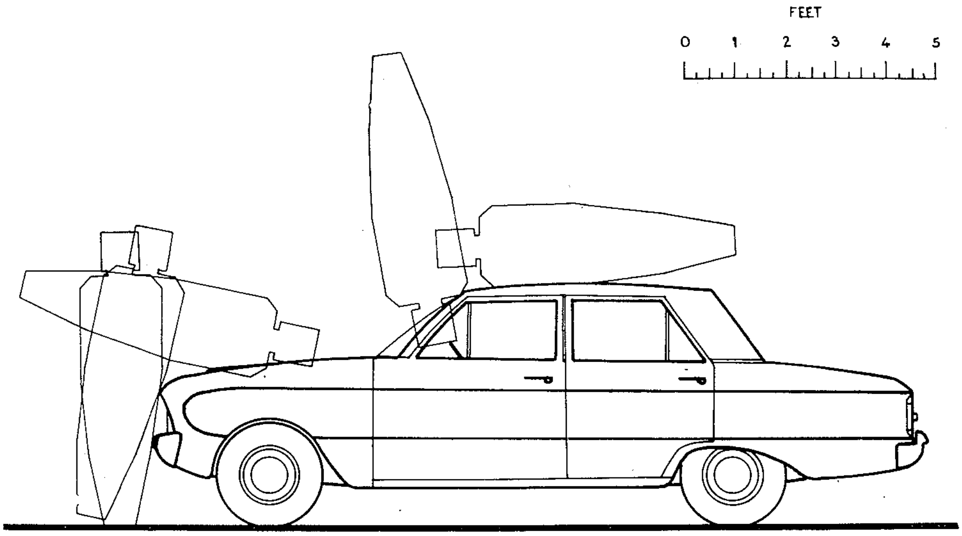


Fig. 4.17—Movements of an adult pedestrian struck by a Ford Falcon sedan

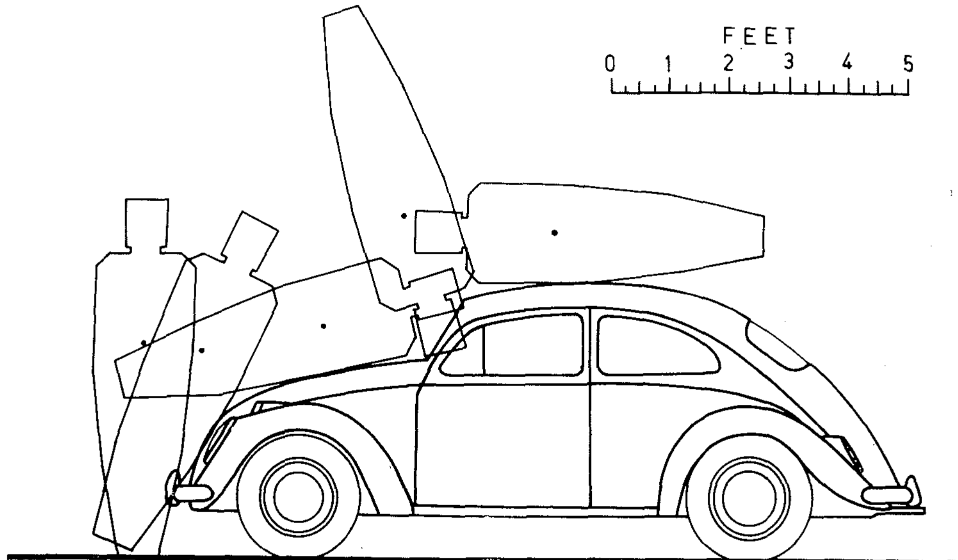


Fig. 4.18—Movements of an adult pedestrian struck by a Volkswagen

4.105 It appears that in collisions with trucks and buses most pedestrians injure their heads on the road. The impact with the vehicle causes most of the injuries to the rest of the body.

PEDESTRIANS AND CARS

4.106 There were 60 pedestrian-car accidents, involving 63 pedestrians and 61 cars. On three occasions one car struck two pedestrians and on one occasion one pedestrian was struck by two cars.

4.107 It has been seen that pedestrians when struck by motor-cycles and trucks suffer head injuries from striking the road, and injuries to the rest of the body from direct impact with the striking vehicle. This pattern is seen again when pedestrians are struck by cars.

4.108 Contrary to common belief, pedestrians are not 'run over' by cars but are 'run under'. The adult pedestrian, when standing or walking and struck by a car, is thrown in the air. This is because the pedestrian's centre of gravity is above the top of the bonnet of the car, and when the pedestrian's legs are knocked from under him his trunk stays approximately in the same place. Children and small adults, whose centre of gravity is below the top of the bonnet, are thrown forwards at impact with the car in much the same way as the adult is pushed forwards when struck by a bus.

4.109 There is of course a possibility of being run 'over', but this would seem to be when a body is actually lying on the road, e.g. after an accident, and is then struck by a car.

Movements of the pedestrian during impact

4.110 The sequence of events when a car strikes a pedestrian is shown in *Fig. 4.17* and *4.18* (assuming the pedestrian is an adult and is standing with one side towards the car). The initial impact is from the bumper bar, which strikes the lower leg. The effects of this impact for a given vehicle speed depend partly on the amount of body weight this limb is supporting at impact, and partly on the limb's own inertia. Almost at the same instant, but slightly later, the leading edge of the bonnet (hood) of the car will strike the hip of the pedes-

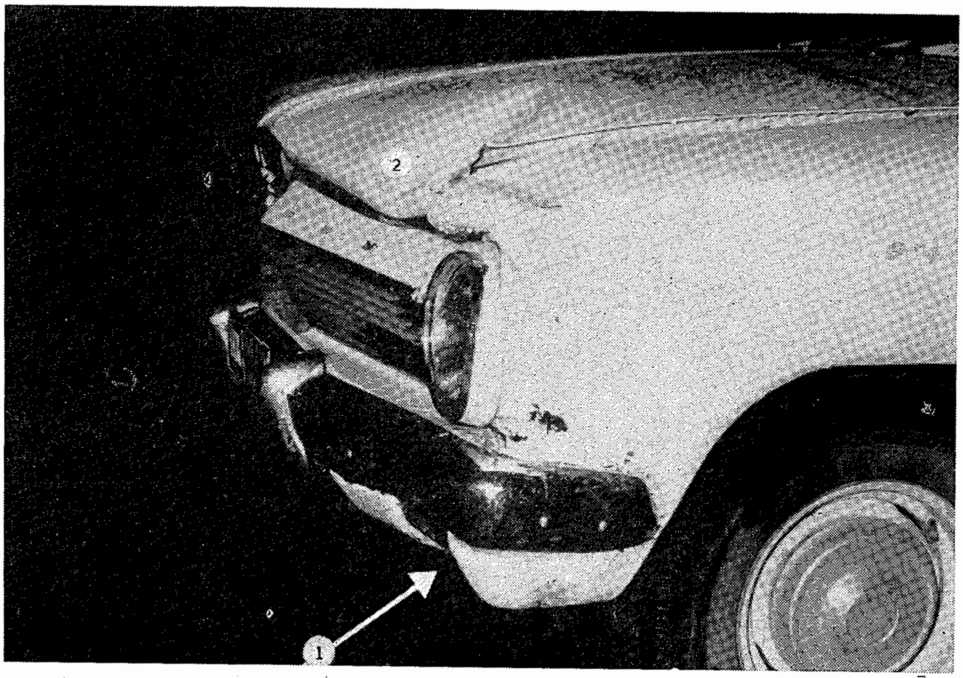


Fig. 4.19—Case 0105: Holden EJ versus pedestrian. Numbers show first and second impact points

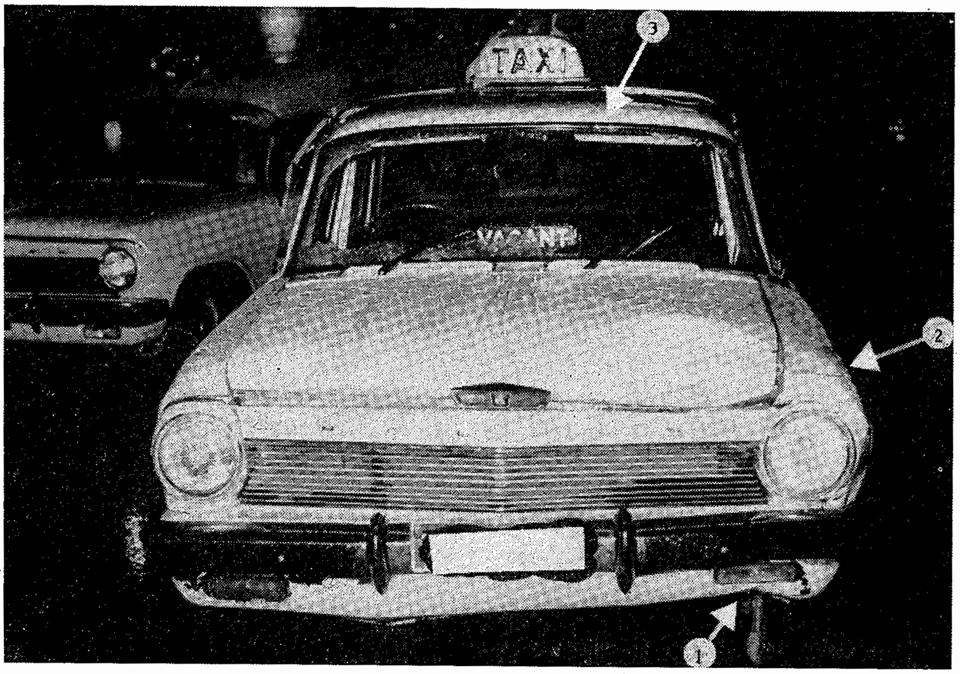


Fig. 4.20—Case 0105: Holden EJ versus pedestrian.
Note: 1. (First impact) smear on bumper, dent in metal beneath bumper
2. (Second impact) dents in edge of bonnet and headlight
3. (Third impact) broken windscreen, small dent in surround

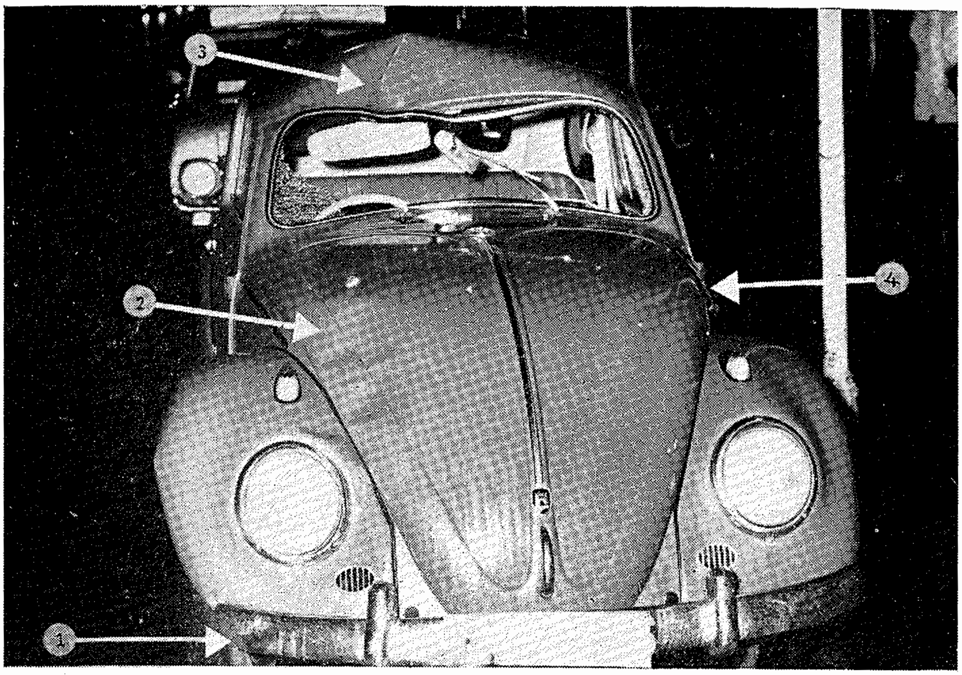


Fig. 4.21—Case 0414: Volkswagen versus pedestrian
Note: 1. Smears on bumper, which is pushed back against mudguard
2. Dent in bonnet and mudguard caused by pedestrian's hip
3. Dent in roof and broken windscreen caused by pedestrian's head
4. Radio aerial pushed forwards as pedestrians slid off roof onto road

Fig. 4.22—Case 0414: Volkswagen versus pedestrian. Arrow shows dent 5 in. deep in roof, produced by the impact of the pedestrian's legs (fourth impact point)

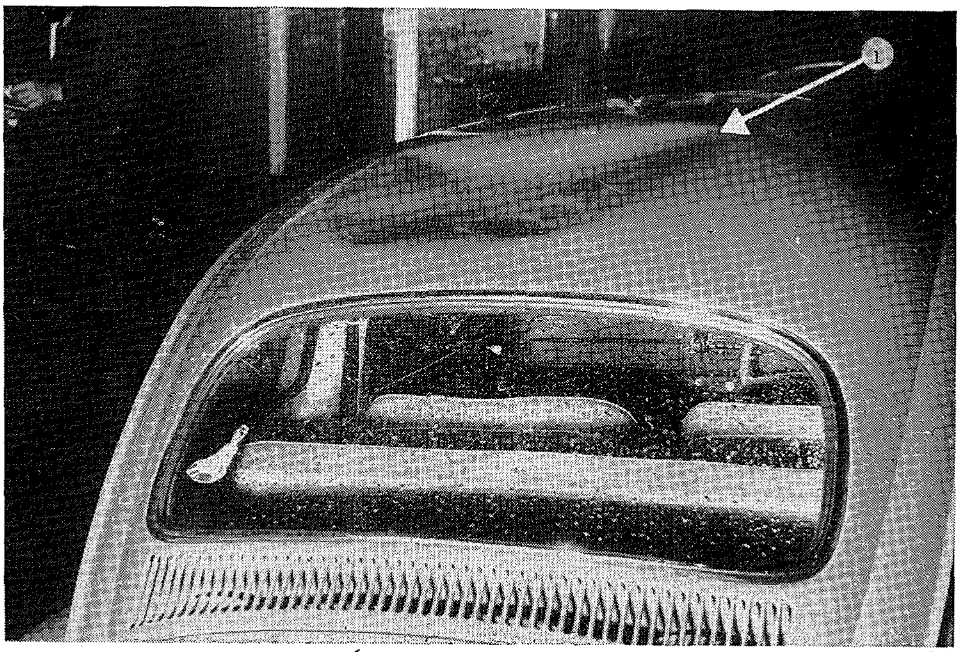


Fig. 4.23— Case 0414: Volkswagen versus pedestrian. Dent in rear of roof was probably produced by impact of pedestrian's legs (fourth impact point)

trian. The pedestrian then rotates about this secondary impact point until his head and chest strike the bonnet, windscreen and/or the windscreen surround. The higher the impact speed the further back along the car this third impact point will be (*Fig. 4.19* to *4.22*).

4.111 At still higher speeds the pedestrian now rotates about his head and shoulders, i.e. the third impact point. This can result in either a fourth impact with the car or in the car passing under the pedestrian, who then falls to the road. On this fourth impact with the car the pedestrian's legs strike the rear of the roof of the car. From this point, if the car does not slow down, the pedestrian, who is now travelling almost at the speed of the car, will fall to the road, either behind or on one side of the car. (*Fig. 4.23.*)

4.112 If the driver of the car should suddenly brake, the car will then slow down at a much faster rate than the pedestrian, who tends to continue forwards with undiminished speed, sliding over the roof and bonnet and then falling to the road in front of the car. He finally comes to rest after sliding and rolling along the road.

4.113 From this it appears that the pedestrian is subjected to a series of impacts to different parts of his body, culminating in a fall to the unyielding road surface from a height of between 3 and 5 ft, at a speed approximating the then travelling speed of the car.

4.114 This sequence of multiple impacts was worked out by observing characteristic marks on the car made by the pedestrian during his passage over it. There are dents, or brush marks in the dust on the bumper, headlight rims, and the edge of the bonnet. These often correspond to the injuries on the pedestrian's legs and hips. Dents, brush marks and scratches on the top of the bon-

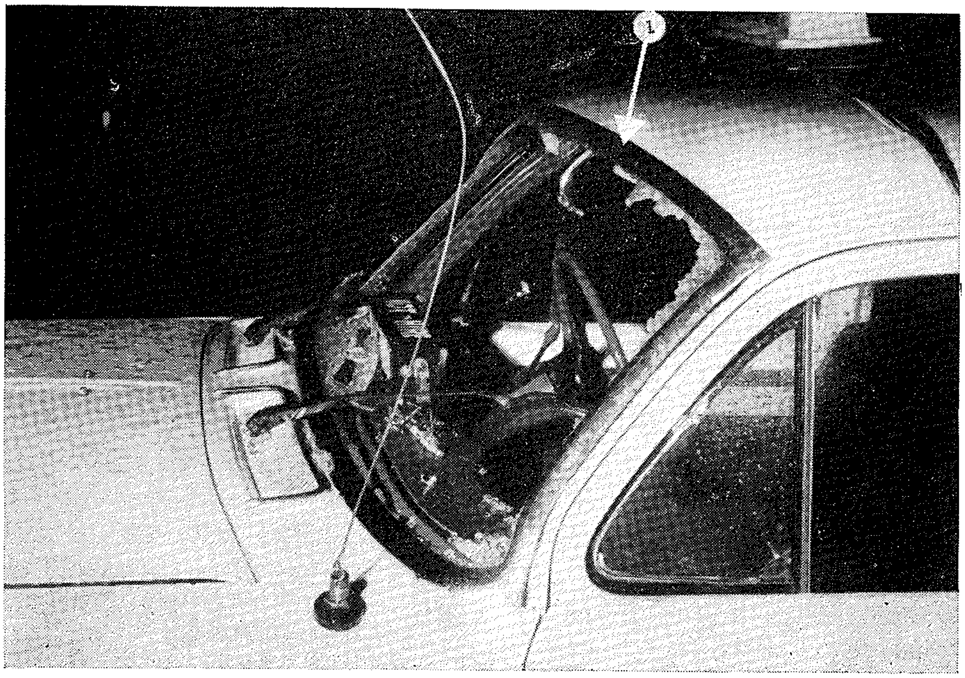


Fig. 4.24—Case 0105: Holden EJ versus pedestrian. Arrow shows third impact point.

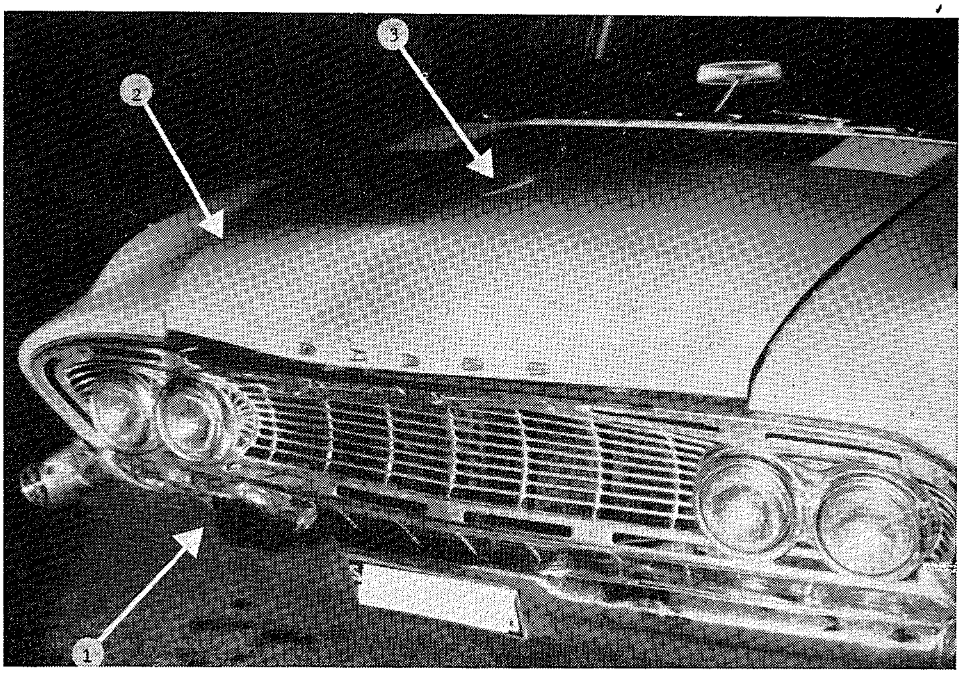


Fig. 4.25—Case 0316: Dodge versus pedestrian

Note: 1. (First impact) dents and smears on bumper
2. (Second impact) dent in bonnet and grill
3. (Third impact) dent in centre of bonnet produced by the impac of the pedestrian's elbow

TABLE 4.18

PEDESTRIANS STRUCK BY THE FRONT OF THE CAR

Farthest Point on Car Reached by Pedestrian	Impact Speed (m.p.h.)						
	1-10	11-20	21-30	31-40	41-50	Not known	Total
Not known	0	0	2	0	0	3	5
Roof	0	0	2(1)	3(1)	1(1)	0	6
Windscreen	1	3	2	1	1(1)	0	8
Top of bonnet	1	5	5(2)	2(1)	1	1	15
Pushed in front	4	2	2	2(1)	0	1	11
Total	6	10	13(3)	8(3)	3(2)	5	45

(Figures in brackets are number killed)

TABLE 4.19

PEDESTRIANS LESS THAN 15 YEARS

Farthest Point on Car Reached by Pedestrian	Impact Speed (m.p.h.)					
	1-10	11-20	21-30	31-40	41-50	Total
Roof	0	0	0	0	0	0
Windscreen	0	0	0	0	0	0
Top of bonnet	0	0	0	1(1)	1	2(1)
Pushed in front of car	2	1	2	2(1)	0	7(1)
Total	2	1	2	3(2)	1	9(2)

(Figures in brackets are number killed)

TABLE 4.20

PEDESTRIANS AGED 15 YEARS AND OLDER

Farthest Point on Car Reached by Pedestrian	Impact Speed (m.p.h.)					
	1-10	11-20	21-30	31-40	41-50	Total
Roof	0	0	2(1)	3(1)	1(1)	6(3)
Windscreen	1	3	2	1	1(1)	8(1)
Top of bonnet	1	5	5(2)	1	0	12(2)
Pushed in front of car	2	1	0	0	0	3
Total	4	9	9(3)	5(1)	2(2)	29(6)

(Figures in brackets are number killed)

TABLE 4.21

PEDESTRIANS VERSUS CARS — 63 PEDESTRIANS INVOLVED

Degree of Injury	Head and Neck	Thorax	Abdomen	Spine and Pelvis	Upper Limb	Lower Limb
Minor	9	4	5	0	24	33
Moderate	25	4	1	0	1	7
Severe	7	1	1	7	6	4
Very severe	1	1	2	3	1	11
Fatal	6	4	1	1	0	0
	48	14	10	11	32	55
Per cent injured to any degree	76.2	22.2	15.9	17.5	50.8	87.3

net indicate where the trunk and head hit. There may be grease marks from the head on the windscreen and surrounds; or if the windscreen is broken, there may be hair and skin on the jagged glass fragments retained in the frame (*Fig. 4.24* and *4.25*).

4.115 The driver was often able to recall part of the motion of the pedestrian on impact. Witnesses outside the vehicle could say little more than that the pedestrian was thrown into the air.

4.116 The progression of the furthest point reached by the pedestrian along the car as the impact speed rises is shown in TABLE 4.18.

4.117 It can be seen that there is a tendency for the pedestrian to strike further up the car with increasing speed. Relatively more pedestrians are pushed in front of the car, onto the road, at lower speeds than at higher speeds. The deaths occurred at speeds greater than 20 m.p.h. One pedestrian who died at home from a pulmonary embolus five days after being struck by a car is not included as a death in TABLE 4.18.

4.118 The influence of the size of the pedestrian on his motions during impact is seen if we construct tables similar to TABLE 4.18 for pedestrians aged less than 15 years, and those 15 years and older. The former group is considered to contain all children (see TABLES 4.19 and 4.20).

4.119 TABLE 4.20 for pedestrians aged 15 years and older shows that it is only below 20 m.p.h. that adult pedestrians are pushed forwards in front of the car. Above this speed they all fall onto the top of the bonnet and windscreen. Children, on the other hand (TABLE 4.19) are pushed forwards in front of the car at impact speeds of up to 30 m.p.h., after which they are rotated so that they strike the top of the bonnet. In the case of pedestrians aged less than 15 years their centre of gravity is below the top of the bonnet of the striking car, so that at impact they tend to be pushed forwards in front of the car. However, at higher speeds (more than 30 m.p.h.) inertia forces on the upper part of the pedestrian's body are greater and cause the pedestrian to rotate backwards, on to the top of the bonnet of the car. For adult pedestrians, whose centre of gravity lies at or above the level of the top of the bonnet, the inertia forces are sufficient to produce rotation towards the bonnet of the car at much lower impact speeds.

INJURIES

4.120 If we examine the injuries sustained by the 63 pedestrians struck by cars a definite pattern emerges. TABLE 4.21 shows the degree of injury sustained in each body area. All of the 63 pedestrians except one were injured to some degree. The exception was a 3-year old boy in a baby carriage. Although the carriage was damaged, the occupant was not. His mother, who was wheeling the carriage, suffered concussion and abrasions.

4.121 Nine of the 63 pedestrians were killed. There were 12 injuries listed, each of which, taken individually, would have been fatal. Two of the nine died of complications. The other seven died directly as a result of injuries received.

4.122 As can be seen, injuries to the lower limb are most numerous, followed by head injuries, injuries to the upper limb, thorax, spine and pelvis, and abdomen in that order. This distribution of injuries is consistent with the multiple impacts the pedestrian receives from the car and the road. The legs are struck first and bear the brunt of the initial impact. The head then swings over and is struck by the top of the car, the frame around the windscreen, or the windscreen itself. When the pedestrian falls on to the road the head will again suffer a severe impact.

TABLE 4.22

PEDESTRIANS VERSUS CARS — 63 PEDESTRIANS INVOLVED

Degree of Injury	Head and Neck	Thorax	Abdomen	Spine and Pelvis	Upper Limb	Lower Limb
Moderate to fatal	39	10	5	11	8	22
Per cent injured to this degree	*61.9*	*15.9*	*7.9*	*17.5*	*12.7*	*35.0*

4.123 More important than the total number of injuries to each body area is the severity of the injuries; for example, injuries to the head account for one half of the fatal injuries, and injuries to the thorax account for one third.

4.124 If we consider only injuries of moderate or greater severity, the figures for each body area are as shown in TABLE 4.22. The rather striking difference between this table and the previous one is important. Comparing the two tables we find that injuries to the head are second in number, but they are more severe than injuries to other parts of the body. An added factor is that any head injury may have an aftermath of headache, lost concentration and personality change which may last for months, to say nothing of the immediate danger to life involved in the injury.

4.125 Also of importance is the fact that four (28.5 per cent) of the 14 thoracic injuries were fatal. Evidently thoracic injuries (i.e. injuries to ribs, lungs, heart and large blood vessels), although not so common, are fatal nearly as often as head injuries.

4.126 Injuries to the abdomen and spine and pelvis are infrequent, but, when they occur, they tend to be severe and even fatal. Two of the 11 cases who fractured their pelvis also suffered a fractured spine and died as a result.

4.127 Injuries to the limbs — upper and lower — are mostly minor (57 of 87). These are abrasions, bruises, and lacerations of a superficial nature. The other 30 moderate, severe and very severe injuries are fractures of varying degrees of severity. These fractures, while not endangering life to a great extent, are nevertheless a source of great inconvenience and financial loss to the individual and the community. For example, a fracture of the lower leg prevents an injured person from working for at least 6 to 9 months.

4.128 Definite causes were assigned to the chief injury in each body area, where this was possible. Sometimes there was not enough evidence to fix the cause with any degree of certainty. The car was divided into specific areas for this purpose, e.g.

The front: includes bumper, grille, headlights and the front edge of the bonnet (or hood).

Top of the bonnet: from the leading edge of the bonnet back to the base of the windscreen frame. Includes the top of the mudguards on each side.

Windscreen and frame.

Side of the car: wheels, mudguards, doors and windows.

Other: anything not listed elsewhere.

Road surface: includes fixed objects, kerbs etc.

4.129 TABLE 4.23 sets out our findings.

4.130 Most (60 per cent) of the head injuries are produced by contact with the road. The front of the car was not found to be a cause of any head injury. The front of the car and the top of the bonnet produced most of the thoracic injuries. There were two thoracic injuries caused by the side of the car. The abdominal injuries were caused mostly by the front of the car, which also caused the majority of the pelvic injuries. The road and the top of the bon-

TABLE 4.23

PEDESTRIANS VERSUS CARS: CAUSES OF INJURY TO SPECIFIC BODY AREAS

	Head and Neck	Thorax	Abdomen	Spine and Pelvis	Upper Limb	Lower Limb	Total
Road	31(3)	1	2	—	9	9	52(3)
Front of car	—	3(1)	4(1)	9	4	41	61(2)
Top of bonnet or mudguard	2(1)	3(1)	3	2(1)	6	2	18(3)
Windscreen and frame	4(1)	—	—	—	—	—	4(1)
Side of vehicle	4	2(2)	—	—	4	1	11(2)
Other	2(1)	—	—	—	—	—	2(1)
N.R.	5	5	1	—	9	2	22
Total	48(6)	14(4)	10(1)	11(1)	32	55	170(12)

(Numbers in brackets indicate fatal injuries)

net caused most injuries to the upper limb, while the front of the car caused the vast majority of lower limb injuries. Fatal injuries have generally followed the same distribution of cause as that for all injuries.

4.131 Factors involved in determining the severity of injury in a particular collision between the pedestrian and a car are the height, age and possibly weight of the pedestrian, the point of impact with the car, the shape of the front of the car, and the speed at which the car is travelling at impact.

4.132 We have tried to determine the cause of each injury sustained by a pedestrian when struck by a vehicle. The two main groups of injuries are thoracic, pelvic and limb injuries caused by the direct impact of the vehicle, and head injuries caused by subsequent contact with the road surface.

SPECIFIC INJURIES TO EACH BODY AREA

4.133 We will now describe briefly the injuries to each body area sustained by all 82 pedestrians. In the tables given, each person was counted only once for soft tissue injuries in each area, e.g. once for face, and once for scalp injuries. Each skeletal injury was counted once; therefore there can be more skeletal injuries than persons.

Head injuries

4.134 Concussion was the most common single head injury, as shown by the following tabulation.

Head injuries to pedestrians (N = 82)

Superficial face injuries		40
abrasions	22	
bruises	7	
lacerations	11	
Skeletal face injuries		3
fractures of nose	1	
teeth	1	
zygoma	1	
Concussion		46
Superficial scalp injuries		39
abrasions	11	
bruises	5	
lacerations	23	
Fractures of the skull		8

There are about equal numbers of soft tissue injuries to the scalp and face, with the proportions of lacerations and abrasions being reversed in each case. There are more abrasions than lacerations of the face (*Fig. 4.26*), and more lacerations of the scalp than abrasions. There were only three fractures of the face, but eight fractures of the skull, five of these being associated with fatal head injury.

Injuries to the neck

4.135 No soft tissue neck injuries were recorded in any pedestrian. There were four injuries to the cervical spine in three cases. Three of these injuries were ruptures of the anterior spinal ligament, associated with

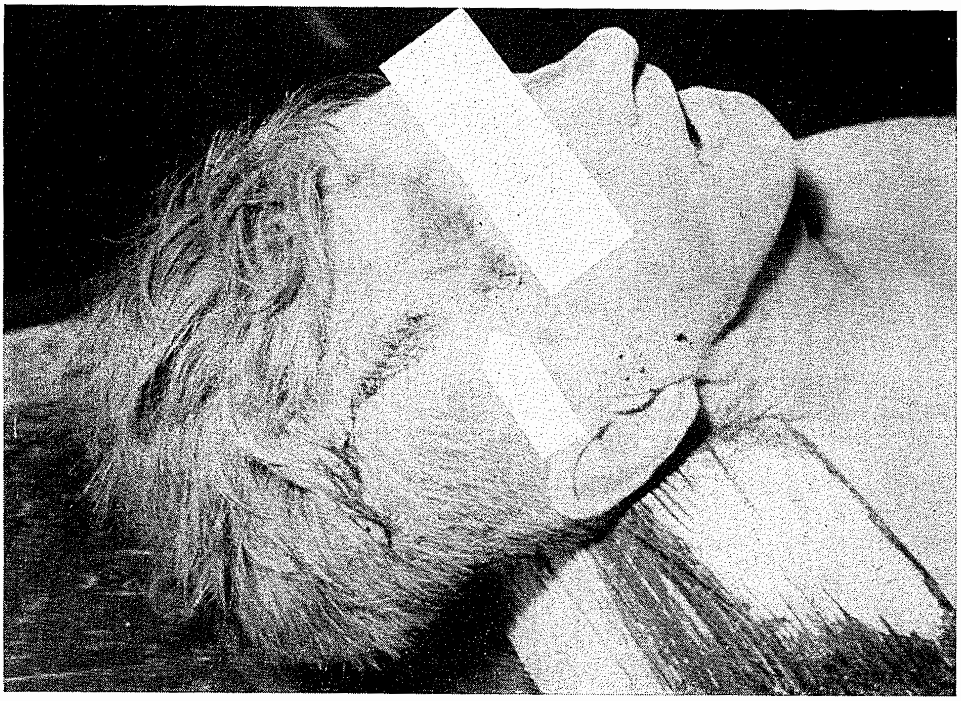


Fig. 4.26—Case 0234: abrasions to forehead by striking the road surface

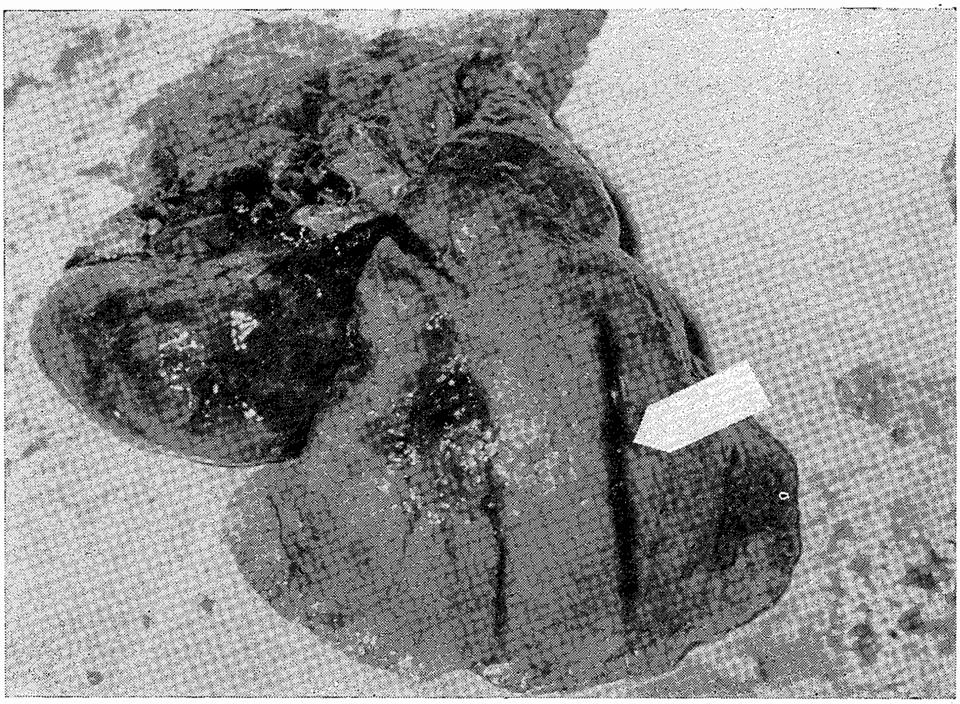


Fig. 4.27—Case 0234: lung showing bruises caused by ribs (arrow) with, just above, a laceration of the lung substance

disruption of the intervertebral disc with no apparent damage to the spinal cord. These injuries appear to have been due to an extreme degree of extension of the cervical spine, associated with some torsion. The intervertebral discs concerned were C5/6, C6/7 and C7/T1. In the last case there was also a complete dislocation of the atlanto-occipital joint with transection of the spinal cord. All these three victims died. The fourth case involved a man aged 40 years who suffered an injury to his brachial plexus at about C7. He showed signs of denervation of his triceps, but survived. (These neck injuries were included in the group 'spine and pelvis' in TABLE 4.21.)

Injuries to the thorax

4.136 These were mostly fractured ribs, with and without associated injuries to the lungs, heart and great vessels.

Superficial injuries		8
abrasions	3	
bruises	5	
Skeletal injuries		12
fractured clavicle	2	
fractured scapula	1	
fractured ribs alone	4	
fractured ribs and internal injury	5	
Internal injuries		9

The lungs were injured in all nine cases of internal injury (*Fig. 4.27*). The heart and great vessels were injured in three of these cases, including two instances of rupture of the aorta.

4.137 Of the nine persons with fractured ribs, only one was aged less than 55 years. The four persons with internal thoracic injuries without rib fractures were aged 6, 13, 19 and 54 years respectively. This suggests that the incidence of rib fractures in thoracic injury depends more on the age of the person concerned than on the magnitude of the impact force. Ribs in the elderly are brittle and easily broken.

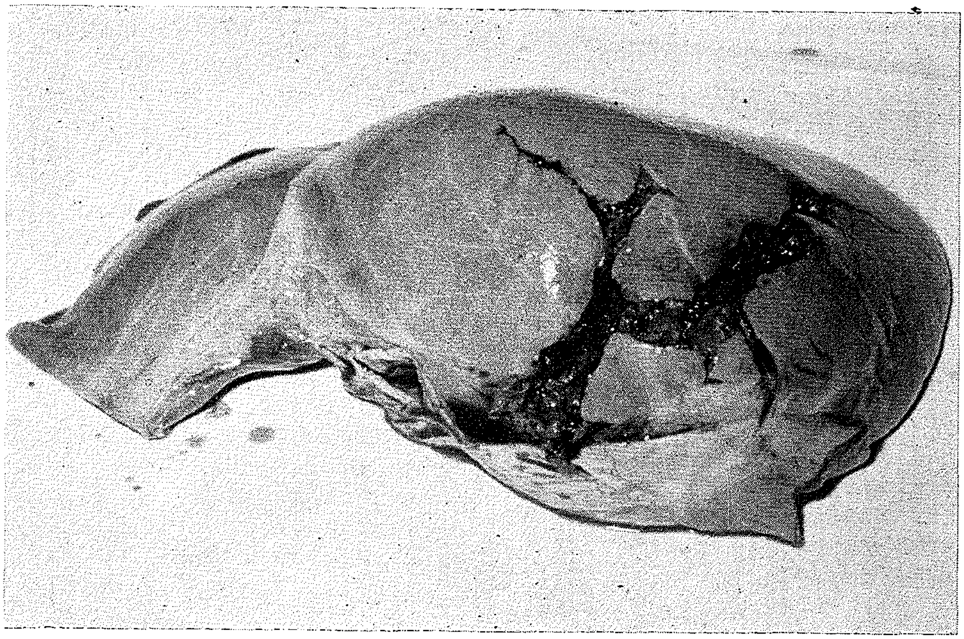


Fig. 4.28—Case 0234: extensive lacerations to the right lobe of the liver

Fig. 4.29—Case 0234: disruption of the inter-vertebral disc between the third and fourth thoracic vertebrae

Injuries to the abdomen

4.138 There were five cases with bruises and abrasions to the lumbar region, and five superficial injuries to the front of the abdomen, over the bony iliac crests. Internal abdominal injuries occurred in six cases (*Fig. 4.28*). The injuries are tabulated as follows:

Injury to the spleen		5 cases
haematoma	1	
laceration	4	
Injury to the liver		2 cases
bruise	1	
laceration	1	
Bruise of duodenum and pancreas		1 case

In all six cases the injured persons died, the abdominal injuries contributing towards their deaths.

Injuries to the thoracic and lumbar spine

4.139 There was one case with a ruptured intervertebral disc between T3/4 (*Fig. 4.29*) and one case of crush fracture of the body of T10. Both of these pedestrians also sustained many severe injuries to all body areas.

Injuries to the pelvis

4.140 Eleven pedestrians (of whom six died) suffered fractures of the pelvis. Six cases received fractures of the pubic bones (rami and body). In three cases there were fractures of the acetabulum, of which two were associated with fractures of the pubis, and one with fractures of pubis and ilium. There were two cases of fracture through the sacrum, one at S3/4, and the other at S4/5. This latter fracture was associated with dislocations of both sacro-iliac joints. Consideration of these cases suggests that where the impact is from the side, applied to the pelvis through the head of the femur, fractures first appear in the pubic rami on the side on which the impact takes place.

Injuries to the upper limb

4.141 These injuries are summarized as follows:

Soft tissue injuries		29
abrasions	15	
bruises	11	
lacerations	3	
Dislocations of shoulder		2
anterior	1	
sub-coracoid	1	
Fractures of the humerus		4
surgical neck	1	
upper end	2	
lateral epicondyle	1	
Fractures of the lower arm		7
midshaft of ulna (compound)	1	
upper third of ulna with dislocation of head of radius	2	
midshaft of radius and ulna	1	
lower end of radius	1	
metacarpals	2	

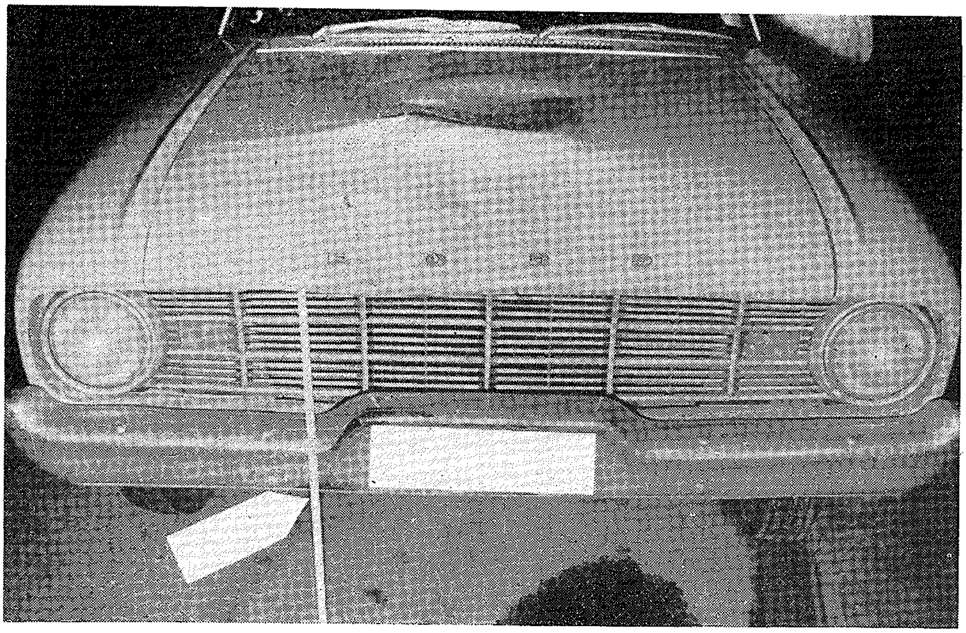


Fig. 4.30—Case 0131: brush marks on bumper bar (arrow) from impact with pedestrian's legs. Dents in bonnet produced by pedestrian's head and trunk

The fractures of the lower arm seem to be due to direct blows, while the fractures of the upper humerus and the dislocations are possibly due to impacts in the longitudinal axis of the humerus, as in falling on the extended arm.

Injuries to the lower limb

4.142 There are many fractures of the lower limb, as shown in the following tabulation:

Soft tissue injuries			48
abrasions		26	
bruises		17	
lacerations		5	
Skeletal injuries			27
Fractures of the femur		6	
midshaft	3		
trochanteric	3		
Fractures of the tibia		15 (4 compound)	
Fractures of the fibula		2	
Fractures of the ankle		2	
Dislocation of the ankle		2	

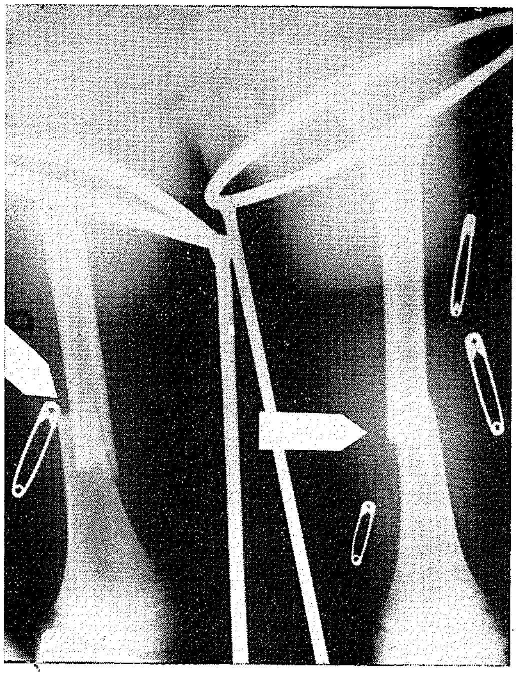


Fig. 4.31—Case 0131: X-ray showing fractures of both femurs

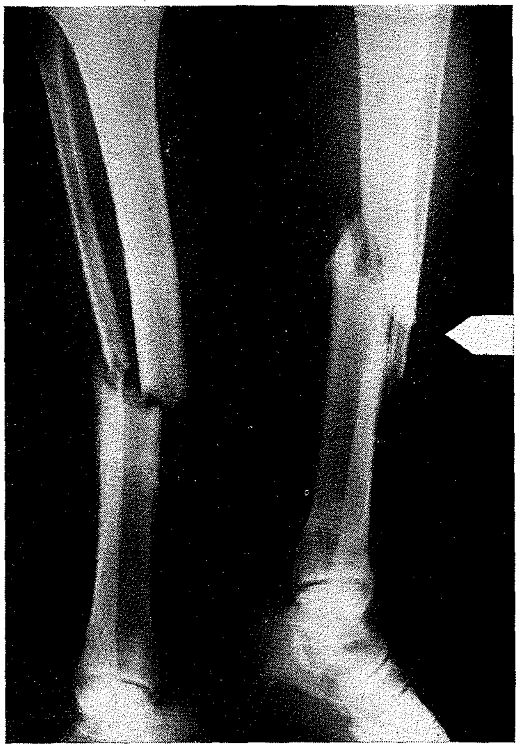


Fig. 4.32—Case 0276: X-ray showing fractures of both tibiae

One 9-year old boy was struck by a Ford Falcon (*Fig. 4.30*) and received midshaft fractures of both femurs (*Fig. 4.31*). Two of the trochanteric fractures were associated with fractures of the pelvis. There were two cases with bilateral fractures of the tibia (*Fig. 4.32*). Both survived. Most of the tibial fractures were at or about the height of the bumper when the pedestrian was struck by a car. Glancing blows from the corners of cars, or collisions with motorcycles often produce dislocation of the ankle or oblique or spiral fractures of the lower tibial shaft.

INJURY POTENTIAL OF MAKES OF CAR

4.143 Obviously little can be done to alleviate injuries caused by being thrown along the road. We believe that there is much that could be done to reduce the severity of injuries caused by the striking vehicle itself.

4.144 There may be some shapes of the fronts of cars which are less likely to injure pedestrians than are other shapes. For example the Volkswagen 1200 has a gently sloping front compared with that of the Ford Falcon. Is the Volkswagen 1200 kinder to pedestrians? To seek an answer to this we studied all pedestrian accidents in the following category, viz: the striking vehicle was a passenger car and the point of impact was across the front of the car only; that is, we excluded cases in which the pedestrian was brushed by the side of the car, and we also excluded pedestrians under the age of 15 years. This last exclusion was made to ensure some order of consistency in the height of the pedestrians. As noted above, children, being shorter than adults, are thrown forwards by the car rather than upwards. This left us with 32 cases from the total sample of 79 cases. In one of these 32 cases two pedestrians were struck by the same vehicle. One of these two was a child and was therefore excluded. It is unlikely that the fact that two pedestrians were struck by the one vehicle will have had any significant effect on the injuries sustained.

4.145 Care has been taken to ensure that the injury severity assigned to each pedestrian relates to the injuries due only to impact with the car. This has resulted in the reduction of some injury ratings from 'fatal' to 'very severe', in cases when death has been primarily due to causes other than injuries sustained in the accident.

4.146 The 32 cars have been grouped according to the shape of the front of the car. This also means grouping according to make and model. The only models that occur often enough in these 32 cases to be considered as a group are the Ford Falcon and the Volkswagen 1200. This has enabled us to compare the injury potential of

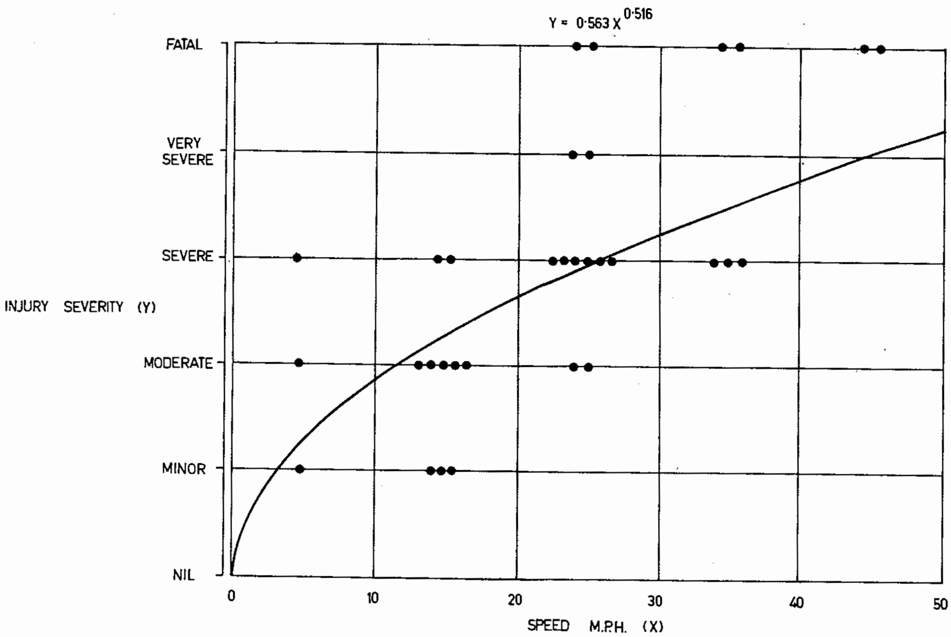


Fig. 4.33—Pedestrian injury severity by speed of striking car: 32 cases of frontal impact with adult pedestrians

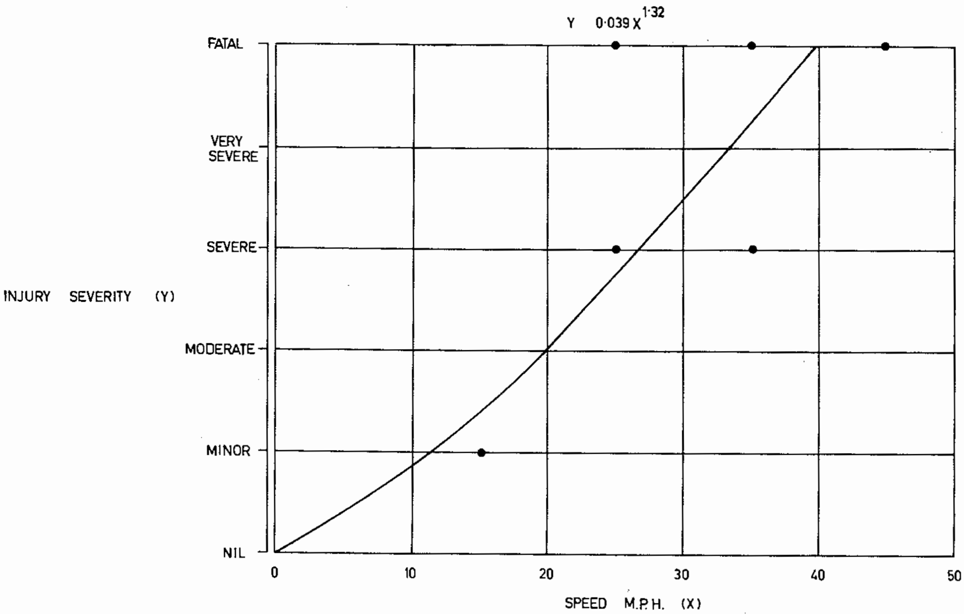


Fig. 4.34—Pedestrian injury severity by speed of striking car: 6 cases of frontal impact by Volkswagen 1200 with adult pedestrians

these two models, the fronts of which are of very different shapes. Logarithmic regression analyses were performed to find the line of best fit and also to test for significant variations of form. Rating injury severity in five stages from minor through to fatal, and grouping speeds in 10 m.p.h. intervals, the curves shown in *Fig. 4.33, 4.34* and *4.35* result. The whole 32 cases taken together show the expected increase in injury severity with increase in impact speed (*Fig. 4.33*). The curves for the Falcon and the Volkswagen 1200 have significantly different slopes (see Appendix C). The injury-producing potential of the Falcon is moderate at even very low impact speeds, but does not increase greatly with increasing speed up to the end of the range covered by our data, viz. 30 m.p.h. The injury-producing potential of the Volkswagen 1200 is almost directly related to the impact speed. The information shown in *Fig. 4.34* and *4.35* can be expressed thus: (a) below 20 m.p.h. a Falcon is more likely to injure a pedestrian seriously than is a Volkswagen 1200; (b) in the speed range 20 to 25 m.p.h. the injury-producing potential is the same for each of these two cars; (c) above 25 m.p.h. the Volkswagen 1200 will probably cause more serious injuries than the Falcon. In fact, *Fig. 4.34* suggests that the Volkswagen 1200 will usually inflict fatal injuries at impact speeds greater than 40 m.p.h. We emphasize that *Fig. 4.35* should not be taken to mean that a Falcon will not also inflict fatal injuries at similar speeds.

4.147 The differences between the two cars in producing injuries are most apparent at low speeds and depend on the dimensions of the vehicles and of the pedestrian. When a standing adult pedestrian is struck by a Volkswagen 1200 the initial point of impact is the bumper, which strikes below his knees. The impact point is a considerable distance below his centre of gravity, which is about the height of his navel. At low speeds his legs are pushed from under him,

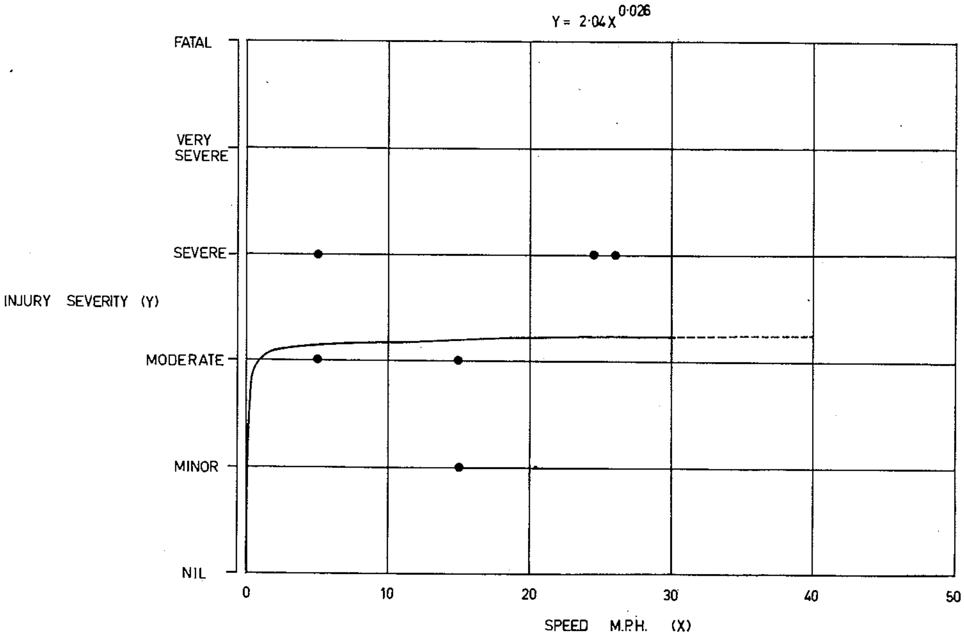


Fig. 4.35—Pedestrian injury severity by speed of striking car: 6 cases of frontal impact by Ford Falcon with adult pedestrians

and his trunk and head rotate downwards, striking the bonnet. If his height and the speed of the car are great enough, he will strike his head and shoulders on the area of the car body around the windscreen.

4.148 However, if the same pedestrian is struck by a Falcon there are important differences in his movements. The initial impact point is again the bumper. But now the bumper is higher, close to the knee joint itself. Almost simultaneously the pedestrian is struck on the hip by the front edge of the bonnet. This second and higher impact point is only just below the centre of gravity of the pedestrian. At low impact speeds he is pushed forwards bodily by the car, falling to the road. This series of movements is markedly different from that produced by impact with a Volkswagen 1200, where the pedestrian falls back on the car.

4.149 At higher impact speeds a pedestrian hit by a Volkswagen 1200 will strike his head on the windscreen and roof, causing severe injuries. The higher impact speed will also cause severe lower leg injuries. When a pedestrian is struck by a Falcon at the higher speeds he suffers severe lower leg injuries (from the bumper) and severe injuries to the pelvis (from the front of the bonnet). He is not pushed forwards on to the road, but his trunk and head rotate towards the car and strike the top of the bonnet, the point of impact of the hips and front of the bonnet acting as a pivot. The pedestrian's head does not strike the windscreen, for the distance from the front of the bonnet is greater than the length of his trunk and head.

4.150 At still higher speeds both the Volkswagen and cars of a similar shape to the Falcon hurl the pedestrian upwards, allowing him to be struck by the area around the screen and even by the roof of the car (*Fig. 4.20, 4.21*). The pattern of injuries to the pelvis and lower limbs is as described above, but severe head injuries become common. In these cases it is exceptional for the pedestrian to survive.

4.151 We are not primarily concerned here with a quantitative assessment of the data presented. We are attempting to show that the shape of the front of the car determines the nature and severity of injury to a pedestrian for a given impact speed. It is not enough merely to demonstrate this variation. With a larger amount of data it would be possible to describe the frontal shape of a car that will inflict minimal injuries when it strikes a pedestrian.

WHAT KIND OF DRIVERS HIT PEDESTRIANS?

4.152 TABLE 4.1A (in Appendix A) shows the age and sex distribution of drivers of vehicles which struck pedestrians. The distribution is very similar to the age distribution of drivers involved in other types of accidents, i.e. there is a peak at age 20 to 24 and a gradual fall to age 75. There were eight female and 72 male drivers. There were only four drivers obviously affected by alcohol — all males, two in the 20 to 24 age group, one in the 30 to 34, and one in the 45 to 49 age group. These drivers involved in pedestrian accidents do not seem to be very different from the other accident-involved drivers in our survey.

WHAT HAPPENS TO THE PEDESTRIAN AFTER THE ACCIDENT?

4.153 We found in our first 200 accidents that pedestrians are injured more often and more severely than other classes of participants in road accidents. The second 208 accidents confirmed this. The 82 pedestrians suffered injuries as follows:

Nil	1
Minor	14
Moderate	29
Severe	19
Very severe	8
Fatal	11

4.154 Consequently most of them were admitted to hospital, as the following tabulation shows:

No treatment	5	6.1%
Casualty treatment only	10	12.2%
Admitted and later discharged	57	69.5%
Admitted, died in hospital	6	7.4%
Dead on arrival at hospital	1	1.2%
Dead at scene	3	3.6%
Total	82	100.0%

One person was admitted and discharged after 24 hours and died five days later at home, as a result of injuries received in the accident. This makes a total of 11 pedestrians killed in our sample of 82 (13.4 per cent).

4.155 The length of stay in hospital of those admitted and discharged was:

Less than 24 hours	14
1- 2 days	8
3- 5 days	10
6-10 days	3
11-15 days	5
16-20 days	1
21-25 days	2
26-30 days	1
30+ days	13
	57

The mean length of stay was 11 days.

4.156 Twenty-five persons stayed longer than six days, i.e. 44 per cent or nearly half of those admitted spent a week or more in hospital. This means that 35 per cent of pedestrians involved in an accident, and who are not killed, spend a week or more in hospital. This places a considerable burden on the hospitals in the city.

WHAT CAN BE DONE TO REDUCE THE NUMBER OF PEDESTRIAN ACCIDENTS?

4.157 Roads are dangerous places for pedestrians who use them (as it may seem) only on sufferance from motor vehicles. Except at legally designated crossings pedestrians, in practice, have no right of way, even though they feel that the drivers of motor vehicles should have some consideration for them. Therefore the commonest way to cross a road is by threading a perilous passage through lines of moving vehicles, the drivers of which take little account of the wishes or welfare of pedestrians who are intruding on their domain. The successful completion of this task requires a sharp eye, sobriety, experience, sound judgement of relative speeds, awareness of possible sources of danger and strong and supple limbs. The lack of any of these characteristics increases the pedestrian's chances of disaster while crossing a road.

4.158 This is illustrated by *Fig. 4.5,* which shows the number of pedestrians in each age group in our sample, compared with the number of the general population. The rate is elevated in childhood where judgements of speed and awareness of danger are perhaps not well developed. The rate falls to a minimum at ages 20 to 29, where presumably all the above characteristics are at a maximum. The rate then rises steadily through the middle years where mind and sight are often clouded by alcohol, to old age where vision and judgement are becoming uncertain, the preoccupied mind is perhaps not so aware of danger, and the body is not so quick to respond as it was.

4.159 Therefore, of the three main groups of people who together form the majority of those pedestrians involved in accidents, we can hope for education to have some effect on children, and possibly on elderly adults. It is doubtful whether education alone will reduce the number of inebriated pedestrians in our city. However, as large sums are now spent to persuade people that drinking and driving do not mix, it is just as logical to point out that there are similar hazards associated with walking in traffic after drinking.

4.160 Most of the children involved as pedestrians in accidents were running across the road. It is therefore particularly important that children should be taught to take great care when crossing roads. It would not be unreasonable to teach a child to take as much care when crossing a road as when crossing a railway line. At times of heavy traffic young children should not be expected to cross roads unaided, for such a task can be dangerous even for an adult.

4.161 The third group, elderly pedestrians, need to be reminded that the roads of today demand much more respect from the pedestrian than did the roads of thirty years ago. It is not safe to assume that drivers will see a pedestrian. Nor is it reasonable to assume that, even if they do see the pedestrian, they can avoid hitting him, either by braking or by passing to one side. We suspect that many elderly pedestrians, who may perhaps never have driven a car, have little understanding of the considerable distance that is needed for a car to stop from even 30 m.p.h.* This is also unfortunately true of many drivers.

4.162 Pedestrians of all ages would minimize risks to themselves if they observed comparatively simple precautions such as ensuring that the road is clear, in both directions, before they leave the footpath. It is dangerous to have to wait in the middle of the road.

4.163 The driver may also be assisted by a clearer understanding of the more common actions which endanger pedestrians, such as overtaking another vehicle. The pedestrian can appear almost instantaneously from in front of an overtaken vehicle, whether it be moving or stationary. It is even more tragic when pedestrians who are standing in the centre of the road waiting for the traffic to pass are hit by a driver who pulls out to overtake the car in front without ensuring that it is safe to do so.

4.164 Apart from education, efforts to safeguard pedestrians can concentrate on separating them from vehicular traffic by either complete separation of their paths, e.g. subways, bridges, or to a lesser degree, refuges, or by allocating each type of traffic right of way at separate times. Partial physical separation can be achieved by installing a median strip. This separates pedestrians from vehicles only while the pedestrian is on the median, but it greatly reduces the risk of a pedestrian being struck by a vehicle when he is standing in the centre of the road. (Such cases accounted for one seventh of all pedestrian accidents in our survey.)

4.165 The benefit of a median strip extends beyond direct protection to pedestrians who are 'stranded' in the centre of the road. It also more than halves the effective road width on which the pedestrian must concentrate at any one time. He is further aided by the fact that each half of the roadway now carries one-way traffic. The pedestrian then has to concentrate on traffic coming from only one direction at a time and over a shorter distance. The pedestrian benefits even further because a median strip controls vehicles performing U turns, a manoeuvre which can confound even the most alert pedestrian.

4.166 Pedestrian crossings separate pedestrian and vehicular traffic in time by allotting each right of way at different times. We have mentioned some of the factors relating to the provision of pedestrian crossings in para. 4.76 et seq.

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*In 'locked wheel' skids from 30 m.p.h. our test vehicle, a Ford Falcon, skidded a distance that was never less than 11 yd and once was as great as 22 yd, on dry clean bitumen.

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4.169 Pedestrian crossings separate pedestrian and vehicular traffic in time by allotting each right of way at different times. We have mentioned some of the factors relating to the provision of pedestrian crossings in para. 4.76 et seq.

4.170 In summary, the most promising methods of attempting to reduce pedestrian accidents seem to be education, especially of children, in safe road-crossing techniques, the provision of median strips, and the installation of pedestrian crossings. The injuries sustained in the accidents could be reduced by modifying the shapes of the front of cars.

5.1 We attended 44 accidents involving 44 pedal cyclists. This is 11 per cent of the 408 accidents which we studied. Because the total number of cyclists in the metropolitan area is unknown, we cannot say what fraction of them are involved in accidents. The locations of these accidents are shown in *Fig. 5.1,* and it may be seen that all except two occurred in the suburbs and not in the city proper.

5.2 An accident between a tricycle and a semi-trailer, case 0078, is not included in these 44 pedal cycle accidents.

● Case 0078

A 3-year old boy was riding a child's tricycle on a footpath when he collided with the rear wheel of a semi-trailer which was coming out of a driveway. The child fell to the ground and received concussion and abrasions to the head.

AGES OF CYCLISTS INVOLVED IN ACCIDENTS

5.3 *Fig. 5.2* shows the age distribution of the cyclists whose accidents we studied. There is a marked peak in the 10 to 14 years age group. Twenty-six, or more than half, of the cyclists were less than 20 years old. This histogram does not represent the relative degrees of accident liability for each age group. We do not have any information on the age distribution of all cyclists in the metropolitan area, or on the length of time each age group spends cycling on the road. Without this information we cannot calculate a cyclist's risk of being involved in an accident. The inability to calculate these risks of involvement, of which this is merely one example, bedevils all serious quantitative studies of accidents. Almost all the cyclists were males, there being only four females in the 44 cases. As far as we were able to judge, alcohol is not often a factor directly affecting cyclists. Only one cyclist had obviously been drinking before being involved in an accident.

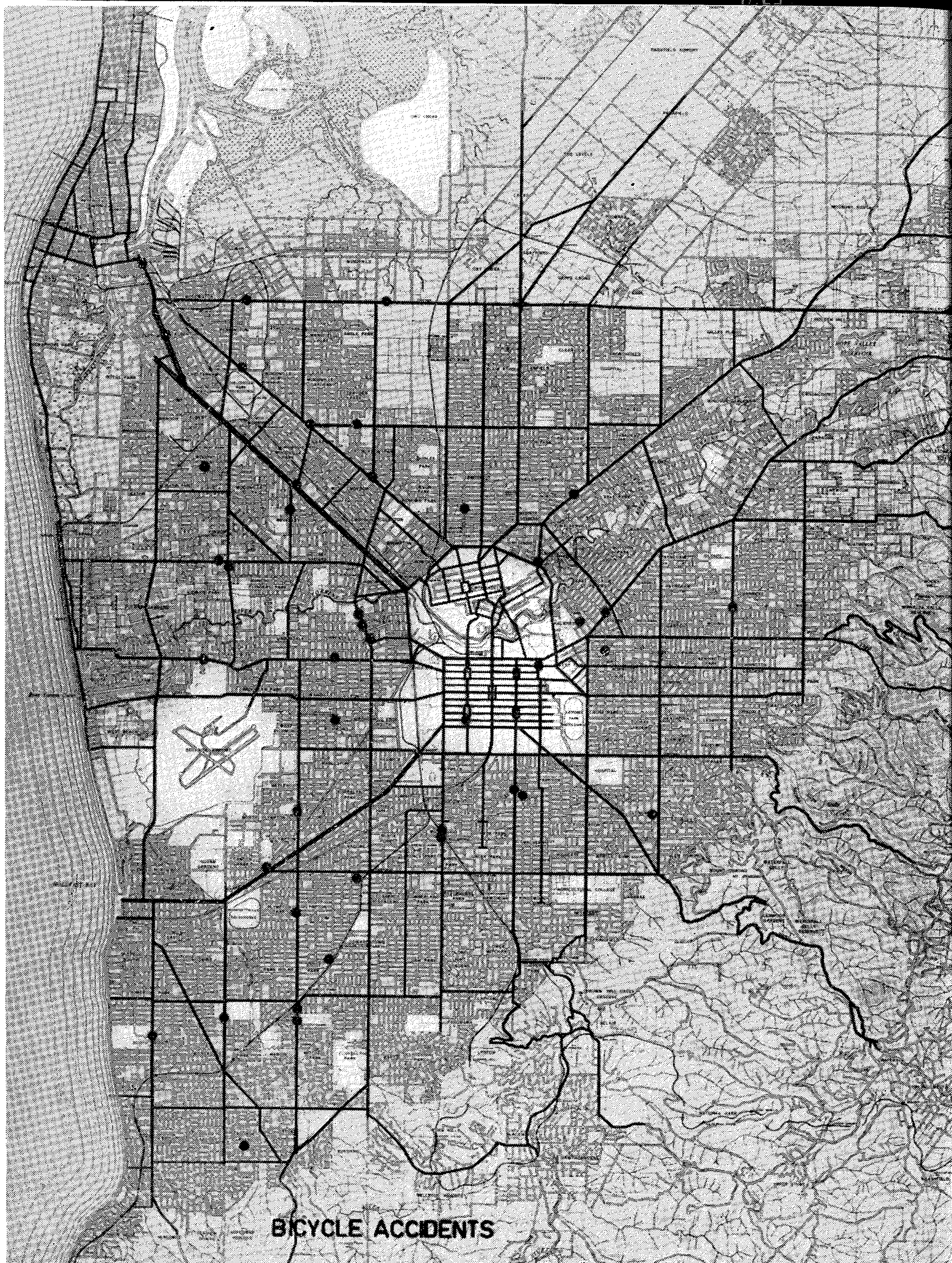
WHEN ARE CYCLISTS INVOLVED IN ACCIDENTS?

5.4 Almost half of all the cycle accidents we attended happened in the two hours between 4 p.m. and 6 p.m. (*Fig. 5.3*). This suggests that well over half of all injury-producing pedal cycle accidents in the metropolitan area occur during these two hours, because our sample contains a higher proportion of off-peak period accidents than of those that happened at peak periods. This time distribution of accidents is much the same for each weekday. TABLE 5.1 shows that we attended many more accidents involving a cyclist on Fridays than on any other day. Statistical tests show however that this bias towards Fridays could be due to chance.

DAY AND NIGHT

5.5 TABLE 5.1A relates the age of the cyclist to the time of day at which each accident occurred. Most cycle accidents, to cyclists of all ages, happen between 4 and 6 o'clock in the afternoon. Just over a quarter of these 44 accidents happened at night (because of seasonal variations in the time of sunset TABLE 5.1A cannot be used to distinguish between day and night accidents in all cases). Naturally enough there were not many children (i.e., under the age of 15 years) involved in those accidents which happened at night (see TABLE 5.2).

5.6 This relationship between the age of the cyclist and accidents by day and by night leads us on to a feature of pedal cycle accidents which became very obvious to us as our survey proceeded. We began to get the impression that daytime accidents to pedal cyclists very often resulted from a child cyclist suddenly attempting a


BICYCLE ACCIDENTS

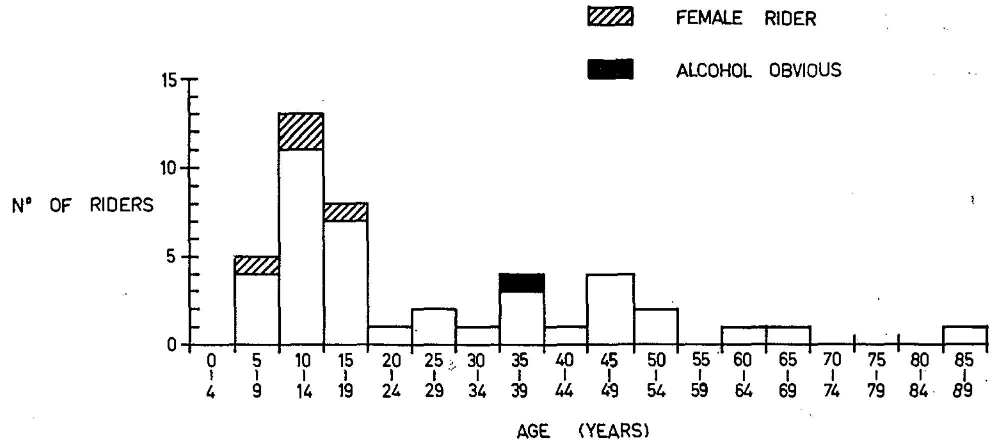


Fig. 5.2—Number of pedal cycle accidents by age of rider

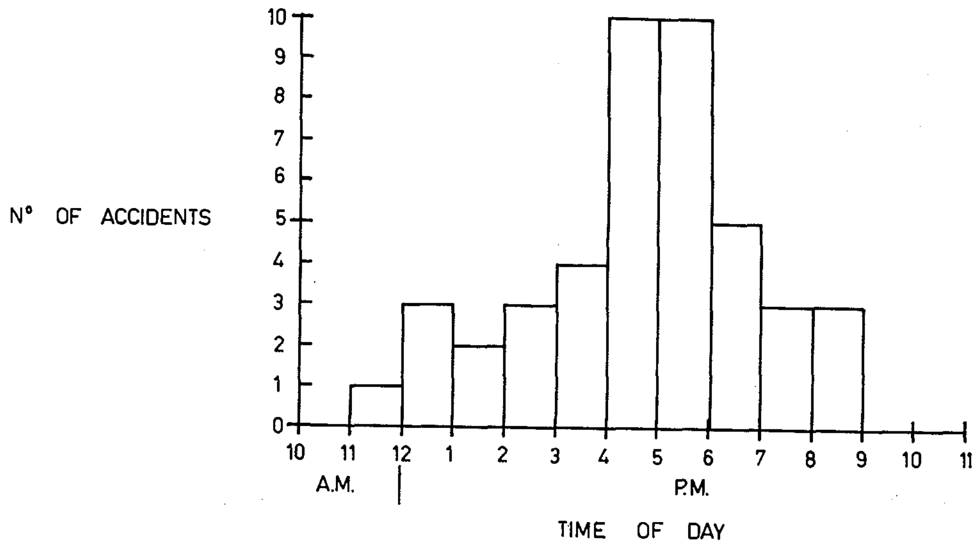


Fig. 5.3—Number of pedal cycle accidents by time of day

U turn or a right turn in front of a following car. Night-time accidents usually seemed to be cases of the driver simply not seeing the cyclist, who was merely riding along at the side of the road. These are only generalizations of course, but TABLE 5.3 provides some justification. The very marked difference in the behaviour of the cyclists between day and night accidents is, we believe, due to there being very few child cyclists on the roads at night. This would seem to suggest that children should be taught not only how to ride a cycle but also to take much greater care when changing direction in traffic.

←*Fig. 5.1*—Location of bicycle accidents

5.7 Whether or not a driver sees a cyclist at night will depend largely on how

TABLE 5.1

DISTRIBUTION OF ACCIDENTS VERSUS DAY OF WEEK

	No. of Cycle Accidents Involving a Second Vehicle	No. of Other Types of Accidents	Ratio Cycle Accidents to Other Types of Accidents
Monday	5	43	12:100
Tuesday	6	50	12:100
Wednesday	8	65	12:100
Thursday	6	61	10:100
Friday	15	74	20:100
Total	40	293	

$\chi^2 = 2.8 \; P_{0\cdot05} = 11.1$ N.S.

(Note: Four non-collision cycle are not included in this table.)

TABLE 5.2

AGE OF CYCLIST RELATED TO TIME OF DAY

Age of Cyclist	Accident Happened by		Total
	Day	Night	
Under 15 years	16	2	18
Over 15 years	16	10	26
Total	32	12	44

$\chi^2 = 3.989$*

TABLE 5.3

PARTIES INITIATING COLLISION BY DAY AND NIGHT

Party Initiating Events Which Resulted in a Collision	Accident Happened by		Total
	Day	Night	
Driver of striking vehicle	9	7	16
Cyclist	19	5	24
	28	12	40

$\chi^2 = 2.4$ N.S.

well the cyclist contrasts with his background. On a poorly lit road this contrast is first achieved by the tail light on the bicycle. We recommend large tail lights on bicycles, for they have a very important function. The next stage comes when the headlights of the car illuminate the cyclist, who is then visible against a dark background. Unfortunately, with dipped headlights the vehicle is often too close to the cyclist to avoid a collision at this stage. With improved street lighting the situation may, curiously enough, become worse, unless the lighting is very good indeed. If the background is not dark, but rather poorly illuminated, a tail light on a bicycle will no longer show up clearly. Similarly the headlights of the car, as they bear on the cyclist, may diminish the contrast between the illumination on the cyclist and that of the background lighting so that for a short time all contrast may be lost and the cyclist blends into the background. By the time the car is close enough for its headlights to illuminate the cyclist strongly a collision is almost inevitable, at present-day traffic speeds. It is not surprising therefore that 11 of the 12 night-time pedal cycle accidents were under lighting which is considered, perhaps mistakenly, to be 'good' (see TABLE 5.4).

5.8 We understand that there is a tendency for local government authorities to try to reduce the considerable costs of street lighting by increasing the spacing between lights. It seems that a better approach would be to illuminate a few roads to the recommended standard, leaving others almost without illumination, rather than to attempt to cover a greater length of road with sub-standard lighting.

5.9 There were five accidents where the cyclist was struck from the rear while riding on the left side of the road, i.e., the driver did not see the cycle. Four of these occurred at night, e.g. case 0121 (*Fig. 5.4*).

● **Case 0121**

A 15-year old girl riding a bicycle was struck from behind by a Holden FE panel van. She was thrown up onto the bonnet of the car, striking the windscreen. Some threads of green wool from the cyclist's cardigan were found caught on the ends of some lengths of wood which were carried on the roof rack and projected forwards over the bonnet. The driver did not brake until he was about 8 yards past the presumed point of impact. The car then skidded for 30 yards, and as it stopped the cyclist was thrown from the bonnet on to the ground, coming to rest 7 yards in front of the car. The cyclist sustained concussion and abrasions to the left side of the neck and back, and extensive abrasions to both buttocks and the inner side of both legs. The driver of the car — a 43-year old man — was appreciably affected by alcohol and was uninjured.

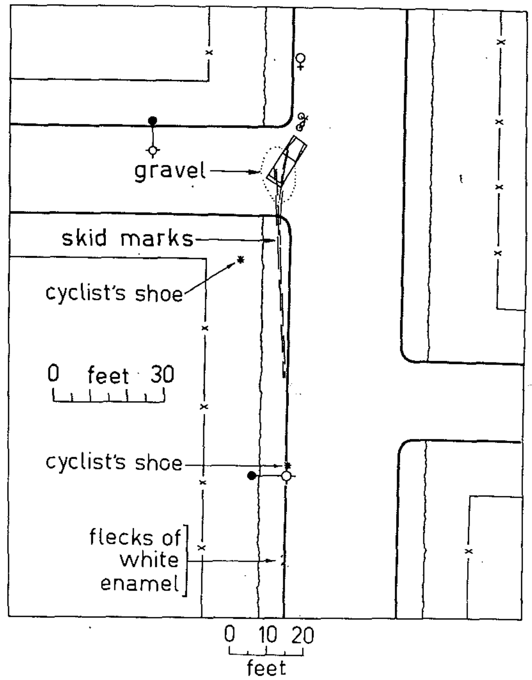


Fig. 5.4—Case 0121

TABLE 5.4

TYPE OF LIGHTING IN WHICH NIGHT CYCLE ACCIDENTS OCCURRED

Type of Street Lighting	No. of Cases
Incandescent	1
Mercury vapour	3
Sodium vapour	7
Fluorescent	1
Total number of night-time accidents	12

ALCOHOL

5.10 The other three night-time accidents of this type all involved drivers who had obviously been drinking. Indeed, of the 40 drivers whose vehicles collided with cyclists, these four were the only ones who had obviously been drinking, and in each case they should have been able to avoid the collision. In these 44 accidents there was only one case in which a cyclist had obviously been drinking (refer to *Fig. 5.2*). Note again the distinction between 'obviously been drinking' and 'affected by alcohol'. It is probable that the number of drivers who had obviously been drinking is a conservative estimate of the number who actually were affected by alcohol. We realized this towards the end of our survey when we were able to check the breath-alcohol level of a driver who gave no sign of having been drinking, only to find evidence of a blood alcohol level consistent with a considerable deterioration in driving ability. Therefore, to sum up this paragraph: one tenth of these accidents involving a cyclist and a motor vehicle might have been avoided if the driver of the motor vehicle had not consumed alcohol a short time before driving.

MOVEMENTS OF CYCLISTS

5.11 As is shown in TABLE 5.5, two movements predominate, viz. proceeding straight ahead and turning right.

5.12 It is interesting to regroup TABLE 5.5 into those cyclists who were proceeding straight ahead and those who were changing direction. Two thirds of those changing direction were less than 15 years old. Most of these were turning right, or attempting a 'U' turn. TABLE 5.6 compares the behaviour of cyclists less than 15 years and 15 years and over.

5.13 As we have already mentioned, this pattern became quite obvious as our survey progressed. The commonest pedal cycle accident was that involving a young boy cyclist who turned right across the path of a car travelling in the same or the opposite direction, without looking or signalling. Most drivers do not seem to be aware of the fact that cyclists can and do turn right suddenly, without signalling, e.g. cases 0221 and 0367.

● Case 0221

A 13-year old boy cyclist turned right from the left hand kerb and crossed the path of a Morris Elite sedan which was travelling in the same direction. The driver of the car said that he was travelling at 30 to 35 m.p.h. when he saw the bicycle come from the left side of the road. He swerved to the right and braked, but the bicycle kept turning in front of him. The car then struck the bicycle on the centre of the right side of the latter. The windscreen of the car was broken. The rider of the bicycle sustained concussion and abrasions and a small laceration to his chin. The car skidded for 20 yards, which, in this case, indicated a speed of more than 40 m.p.h.

TABLE 5.5

MOVEMENTS OF CYCLISTS

Motion of Cyclist	Age of Cyclist (Years)		Total
	Less than 15	15 or over	
Proceeding straight ahead	1	15	16
Turning right	9	6	15
'U' turn	3	1	4
Entering traffic lane	3	—	3
On cycle track at crossover of a dual highway	—	1	1
Crossing roadway not at an intersection	—	1	1
Total	16	24	40

TABLE 5.6

BEHAVIOUR OF CYCLISTS ACCORDING TO AGE

Motion of Cyclist Involved in a Collision	Age of Cyclist (Years)		Total
	Less than 15	15 or over	
Proceeding straight ahead	1	15	16
Turning right, 'U' turn, entering traffic lane	15	7	22
Total	16	22	38

(Note: two cases not in the above categories.)
$\chi^2 = 12.1^{**}$ after Yates correction.

before the driver started braking (see *Fig. 5.5*).

● Case 0367

A 12-year old boy cyclist turned right from a main road into a side street. He was struck by a Holden EJ sedan which was travelling in the opposite direction along the main road. The Holden was being repaired and had most of the front grille and bumper bar removed. The speed at impact was between 30 and 40 m.p.h. The cyclist sustained a compound fracture of the left tibia caused by the impact from the front edge of the bonnet, separation of the pubic symphysis and sacro-iliac joints and a laceration of the anterior wall of his rectum. The cause of these injuries is obscure. He sustained concussion and abrasions to the left side of his face, possibly from striking and breaking the windscreen of the car. His legs swung upwards as his head hit the windscreen, and he slid along the roof of the car and then fell to the ground, in soft mud at the roadside, as the car braked to a halt. (*Fig. 5.6, 5.7, 5.8* and *5.9*).

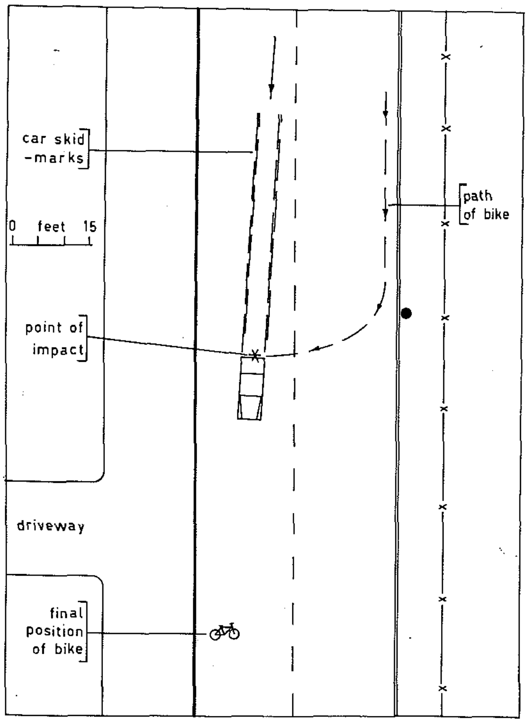
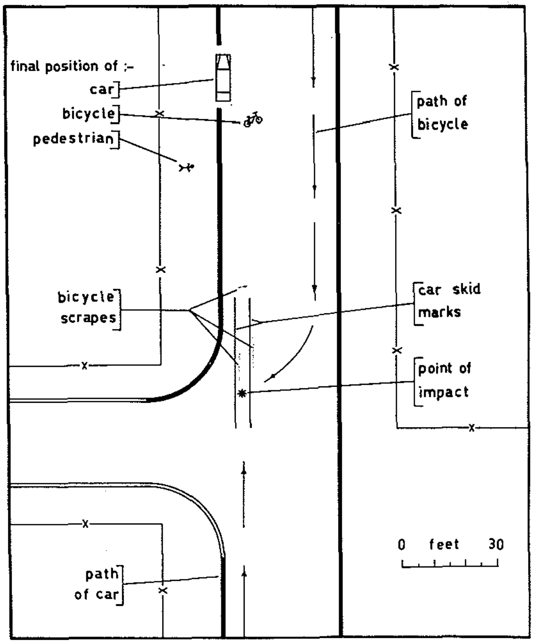


Fig. 5.5—Case 0221

MOVEMENTS OF STRIKING VEHICLES

5.14 The movements of the striking vehicles are set out in TABLE 5.7. Twenty-eight of the 35 cars were proceeding straight ahead. Seven vehicles were overtaking, and five turning right.

5.15 TABLE 5.8 relates the movements of the cyclists to those of the striking vehicles. This shows that most (70 per cent) of the striking vehicles were proceeding straight ahead, while 55 per cent of the



cycles were changing direction at the time of collision.

LOCATION OF THESE ACCIDENTS

5.16 Seventy per cent of these collisions occurred at or near intersections. TABLE 5.9 shows the location of these accidents according to the participant who may be considered to have initiated the movement which resulted in a collision. The group of nine cyclists who initiated collisions away from intersections represent those cases in which the cyclist either turned right, attempted a 'U' turn, or entered a traffic lane without first ensuring that the road was clear. Of the three cases in which there was no collision, i.e., the cyclist 'fell off', two occurred away from intersections and the third at an intersection.

←Fig. 5.6—Case 0367

Fig. 5.7—Case 0367: rider of bicycle made dent in top of bonnet, broke the windscreen and slid along the roof (bumper and grille had been removed before the accident)

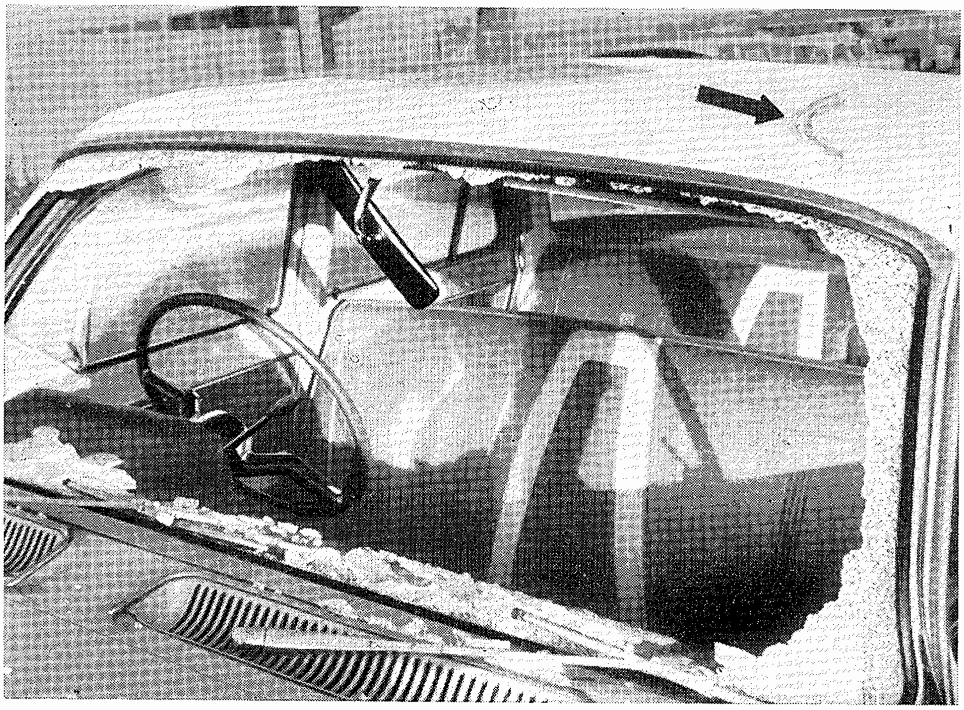


Fig. 5.8—Case 0367: blood smears on roof of car

Fig. 5.9—Case 0367: bicycle which was struck by the car shown in *Fig. 5.6*

TABLE 5.7

MOVEMENTS OF STRIKING VEHICLES

Motion on Impact	Type of Striking Vehicle			
	Car	Motor-cycle	Truck	Total
Proceeding straight ahead	28	—	—	28
Proceeding straight ahead and overtaking	5	1	1	7
Turning right	2	1	2	5
Total	35	2	3	40

TABLE 5.8

MOTION OF CYCLES RELATED TO MOTION OF STRIKING VEHICLES

Motion of Pedal Cycle	Motion of Striking Vehicle			
	Proceeding straight ahead	Proceeding straight ahead and overtaking	Turning right	Total
Proceeding straight ahead	11	2	3	16
Turning right	11	3	1	15
Entering traffic lane	3	—	—	3
'U' turn	3	1	—	4
On cycle track	—	—	1	1
Crossing roadway	—	1	—	1
Total	28	7	5	40

TABLE 5.9

LOCATION OF ACCIDENTS

Persons Initiating Accident	At Intersection	Within 20 Yd	Not at Intersection	Total
Cyclist	13	2	9	24
Driver	11	2	3	16
Total	24	4	12	40

TABLE 5.10

DISTANCE AT WHICH DRIVER SAW CYCLIST

	At or within 20 Yd of an Intersection	Not at an Intersection	Total
Driver saw the cyclist in the distance	8	6	14
Driver did not see the cyclist until immediately before the impact, or not at all	15	4	19
Total	23	10	33

TABLE 5.11

DISTANCE AT WHICH CYCLIST SAW STRIKING VEHICLE

	At or within 20 Yd of an Intersection	Not at an Intersection	Total
Cyclist saw the striking vehicle in the distance	4	2	6
Cyclist did not see the striking vehicle until immediately before the impact, or not at all	9	3	12
Total	13	5	18

5.17 The reason for a large proportion (24/40) of these accidents occurring at intersections may be due to drivers having many things to look for at an intersection. At an intersection the driver must attempt to sum up the situation very quickly. This means that he will be looking for obvious features such as cars, trucks, etc. The cyclist, who is not so easy to see as a car, may well be not noticed, and a collision result. We have asked the drivers whether or not they saw the cyclist before the collision. The results of these questions are shown in TABLE 5.10. The large number of drivers who did not see the cyclist at an intersection until it was too late to avoid a collision (15/23 = 65 per cent) tends to support the above explanation. Perhaps the point to be emphasized here is that the cyclist should not assume that the driver has seen him, particularly at or near an intersection.

5.18 A similar table has been drawn up to show the same information for the cyclist (TABLE 5.11). Unfortunately there is a large number of cases in which we were unable to get an answer because the cyclist's injuries left him with no recollection of the events leading up to the collision. A high percentage (69 per cent) of cyclists at intersections did not see the striking vehicle. This is despite the fact that they travel at much lower speeds than cars and have excellent visibility.

NON-COLLISION CYCLE ACCIDENTS

5.19 The three non-collision accidents in our sample all resulted from some object suddenly locking the front wheel of the bicycle. In one case it was the generator which was dislodged and became locked in the spokes of the front wheel. Another case resulted from a loose front mudguard catching on the tyre and locking the wheel. In the third case a fishing rod carried by the rider slipped from his grasp and became entangled with the front wheel. In each case the rider sustained concussion from striking his head on the road. In one further case, mentioned below, a pedal cycle collided with a pedestrian.

COLLISION ACCIDENTS

5.20 The types of collisions were as follows:

- 2 pedal cyclists were struck by motor-cycles,
- 3 pedal cyclists were struck by trucks,
- 1 pedal cyclist struck a pedestrian,
- 3 pedal cyclists fell off without a collision,
- 35 pedal cyclists were struck by cars

Pedal cycle versus motor-cycle

5.21 Both of these collisions seem to have been glancing impacts, and the injuries to both parties were caused mainly by hitting the road.

● **Case 0343**

The rider of a motor-scooter swerved to his left to pass a car turning right from the centre of the road. He brushed a pedal cyclist travelling in the same direction. The pedal cyclist — male, 35 — sustained concussion from striking his head on the road. The rider of the scooter fell from his machine but was not injured. His breath smelt faintly of alcohol.

● **Case 0413**

A motor-cycle, turning right at an intersection at night, struck a 12-year old boy on a pedal cycle. Both riders fell off, each hitting his head on the road. The motorcyclist, who was not wearing a protective helmet, received concussion and facial abrasions. The cyclist received only an abrasion on his forehead.

Pedal cycle versus truck

5.22 Two of the pedal cyclists rode into the sides of trucks which were turning right across their path. These were both daytime accidents and the drivers of the trucks saw the cyclists, but thought they had time to cross in front of them. One of the drivers said 'If the cyclist had slowed down he wouldn't have run into me'. This cyclist struck his head on the front corner of the tray of the truck and suffered concussion. The other case was similar to this. In the third case (case 0419) the cyclist turned in front of the truck.

● **Case 0136**

A cyclist struck the tray of a truck which had turned right in front of him across the cycle track on the median of a divided highway. He received facial abrasions and a fractured left forearm. His breath smelt of alcohol. One month previously he had been knocked off his bicycle and had suffered a fractured skull.

● **Case 0419**

An 8-year old girl riding a small pedal cycle turned right, across the path of a heavy utility which was about to overtake her. The driver braked hard and the truck had almost stopped when it struck the right side of the cycle, pushing the cycle and rider on to the road. The rider suffered concussion, probably from striking the road, and abrasions to the right leg, probably from the impact with the truck.

Pedal cycle versus pedestrian

5.23 (The following case has also been considered in the section on pedestrians.)

● **Case 0167**

A boy aged 16 rode his bicycle out of the driveway of a house, turned left into the road and looked over his left shoulder to talk to a friend on the footpath. When he looked ahead he saw a pedestrian walking with her back to him. He shouted a warning and after the impact the cyclist and the pedestrian fell to the road. The pedestrian suffered concussion and abrasions to the right side of the face. The cyclist was not injured.

Pedal cycle alone

5.24 There were three cyclists who fell off their machines, without having first collided with anything, and sustained sufficient injury to require an ambulance to be called.

● Case 0130

An 11-year old girl suffered concussion and abrasions when the front mudguard jammed the wheel and she fell to the road.

● Case 0138

A 28-year old male received concussion when the generator on the front wheel became caught in the spokes, jamming the wheel and causing him to fall off.

● Case 0265

A 12-year old boy cyclist, carrying a fishing rod, became alarmed when a car passed very close to his right side. The fishing rod slipped between the front wheel and the frame of the cycle, causing him to fall off. He sustained concussion and abrasions.

The head injury in each case was produced by the rider's head striking the road.

Pedal cycles and cars

5.25 There were 35 collisions between cars and pedal cycles. When struck by a car the pedal cyclist, like the pedestrian, has no protection from the impacts with the car and subsequently with the road. The impact geometry of these 35 pedal cycle/car collisions was as follows:

Side of bicycle to front of car		24
rider fell on bonnet	14	
rider slid down the side of the		
car	7	
bonnet	3	
Rear of bicycle to front of car		5
rider fell on top of bonnet	4	
rider's movements not known	1	
Front of bicycle to front of car		3
rider fell on bonnet	1	
rider slid down the side of the		
car	2	
Front of cycle to side of car		2
Position of cycle not known		1
Total		35

Twenty-four of the impacts were on the side of the bicycle, and in two-thirds (14) of these impacts the rider fell on top of the bonnet of the striking car. The further trajectories of this group are considered in detail below.

Position of centre of gravity of bicycle and rider

5.26 The motions of the pedal cyclist during and after the impact depend on the relative positions of the centre of gravity of the cycle plus rider and the top of the bonnet of the striking car. We located the position of the centre of gravity of a rider and bicycle together. The rider was a 5 ft 8 in. male weighing 140 lb, and the bicycle had wheels 28 in. in diameter and a seat height of 35 in. above the ground. The horizontal location of the centre of gravity varied according to the attitude adopted by the rider. If he sat normally, the centre of gravity was located near the front of the seat; while if he remained seated but leant forwards over the handlebars the centre of gravity moved forwards 7 in. (*Fig. 5.10*). With the rider normally seated the centre of gravity of rider and machine together was 33 in. above the ground, which was just below the saddle height of 35 in.

5.27 At 33 in. above the ground the centre of gravity of a cyclist together with

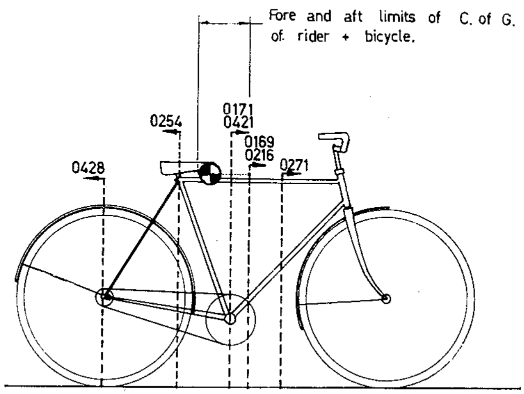


Fig. 5.10—Position of centre of gravity of rider and cycle and points of impact for cases shown

his bicycle is close to the top of the bonnet of a car of conventional frontal design. This means, if a cyclist is assumed to be rigidly attached to his machine, that when struck from the side by a car the rider and cycle will be pushed sideways away from the car.

5.28 However, this assumption that the rider and cycle act as one rigid body is only acceptable at very low impact speeds (less than 10 m.p.h.). The rider is, of course, not rigidly fixed to his bicycle, even though he is astride it, and the two are readily separated on impact. We must therefore consider the rider and the cycle separately, and the post-impact motion of each can be derived by relating the point and direction of the impact to the positions of their individual centres of gravity. There are also other factors such as rotational inertias which influence these motions, but for our present purposes it is sufficient to allow for them in a purely qualitative way.

Kinematics of the pedal cycle/car collision

5.29 An impact from the side at a height of 33 in. — the height of a car bonnet — will strike the rider on the hip and will cause the cycle to be pushed away in front of the car, while the rider will be rotated about his centre of gravity, his head moving towards the car. The rider's legs, being below the top of the bonnet of the car, will be pushed forwards and thus assist in rotating his trunk towards the car. The distance back from the front of the car that the rider's head strikes is determined by the speed of the car at impact. With increasing speed, the rider strikes successively the top of the bonnet (*Fig. 5.11*), the windscreen and, at higher speeds still, the roof just above the upper edge of the windscreen

Fig. 5.11—Case 0160: impact of front of car with side of bicycle. Arrows indicate marks made by:
(1) handlebar on left headlight of car.
(2) the seat of the bicycle on the rider's hip on the top of the bonnet.
(3) the rear axle of the bicycle on the right bumper overridden.

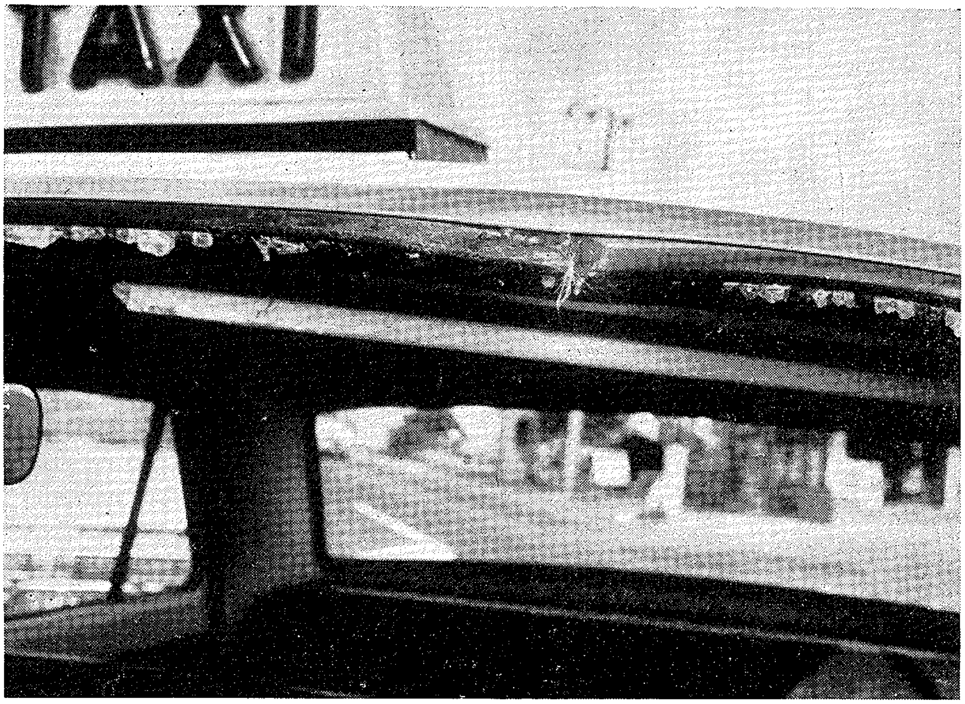


Fig. 5.12—Dent in roof of car made by cyclist's head (note hair stuck to chrome strip)

(*Fig. 5.12*). The height of the rider's trajectory will also be affected to some extent by his position, e.g., seated or standing on the pedals, and by his stature, but we consider that speed at impact probably has the greatest effect.

5.30 TABLE 5.12 shows the furthest point reached by the pedal cyclist after impact, at each group of impact speeds, for impacts between the front of the car and the side of the bicycle. The cyclist's trajectory was determined by careful examination

TABLE 5.12

FURTHEST POINT REACHED BY CYCLISTS AFTER IMPACT BETWEEN FRONT OF CAR AND SIDE OF BICYCLE

Furthest Point Reached on the Car	Speed at Impact (m.p.h.)				Total
	0-10	11-20	21-30	31-40	
Roof	—	—	2	—	2
Windscreen	1	2	1	1	5
Top of bonnet	—	1	2	—	3
Pushed in front of the car	2	1	1	—	4
Total	3	4	6	1	14

of the car for marks from the impact, and also by close examination of the cyclist's injuries.

5.31 It can be seen that as the impact speed increases the rider strikes further up the car. 'Pushed in front of the car' refers to those cases in which the cycle and rider were pushed in front of the car and did not fall back on the bonnet, i.e., cycle and rider remained together. One of these cases involved a boy whose cycle was trapped under a front wheel of the car and pushed down the road. The cyclist was caught on the front of the car and was not injured.

5.32 The variation in trajectory in each range of impact speed is influenced, as stated before, by the stature and the position of the cyclist, and also by the speed of the cycle at impact. After striking the car, the rider then falls to the road on one side or behind the car. If the car stops quickly the cyclist may be projected onto the road in front of the car. There need not necessarily be contact between the rider and the striking car in all cases. In addition to these 14 cases there were three cases of impact between the front of the car and the side of the cycle where the rider passed diagonally over the bonnet of the car, without touching it, landing directly on the road.

5.33 In the above 17 cases the centre of gravity of the cycle and rider was struck by the front of the car. There were a further seven cases of impacts on the side of the cycle, where the centre of gravity of the cycle and rider must have been beyond a corner of the front of the car, because the cycle and rider pivoted about the corner of the car and slid down the side of the car to the road. *Fig. 5.10* shows the positions of the corners of the cars in the seven cases. By this means the forward and backward limits of the position of the centre of gravity were established. This was confirmed by measuring the position of the centre of gravity of a bicycle and a rider in various positions, as mentioned before. The fore and aft limits of the centre of gravity as measured are shown in *Fig. 5.10.*

5.34 There were five cases where the cycle was struck directly from the rear. In one case we have no information about the car because the driver did not remain at the scene of the accident. TABLE 5.13 relates the impact speeds to the riders' trajectories. There is the same increase in distance travelled up the car with increasing speed as was found with side impacts.

5.35 There were three collisions that were head-on or close to head-on. In one of these the rider struck the centre of the front of the car and then broke the windscreen and dented the roof with his head (*Fig. 5.13* and *5.14*). In the other two

TABLE 5.13

REAR IMPACTS

Furthest Point Reached on the Car	Impact Speed (m.p.h.)					Total
	0-10	11-20	21-30	31-40	41-50	
Roof	—	—	—	—	1	1
Windscreen	—	—	—	2	—	2
Top of bonnet	—	1	—	—	—	1
Pushed in front of the car	—	—	—	—	—	—
Total	—	1	—	2	1	4

cases the riders slid down the side of the car, striking the road.

5.36 In three cases there was insufficient information available to determine what happened. In a further two cases the cyclist struck the side of the car.

5.37 All except two of the car-cycle impacts were with the front of the striking car. The trajectory of the cyclist depends on the speed of the car and the position of the bicycle across the front of it. The rider may fall in front of the car, or be thrown up on to the bonnet, windscreen or roof, subsequently falling on to the road; or slide down the side of the car on to the road. Therefore, like the pedestrian, the pedal cyclist suffers multiple impacts with the car and with the road. Consequently, the pedal cyclist also suffers multiple injuries.

INJURIES TO PEDAL CYCLISTS

5.38 The 35 pedal cyclists struck by cars sustained a total of 98 injuries to all body areas, an average of 2.8 injuries per cyclist. The injuries were distributed as shown in TABLE 5.14. Three cyclists were killed. There were six fatal injuries, or an average of two fatal injuries per person killed. Injuries to the head and lower limb were most common, but differed in that 27 of 31 (87 per cent) lower limb injuries were minor, while only six of 29 (21 per cent) head injuries were minor.

5.39 This difference is remarkable when the apparent exposure of the lower limbs of a cyclist to injury from impact with a car is considered. The lack of severe injury could be explained by the fact that the legs are not restrained against the cycle frame, but move with the impact, sustaining only abrasions, bruises and an occasional laceration.

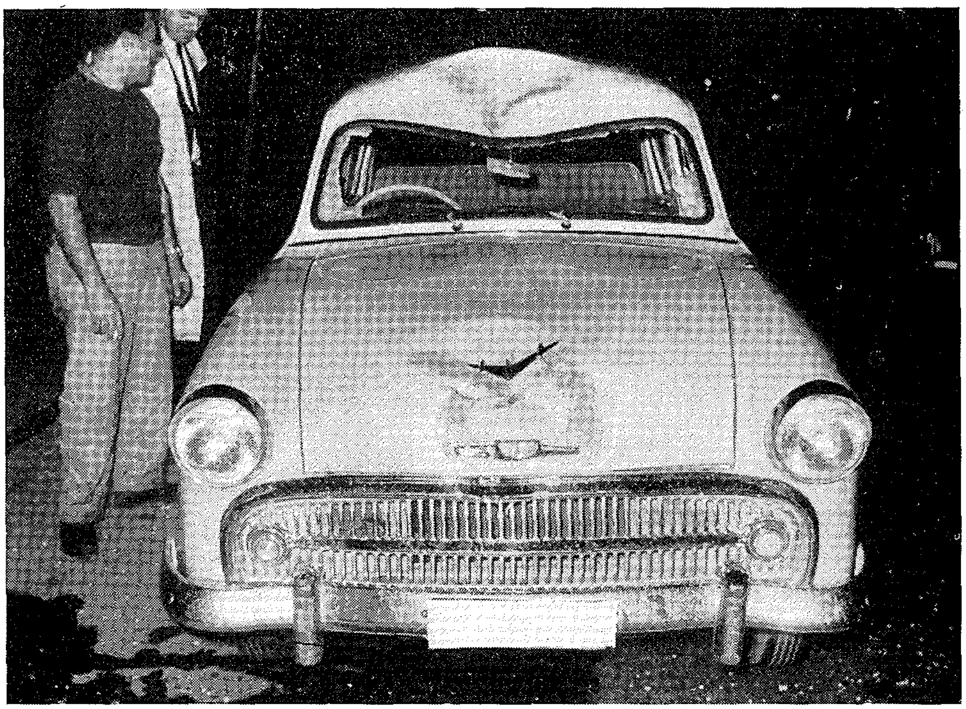


Fig. 5.13—Head-on collision between car and bicycle (dent in roof made by rider's head)

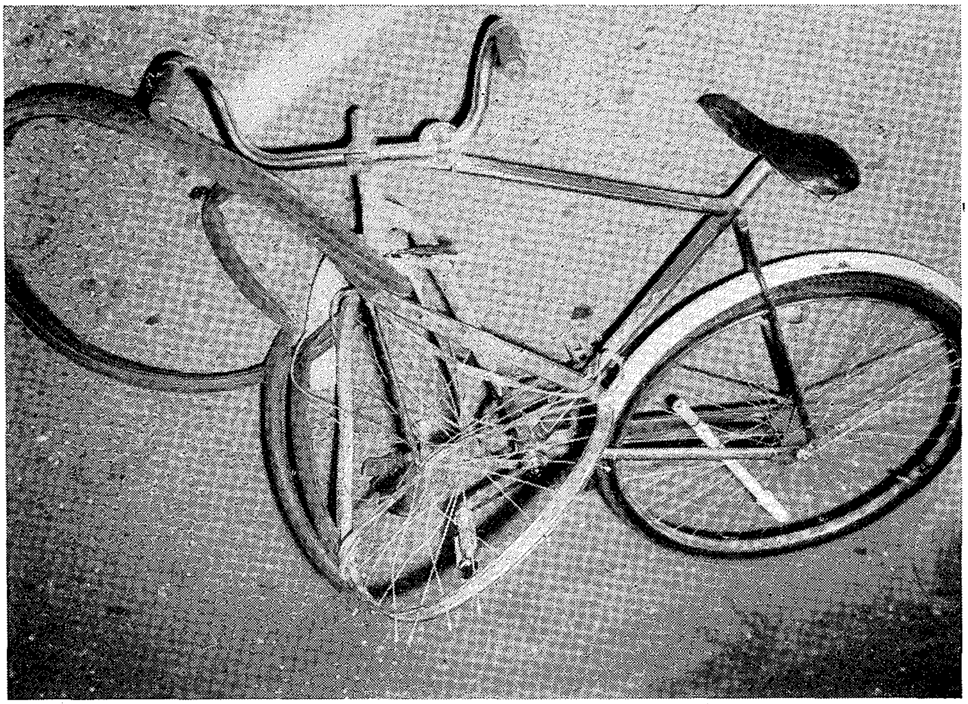


Fig. 5.14—Bicycle which collided with car shown in *Fig. 5.13*

5.40 In the following discussion of injuries in each body area the injuries sustained by the 35 cyclists struck by cars are considered first, then the injuries of the whole 44 cyclists are summarized in a table for each body area.

Head injuries

5.41 The minor head injuries were mostly abrasions and bruises caused by contact with the road. Fifteen of the 20 remaining non-fatal injuries were concussions, where the major impact was with the road. Three

TABLE 5.14

CYCLISTS' INJURIES

Degree of Injury	Body Area						Total
	Head	Thorax	Abdomen	Spine and pelvis	Upper limb	Lower limb	
Minor	6	6	6	0	13	27	58
Moderate	18	0	0	0	1	2	21
Severe	2	0	0	3	4	0	9
Very severe	0	1	1	0	0	2	4
Fatal	3	1	0	2	0	0	6
Total	29	8	7	5	18	31	98

other concussions were caused by striking the windscreen of the car. There was one severe head injury caused by striking the side of the car. Two of the three fatal head injuries were fractures of the skull associated with fatal brain damage. The third case had a transection of the brain stem associated with a dislocation of the atlanto-occipital joint. These fatal injuries were caused by striking respectively the road, the top of the bonnet, and the windscreen and adjacent roof of the striking cars. Altogether, 19 of the 29 head injuries (66 per cent) were caused by striking the road. Of the remainder, four were caused by the windscreen, two by the top of the bonnet, and one by the side of the car. In three cases no cause could be established.

5.42 The head injuries of all 44 pedal cyclists are summarized in the following tabulation. Each person is counted once in each area for soft tissue injuries. Each skeletal injury and concussion is counted individually.

No injury		6
Soft tissue injuries of face		25
abrasions	16	
lacerations	3	
bruises	6	
Concussion		28
Fatal brain damage		3
Soft tissue injuries of scalp		15
abrasians	4	
lacerations	6	
bruises	5	
Fractures of the skull (2 fatal)		3

Nineteen of the 25 soft tissue face injuries were caused by the road, as were 8 of 15 soft tissue injuries of the scalp. The rest were caused by impacts with the striking vehicle.

Neck injuries

5.43 Two fatal neck injuries are included in TABLE 5.14, in the group 'spine and pelvis'. One was a fracture-dislocation of the first and second cervical vertebrae, with transection of the spinal cord, and the other was a dislocation of the atlanto-occipital joint associated with transection of the brain stem as mentioned above. There were two superficial injuries of the neck. No other neck injury was observed.

Thoracic injuries

5.44 There were relatively few thoracic injuries. Minor injuries were bruises and abrasions, caused about equally often by the car and the road. Injuries to the bones of the thorax consisted of a fracture-dislocation of the right sterno-clavicular joint, together with a fracture of the tip of the right coracoid process. The exact cause was not determined. Also, one victim had fractures of the left and right ribs associated with lacerations of both lungs, produced by an impact with the top of the bonnet. There was one fatal injury: a rupture of the thoracic aorta, again caused by striking the top of the car bonnet. About half the thoracic injuries were caused by striking the road, and half by striking some part of the car.

5.45 The thoracic injuries of all 44 pedal cyclists are summarized in the following tabulation.

Soft tissue thoracic injuries		6
abrasions	2	
bruises	3	
subcutaneous emphysema	1	
Internal abdominal injuries		2
bruise of liver	1	
laceration of rectum	1	

The soft tissue injuries were all in the lumbar region and over the sacrum. The subcutaneous emphysema occupied the right lower quadrant of the anterior abdominal wall. This was case 0367 where a 12-year old boy was struck by the front of the bonnet of an EJ Holden as he crossed in front of it (*Fig. 5.7, 5.8* and *5.9*). He suffered a laceration of the anterior wall of the rectum, associated with separation of the pubic symphysis and both sacroiliac joints. The cause of the laceration could not be determined. He also suffered concussion, and a compound fracture of the left tibia.

Injuries to the spine

5.46 These injuries are comparatively rare, but when they occur they are of considerable severity. As mentioned above, there were two fatal neck injuries, both involving severance of the spinal cord. There were two non-fatal spinal injuries. One was a crush fracture of the anterior border of the second lumbar vertebra, produced when the rider struck the side of the front mudguard with his back. The other injury was fractures of the left transverse processes of the upper four lumbar vertebrae, produced by a direct blow on the back on striking the top of the car bonnet in an impact from the rear. No other spinal injuries were observed in any of the other cases.

Pelvic injuries

5.47 Injuries to the pelvis occur when the front of the car strikes the hip of the cyclist, seated on his machine, with sufficient force to produce a fracture. There were three of these injuries, and they were all fairly severe. In one case a cyclist who was struck on the right hip received a comminuted fracture of the right acetabulum, among other (fatal) injuries. Another cyclist, struck on the right hip, suffered a fracture of the left inferior pubic ramus, produced by the impact from the front of the car. In one other case (0367) a separation of the pubic symphysis was produced together with separation of the sacro-iliac joints but the cause was not determined. No other pelvic injuries were observed in the other cases.

Upper limb injuries

5.48 Thirteen of the 18 upper limb injuries (72 per cent) were abrasions or bruises, almost entirely caused by striking the road. There were five moderate or severe injuries. These were all fractures or dislocations of the left arm. There were three fractures of the shaft of the radius; one was due to impact on the road, but the cause of the other two fractures could not be determined. A 12-year old boy suffered a fracture of the surgical neck of his left humerus when he landed on his left elbow after a very low speed impact from his right. The other shoulder injury was in an 83-year old man who was struck from the right at considerable speed, breaking the windscreen with his head (*Fig. 5.12*) and dislocating his left shoulder as he fell to the road. He also suffered a compound fracture of his left thumb (case 0347). It seems to be merely coincidence that all five arm injuries should be on the one side, for only two of the impacts were from the right, two more being head on, and one being from the rear.

5.49 The injuries to the upper limb of all 44 pedal cyclists are summarized here.

Soft tissue injuries		19
abrasions	17	
bruises	2	
Skeletal injuries		7
dislocation of left shoulder	1	
fracture of left humerus (surgical neck)	4	
fracture of left radius	1	
fracture of left thumb (compound)	1	

Twenty-two of these 26 injuries were caused by striking the road. The causes of the other four are not known.

Lower limb injuries

5.50 There were only two very severe leg injuries. One was a fractured left lower leg with a large laceration which was caused by being struck by the front edge of the bonnet of an EJ Holden, the cycle being at an angle to the front of the car (case 0367). The other was a fracture of the left femur which occurred in a severe impact from the rear which killed the rider.

5.51 The lower limb injuries to all 44 pedal cyclists are summarized thus:

Soft tissue injuries		47
abrasions	26	
bruises	17	
lacerations	4	
Skeletal injuries		2
fracture of the left femur	1	
fracture of the left tibia (compound)	1	

Almost half (23) of the soft tissue injuries are caused by the front of the car. Impact with the road is the next largest cause.

Treatment

5.52 Since we were attending only accidents to which an ambulance was called, most of these cyclists were carried to hospital by the ambulance. Once there, most were admitted and a few were sent home after treatment, as the following figures show.

No treatment required	6
Casualty treatment only	7
Admitted, later discharged	28
Dead on arrival at hospital	2
Dead at scene	1
Total	44

Sixty-four per cent of these 44 cyclists were admitted. The injuries of the persons killed were so severe that they died before reaching hospital.

5.53 The lengths of stay of those admitted to hospital were as follows:

24 hours or less	10
1-2 days	7
3-5	4
6-10	2
11-15	3
16-20	1
21-25	0
26-30	0
More than 30 days	1

Ten (35 per cent) of those admitted stayed 24 hours or less, and only two persons stayed longer than 15 days.

INTRODUCTION

6.1 Our sample of 408 traffic accidents in metropolitan Adelaide contains 66 motor-cycle accidents, i.e. 16 per cent of the total. This proportion increased in the two years of our survey from 14 per cent in 1963 to 18 per cent in 1964. This may be a chance variation, although it has been suggested (Ref. 14) that as motor-cycles become a smaller fraction of the total traffic so the risk of a motor-cycle being involved in a traffic accident increases. In South Australia, motor-cycles were 4.15 per cent of all registered motor vehicles in 1963 and 3.48 per cent in 1964. We will show that many motor-cycle accidents arise from other vehicles turning into the path of the motor-cycle. We presume that such drivers, seeing the road to be clear of cars, proceeded to turn, not realizing that a motor-cycle is much more difficult to see than a car. Of course, if there were many more motor-cycles than cars on the roads, car drivers would be accustomed to looking carefully for a motor-cyclist when checking whether it is safe to proceed. As it is today, drivers can almost assume, as many do, that only cars need to be watched for, because smaller vehicles are so few.

6.2 This section deals with accidents to motor-cycles, motor-scooters, and one motor-cycle and sidecar. Unless otherwise stated 'motor-cycle' includes motor-scooters. One case, case 0026, we have considered as two separate accidents to make our subsequent analyses clearer.

● **Case 0026**

A motor-scooter, ridden by a 38-year old man with his 9-year old daughter on the pillion, began to swing from side to side of a ridge along the edge of a newly laid road surface. A heavy load on the luggage carrier may have prevented the rider from regaining control. He and his passenger eventually fell off, both sustaining abrasions. A car following closely behind this scooter braked suddenly to avoid hitting it, and was struck in the rear by a second motor-scooter which was unable to stop as quickly as the car. This second scooter skidded sideways on braking and slid in under the back of the car. Its rider was not injured.

By considering these two scooters to be involved in separate accidents, viz. one single vehicle accident (case 0026A) and one collision between a motor-scooter and a car (case 0026B), we increase our total number of motor-cycle accidents to 67. Note however that when making comparisons such as that at the beginning of this section we use our original definition, viz. this whole series of events constitutes one accident.

TIME DISTRIBUTION

6.3 Over two thirds (45/66) of these accidents happened in the daytime. The previously noted peak of traffic accidents around 6 p.m. is very pronounced in this group of motor-cycle accidents. *Fig. 6.1* shows the distribution of accidents in our survey time (10 a.m. to 11 p.m.). The histogram shows that over one third (24/66) of these accidents happened in the two hours between 4 p.m. and 6 p.m. When reduced into two histograms, one for motor-cycles and the other for motor-scooters,* this peak becomes very much more pronounced for motor-cycles (*Fig.*

*Motor-cycles and motor-scooters are not always obviously exclusive categories. We have considered an open-frame machine such as a Honda Cub to be a motor-cycle because the rider's foot rests on a peg, not on a flat plate, and his lower leg can be trapped against the machine in the event of an impact from the side.

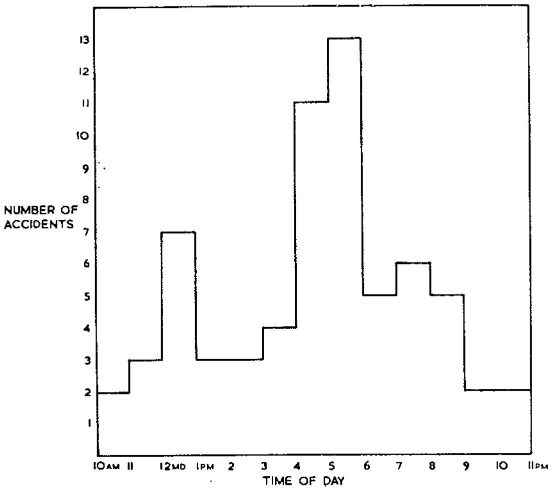


Fig. 6.1—Total motor-cycle accidents by time of day

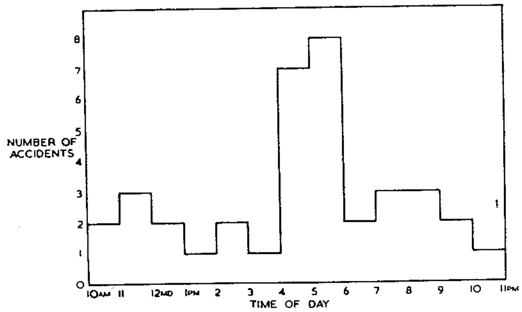


Fig. 6.2—Time distribution of motor-cycle accidents

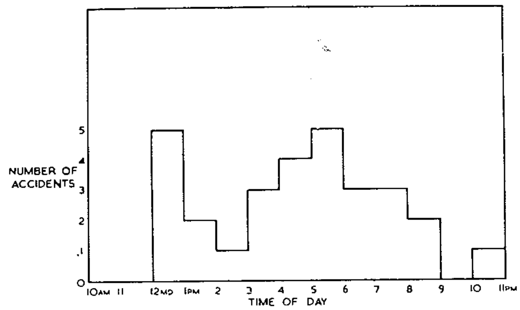


Fig. 6.3—Time distribution of motor-scooter accidents

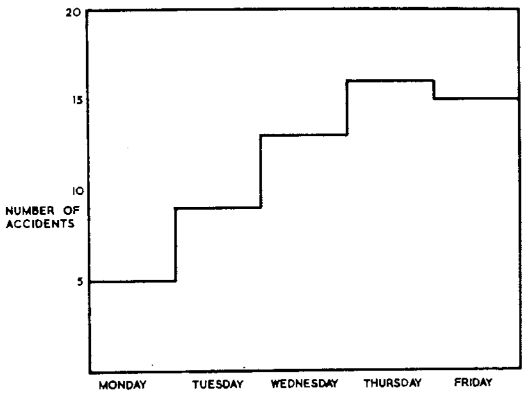


Fig. 6.4—Total motor-cycle accidents by day of week

6.2) but is diminished in the case of motor-scooter accidents (*Fig. 6.3*). There is also a slight peak during lunch hours (12 p.m. to 2 p.m.) and the evening peak continues, although diminished, to between 8 p.m. and 9 p.m. The differences between the two distributions may be due to chance. It may be necessary to remind our readers that our sampling method was biased towards periods of low accident frequency. These peaks in the distribution are therefore much less marked than is actually the case.

6.4 When we look at the distribution of motor-cycle accidents by day of the week we see that the number increases from Monday to Thursday (*Fig. 6.4*). We have not shown here the accidents we collected on Saturdays and Sundays because we sampled very few Sundays and only alternate Saturdays. This increase in the number of accidents through the week is shown also in the calls ambulances received to traffic accidents. A similar trend is shown in the total figures for our survey, but is much more marked in the case of motor-cycle accidents. We have been unable to demonstrate any relationship between this trend and any specific features of the environment, e.g. traffic conditions. It may be that people become more impatient as the week goes by!

WEATHER CONDITIONS

6.5 The motor-cycle, being a single track vehicle, relies on the stabilizing effect of its rotating wheels to enable the rider

TABLE 6.1

EFFECT OF TYRES ON SKIDDING

	Condition of Tyres			
	Good	Poor	Not recorded	Total
Skidding when braking	6	5	2	13
No skidding observed	28	14	12	54
Total	34	19	14	67

to balance his machine. When either or both wheels are locked by the brakes it is extremely difficult for even a skilled rider to maintain control. Similarly, when cornering, skidding can be very hazardous for the motor-cyclist because both his directional control and the stability of his machine are affected.

6.6 Because of these dangers associated with skidding, and the obvious relationship between reduced skid resistance and wet roads, we would expect motor-cycle accidents to be closely related to weather conditions. It comes as a considerable surprise therefore to find that only one of these accidents occurred when it was raining and only three on wet roads. Of these three accidents the condition of the road surface was significant in two cases. These two accidents both involved a car turning across the path of a motor-cycle. Each rider braked hard and his machine (in one case a heavy motor-cycle, in the other a scooter) skidded and slid sideways into the car. The scooter rider sustained bruises and abrasions. The motor-cyclist was not injured. Both were wearing safety helmets.

TYRES

6.7 Our figures do not show any significant relationship between the condition of the tyres on motor-cycles and the incidence of skidding. In these 67 accidents we recorded 13 cases in which a motor-cycle skidded when braking. TABLE 6.1 shows how the conditions of the tyres of these machines compared with those of motor-cycles which did not skid.

6.8 Of the three categories of motor-cycles, viz. motor-cycles over 200 cc, under 200 cc, and scooters, we found that light motor-cycles appear to be less susceptible to skidding while braking than the heavier machines and scooters (see TABLE 6.2).

6.9 There are two possible explanations here: one is that the lighter, less powerful motor-cycles may not have been travelling as fast as the heavier machines. This is largely true in this sample of accidents, as

TABLE 6.2

SUSCEPTIBILITY TO SKIDDING OF DIFFERENT TYPES OF MACHINE

	Motor-cycles		Scooters	Total
	Heavy	Light		
Skidding while braking	7	—	6	13
No skidding observed	16	13	24	53
Total	23	13	30	66

TABLE 6.3

TRAVELLING SPEEDS

Travelling Speeds	Motor-cycles		Scooters	Total
	Heavy	Light		
Up to 20 m.p.h.	3	4	4	11
Over 20 m.p.h.	15	6	18	39
Speed not recorded	5	3	8	16
Total	23	13	30	66

TABLE 6.3 shows. The other possible explanation is that the brakes on the lighter motor-cycles do not lock the wheels as easily as on the heavier machines.

AGE OF MOTOR-CYCLISTS

6.10 The age distribution of motor-cyclists involved in the accidents in our survey is shown in *Fig. 6.5*. There were 67 riders (of whom 60 were males and 7 females) and 7 pillion passengers (of whom 4 were females and 3 males). There were no riders less than 16-years old (16 years is the minimum age for holding a driving licence). One pillion passenger, a girl, was 9 years old. The histogram shows a marked peak at 15 to 19 years; while from 20 to 34 years the number of riders is almost constant. After 35 years the numbers fall to a minimum. Twenty-three (38 per cent) or more than one third of the riders involved were less than 20 years old, and 32 (53 per cent) were less than 24 years old.

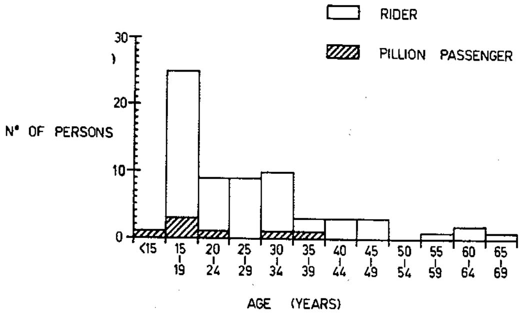


Fig. 6.5—Age distribution of motor-cycle riders and pillion passengers

Age and length of driving experience

6.11 TABLE 6.1A in Appendix A shows how age and length of experience in driving are related. It can be seen that the length of experience increases with age. Most riders had been driving since they had reached the legal minimum age. Most accidents seemed to happen in the second to fifth year of driving experience.

Helmets and age of rider

6.12 A total of 21 riders and one pillion passenger were wearing safety helmets. In TABLE 6.4 the number of riders in each age group wearing helmets is compared with the total number in each group. 30.5 per cent of those less than 20 years of age were wearing helmets, while 56 per cent of those between 20 and 35 years wore helmets. Nobody over 35 years of age wore a helmet. One pillion passenger, aged 30 years, who wore a helmet, is not included in TABLE 6.4. This distribution suggests that more riders aged from 20 to 34 years realize the dangers of motor-cycle riding and are willing to wear a helmet, than those younger or older. A detailed discussion of the role of helmets in injury prevention appears in a later section (para. 6.105).

Type of machine and age of rider

6.13 The age distribution of motor-scooter and motor-cycle riders is shown in TABLE 6.5. The χ^2 test shows that the differences in the distribution could be due to

TABLE 6.4

SAFETY HELMETS

	Age of Rider (in Years)						Total
	15-19	20-24	25-29	30-34	35-69	N.R.	
Wearing helmet	7	4	5	5	0	0	21
No helmet	18	5	4	5	13	1	46
Total	25	9	9	10	13	1	66

chance. But nearly half (43 per cent) of the motor-cycles were ridden by riders under 20 years, and only 30 per cent of the motor-scooters by riders of the same age group. The use of motor-scooters was more evenly spread throughout the age groups.

TYPES OF MOTOR-CYCLE ACCIDENTS

6.14 The 67 motor-cycle accidents can be divided into groups as follows:

Collision between motor-cycle and car	47
Collision between motor-cycle and pedestrian	7
Collision between motor-cycle and truck	4
Collision between motor-cycle and pedal cycle	2
Collision between motor-cycle and train	1
Motor-cycle alone	6
Total number of cases	67

(Case 0026 is counted in two categories) Collisions with cars and trucks make up 76 per cent of all motor-cycle accidents.

TABLE 6.5

TYPE OF MACHINE

Age of Rider (in Years)	Motor-scooter	Motor-cycle	Total
15-19	9	16	25
20-24	5	4	9
25-29	3	6	9
30-34	7	3	10
25-39	1	2	3
40-44	2	1	3
45-49	2	1	3
50-54	0	0	0
55-59	0	1	1
50-54	0	2	2
65-69	0	1	1
N.R.	1	0	1
Total	30	37	67

TABLE 6.6

LOCATION OF ACCIDENTS WITH RESPECT TO INTERSECTIONS

Collision of Motor-cycle with	Location of the Accident				Total
	Not at intersection	At intersection	Within 20 yd before intersection	Within 20 yd after intersection	
Car	9	32	4	2	47
Truck	0	4	0	0	4
Pedestrian	3	1	0	3	7
Pedal cycle	0	2	0	0	2
Motor-cycle alone	2	1	2	1	6
Train	Not applicable				1
Total	14	40	6	6	67

The accidents involving a motor-cycle alone consist of two cases of collision with a fixed object, and four cases where the motor-cycle and rider fell to the road without striking any other vehicle.

LOCATIONS OF MOTOR-CYCLE ACCIDENTS

6.15 A spot map giving the location of each of these accidents is presented in *Fig. 6.6*. The accidents are distributed more evenly between the central city area and the suburbs than is the case for pedal cycle accidents. Note that nearly all of these motor-cycle accidents happened on busy roads.

6.16 The locations of these accidents with respect to intersections are shown in TABLE 6.6.

6.17 The collision between a motor-scooter and a train occurred at a level crossing, and so is not classified in TABLE 6.6. Forty (61 per cent) of the other 66 accidents happened within an intersection, 12 (18 per cent) happened within 20 yd of an intersection and 14 (21 per cent) more than 20 yards from an intersection. Only one of the seven pedestrian accidents happened at an intersection, the rest took place some distance away from the intersection.

PRE-COLLISION MOVEMENTS OF EACH VEHICLE

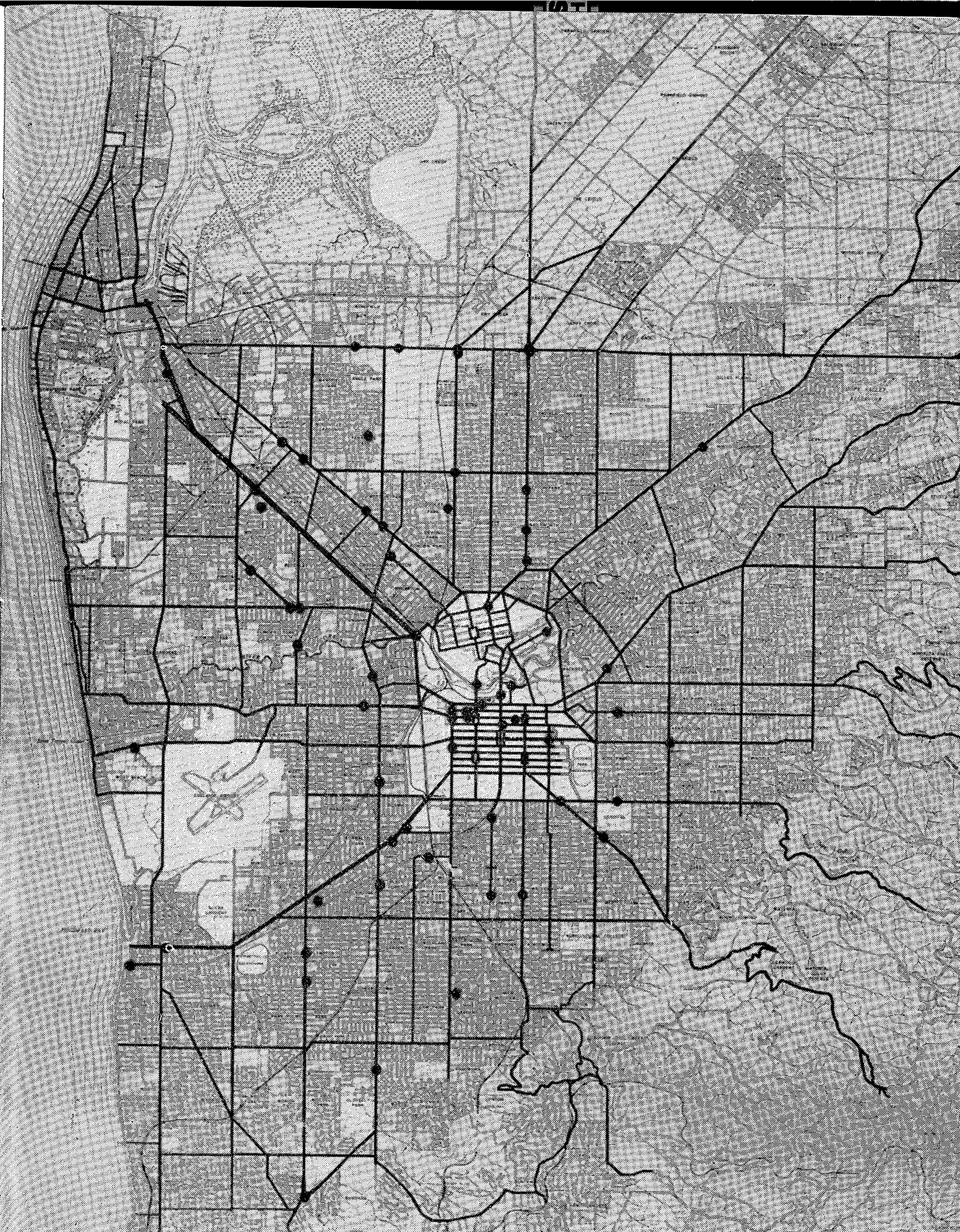
6.18 The movements of the motor-cycles before the collision in each class of accident are set out in TABLE 6.2A in the Appendix. This table shows that 52 (79 per cent) of motor-cycles were travelling straight ahead before their collision and only five (8 per cent) were changing direction.

6.19 TABLE 6.3A in Appendix A sets out the movements of the other vehicles in the collisions. It shows that 33 (70 per cent) of the cars were changing direction when they struck motor-cycles, and 23 of these were turning right. Altogether, 34 (64 per cent) of the vehicles which struck motor-cycles were changing direction at the time of the collision.

ACCIDENTS INVOLVING MOTOR-CYCLES ALONE

6.20 There were six accidents where the motor-cycle was the only vehicle involved. In each case the motor-cycle was proceeding straight ahead. There were two cases of collisions with fixed objects, and four cases of falls when the rider lost control of his machine.

Fig. 6.6—Location of accidents→



MOTOR CYCLE ACCIDENTS

6.21 In two cases the motor-cyclist was forced to swerve to avoid a vehicle turning into his path, and in so doing came to grief. In the first case, case 0037 (see *Fig. 6.7*), a 25-year old male riding a B.M.W. motor-cycle was forced into the left hand kerb by a semi-trailer which turned on to the dual highway from the median. The motor-cycle scraped along the kerb, still upright, until it struck a 6 ft high pile of bricks stacked on the footpath level with the edge of the kerb. The left side of the rider and the motor-cycle struck the edge of the pile of bricks. The rider, who was wearing a crash helmet, suffered concussion, lacerations of the left eyebrow and left cheek, a fracture of the left clavicle, a left pneumothorax, and a comminuted fracture of the left patella, all produced by the impact with the pile of bricks.

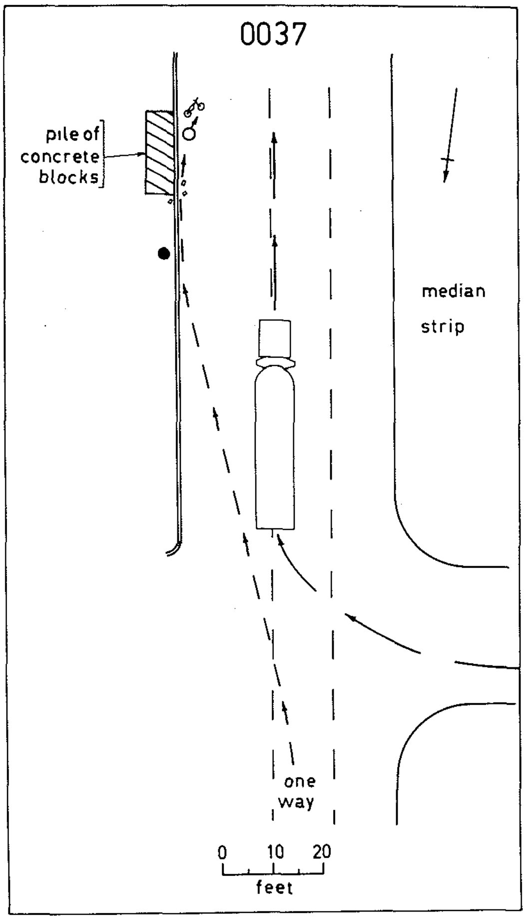


Fig. 6.7—Case 0037

6.22 In the second case (case 0197)' a 19-year old female riding a motor-scooter swerved and braked to avoid a taxi which turned sharply across in front of her. The scooter fell on its side and slid down the road. The rider suffered concussion, an abrasion to the left cheek, a laceration of the posterior parietal region of the skull, a fracture of the right clavicle and abrasions to hands, hips, knees and ankles.

6.23 In one of the two cases where a motor-scooter struck a join in the road surface, and the rider lost control, the rider and scooter struck a steel and concrete utility pole. The rider suffered concussion (case 0321). In the other case (case 0026), the scooter had a large parcel on the carrier at the rear, as well as a pillion passenger. The scooter and load fell to the road, rider and passenger suffering abrasions.

6.24 In the fifth case (case 0182) a 19-year old male, unlicensed and testing his unregistered motor-cycle, braked on loose gravel. The cycle skidded and fell on its side and slid into a concrete kerb. The rider suffered concussion, a bruise on the left temple, left shoulder and over his sacrum.

6.25 In the last of these cases (case 0303), a female approximately 30 years old was stationary on a motor-scooter at traffic lights when she was seen (and heard) to open the throttle wide, and to let the clutch out suddenly. The scooter reared up in the air, slid into the next lane and the rider fell off. She was unconscious for approximately 5 minutes after the incident, and on recovering she was very uncooperative. The story is suggestive of an epileptiform fit.

6.26 Prevention of single vehicle motor-cycle accidents would seem to be a matter of improving riding ability, particularly of scooter riders. The cases which resulted from careless manoeuvres by other vehicles set the pattern for the causation of the majority of the motor-cycle accidents in our survey.

MOTOR-CYCLES AND PEDESTRIANS

6.27 The pedestrian injuries and circumstances of the accidents have already been described in Section 4 on pedestrian accidents. The riders of the motor-cycles all fell off after the collision. They all sustained abrasions and bruises to their extremities and in two cases they sustained concussion. One rider wearing a crash helmet struck his head on the side of a parked car as he fell to the road after impact with the pedestrian (case 0424). The other rider, who was not wearing a helmet, struck his head as he fell to the road. Only one of these accidents was at night, whereas over two-fifths of the total number of pedestrian accidents happened at night. This may be due to chance, but it is possible that an approaching motor-cycle is more noticeable at night, when its headlight is on, than in the daytime.

MOTOR-CYCLES AND PEDAL CYCLES

6.28 There were two of these collisions. Both have been considered in the section on pedal cycles (Section 5). In one case the motor-cyclist suffered concussion and abrasions to his face, and in the other the motor-cyclist was unhurt. These collisions are rather akin to collisions with pedestrians in that the fall to the road, rather than the collision itself, causes injury to the motor-cyclist.

MOTOR-CYCLE AND TRAIN

6.29 The one death among motor-cyclists occurred when a 47-year old man stopped at a level crossing to allow a train to go past on the track farthest away from him. He then moved on to the closer track and was struck by a diesel railcar travelling in the opposite direction, as he tried to push his machine back off the track (*Fig. 6.8*). The warning signals were operating at the time. The front left corner of the railcar struck the right side of the rider's head causing extensive fracturing of skull, maxilla, and mandible, also extensive brain lacerations and transection of the brainstem below the pons (*Fig. 6.9*). His other injuries were abrasions to his right shoulder and left leg.

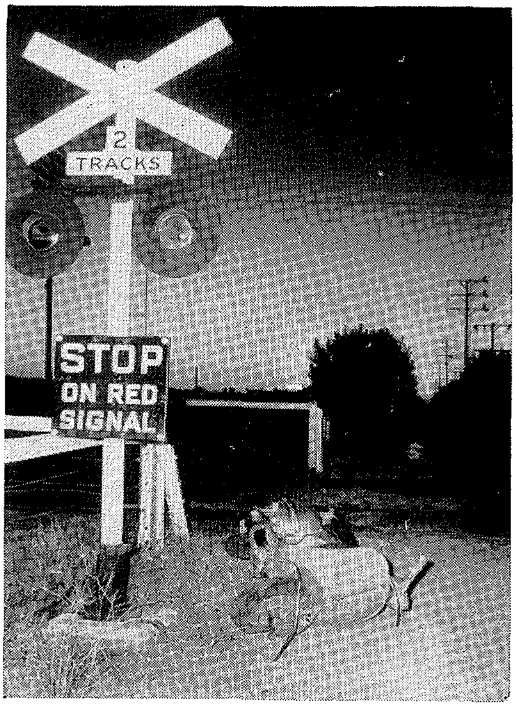


Fig. 6.8—Scooter stopped alongside these lights, then moved forward and was struck, from the right, by the train shown in *Fig. 6.9*

MOTOR-CYCLE AND CAR

6.30 There were 47 collisions between cars and motor-cycles. TABLE 6.3A shows

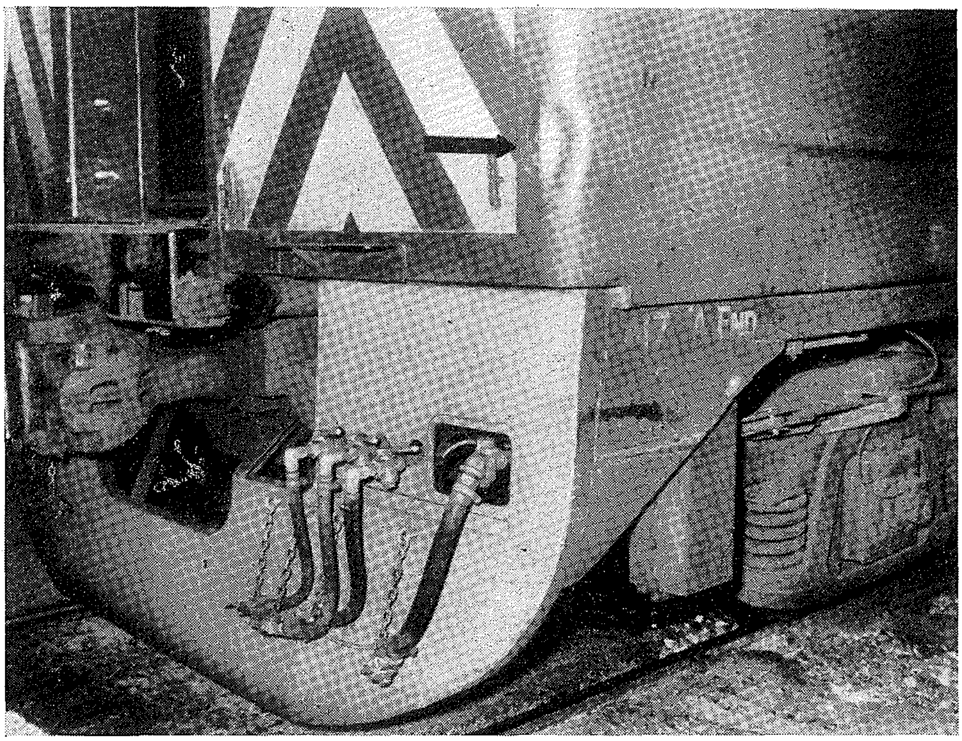


Fig. 6.9—Front of train which struck motor-scooter shown in *Fig. 6.8*. Arrow indicates dent made by impact with rider's head

that almost half of these cars were turning right.

Cars turning right colliding with a motor-cycle

6.31 This category comprises a third of all motor-cycle accidents in our survey. The alarming feature of this type of accident is that there is very little that the motor-cyclist can do to avoid such a collision.

6.32 Thirteen cases involved a car turning right across the path of motor-cycle approaching on the same road.

● Case 0087

This accident happened in the city just before dusk on a fine clear day. A youth on a motor-scooter struck the left side of a car which had been coming towards him and had turned right, across his path, at a traffic-light-controlled intersection (*Fig. 6.10*). The scooter rider's head struck and shattered the glass of the left front door of the car (*Fig. 6.11, 6.12* and *6.13*). The jagged edges of the glass remaining in the frame caused extensive lacerations of the left side of the base of his neck and left shoulder (*Fig. 6.14*). The impact with the centre post fractured his lower jaw and left clavicle. A safety helmet protected his scalp from abrasions (see *Fig. 6.15*), but he was concussed. The elderly male driver of the car received only small lacerations from fragments of glass from the broken window.

6.33 All of these 13 accidents involved passenger cars. Five cases were at traffic-light-controlled intersections. At one of these, (O'Connell Street and the Main North Road) the layout of the lights is

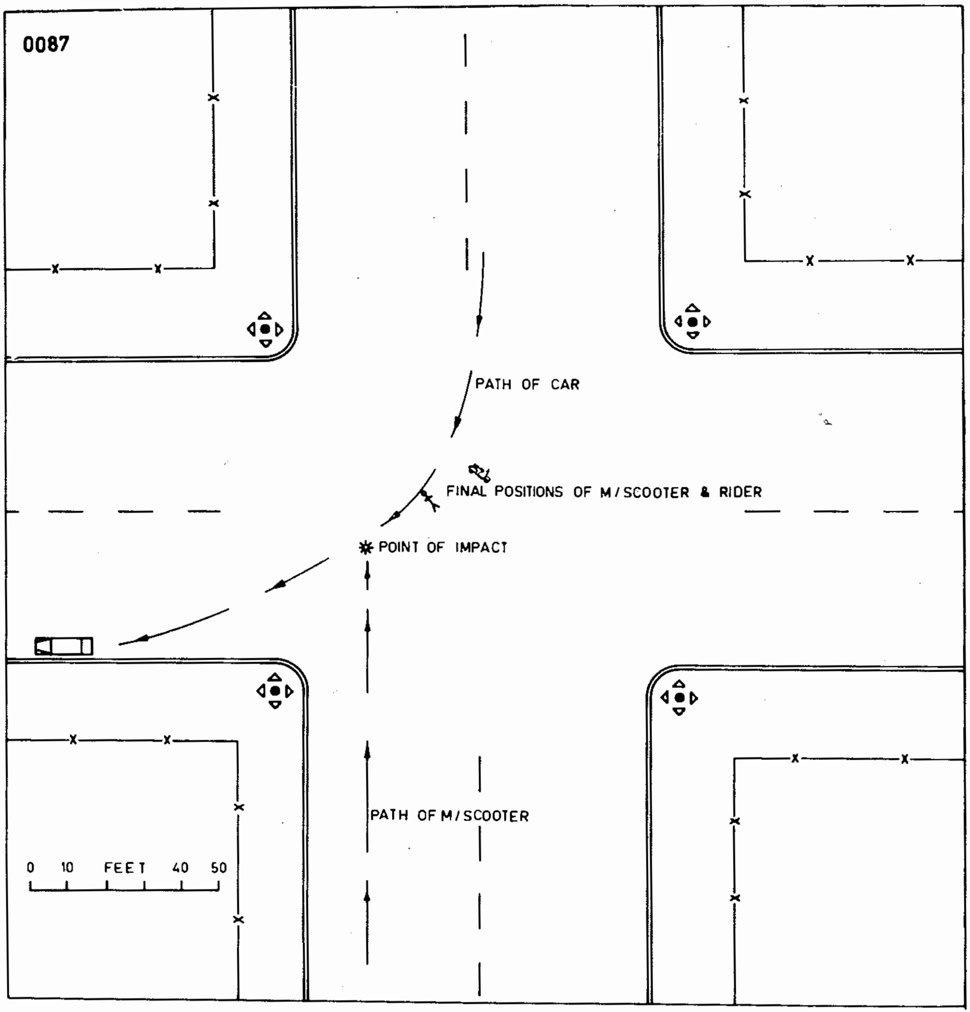


Fig. 6.10—Case 0087

confusing and tends to give the turning driver the impression that he has the right to turn whereas in fact he has to yield to oncoming traffic. At one other location (West Terrace and Currie Street) during peak traffic periods, the West Terrace traffic has a split green phase; that is the southbound green phase is shorter than the northbound. This has the effect that a driver who is facing south waiting to turn right sees his light change to red and completes his turn, unaware that the northbound traffic still has the green light. According to the participants' accounts, the lights could have been on split phase operation at the time of the accident which we attended at this intersection, although we have been told that the time of day at which the accident happened was before the time switch changes the lights to split phase operation.

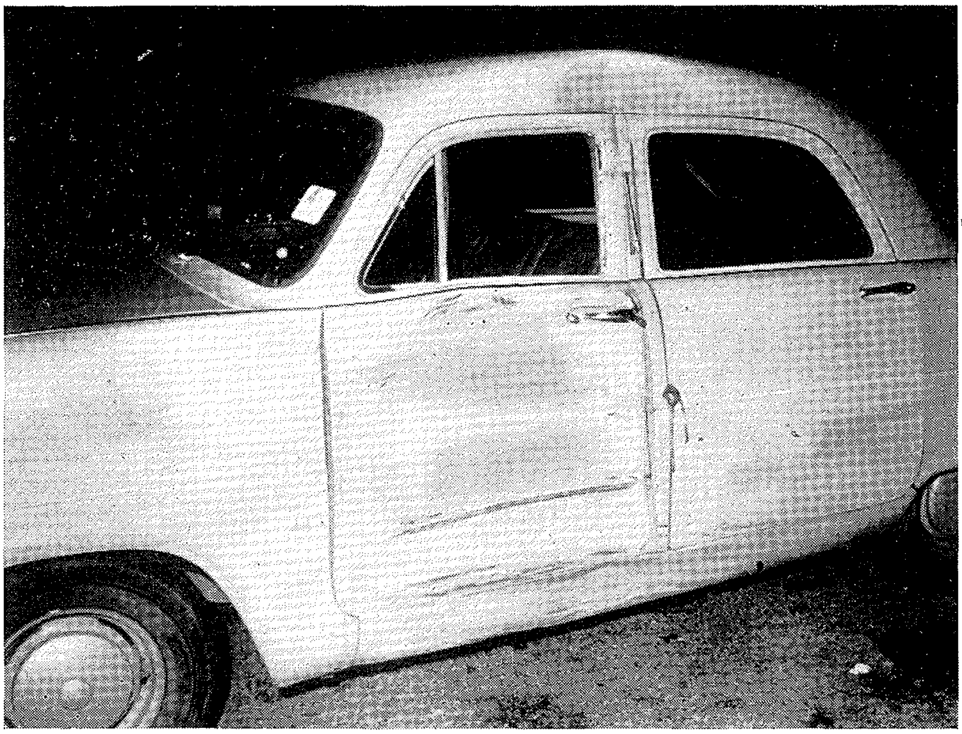


Fig. 6.11—Case 0087: motor-scooter struck left door of car. Damage around centre post caused by impact of rider's head

Split phase operation of traffic lights appears to place unfair demands on a driver, who has no way of knowing whether the lights are on normal or split phase operation. It is not desirable to increase the rate of the traffic flow by reducing the safety margin of a traffic control device.

6.34 By contrast with the motor-cycle collisions with pedestrians, which were nearly all in the daytime, we find that these accidents involving cars turning right were equally divided between day and night (see TABLE 6.7).

6.35 The above result conflicts with the suggestion we made earlier that it may be harder to see an approaching motor-cycle in the daytime than at night. This sighting will obviously depend on many factors, among them the nature of the background behind the motor-cycle. If, at night, it is a dark background, with no other lights apart from the headlight of the motor-cycle, it should not be difficult to see the machine approaching. If it is only one of many lights the headlight could easily be overlooked. It seems that drivers should at all times look first for motor-cyclists, then for other vehicles, before completing a turn to the right. TABLE 6.8 shows that while the motor-cyclist usually saw the car approaching in the distance, the car driver usually saw the motor-cyclist only just before the collision. Because the number of cases is small the distribution is likely to be due to chance.

6.36 It might be suspected that the motor-cyclists who are involved in this type of accident were travelling unusually

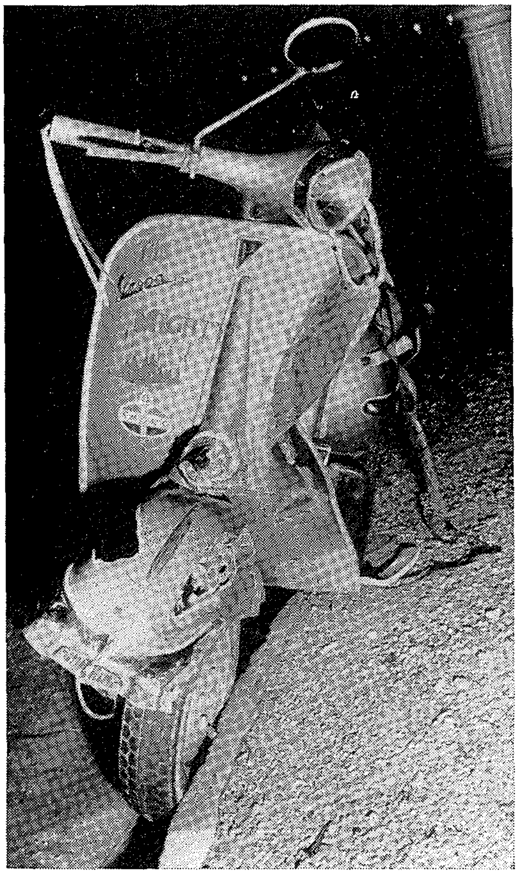


Fig. 6.12—Case 0087: Motor-scooter struck car shown in *Fig. 6.11*

fast, this making it difficult for the car drivers to judge their speed. Our data do not support this suspicion. The average travelling speed for the 12 cases for which we were able to obtain information is less than 30 m.p.h.

6.37 There seems to be little that can be done to minimize the occurrence of this type of accident. However, it would be wise to ensure that, at traffic light installations, the driver turning right is not encouraged to do so before the road is clear.

6.38 In a similar category, there were ten cases in which a car turned right from one road and hit a motor-cyclist travelling towards the intersection along the other road.

● **Case 0341**

The middle-aged male driver of a car proceeded with a right hand turn from a side street, despite the fact that his view to his right was obscured by a bus which was taking on passengers. A motor-scooter suddenly came past the bus from his right and struck the right front corner of the car (*Fig. 6.16*). The rider of the scooter said he saw the car appear from behind the bus

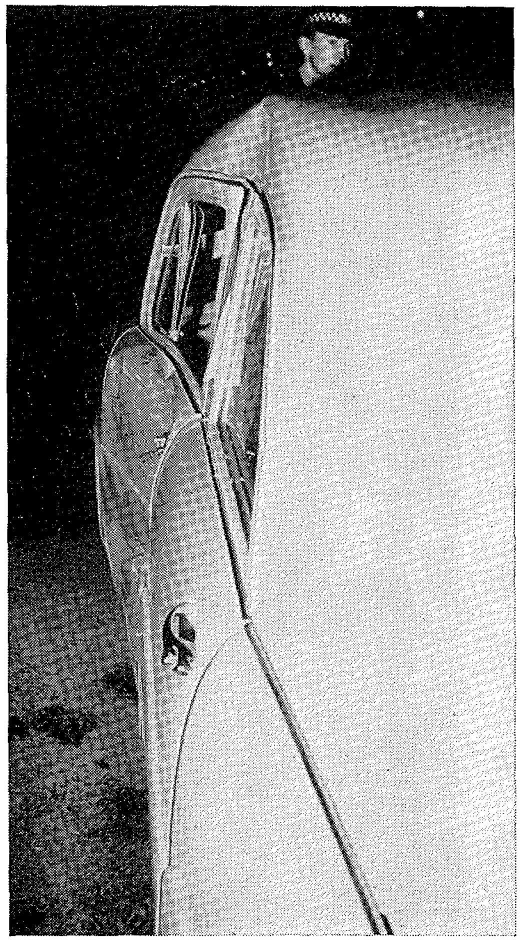


Fig. 6.13—Case 0087: deformation of car produced by impact of motor-scooter and rider

Fig. 6.14—Case 0087: close-up of window showing glass fragments retained in frame and particles of skin adhering to paint

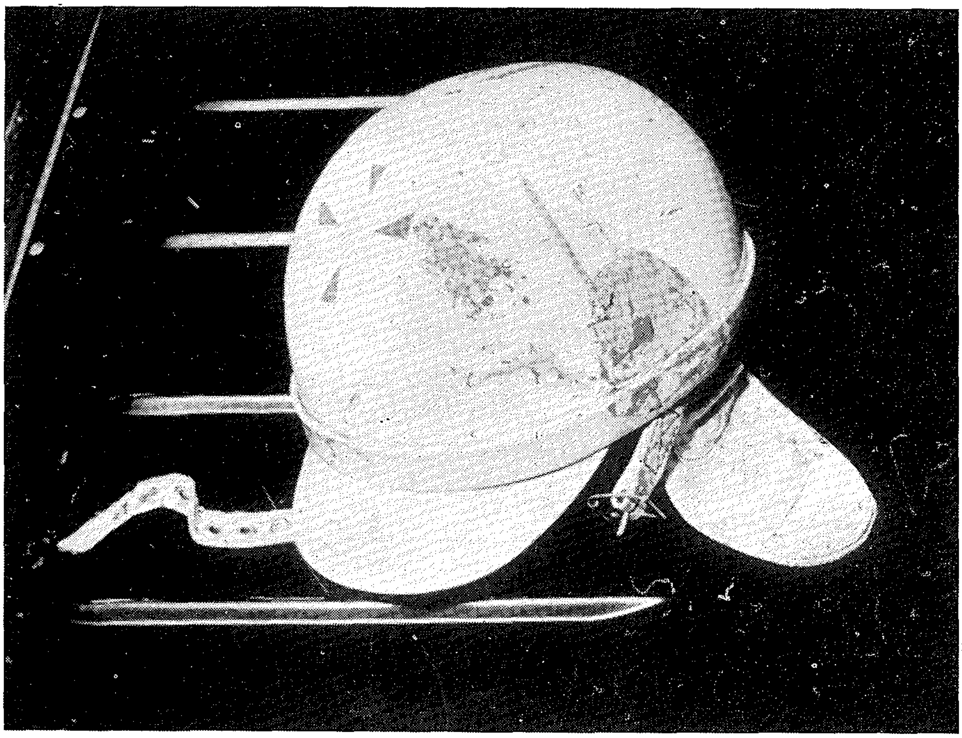


Fig. 6.15—Case 0087: helmet worn by motor-scooter rider (note abrasions of paint)

TABLE 6.7

DAY AND NIGHT ACCIDENTS

	Day	Night	Total
Cars turning right—motor-cycle approaching	6	7	13
Other motor-cycle accidents	40	14	54
Total	46	21	67

$\chi^2 = 3.5$ N.S.

TABLE 6.8

DISTANCE AT WHICH OTHER VEHICLE WAS SEEN (CARS TURNING RIGHT ACROSS PATH OF CYCLES)

	Participant Saw the Other Vehicle				Total
	In the distance	Close	Not at all	Not known	
Motor-cyclist	8	3	0	2	13
Car driver	3	6	3	1	13
Total	11	9	3	3	26

(Grouping 'close' and 'not at all') $\chi^2 = 3.51$ (after Yates) N.S.

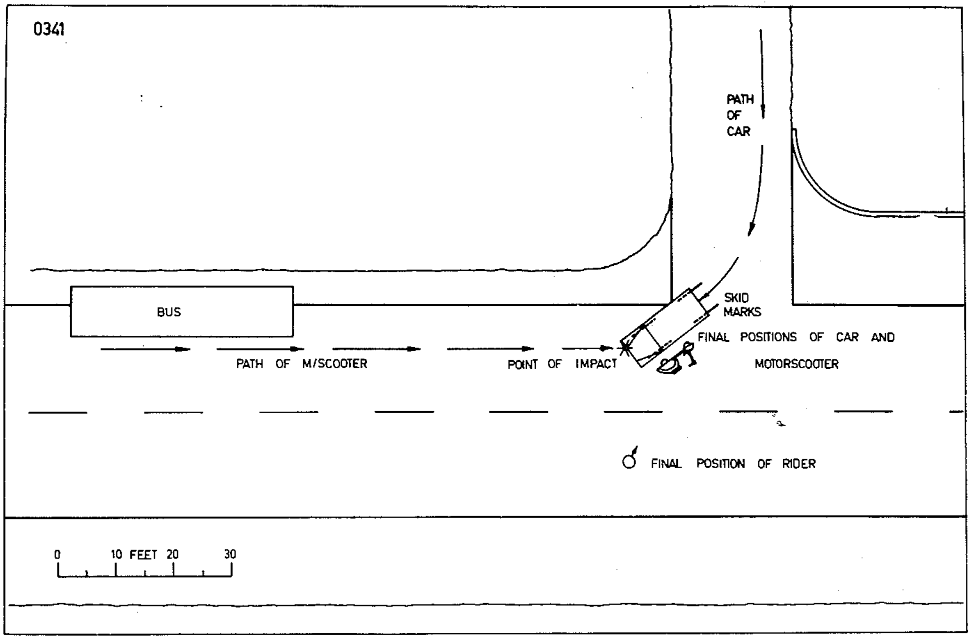


Fig. 6.16—Case 0341

with the driver looking to his left. Although he tried to stop he was unable to avoid the collision with the car. He sustained a fracture of his left tibia. He was wearing a safety helmet.

6.39 This occurrence of a stationary vehicle obscuring a driver's view is repeated in three other cases in this group of ten accidents. The difference between the care with which motor-cyclists and car drivers look for other vehicles is particularly marked here, as TABLE 6.9 shows.

6.40 The average travelling speed of these motor-cyclists is slightly higher than in the previous group, but is still below 30 m.p.h. Seven of these ten accidents happened in the daytime, none of them at light-controlled intersections. In each case the car was turning from a side road into a through road. There is no noticeable distinction between motor-cycles and scooters in these 23 accidents. This is not surprising, for the performance of the cycle has little bearing on such accidents. In 20 cases

TABLE 6.9

DISTANCE AT WHICH OTHER VEHICLE WAS SEEN (COLLISIONS WITH RIGHT-TURNING CARS AT INTERSECTION)

	Participant Saw the Other Vehicle				Total
	In the distance	Close	Not at all	Not known	
Motor-cyclist	5	4	—	1	10
Car driver	—	7	2	1	10
Total	5	11	2	2	20

there was virtually nothing that the motor-cyclist could have done to have avoided the collision. The other three cases may have been avoided if both participants had taken more care.

Cars performing 'U' turns

6.41 There were seven cases involving cars which struck a motor-cyclist while attempting a 'U' turn from a parked position alongside the kerb. Six of these seven accidents happened in the daytime. The types of motor-cycles involved were four scooters, two light motor-cycles, and one heavy motor-cycle.

● Case 0418

The driver of a Holden sedan, ranked on the left side of a road 70 ft wide, looked both ways before starting a 'U' turn. He saw a motor-scooter some distance away behind him, but thought that he had time to turn in front of it. The rider of the motor-scooter said that the car suddenly made a 'U' turn in front of him without any warning (*Fig. 6.17*). His machine struck the right rear wheel of the car (*Fig. 6.18*) and he hit his face on the right rear corner of the roof (*Fig. 6.19*). He was concussed, and also fractured his right cheekbone and some teeth. Damage to the infra-orbital nerve resulted in partial loss of feeling in the right side of his face. His left hand and both knees were bruised.

6.42 Once again there is very little that the motor-cyclist can do to avoid a collision of this nature. Both motor-cyclists and car drivers saw each other with equal frequency (see TABLE 6.10). It seems likely that the car drivers underestimated the speed of the motor-cycle and also the time needed to complete a 'U' turn. The average travelling speed for these motor-cyclists is high, being between 30 and 40 m.p.h., but this is not beyond the range of speeds that a driver should allow for when

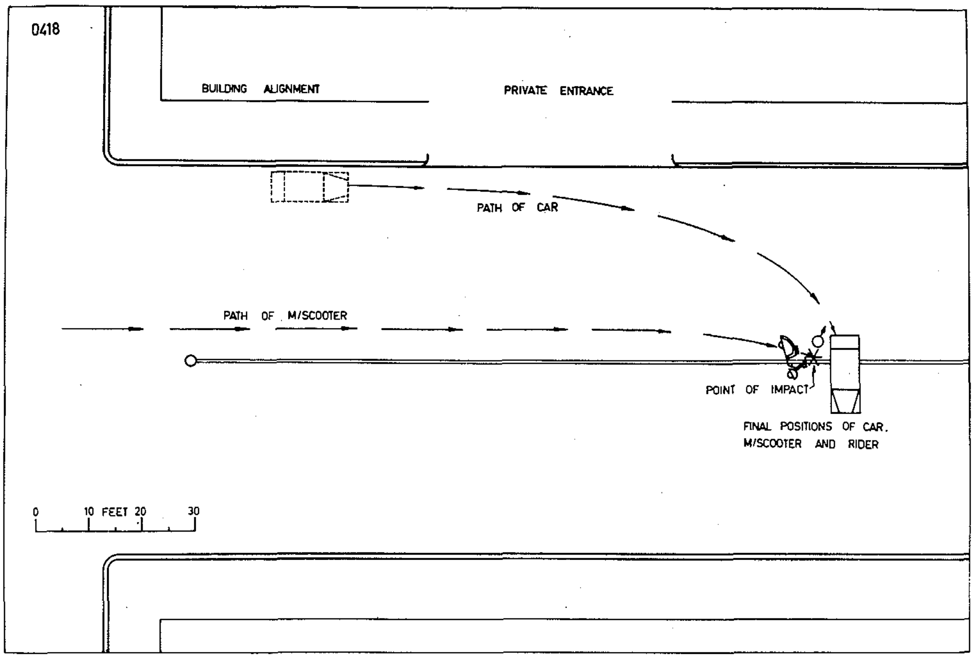


Fig. 6.17—Case 0418

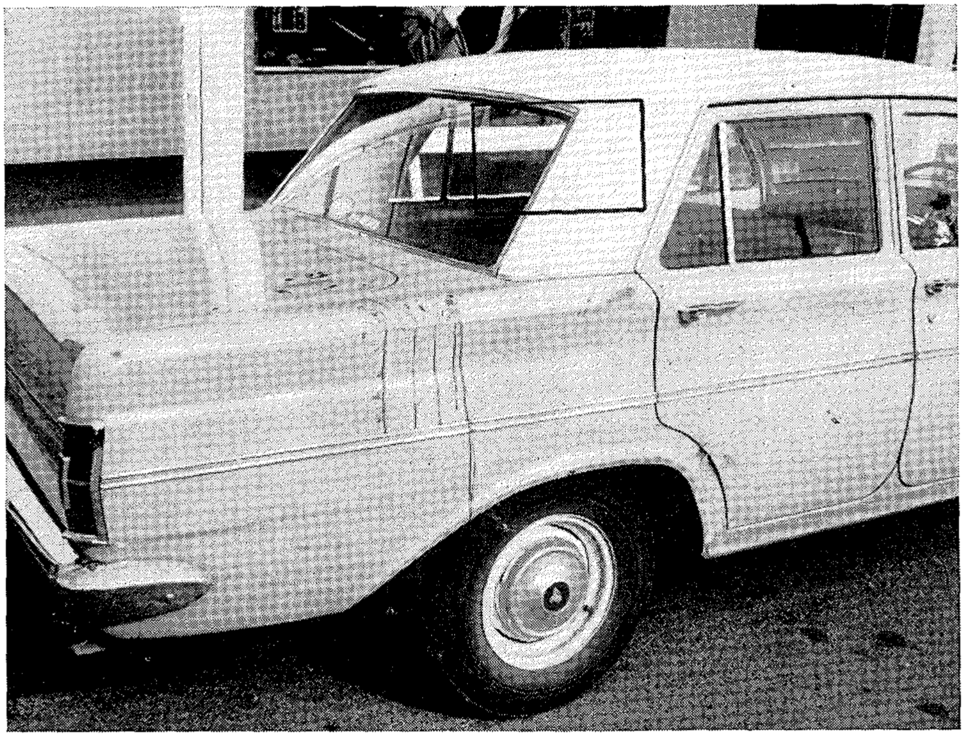


Fig. 6.18—Case 0418: motor-scooter struck right rear wheel, rider's face struck in area outlined (see also *Fig. 6.19*)

turning across the path of an approaching vehicle.

6.43 There is one other accident similar to those in this group. A driver moved off from a ranked position to turn right into a side street and was struck by a motor-scooter which he had not seen coming up behind him.

Collisions at intersections

6.44 In these eight accidents both the motor-cycle and the car were proceeding straight across the intersection.

● Case 0379

The young driver of an old light car moved off to cross to the median of a divided highway when the car alongside him on his right started to move off. In fact this car allowed a motor-scooter to pass along the highway from the right. The driver of the case car could not see the motor-scooter approaching and continued to move forwards, striking the scooter (*Fig. 6.20*). The young scooter rider, who was wearing a safety helmet, sustained bruises to his left leg. The pillion passenger, who was not wearing a helmet, sustained concussion in addition to bruises.

6.45 This example of a driver moving off because the car alongside him on his right starts to move is one of the manoeuvres which we have found commonly to result in an accident.

6.46 There was little difference between the motor-cyclists or the drivers as far as awareness of the approach of the other vehicle was concerned (see TABLE 6.11). Three quarters of these were daytime accidents.

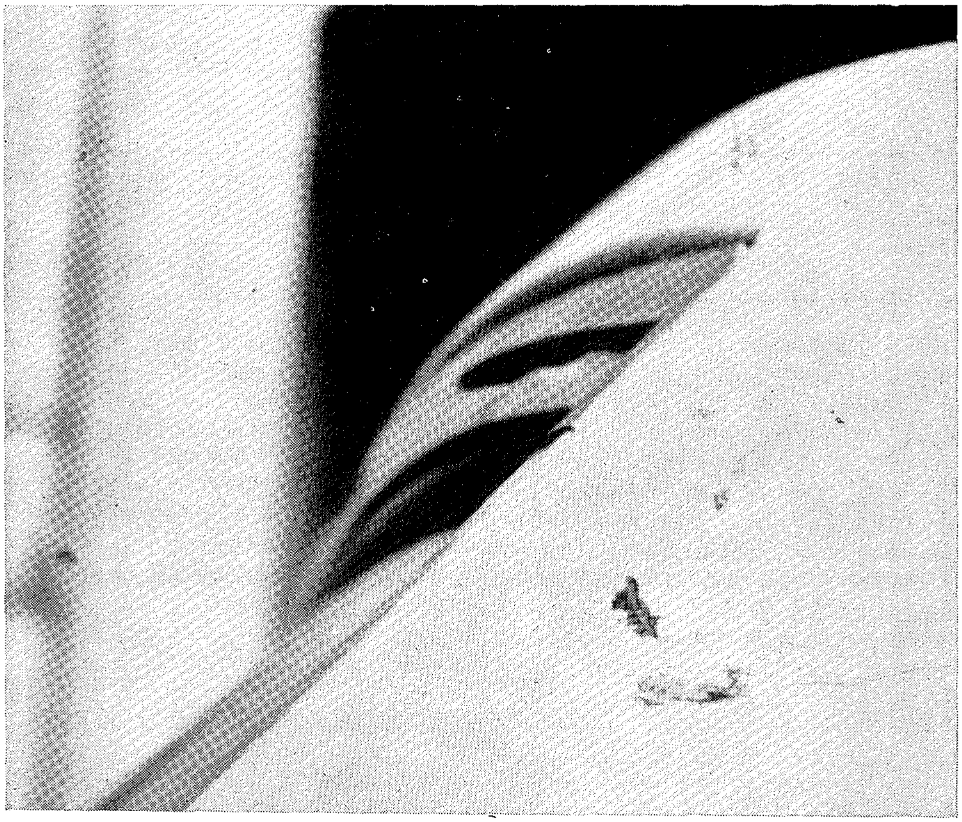


Fig. 6.19—Case 0418: teeth marks made by motor-scooter rider

6.47 In two cases the motor-cyclist was travelling unreasonably fast for the particular situation. By 'unreasonably fast' we mean, in one case, any speed above 5 to 10 m.p.h. on entering the intersection, which had a blind corner. In the other case the car driver was, at a speed of over 50 m.p.h., inviting a collision with any unfortunate person who emerged from a side street without first looking rather a long way up the road to his right.

Rear end collisions

6.48 Of the three accidents of this type two resulted simply from the motor-cyclist running into the back of a car which had stopped because the vehicles ahead of it had stopped. In the other case the car skidded to a stop to avoid a fallen scooter rider, and a motor-scooter following closely behind the car was unable to avoid running into the back of it.

Car turning left across path of motor-cycle

6.49 Two cases of a similar nature resulted from cars turning left, one into a private entrance, the other to park. By turning left from near the centre of the roadway they each cut across the path of a motor-scooter which was travelling in the same direction but keeping further to the left side of the road.

Miscellaneous motor-cycle accidents with cars

6.50 The remaining five motorcycle accidents are all different from each other and

TABLE 6.10

DISTANCE AT WHICH OTHER VEHICLE WAS SEEN (CARS MAKING 'U' TURN)

	Participant Saw the Other Vehicle				Total
	In the distance	Close	Not at all	Not known	
Motor-cyclist	3	2	—	2	7
Car driver	3	3	—	1	7
Total	6	5	—	3	14

from those listed above. There are some similarities however:

(a) A sideswipe collision between a motor-cycle and an overtaking car.

(b) A rider on a heavy motor-cycle making a 'U' turn when unable to see beyond a van double-ranked behind him. He was struck on the side by a car.

(c) A motor-cyclist turning right at a roundabout on a divided highway saw one car yield to him and proceeded to turn, only to be struck by a second car which did not stop. Confusion regarding the right of way rule at such a location may have been a significant factor in this accident.

MOTOR-CYCLES AND TRUCKS

6.51 There were four collisions with trucks. Two occurred at the same light-controlled intersection (Gepps Cross).

6.52 One of these accidents (case 0239) involved the familiar manoeuvre of one participant, in this case the motor-cyclist,

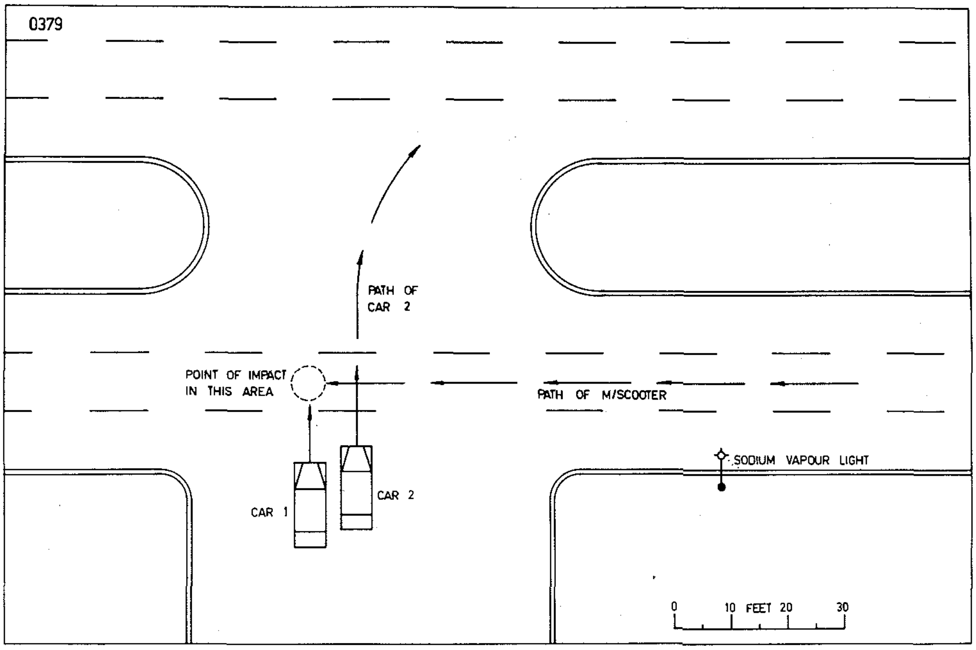


Fig. 6.20—Case 0379

TABLE 6.11

DISTANCE AT WHICH OTHER VEHICLE WAS SEEN (COLLISIONS AT INTERSECTIONS)

	Participant Saw the Other Vehicle				Total
	In the distance	Close	Not at all	Not known	
Motor-cyclist	—	4	—	4	8
Car driver	1	4	3	—	8
Total	1	8	3	4	16

moving off when the traffic lights turned green, even though he could not see past a car alongside him on his right. A truck approaching along the road on the right had entered the intersection just *before* the amber phase of the lights. The amber phase was not long enough to allow the truck to clear the intersection before the lights changed to red, and simultaneously to green for the motor-cycle. The scooter struck the left side of the truck, which was travelling at little more than 20 m.p.h. The rider suffered an abrasion of the right lumbar region with a fracture of the right tenth rib, probably from impact with the tray of the truck, and bruises and abrasions of both thighs. The pillion passenger suffered abrasions to the lumbar region and a laceration of the right knee. Both the rider and his pillion passenger were wearing safety helmets which showed signs of having struck the road surface.

6.53 In the other accident (case 0376) a motor-scooter ran into the right side of the cab of a truck which was still crossing the intersection after the light had changed to red. The rider was wearing a crash helmet, but sustained concussion with signs of cerebral irritation, bruises to the left shoulder and right buttock, and abrasions to both knees and the left lower leg.

6.54 In another collision (case 0147) a motor-scooter swung wide on turning left at a corner and, while still heeled over to the left, struck the front of a truck travelling in the opposite direction. The rider's right leg struck the bumper bar of the truck, producing a fracture of the right tibia and fibula.

6.55 The fourth collision (case 0178) was between a van, which did not stop before entering a main road, and a motor-cycle. The motor-cycle struck the left front door of the van and the rider, a male aged 18 years, suffered a laceration of the right forehead and abrasions to both hands. The cause of the injuries could not be accurately determined.

6.56 While it may be obvious in the above descriptions, we would point out again that the motor-cyclist very often is the 'victim' in the causation of these accidents. In only 15 of these 67 cases could the motor-cyclist reasonably be expected to have been able, by his own action, to have avoided the accident.

A COMPARISON BETWEEN MOTOR-SCOOTERS AND MOTOR-CYCLES IN COLLISIONS WITH CARS

6.57 We have considered collisions between motor-scooters and cars and motor-cycles and cars separately, so that we could determine whether there was any significant difference between motor-scooters and motor-cycles in either configurations of accident or degree of injury.

6.58 Motor-cycles are considered to be machines where the rider sits astride the

TABLE 6.12

COMPARISON OF COLLISIONS WITH CARS

	Front Impact	Side Impact	Total
Motor-scooter	16	5	21
Motor-cycle	13	12	25
Total	29	17	46

$\chi^2 = 2.860$ N.S.

TABLE 6.13

DEGREE OF INJURY

	Injuries		
	Nil and minor	Moderate and greater	Total
Motor-scooter	9	15	24
Motor-cycle	17	10	27
Total	26	25	51

$\chi^2 = 3.307$ N.S. (p $0.05 = 3.841$)

TABLE 6.14

DEGREE OF INJURY (FRONT IMPACT)

	Injuries		
	Nil and minor	Moderate and greater	Total
Motor-scooter	8	11	19
Motor-cycle	9	4	13
Total	17	15	32

$\chi^2 = 2.272$ N.S.

TABLE 6.15

DISTRIBUTION OF INJURIES (FRONT IMPACTS)

	No. Injured in Each Body Area		
	Motor-scooter riders	Motor-cycle riders	Total
Head	11	6	17
Thorax, abdomen, spine and upper limb	9	7	16
Lower limb	16	11	27
Total	36	24	60

$\chi^2 = 0.257$ N.S.

fuel tank and engine, whereas with motor-scooters the rider sits *on* the machine, with his feet on footboards, not pegs. As mentioned before, the Honda Cub is classed as a motor-cycle.

6.59 There are two main configurations of collisions between cars and motor-scooters and motor-cycles. These are front impacts, where the front of the machine strikes the car first, and the rider travels forwards; and side impacts, where the front of the car strikes the side of the machine and the rider travels sideways. In this case the rider is struck directly by the car.

6.60 TABLE 6.12 shows the numbers in each category. The value of χ^2 shows that the preponderance of front impacts for motor-scooters as compared with motor-cycles could be due to chance. In one other accident (case 0370) a motor-cycle was sideswiped by a Mini-Minor travelling in the same direction. The rider received abrasions from striking the road.

6.61 A listing of the degree of injury sustained by riders and pillion passengers of each kind of machine in each type of impact is shown in TABLE 6.4A in the Appendix which is summarized here in TABLE 6.13. This value of χ^2 suggests that there is statistically no significant difference between motor-scooters and motor-cycles in the severity of the injury produced. However, the value of χ^2 approaches significance, so this result must be viewed with some reserve. More data are needed on this important comparison.

6.62 If we compare the severity of injuries received in 'front' collisions for motor-scooters and motor-cycles, there is a difference. Again, this could be due to chance, as shown by the value of χ^2 (see TABLE 6.14).

6.63 If we compare the number of people injured in each of the six body areas, for front and side impacts, on motor-cycles and motor-scooters, we find that the distribution of injuries is very similar (TABLES 6.5A and 6.6A in the Appendix). These tables are summarized in TABLES 6.15 and 6.16. These values of χ^2 indicate that the differences between these distributions may be due to chance.

6.64 This strengthens the previous conclusion that the differences in injury severity between riders of motor-cycles and the riders of motor-scooters are not significant. Consequently, the riders of both motor-scooters and motor-cycles can be grouped together when considering injuries.

COMPARISONS BETWEEN FRONT AND SIDE IMPACTS WITH CARS

6.65 To compare the injury patterns of front and side impacts, motor-cycle and motor-scooter riders are grouped together in TABLES 6.17 and 6.18.

TABLE 6.16

DISTRIBUTION OF INJURIES (SIDE IMPACTS)

	No. Injured in Each Body Area		
	Motor-scooter riders	Motor-cycle riders	Total
Head, thorax, abdomen, spine and pelvis, upper limb	6	14	20
Lower limb	5	13	18
Total	11	27	38

$\chi^2 = 0.025$ N.S.

TABLE 6.17

FRONT IMPACTS — 32 PERSONS

Body Area	Degree of Injury				
	Minor	Moderate	Severe	Very severe	Total
Head	5	8	3	1	17
Thorax	1	2	0	0	3
Abdomen	1	0	0	0	1
Spine and pelvis	0	0	0	0	0
Upper limb	10	1	1	3	12
Lower limb	22	1	1	0	27
Total	39	12	5	4	60

TABLE 6.18

SIDE IMPACTS — 19 PERSONS

Body Area	Degree of Injury				
	Minor	Moderate	Severe	Very severe	Total
Head	5	4	1	0	10
Thorax	2	0	0	0	2
Abdomen	1	0	0	0	1
Spine and pelvis	0	0	0	0	0
Upper limb	5	2	0	0	7
Lower limb	11	0	4	3	18
Total	24	6	5	3	38

TABLE 6.19

LOWER LIMB INJURIES

	Degree of Injury		
	Nil and minor	Moderate and greater	Total
Front impact	22	5	27
Side impact	11	7	18
Total	33	12	45

$\chi^2 = 2.41$ N.S.

TABLE 6.20

HEAD INJURIES

	Degree of Injury		
	Nil and minor	Moderate and greater	Total
Front impact	5	12	17
Side impact	5	5	10
Total	10	17	27

$\chi^2 = 1.165$ N.S.

6.66 The majority of the injuries in both accident configurations are minor. Injuries to the head and lower limb are most numerous. There are relatively more severe and very severe lower limb injuries in side impacts than in front impacts. There are also more severe head injuries in front impacts than in side impacts. Neither of these differences reach statistical significance, as shown in TABLES 6.19 and 6.20. Therefore we cannot show any real difference between the severity of the injuries received in front and side impacts.

6.67 Although the difference in injury severity is not great enough to be statistically significant, there is nevertheless a marked difference in the mechanics of front and side impacts. There were 29 front impacts and 17 side impacts. In the cases of front impacts the motor-cycles struck the front, the sides, and the rear of the cars.

FRONT IMPACTS

6.68 The parts of the car struck were subdivided to obtain more accurate information on the way the motor-cycle rider impacted the car. These divisions and the numbers of machines impacting each area were as follows:

Front of car (front of bonnet, headlights, grille, bumper)		5
Side of car		20
front mudguard (from headlight back to front door)	9	
door (leading edge of front door to a line level with rear of rear window)	7	
rear mudguard (from rear window to tail light)	4	
Rear of car (back of boot, tail lights and bumper)		4

Impacts with the front of the car

6.69 There were no completely head-on collisions. In four of the five cases the motor-cycle was at an angle to the front of the car, and in one case the motor-cycle slid into the front of the car on its side, the rider not being injured at all. In the four angle collisions the riders sustained minor abrasions and bruises to their knees, ankles and hips as they struck the front of the car. None of these riders landed on the top of the bonnet, but they bounced off to one side or other of the car.

Impacts with the side of the car

6.70 When the motor-cycle strikes the side of the car the machine either strikes 'head on' and falls to the road, or the front of the motor-cycle is jerked violently to one side by the car, rotating the whole machine. In the first type the rider travels directly forwards into the side of the car, over the handlebars. In the second type the rider is thrown sideways against the side of the car.

6.71 The speeds at impact of car and motor-cycle are compared in nine cases where the speeds of both vehicles are known. The midpoints of the speed ranges to which each vehicle was allotted have been averaged. There is a marked difference between cases where the motor-cycle was rotated and those where it was not (see TABLE 6.21).

6.72 It can be seen that where the motor-cycle was rotated the speeds were the same

TABLE 6.21

IMPACTS ON THE SIDE OF THE CAR

Motor-cycle	Average Speed at Impact (m.p.h.)		
	Motorcycle	Car	
Rotated	15	16	4 cases
Not rotated	27	5	5 cases

for both vehicles, whereas in the other cases the motor-cycle was travelling much faster than the car. Presumably, in cases where the speed of the car is much greater than that of the motor-cycle, the motor-cycle will also be rotated sideways. Other factors influencing the rotation of the motor-cycle are the state of its tyres, any pre-impact rotations produced by braking, or steering efforts of the rider. Also, if the motor-cycle is braking there will be only a small load on the rear wheel to resist sideways forces.

(a) Impacts with the front mudguard

6.73 In five of the nine cases the motor-cycle was at right angles to the side of the car. In two cases the rider continued forward over the bonnet after impact, striking his thighs on the handlebars or on the top of the bonnet. One rider landed on the bonnet of the car, the other went right over the bonnet to land on the road. One of these riders received a fracture of the mid-shaft of the left femur. The shape of the fracture suggested that the bone was not weight-bearing when fractured, but failed as it was bent over the mudguard or handle bar.

6.74 There were three cases of impacts at right angles where the motor-cycle and rider were rotated as described above. One rider received a bruised thigh and elbow when he struck the side of the car, and another suffered concussion from striking his head on the door and a fracture of the left fifth metacarpal, produced when his left hand, gripped around the handlebar, struck the side of the car. In one other case we could not determine the paths followed by the rider and pillion passenger.

6.75 There were four cases of impacts with the front mudguard where the motor-cycle was at an angle to the car. These all occurred when the car turned across the path of the motor-cycle. In two cases the car and motor-cycle were travelling in the same direction. One car turned right and was struck on the right front wheel by a motor-scooter whose rider suffered a compound fracture of his left tibia and fibula when his leg became jammed behind the end of the bumper bar. The other car turned left, the motor-scooter struck the left front mudguard a glancing blow and rider and pillion passenger fell to the road. The rider was unhurt. The pillion passenger suffered a fracture of the right fifth metacarpal, possibly from striking the car.

6.76 In the other two cases the vehicles were travelling in opposite directions. In both cases the motor-cycles were violently rotated on impact, throwing the riders into the side of the cars. One rider suffered a fractured scapula, through striking the car door. The other rider struck his head on the corner of the roof above the door, causing concussion, while his pillion passenger suffered a laceration of the inner side of his left thigh, caused by the bare metal frame of the rider's seat.

(b) Impacts with the doors

6.77 There were five impacts at right angles. In three of these there was no rotation of the motor-cycle, the riders striking the side of the car literally 'face-on'. One fractured his upper central incisor teeth and lacerated his tongue when he struck the roof and the rain gutter above the doors on the side of the car. Another rider struck the side of the car behind the rear door and above the rear quarter window (*Fig. 6.18* and *6.19*). He received concussion, a fractured zygoma (cheek-bone) and fractured central incisor teeth. Both of these accidents occurred when the cars attempted a U-turn. In the third case the motor-cycle struck the rear door and the rider bruised his shin on the crash bar of his own machine and broke the window with his arm as he struck the car.

6.78 In the fourth case (case 0115), where a motor-cycle and sidecar struck the side of an Austin A40 car, the car rolled over after the impact. The motor-cycle was rotated anticlockwise as it struck the left doors of the car. The rider suffered concussion, a fracture of his right radius and fractures of the first and fifth metacarpal, probably from striking the side of the car. In the remaining case the rider appeared to fall away from the car without striking it and without causing any damage.

6.79 There were two impacts with the motor-cycle at an angle to the side of the car. Both occurred when the car turned right, across the front of the motor-cycle, which was travelling in the opposite direction. In the first accident (case 0087) the rider struck the left front door of the car, his head protected by his helmet broke the tempered glass window, and he then struck the window frame, breaking his lower jaw in two places. The jagged fragments of tempered glass remaining in the window frame (*Fig. 6.14*) caused severe lacerations of his neck and shoulder. The impact with the window frame also caused a fracture of the middle of his left clavicle, with a laceration of the left subclavian vein beneath it. The rider also suffered concussion. In the other angle impact the motor-scooter was rotated by the impact and the rider struck the door and the roof above the doors, causing concussion and also bruises of his shoulder and legs.

(c) Impacts with the rear mudguard

6.80 There were four of these, all at right angles. All the riders seemed to have abrasions of their knees. It is difficult to determine whether these were produced by striking the car or the crash bars on the motor-cycle or the leg shield of a motor-scooter. One rider of a motor-scooter struck his nose on the perspex windshield fitted to his machine. Another probably went over the handlebars and the boot of the car, receiving concussion when he struck the road. The other riders sustained only minor injuries.

Impacts on the rear of the car

6.81 There were four of these impacts. They occurred when a car stopped or turned

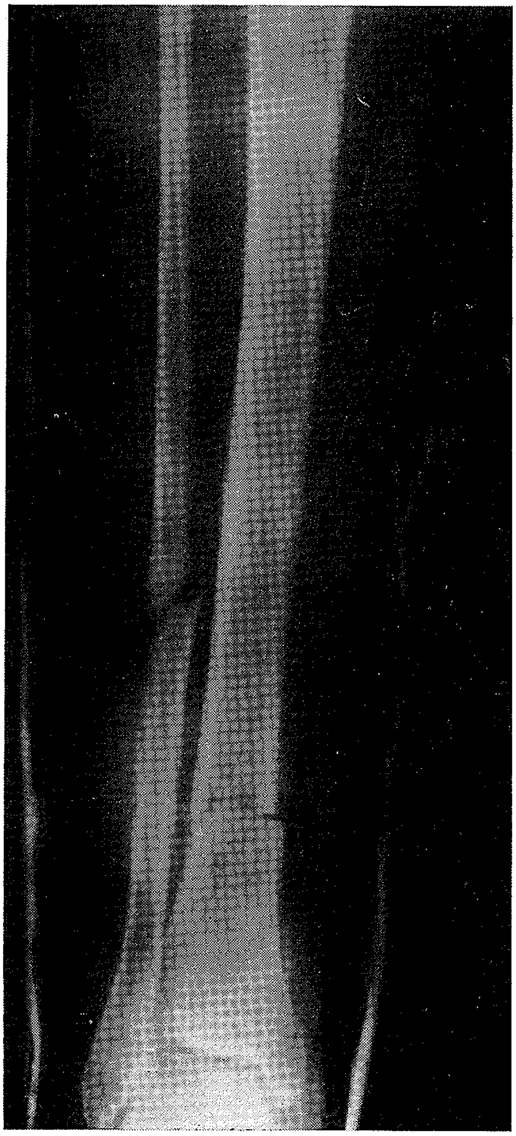


Fig. 6.21—Compound fracture of the right tibia and fibula (case 0399)

and the motor-cyclist was unable to avoid striking the rear of the car. In one case the motor-scooter fell on its right side and slid under the rear of the car, with no injury to its rider. In another case the motor-cycle struck the end of the bumper bar, then scraped down the side of the car. The rider suffered a fracture of the right tibia through impact with the bumper, and concussion from striking the road. Another motor-cycle struck the rear corner of a car which stopped suddenly, but the rider suffered only abrasions to his legs as his machine fell on them after the impact. In the fourth case the car turned left suddenly, in front of the motor-scooter, which struck the rear of the car at an angle. The impact with the bumper fractured the rider's left tibia.

SIDE IMPACTS

6.82 In these cases the side of the motor-cycle, rather than the front, receives the impact. Invariably the motor-cycle is struck by the front of the car. This means that the legs of the rider are exposed to direct impact from the front of the car, particularly the bumper bar. The height of the bumper varies from car to car, but generally seems to be such that it is 6 to 12 in. above the footrest of the motor-cycle or footboard of the motor-scooter. In the impact of the front of the car with the side of the motor-cycle or scooter the bumper bar produces a fracture of the lower half of the tibia and fibula (e.g. case 0399) (*Fig. 6.21*). The fracture may be comminuted (several fragments) if the leg is caught between the bumper and the body of the motor-cycle (*Fig. 6.22*). The knee and the thigh are also injured, but not so frequently as the lower leg.

6.83 Rider and motor-cycle seem to be 'fixed' together more firmly than pedal cycle and rider, for both motor-cycle and rider often seem to 'bounce' off the front of the car. In only three cases did the rider part company with his machine to be thrown over the bonnet of the car, and only one rider touched the bonnet (case 0341). This may be because the higher speeds of

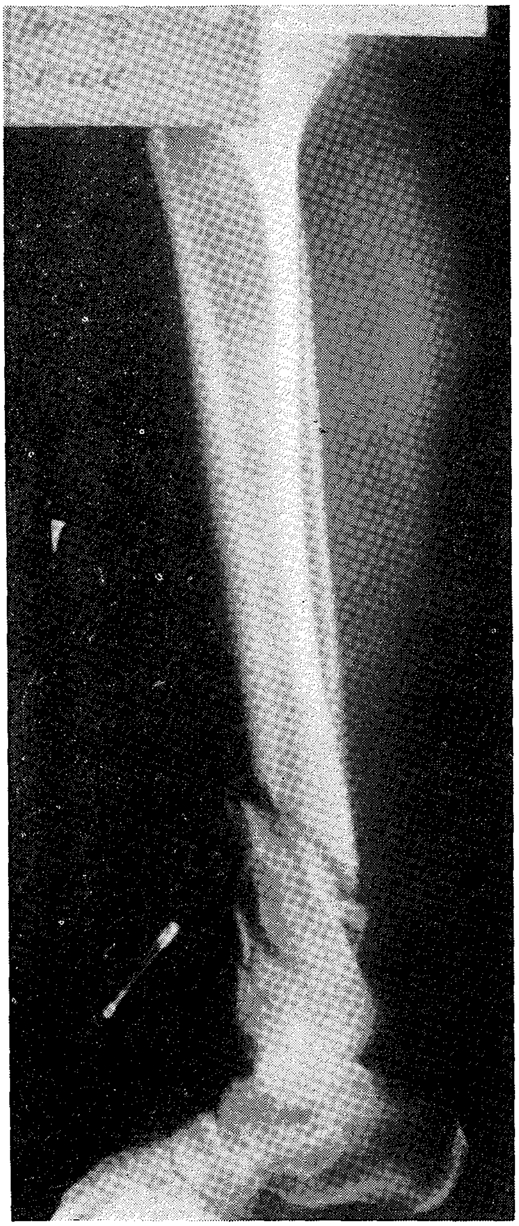


Fig. 6.22—Comminuted fracture of right tibia and fibula (case 0259)

motor-cycles at impact carry the rider diagonally across the bonnet, rather than directly up the bonnet, as is the case in pedal cycle accidents, where the speed of the car is much greater than that of the pedal cycle. Also, since motor-cycles are lower and heavier than pedal cycles, the centre of gravity of the rider and machine is below the top of the front of the bonnet.

6.84 The side impact with the front of the car also causes injury to the hands — fractured fingers and fifth metacarpals, for the handlebar is one of the first parts of the motor-cycle to be struck.

6.85 After the impact with the front of the car, which injures upper and lower limbs, the rider is projected onto the road, along which he slides. This impact with the road causes abrasions over the bony prominences, concussion and, in two of our cases, a fractured skull. One of these was a man wearing a safety helmet, who slid into a raised median strip.

6.86 In one case of side impact the motor-cycle became jammed beneath the front of the car and was pushed down the road as the car ground to a stop. The rider escaped with a bruised ankle. In another case the motor-cycle fell on its side before striking the front of the car. Rider and pillion passenger sustained bruises and abrasions from striking the road and concrete kerb after bouncing off the front of the car. There were two cases where we could not determine what happened to the rider.

6.87 The movements of the rider in 17 cases of side impact are summarized in the following table.

	No. of cases
The motor-cycle struck the front of the car and bounced off.	9
The motor-cycle became jammed under the car and was pushed forwards.	1
Rider thrown diagonally across the bonnet.	3
The motor-cycle slid on its side into the front of the car.	1
Unable to determine what happened.	3
Total	17

6.88 To summarize, in frontal impacts of the motor-cycle with a car, the rider either travels straight forward over the handlebars and strikes the side of the car head first, or is thrown onto or over the bonnet or rear of the car, or the motor-cycle (with rider) is rotated sideways into the side of the car. In impacts on the side of the motor-cycle, the rider's legs are struck by the front of the car, then rider and machine bounce off onto the road, or the rider is thrown diagonally across the bonnet. In all cases the rider sustains more injuries, particularly to his head, through striking the road after the impact with the car.

INJURIES TO MOTOR-CYCLISTS

6.89 The motor-cyclist, like the pedestrian and the pedal cyclist, is exposed to many injury-producing impacts when involved in an accident. Consequently, like the pedestrian and the pedal cyclist, the motor-cyclist is injured in almost every case when he is involved in an accident. TABLE 6.22 shows the degree of injury suffered by the 74 riders and pillion passengers: 96 per cent of motor-cyclists were injured to some degree, and 51.5 per cent sustained moderate or greater injuries. There was one death (case 0242) where a motor-cycle rider was struck by a railcar.

6.90 The injuries to each body area for the 71 injured motor-cyclists were distributed as in TABLE 6.23. There is a total of 148 injuries, which means there is an average of 2.0 injuries per person injured. The lower limbs are most frequently injured (90.0 per cent), followed by the

TABLE 6.22

DEGREE OF INJURY

	Degree of Injury						
	Nil	Minor	Moderate	Severe	Very severe	Fatal	Total
Riders	3	31	13	16	3	1	67
Pillion passengers	0	2	4	1	0	0	7
Total	3	33	17	17	3	1	74

TABLE 6.23

INJURIES TO EACH BODY AREA

Degree of Injury	Body Area						
	Head and neck	Thorax	Abdomen	Spine and pelvis	Upper limb	Lower limb	Total
Minor	13 (18.3)	4 (5.6)	4 (5.6)	0	27 (38.0)	49 (69.0)	97 (65.5)
Moderate	18 (25.4)	4 (5.6)	0	0	4 (5.6)	2 (2.8)	28 (18.9)
Severe	6 (8.4)	1 (1.4)	0	0	1 (1.4)	7 (9.8)	15 (10.2)
Very severe	1 (1.4)	0	0	0	0	6 (8.4)	7 (4.7)
Fatal	1 (1.4)	0	0	0	0	0	1 (0.7)
Total	39 (55.0)	9 (12.7)	4 (5.6)	0	32 (45.0)	64 (90.0)	148

(The figures in brackets are percentages of those injured)

TABLE 6.24

CAUSES OF INJURIES

Cause of Injury	Body Area						
	Head and neck	Thorax	Abdomen	Spine and pelvis	Upper limb	Lower limb	Total (%)
Road or fixed object	22	6	2	0	19	25	74 (50.0)
Front of car	1	0	1	0	2	16	20 (13.5)
Top of bonnet	0	0	0	0	0	0	0
Windscreen	1	0	0	0	0	0	1 (0.7)
Side of vehicle	7	2	0	0	5	6	20 (13.5)
Own motor-cycle	1	0	0	0	0	9	10 (6.7)
Other	0	0	0	0	0	1	1 (0.7)
Not recorded	7	1	1	0	6	7	22 (14.9)
Total	39	9	4	0	32	64	148 (100.0)

head (55.0 per cent) and upper limb (45.0 per cent). Twenty-six of the 39 head injuries (67 per cent) were moderate or greater but only 15 of 64 lower limb injuries (23 per cent) were more than minor. There are relatively few injuries to the trunk, and these are mostly minor; the more severe injuries are concentrated in the head and limbs.

6.91 The causes of these injuries are set out in TABLE 6.24.

6.92 Striking the road or, rarely, a fixed object produces 50 per cent of all injuries to motor-cyclists. The next commonest sources of injury are the front and sides of the striking vehicle (generally a car). A few injuries to the lower limbs are produced by the rider's own motor-cycle. The commonest cause of head injury is striking the road, followed by striking the side of the car. For lower limbs the road is the chief cause of injury, but the front of the car is the greatest source of the more severe injuries.

INJURIES TO EACH BODY AREA

6.93 In the tables of injuries which follow, each person is counted once only for soft tissue injuries in each area, e.g. once for face, and once for scalp; but each skeletal injury and each concussion is counted individally, i.e. one person may have two skeletal injuries.

Head

6.94 Injuries to the head are summarized in the following table.

Soft tissue face injuries		27
abrasions	11	
bruises	7	
lacerations	9	
Skeletal face injuries		7
fracture of the zygoma	2	
fracture of the mandible	2	
fracture of the teeth (incisors)	3	
Concussion		24
Soft tissue scalp injuries		16
abrasions	1	
bruises	8	
lacerations	7	
Fractures of the skull		3
parietal	1	
base and parietal	1	
squamous temporal	1	

6.95 Soft tissue injuries to the face were the most common injury. There were almost equal numbers of abrasions and lacerations. The teeth commonly fractured were upper central incisors. These were broken when the rider's face struck the side of a car. These impacts also caused fractures of the zygoma and mandible.

6.96 Twelve concussions were caused by striking the road, eight through striking the car, and in four cases the cause could not be determined. The one motor-cyclist with fatal head injuries was struck by a diesel railcar. His injuries consisted of a fracture of the body of the right mandible, a fracture across the base of the skull and into the right parietal bone, a complete transection of the brainstem, and lacerations of the frontal and temporal lobes of the brain. The role of safety helmets in the prevention of head injuries is discussed in a special section on safety helmets (Para. 6.105).

Neck

6.97 Both injuries to the neck were soft tissue. In case 0087 the motor-cyclist received many parallel lacerations of the left side of the neck and shoulder when he struck fragments of tempered glass in the frame of the left front window of a car (*Fig. 6.14*). In case 0420 an 18-year old girl pillion passenger slid into a concrete kerb head first, stretching her left brachial plexus and causing some temporary paraesthesiae of the left arm. There were no bony neck injuries.

Thorax

6.98 Thoracic injuries are relatively few. There was only one internal injury in the whole series of motor-cycle accidents.

Soft tissue thoracic injuries		8
abrasions	4	
bruises	3	
lacerations	1	
Skeletal thoracic injuries		5
fracture of the clavicle	3	
fracture of the ribs	1	
fracture of the scapula	1	
Internal thoracic injuries		1
pneumothorax	1	

The pneumothorax occurred when a young male motor-cyclist struck a pile of bricks. He suffered a fracture of the left clavicle and a left pneumothorax, with no evidence of fractured ribs. There was only one case of fractured ribs, which occurred when a 32-year old man struck the tray of a truck and fractured his right tenth rib.

Spine and pelvis

6.99 There were no injuries to the thoracic or lumbar spine, or to the bony pelvis.

Upper limb

6.100 By far the greatest number of injuries to the upper limb are soft tissue injuries, and most of these are abrasions to the elbows and hands.

Soft tissue injuries		35
abrasions	24	
bruises	9	
lacerations	2	
Skeletal injuries		7
fracture of the radius	1	
fractures of the metacarpals	5	
fracture of a phalanx	1	

There are relatively few skeletal injuries. In case 0115 (*Fig. 6.23*), where a 61-year old man riding a motor-cycle and sidecar collided with the side of a car, the rider sustained a fracture of the distal end of his right radius and fractures of the right first and fifth metacarpals. These probably occurred when the right handlebar struck the side of the car. There were three other fractures of the fifth metatarsal. Two of these occurred when the rider's hand was caught between the handlebar and the side of the car.

Lower limb

6.101 Most lower limb injuries are soft tissue injuries, mainly abrasions to the knee and foot. However, there are a number of severe fractures to the lower leg.

Soft tissue injuries		80
abrasions	59	
bruises	14	
lacerations	7	
Skeletal injuries		16
fracture of the femur	2	
fracture of the patella	2	
fracture of the tibia (5 compound)	10	
fracture of a metatarsal	2	

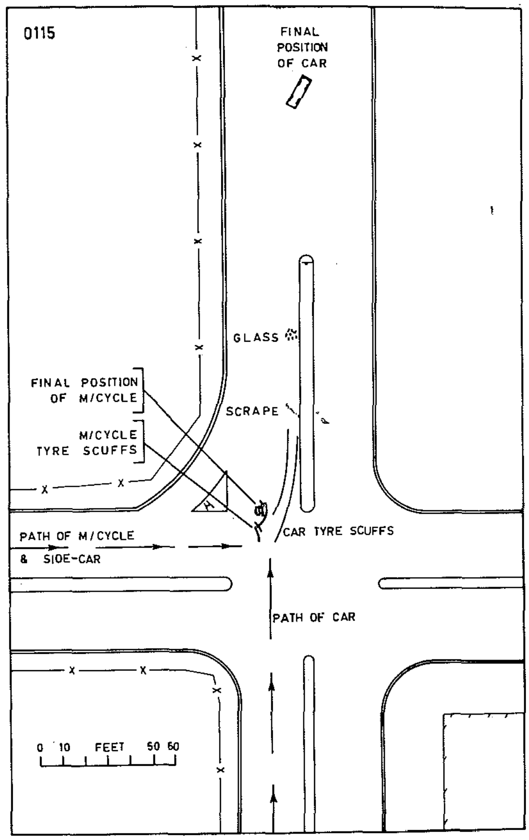


Fig. 6.23—Case 0115

The fractures of the femur were both midshaft. One occurred when the rider of a motor-scooter struck the front mudguard of a car at right angles and was thrown across the bonnet of the car, levering his femur against the edge of the mudguard. The other fracture occurred when the left front corner of a car struck the right side of a motor-cycle, striking the rider's thigh directly. One fractured patella occurred when the rider and motor-cycle struck a pile of bricks. The other patellar fracture was associated with severe disruption of the knee joint involving rupture of the anterior cruciate ligament and the patellar tendon, a comminuted fracture of the upper end of the tibia, and a haemarthrosis. These injuries were due to an impact with the left front headlight of a car which turned into the path of a motor-scooter.

6.102 One tibial fracture was produced when a motor-cycle fell on its rider's left leg after being struck from the right. Seven of the other fractures were caused through impact with the front of the car — commonly the bumper, which is generally just above the height of the footrest of the motor-cycle or motor-scooter, as noted in the previous section on side impacts. The two remaining fractures of the tibia were produced by impacts with the rear bumper of cars, in rear-end collisions. Fractures of the fifth metatarsal are associated with the lower leg being caught between car and motor-cycle.

ADMISSION TO HOSPITAL

6.103 Only 13 (17.6 per cent) of the 74 motor-cyclists did not require any treatment at all, 27 (36.5 per cent) were treated at a casualty department and allowed to go home, and 33 or 44.6 per cent were admitted and later discharged. One motor-cyclist was killed, and he died at the scene of the accident.

6.104 Of the 33 persons admitted to hospital, one third stayed 24 hours or less, and one third stayed more than 15 days, as shown by the following tabulation.

Length of stay in hospital	No. of cases
0- 1 days	10
1- 2	2
3- 5	7
6-10	3
11-15	0
16-20	2
21-25	4
26-30	2
more than 30	3
Total	33

HELMETS

6.105 Cairns (Ref. 10) showed that crash helmets reduced the severity of head injuries received by motor-cyclists. Cairns and Holbourn (Ref. 11), with more cases, confirmed this finding. Their cases were of two kinds, acute head injuries admitted directly, and subacute or chronic cases referred for assessment of their fitness to return to duty, for convalescence, and for special treatment.

6.106 Each group was divided into those wearing a helmet and those not wearing a helmet. In acute cases the incidence of skull fracture was 63 per cent in those not wearing a helmet and 32 per cent in those wearing a helmet. For chronic cases the figures were 39 per cent and 40 per cent respectively. This suggests that the chronic cases were a different population from the acute cases. This is confirmed when the periods of amnesia for each group are compared. In the acute cases there was very little difference between those wearing helmets and those not. A χ^2 test on the figures given shows a value of 0.374, indicating that the differences could be due to chance. However, there is a marked difference between the wearers and non-wearers of helmets in the chronic cases. The duration of amnesia is much shorter in those wearing helmets, and $\chi^2 = 20.627$, indicating that the difference is unlikely to be due to chance.

6.107 The authors did not perform any statistical tests, but grouped the acute and chronic cases together, and concluded that the incidence of fractures and the length of amnesia were reduced in those wearing helmets. On the evidence, there seems to have been two distinct groups of cases. One was the group of acute head injuries, where the wearing of helmets was associated with half the number of fractured skulls, but there was no reduction in amnesia; and the other was the chronic cases where

TABLE 6.25

NUMBER OF SEVERE HEAD INJURIES

	Head Injury						
	Nil	Minor	Moderate	Severe	Very severe	Fatal	Total
Helmet	11	2	6	2	1	0	22
No helmet	25	11	4	4	0	1	52

TABLE 6.26

SEVERITY OF HEAD INJURIES

	Nil and Minor	Moderate and Greater	Total
Helmet	13	9	22
No helmet	36	16	52
Total	49	25	74

$\chi^2 = 0.739$ N.S.

TABLE 6.27

MOTOR-CYCLISTS WHO STRUCK CARS

	Head Injury						
	Nil	Minor	Moderate	Severe	Very severe	Fatal	Total
Helmet	8	2	3	1	1	0	15
No helmet	17	8	8	3	0	0	36

TABLE 6.28

SEVERITY OF INJURIES

	Nil and Minor	Moderate and Greater	Total
Helmet	35	5	15
No helmet	10	11	36
Total	25	16	51

TABLE 6.29

HEAD AND BODY INJURIES

	Head Injuries Only	Body Injuries Only	Injuries to Head and Body	No Injury	Total
Helmet worn	1	9 (41%)	10 (45%)	2	22
No helmet worn	1	22 (42%)	27 (52%)	2	52

wearing a helmet was associated with a reduction in amnesia, but not in incidence of skull fracture. The chronic cases were a selected group which had an unknown relationship to the group of acute injuries, and therefore cannot properly be considered with them. Considering the acute group alone, the helmets worn seem to have reduced the incidence of skull fracture, but they had no influence on the incidence or duration of amnesia.

6.108 Others to investigate the performance of helmets were Chandler and Thompson (Ref. 12), who evaluated the effectiveness of the crash helmets used at that time, and Foldvary and Lane (Ref. 13), who showed that the introduction of legislation making the wearing of safety helmets compulsory for motor-cyclists reduced the number of deaths.

6.109 Twenty-two of the 74 motor-cycle and motor-scooter riders in this survey were wearing crash helmets. The proportion of motor-cycle riders wearing helmets was less than that of motor-scooter riders.

	Motor-scooter	Motor-cycle
Wearing helmet	13 (37%)	9 (23%)
Not wearing helmet	22 (63%)	30 (77%)

Thus 30 per cent of motor-cyclists involved in accidents were wearing helmets.

6.110 We expected to find some difference in the number of severe head injuries sustained by those wearing and not wearing helmets. However, this was not the case, as TABLE 6.25 shows. Grouping the injuries into nil and minor, and moderate and greater, we obtain the figures shown in TABLE 6.26.

6.111 About one third of the head injuries to those with and without helmets were moderate or greater. A similar situation appears when motor-cyclists who struck cars are considered in TABLE 6.27. Grouping the injuries together, the proportions of the 'helmet' and 'no helmet' groups with moderate and greater injuries remains much the same as for all motor-cyclists (see TABLE 6.28).

6.112 A further comparison between the 'helmet' and 'no helmet' groups can be made by using injuries to the body as a control (see TABLE 6.29). It would be expected, if helmets prevent head injury, that there would be fewer persons wearing helmets with injuries to the head only, compared with those not wearing helmets. TABLE 6.29 shows that there is very little difference in the distribution of injuries in the three categories between those wearing helmets and those not. The proportion of persons with injuries to both head and body is reduced slightly, but not significantly ($\chi^2 = 0.124$).

6.113 This does not mean that helmets do not reduce the severity of head injuries, for there were several cases of moderate and greater injury where the rider's helmet almost certainly prevented him from receiving even more severe head injury.

6.114 Cases 0037 and 0087 have been described previously. The helmet worn in case 0087 had been abraded over the left frontal area (*Fig. 6.15*).

6.115 Another example is the following case.

● Case 0376

A 30-year old male riding a motor-scooter struck the front of a Ford Falcon at an angle, as the car moved off from a stop sign. The rider was projected over the bonnet, landing on the road on his helmet, and skidded into the sloping edge of the median. His helmet was fractured right through at the left rear (*Fig. 6.24*). He sustained concussion and bilateral fractures of the squamous temporal bones of his skull.

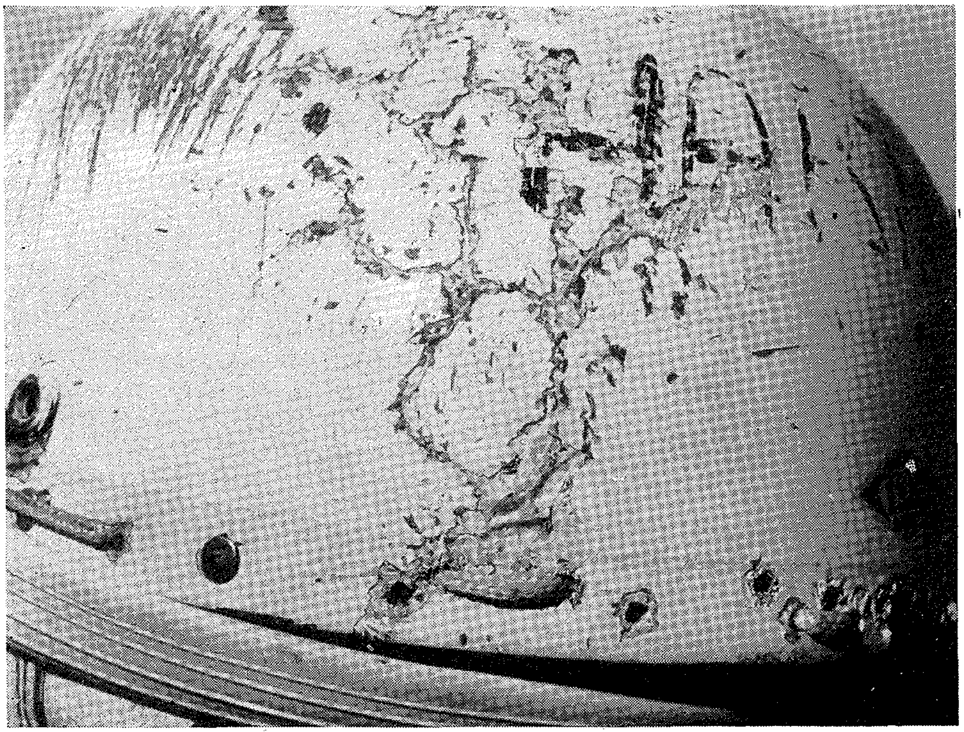


Fig. 6.24—Note fracture through shell of helmet

6.116 We examined the head injuries received by motor-cyclists to determine if any difference could be demonstrated between wearers and non-wearers of safety helmets (see TABLE 6.30). In the group wearing helmets:

(a) there is a slight excess of cases with no head injury;
(b) there are no cases of scalp injury, alone or associated with concussion — this is fewer than expected;
(c) there are more 'concussion only' cases than would be expected.

TABLE 6.30

HEAD INJURIES

Type of Injury	Helmets		No Helmets		No. of Cases
	No. of cases	No. expected	No. of cases	No. expected	
No head injury	12	10.70	24	25.30	36
Face injury only	2	2.08	5	4.92	7
Injury to scalp and ears	0	1.78	6	4.22	6
Injury to scalp and concussion	0	0.89	3	2.11	3
Concussion only	3	1.78	3	4.22	6
Concussion and fractured skull or face injury	5	4.76	11	11.24	16
Total	22		52		74

6.117 These figures could be explained if we assume that helmets prevented scalp injury occurring, but had no influence on the occurrence of concussion. If this were true the cases in which scalp injury was prevented would be distributed to the 'no head injury' and 'concussion only' groups. If the expected values in the table are distributed in this manner a close approximation to the actual values is obtained, for each group.

6.118 It was thought that if helmets had a protective influence, those persons in the group with concussion and face injury who were wearing helmets would have suffered more severe impacts, and possibly had more facial and skull fractures than those with no helmets. This is not confirmed in TABLE 6.31, which shows a proportionately equal number of fractures in each group.

6.119 Therefore there does not seem to be any significant difference between the 'helmet' and 'no helmet' groups in the incidence of concussion. This means either that the helmets as worn by this group of riders are not effective in preventing concussion, or that only the more seriously injured motor-cyclists wearing helmets entered our sample. That is, on occasions where a helmet effectively prevented any head injury, the rider may not have needed assistance and an ambulance may not have been called. However, it was our experience that bystanders called an ambulance first, without waiting to see if it really was needed. However this still remains a possible source of bias.

6.120 Helmets, not unexpectedly, seem to have no influence on the occurrence of face injuries, for the number with face injuries seems to be about the expected level both for those wearing and those not wearing helmets.

6.121 A possible alternative explanation for the incidence of concussion being the same for those wearing helmets and those not wearing helmets is that if helmets are designed primarily for the attenuation of high energy impacts which are reduced in magnitude to just below some arbitrary limit of tolerance by the structure of the helmet, then this same structure may not attenuate lower energy impacts to below concussive levels. Possibly the construction and materials which 'soak up energy' for high energy impacts do not act to the same degree for lower energy impacts. Therefore if most of the impacts sustained by our series of motor-cyclists wearing helmets were of comparatively low or moderate energies this explanation could hold.

6.122 However, this is probably not so. TABLE 6.32 shows the speeds at impact of the 26 motor-cyclists who suffered impacts to the area of their heads which would be protected by a helmet. Thirteen were wearing a helmet, and 13 were not. The arithmetical mean impact speed for both groups

TABLE 6.31

CONCUSSION AND FACE INJURY

Helmets (5 Cases)		No Helmets (11 Cases)	
Injury	No. cases	Injury	No. cases
Fractured mandible	1	Fractured parietal bone of skull	1
Fractured squamous temporal bones of skull	1	Multiple fractures of skull and fractured mandible	1
Soft tissue injuries	3	Fractured zygoma (cheekbone)	1
		Fractured zygoma and fractured teeth	1
		Soft tissue injuries	7

TABLE 6.32

SPEEDS OF MOTOR-CYCLISTS AT IMPACT

	Speed at Impact (m.p.h.)					
	1-10	11-20	21-30	31-40	N.K.	Total
Helmet worn	0	5	4	1	3	13
Helmet not worn	3	0	5	2	3	13

is 16 m.p.h. As most of the impacts were at speeds greater than 20 m.p.h., 20 m.p.h. was chosen as a conservative figure for the following calculations. We assumed that the rider's head is not influenced by forces acting on the rest of the body at impact.

6.123 An estimate of the kinetic energy of the rider's head expressed as potential energy in foot pounds can be obtained by estimating the distance through which the rider's head, considered as a free body, would have to fall to attain the same velocity (30 ft/sec) as at a 20 m.p.h. impact.

$$V^2 = U^2 + 2gS$$
$$30^2 = 0 + 2.32.S$$
$$S = \frac{900}{64} = 14 \text{ ft}$$

where g = acceleration due to gravity = 32 ft/sec.

The weight of the rider's head is approximately 10 lb, therefore at 20 m.p.h. impact speed it can be considered to have 14 × 10 = 140 ft lb of energy. This amount of energy must be dissipated at impact, with force developed at impact depending on the length of time taken to bring the head to a stop.

6.124 For comparison, the British Standard for motor-cyclist helmets, B.S. 2001: 1960, uses a striker of 10 lb mass falling a distance of 9 ft, i.e. it has an energy content of 90 ft lb. The helmet under test must not allow a force greater than 5,000 lb to be developed on the head block holding the helmet.

6.125 It can be seen that this test blow is only two thirds of that developed in most of the motor-cycle impacts in our survey. Therefore the helmets used seem to be sustaining impacts above their test limit, rather than below.

6.126 These helmets are constructed to meet the Australian Standard E33-1959, which is identical with the British Standard B.S. 2001: 1956. This requires that with blows of 90 ft lb energy to the front and back of the helmet a force of not more than 5,000 lb should be transmitted to the head form holding the helmet. There is a test for penetration of the shell, and another for the strength of the chin strap and harness. The standard states that protective padding shall reach to within 1.25 in. of the lower edge of the helmet or the lower edge of the head band. The helmets in use adhere to this exactly. The interior padding, usually ¼ in. cork, stops above the upper edge of the head band. The head band is usually backed by stiff webbing and small amounts of sponge rubber, i.e. there is no energy absorbing material behind the headband. The point of impact on the helmet in the test rig as illustrated in *Research on Road Safety* (from which this standard was derived) appears to be towards the top of the front of the helmet, where both the suspension webbing and the protective padding act to absorb the energy of the impact. However, the 13 impacts on helmets in our series — as shown in *Fig. 6.25* — were mostly towards the bottom edge of the helmet, there being only three impacts on the crown or at the angle at which the test impact takes place.

6.127 For the ten impacts on the side of

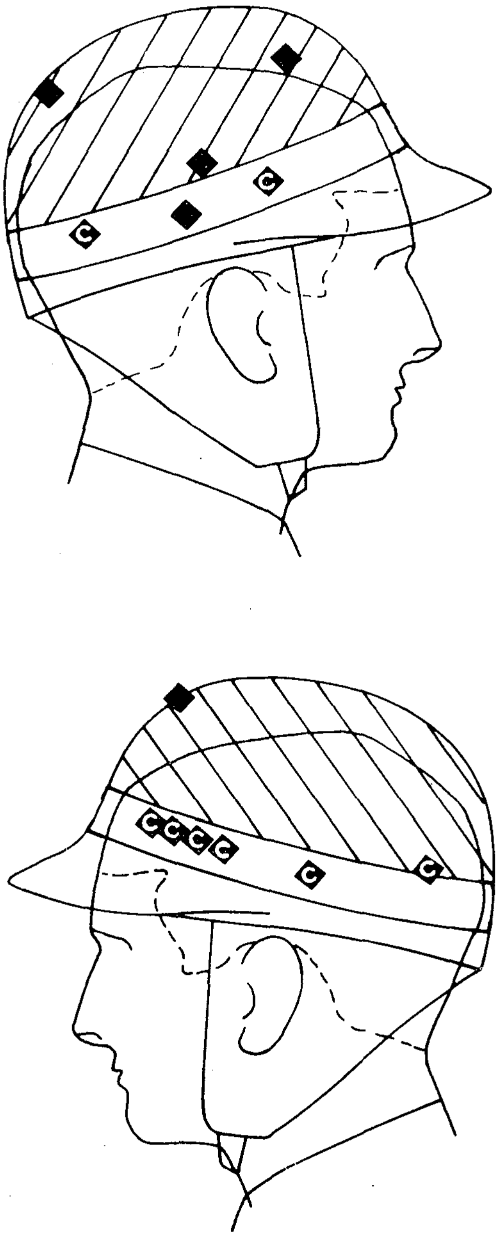


Fig. 6.25—Cases where a helmet was worn, showing the position of impacts in relation to the shell of the helmet and the protective padding. The cross-hatched area indicates the extent of the padding. 'C' indicates an impact causing concussion.

the helmet there is no protective padding in a position to absorb energy; also the suspension harness does not keep the helmet away from the head in impacts in this position. It is probable therefore that the occurrence of concussion in seven of these ten persons may be due to this lack of protective padding where it seems to be most needed.

6.128 *Fig. 6.26* shows the position of impacts on the 24 people who were not wearing helmets. There were 13 impacts in the area which would be covered by a helmet if worn. There were five other impacts about the eyebrows and lower forehead and about the ears, in which a helmet would be expected to provide some protection. The impacts in the helmet area are mostly towards the lower edge of the helmet with a cluster of 5 high on the occiput.

6.129 It can be seen from *Fig. 6.25* and *6.26* that a total of 13 impacts in those with and without helmets are in the area between the lower edge of the protective padding and the lower edge of the helmet. That is, 50 per cent of this series of impacts fall in an area where there is no protective padding in the standard helmet.

6.130 In those wearing helmets, seven of the eight impacts in this area caused concussion, whereas only one of the five impacts in the area of protective padding was associated with concussion.

6.131 We have shown that protective helmets worn by motor-cyclists reduce the incidence of soft tissue injuries to the scalp and ears. They make no difference to the incidence of concussion, probably because of the incomplete lining of protective padding. They make no difference to the incidence of face injuries.

6.132 As mentioned before, it has been shown (Ref. 12 and 13) that helmets save lives and injuries in motor-cyclists. We have shown in a small series that their efficiency in preventing some of the effects of impacts to the head could be improved.

6.133 Our suggestion is that all helmets for motor-cyclists meet the British Standard B.S. 1869: 1960 — Protective Helmets for Racing Motor-Cyclists. This specifies an enveloping helmet which covers the forehead, ears and occiput, and besides a strong webbing suspension, is completely lined throughout with energy-absorbing material. This provides much more complete protection than the standard helmet sold today. A further suggestion is that the shock absorption test as specified in the British Standards should include impacts normal to the shell of the helmet and centred on the headband region. The matter is clearly important, for the wearing of helmets is compulsory by law in one state (Victoria) and the National Health and Medical Research Council has officially urged the introduction of similar legislation in other states.

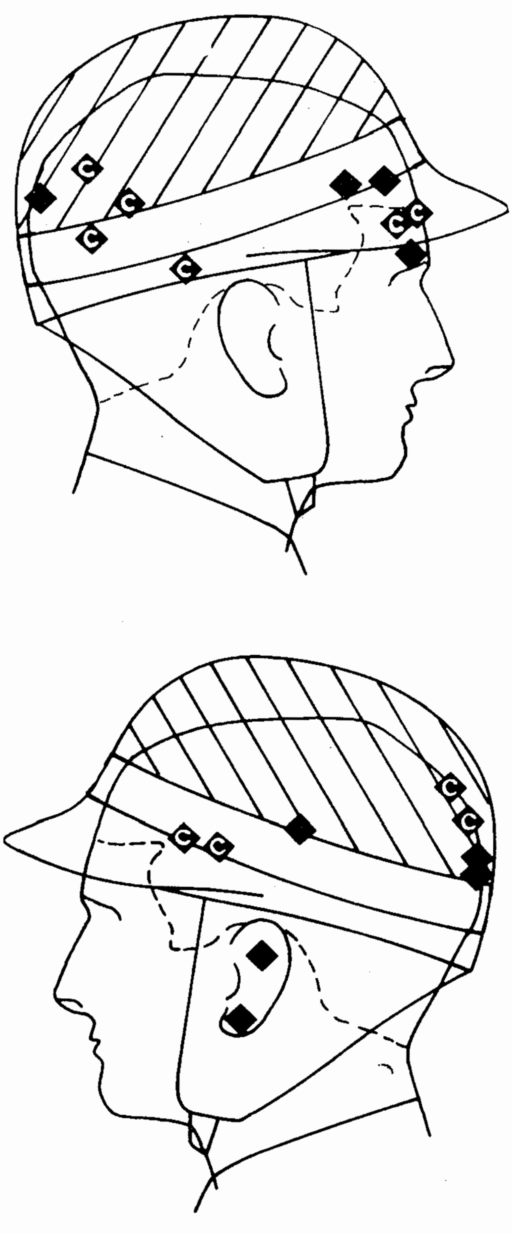


Fig. 6.26—Cases where helmets were not worn, showing the position of the impacts in relation to the area covered by the shell of the helmet and its protective padding. The cross-hatched area indicates the extent of the protective padding. 'C' indicates an impact causing concussion.

SECTION 7 — TRUCK ACCIDENTS

DEFINITION OF VEHICLES LISTED AS 'TRUCKS'

7.1 In this section on 'truck accidents' all heavy vehicles and also some light commercial vehicles are considered. As this obviously covers a wide range of vehicles we attempted to reduce this to two somewhat more homogeneous groups by classifying each vehicle further as either a 'light truck' (up to 2 tons tare weight) or a 'heavy truck' (over 2 tons tare weight). The arbitrary limit of 2 tons has no basis other than being a reasonably convenient value which divides the total number of vehicles into two groups of approximately equal numbers (27 light trucks, 35 heavy trucks).

7.2 Further subdivision into specific types of 'trucks', e.g. light vans, heavy utilities, buses, etc. is only done when this has some relevance to any particular accident. Our justification for having a separate category for all these vehicles is that they are generally distinguishable by their shape, size and/or weight from passenger cars. The smaller trucks, and some utilities and vans, tend to be less obviously distinguishable by size and weight. In the case of units such as the Volkswagen Kombi-Van we have taken the forward control driving position as justification for including this in the category of 'light truck' rather than 'car-type van, utility etc'.

7.3 There were 59 accidents involving trucks. This is one seventh (14.4 per cent) of all the accidents we attended. The 59 accidents were divided into the following types.

Collisions with cars	34
Multiple vehicle collisions (more than two vehicles involved)	8

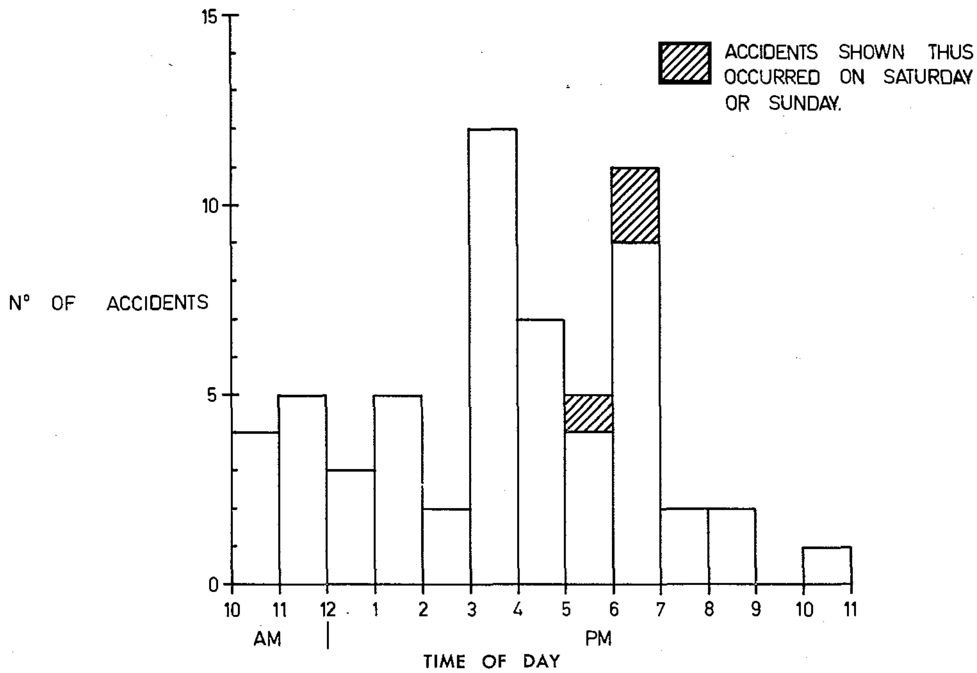


Fig. 7.1—Distribution of truck accidents by time of day

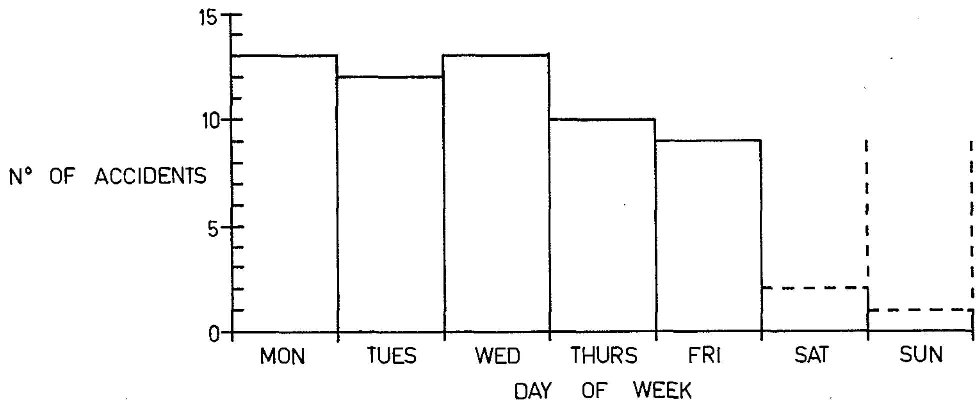


Fig. 7.2—Number of truck accidents by day of week (totals for Saturday and Sunday are not to be directly compared with weekday totals due to variation in working periods)

Collision between two trucks	1
Collision with pedestrian	7
Occupant falling from the tray of a truck	1
Collision with pedal cycle	4
Collision with motorcycle	4
Total	59

There were 62 trucks with 85 occupants involved in the 59 collisions.

TIME DISTRIBUTION OF ACCIDENTS

Time of day

7.4 A histogram (*Fig. 7.1*) shows the distribution of all truck accidents by time of day. There are two peaks, one between 3 and 4 p.m. and the other between 6 and 7 p.m. This is different from the other time distributions we have studied where there is only one peak, generally between 4 and 6 p.m. The height of these peaks may be influenced by the bias of our sampling towards the off-peak periods, i.e. there is a greater proportion of the accidents which occurred between 3 p.m. and 4 p.m. in the sample than of accidents between 6 p.m. and 7 p.m.

Day of week

7.5 The distribution by day of week is shown in *Fig. 7.2*. The incidence is constant from Monday to Wednesday, then falls on Thursday and Friday. Saturday and Sunday cannot be included due to the inadequacies of our sampling technique.

AGE OF TRUCK OCCUPANTS

7.6 The age distribution of the 61 truck drivers in the 62 trucks involved is shown in a graph (*Fig. 7.3*) and TABLE 7.1. Their ages range between 17 and 66 years. There are two peaks: 20 to 29 years, and 35 to 39 years. There were 24 passengers, whose ages were distributed as shown in TABLE 7.1.

LOCATIONS OF TRUCK ACCIDENTS

7.7 Only about one sixth of these truck accidents were in the central city area.

TYPES OF TRUCK ACCIDENT

7.8 In earlier sections of this report we have considered cases in which trucks were involved in collisions with pedestrians, pedal-cycles and motor-cycles. For completeness we repeat these cases in this section, concentrating on the role played by the truck in each accident.

Collisions with pedestrians

7.9 These seven accidents have been discussed in Section 4 of this report. With the exception of one case, each of these pedestrians did not look in the direction

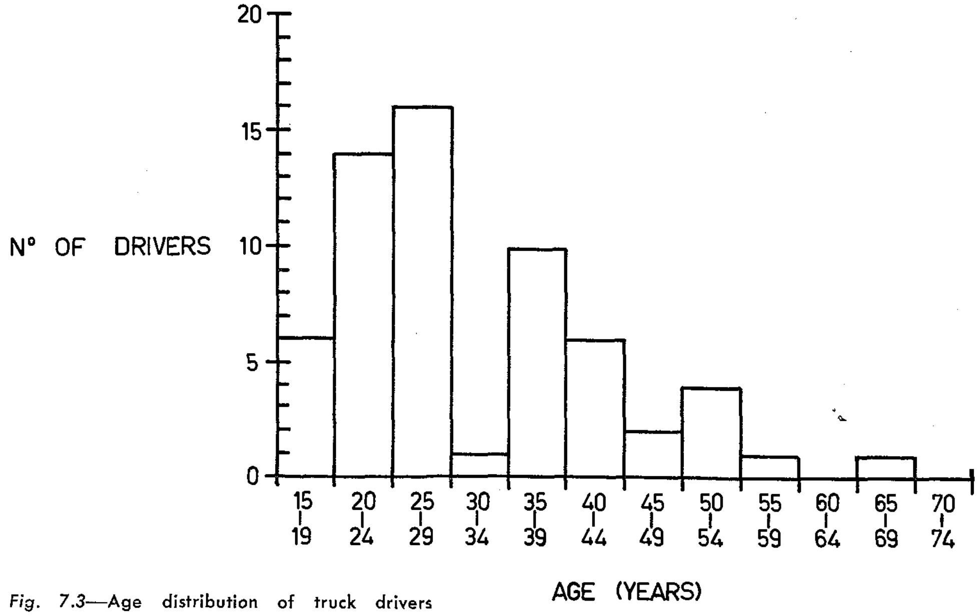


Fig. 7.3—Age distribution of truck drivers

from which the truck was coming. The exception was a man who deliberately ran onto the road into the path of a truck. The speeds of these trucks were all within the 35 m.p.h. speed limit, and all but one were proceeding straight ahead at the time of the accident.

Collisions with pedal cyclists

7.10 The one accident we attended that involved a tricycle is included in this group of four accidents. The truck, a semi-trailer, was leaving a private parking lot and turning left onto the roadway. A small boy riding a 'Pilgrim Hi-speed' tricycle along the footpath rode into the rear wheels of the trailer. Apparently this small boy forgot that semi-trailers have three sets of wheels. Fortunately he was not badly hurt.

7.11. One of the three pedal cycle accidents happened when a small girl made a 'U'

TABLE 7.1

AGE OF TRUCK OCCUPANTS

Age in Years	Drivers	Passengers	Total
5-9	0	1	1
10-14	0	2	2
15-19	6	5	11
20-24	14	2	16
25-29	16	6	22
30-34	1	1	2
35-39	10	2	12
40-44	6	2	8
45-49	2	1	3
50-54	4	2	6
55-59	1	0	1
60-64	0	0	0
65-69	1	0	1
Total	61	24	85

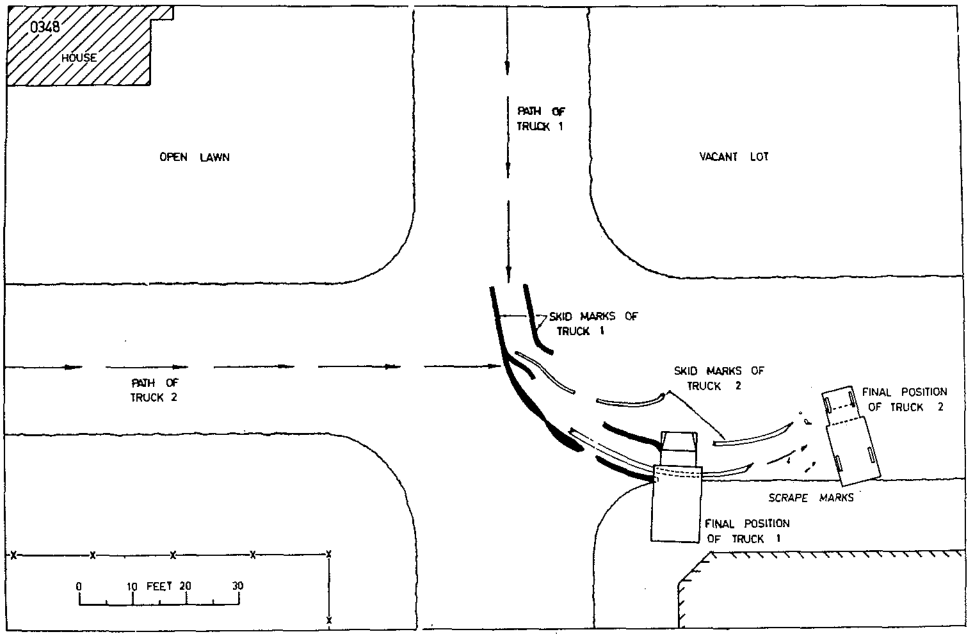


Fig. 7.4—Case 0348

turn in front of a heavy utility. The driver of the utility braked hard and his vehicle had very nearly stopped when it struck the cyclist. This is a typical pedal cyclist accident, in which the cyclist changes direction without giving sufficient warning, or any warning at all, to other traffic.

7.12 Another case resulted from a truck driver turning right, across the path of an approaching cyclist. This driver was annoyed with the cyclist because, as he said, 'If he had slowed down he would not have hit me'.

7.13 The final case was a more complex one as far as an understanding of right-of-way is concerned. It involved a cyclist riding along a cycle track on the median strip of a dual highway and a truck, travelling in the same direction, which turned right on a crossover road across the median. The cyclist rode into the side of the truck. It is not unreasonable to expect the cyclist to yield to the truck in this instance, but confusion can arise when comparing this case with those such as a truck turning left and forcing a cyclist into the kerb. If the cycle track had been on the footpath on the left side of the road there would be no doubt that the cyclist had right of way. The issue is not so clear in the present case.

Collisions with motor-cyclists

7.14 Of the four collisions between motor-cycles and trucks, two occurred at the same intersection. This intersection, known as Gepps Cross and referred to elsewhere in this report, is a five-way junction controlled by traffic lights. In both of these collisions the motor-cyclist struck the side of the truck. The trays of many trucks are close to the level of the head of a motor-cyclist as he is seated on his machine; consequently it is not surprising that in one of these cases the rider hit his head on the edge of the tray of the truck. He was wearing a crash helmet which may have reduced the severity of the injuries to his head.

TABLE 7.2

MULTIPLE VEHICLE COLLISIONS

Accident No.	First Two Vehicles	Type of Initial Collision	Other Units Involved
0186	car light truck	rear end	bus car
0417	light truck car	rear end	light truck
0395	horse and cart heavy truck	rear end	car
0208	heavy truck car	truck reversing across roadway	car
0195	car car	'U' turn collision with overtaking vehicle	truck car
0233	heavy truck car	intersection	car
0240	car car	intersection	heavy truck
0372	heavy truck railcar	level crossing	car

7.15 It would be desirable, with regard to such collisions, for trucks to be fitted with barriers below the tray at the rear and sides. Such barriers, if designed to take the main force of any collision with another vehicle, would reduce the injury potential of this type of accident. A careful study comparing the cost of these modifications to an estimate of the value of possible benefits should be the first step in any further consideration of this suggestion. (See also para. 7.29 and *Fig. 7.6*).

Occupant falling from the tray of a truck

7.16 In this case a 28-year old male fell from the tray of a moving tow truck. The truck was towing a car which had been swaying from side to side. The assistant was riding on the back of the truck to check on the movements of the towed vehicle. He lost his hold and fell to the roadway, sustaining concussion from the impact with the road surface. Accidents of this nature are very similar to some types of industrial accidents and similar prevention programmes may be beneficial.

Collision between two trucks

7.17 This accident (case 0348) involved a heavy truck and a heavy utility (*Fig. 7.4*). The utility was struck on the front of its left side by the front of the truck. The utility was travelling considerably faster than the truck at impact and spun 60° anti-clockwise, before rolling one half turn to its right onto its roof. The driver was ejected. The two passengers remained inside the cabin. The heavy truck was spun 180° anti-clockwise by the impact, coming to rest facing in the direction from which it had come. The driver of this vehicle was ejected when the truck stopped suddenly after sliding sideways. Both of the ejections were through doors which, although not hit in the initial collision, had come open. The precautions which are necessary to prevent the doors of passenger cars opening under collision conditions are obviously also applicable to heavier vehicles.

Multiple vehicle collisions

7.18 These eight accidents involved a total of 25 vehicles including 11 trucks. TABLE 7.2 shows the type of vehicles initiating the collision and also the type of the initial collision.

7.19 What features, if any, caused these initial collisions to result in subsequent collisions with other vehicles? Accidents 0186

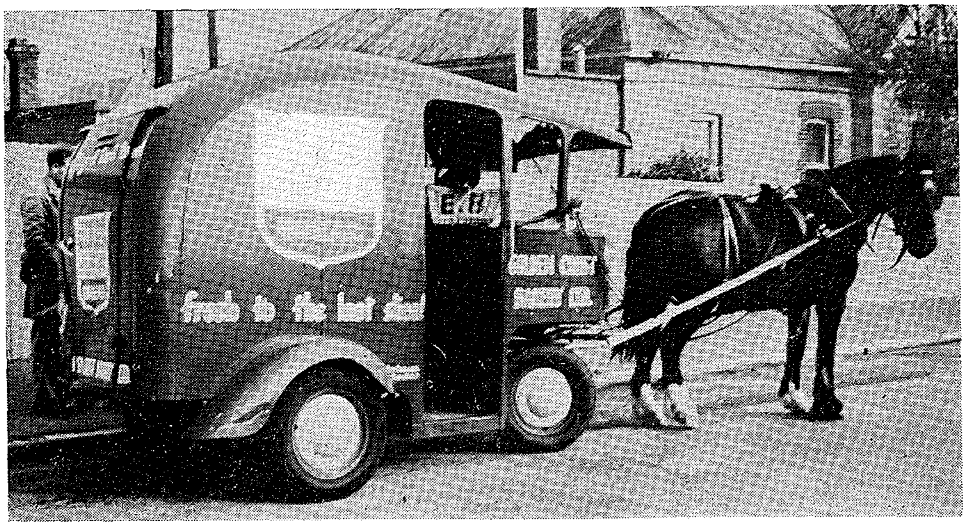


Fig. 7.5—This baker's cart was struck from the rear by a truck. The horse was obviously ill at ease when the photograph was taken soon after the accident

and 0417 are the familiar type of chain collisions. In accident 0395 it was, of course, the truck that ran into the back of the horse and cart (*Fig. 7.5*). The truck then skidded to the left and hit a parked car.

7.20 Accident 0208 is similar to a chain collision in that the third vehicle involved ran into the back of the car that had hit the reversing truck. This type of initial collision can only be attributed to carelessness on the part of the truck driver. While recognizing that many drivers do not have assistants to guide them when reversing, it should be possible to find a person to assist in this task. To attempt to reverse unaided onto a busy road cannot be safe driving.

7.21 Accident 0195 was the most involved collision in our series. A car driver attempted a 'U' turn in the middle of a busy four-lane road. A second car, travelling at an excessive speed in the circumstances, and certainly faster than the legal speed limit, was sideswiped by the turning car. This second car then cannoned off a car approaching from the opposite direction and finally collided head on with a heavy truck. The third car veered to the left after the collision and hit a parked car.

7.22 The two intersection type accidents 0233 and 0240 became multiple collisions when one of the vehicles was deflected into a vehicle approaching the intersection. In case 0233 a heavy truck failed to stop at a stop sign.

7.23 The level crossing accident was at a crossing with no obstruction to vision, although it was dusk at the time. There was a stop sign alongside the roadway on either side of the crossing, but no warning device. The truck driver had stopped at the crossing to buy a newspaper from a paper boy. The driver heard the sound of a horn and thought that it was an impatient driver behind him. He looked both ways along the railway line and not seeing a train, moved off. He was part way across the line when he realized that a railcar was approaching on his left. He tried to accelerate but was struck by the railcar. The truck was spun round and hit a car which was stationary on the roadway some distance back from the crossing. It is probable that the truck driver mistook the sound

TABLE 7.3

LOCATION OF TRUCK ACCIDENTS

Type of Truck Accident	At an Intersection	Within 20 Yd of an Intersection		Not at an Intersection	Intersection Type Accident
		Before	After		
Single vehicle	—	—	—	1	—
Collision with pedestrian	1	1	2	3	1
Collision with pedal cycle	3	—	—	1	2
Collision with motor-cycle	3	1	—	—	4
Collision with truck	1	—	—	—	1
Collision with car	27	—	1	6	27
Multiple collision	3	1	—	4	2
Total for each category	38	3	3	15	37
Per cent of all 59 truck accidents	65%	5%	5%	25%	63%

of the horn on the railcar for that of a vehicle behind him. It would also have been likely, as it was dusk, for the driver to have mistaken the headlight of the railcar for a light from some other source. As with the other level crossing accident in our series, it may be that too much is being expected of motorists by the railway authorities in the prevention of this type of accident.

INTERSECTIONS AND TRUCK ACCIDENTS

7.24 Almost 80 per cent of all collisions between a car and a truck happened at an intersection. Before continuing with the discussion of this type of collision we list the locations of the various types of truck accidents in relation to intersections (TABLE 7.3). An 'intersection type' accident is one in which the intersection played a significant role in the causation of the accident.

Collisions with cars

7.25 Most of these accidents happened at intersections. In fact, 27 of the 34 cases were actually at intersections, and in all but one of these cases the intersection had a significant bearing on the accident. There was one additional case which was located within 20 yards downstream from an intersection. In this case the intersection also played a significant part in the causation of the accident. The remaining six accidents were not near intersections.

7.26 The overall figures for our survey suggest that an intersection played a significant role in approximately 60 per cent of the accidents we attended. In this particular group of accidents it can be seen that the intersection has even greater significance, as approximately 80 per cent of these car-truck collisions are of the intersection type. We have tried to find some possible explanation for the bias towards intersection accidents.

7.27 The first approach we have made has been to separate the 27 intersection type accidents into cases in which a car had a truck approaching from its right and those cases in which a truck had a car on its right. It should be obvious that our suspicion here was that there might be a tendency for the driver of the heavy vehicle to entertain the idea that 'might is right', and so be reluctant to yield to a smaller vehicle. Nineteen of these 27 intersection type accidents involved vehicles which were both travelling straight ahead. There are eight cases of trucks not yielding to cars and 11 cases of cars not yielding to trucks.

7.28 Of the former group six trucks were travelling at such a speed that the drivers were unable to avoid the collision. In these cases the present rule of the road, viz. yield to the vehicle on the right, could not be expected to be effective. We would emphasize

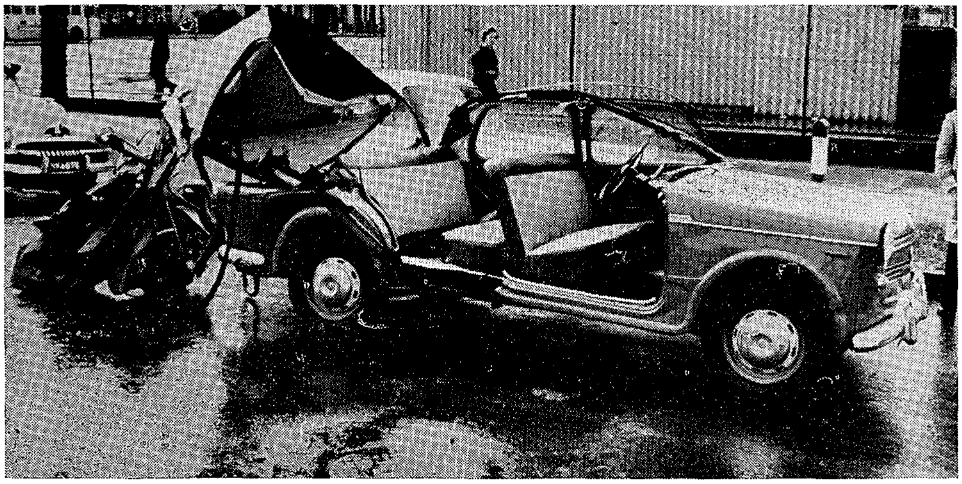


Fig. 7.6—This Fiat 1100 sedan had its roof torn off when it ran under the overhanging tray of a truck

here that at many suburban intersections the maximum safe speed at which one can enter an intersection can be less than 10 m.p.h. It is true that speeding is a cause of accidents, but this is a very relative term, and it is quite possible to drive at an excessive speed and yet never exceed 35 m.p.h. There are some comments that we can make on two of these six accidents. In one case a car driver, having stopped at a stop sign, moved off across the path of a heavy vehicle. While the rule of the road gives this driver the right to proceed once he has stopped at the stop sign, this does not automatically mean that it is safe to do so. In the other case the accident was one of four that we attended at the one intersection, that of Rundle Road and Gooden Avenue. This intersection gives the impression of having excellent visibility, but unfortunately during weekdays parked cars on the included angle of the intersection seriously restrict visibility. The effect of this is to reduce the critical speed across this intersection from 33 m.ph. to 20 m.p.h. (see critical speed calculations for cases 0318 and 0359). It is probable that many of the accidents occurring at this intersection could be avoided by banning parking on the north-western boundary.

Divided highway

7.29 Of the remaining two of these eight cases one resulted from both drivers allowing an insufficient margin of safety at the 'T' intersection of a divided highway and a two-way road (Port Road and Grand Junction Road). Two trucks travelling along this road planned to cross the highway and then turn right and travel along it. The first truck stopped on the crossover of the median strip to allow traffic to pass along the highway from its left. The second truck, which was following closely behind, was then forced to stop, straddling the fast lane on the other side of the divided highway. A car driver, seeing the trucks cross in front of him, decided that they would clear his path without him having to diminish speed. When the second truck suddenly stopped in front of him he had to brake suddenly to attempt to avoid a collision. He was unsuccessful *(Fig. 7.6)*. The point of impact on the car was on the right side of the roof, which hit the overhanging tray of the truck (see also para. 7.15).

7.30 The remaining case was at a similar location on a divided highway where two roads enter the highway on either side (Anzac Highway and Cross Road). A car was crossing from one of these roads over the highway to the other road. The driver of a truck travelling along the highway saw the car approaching from his right but continued on, expecting it to stop, and was unable to avoid hitting the car when it continued across in front of him. At this particular location there is room for doubt as to whether Cross Road does in fact continue straight across the highway. If it does, the car driver has right of way. If there is considered to be a discontinuity here, the truck driver has right of way. Our present road rules do not seem to be adequate under these circumstances.

7.31 Of the other group of accidents, namely cars not yielding to trucks at intersections, there are 11 cases of which six are relevant to our present subject. Each of these six cases involved either one or both of these vehicles travelling too fast for the conditions at the particular intersection, and our remarks on safe speeds in the above section apply equally to these cases.

Stop signs

7.32 Of the remaining five accidents in this category three involved a vehicle driving past a stop sign without stopping. In two of these cases a car drove past a stop sign and collided with a truck which was approaching on its right. The third case involved a large van which drove through a stop sign and struck a car travelling along the busier road on its left. If the truck had stopped at the stop sign it would then have been free to proceed, with right of way over traffic on its left. Traffic on its left, however, is still obliged to yield to the truck even if it does not stop at the stop sign. This accident is also listed in the group of multiple vehicle collisions.

7.33 These drivers, who did not stop, either had no regard for their own safety or they did not see the stop sign. There is little action that can be taken which is likely to produce very much change in the former attitude, but the latter response may be improved by ensuring that stop signs are readily visible under all conditions. This could mean duplicating the sign on the right hand side of the roadway and illuminating the face of the sign at night, as is the practice with some road signs in Britain.

Channelized intersections

7.34 Two of these 11 accidents, and one other, happened at channelized intersections. We list these as a separate category because the placement of these islands did seem to have some bearing on the causation of these accidents.

7.35 Two cases both happened at an intersection where two roads join a divided highway (Port Road and George Street). Islands had been located to lead traffic off the divided highway into one of the side roads. Their placement was such that traffic entering the highway from the other side road had very little warning that a car travelling along the highway was about to turn across their path. Both these accidents occurred in the interim period between the installation of these islands and the installation of traffic lights. A road layout designed for a light-controlled intersection may prove to be unsatisfactory without such control. When there must be an interim period, as in this case, either warning signs or possibly stop signs may be necessary to minimize the risk of accidents of this type.

7.36 The other location apparently has not been designed for use with any additional form of traffic control (Adam and Manton Streets). Most of the traffic from Manton Street turns left into Adam Street. There are some vehicles which continue straight ahead, on the far side of a small traffic island, and pass across Adam Street. This means that a driver approaching the intersection along Adam Street must decide whether a vehicle on his right is turning left or coming across in front of him. Possibly a stop sign for such vehicles from Manton Street would give

Fig. 7.7—The truck attempted to turn right across the path of the car. See also *Fig. 9.33* for another view of this car

drivers in Adam Street a little more time for evasive action, although the critical speed here is about 37 m.p.h. with the existing arrangement.

7.37 The remaining accident in this group of five accidents resulted from a car driver mistaking a green 'turn left' arrow for the green signal for 'straight ahead'. When the green arrow came on, and a car alongside on the left moved off to turn the corner, the driver of the case car also moved off but continued across the intersection and was struck from the left by a light truck which was crossing the intersection with the green light.

7.38 From these two main groups of accidents we see that cars and trucks yield to each other with equal frequency and there does not seem to be, from these figures at least, any basis for an assertion that truck drivers are less likely to yield right of way than car drivers.

Truck turning right

7.39 There is one further group of accidents that we can consider and these are cases in which a truck turns right across the path of a car. We had five such cases, two of which occurred when a truck travelling in a slow lane of a dual highway started to turn right from the slow lane and collided with a car travelling in the same direction but along the fast lane of the highway. Two other cases resulted from a truck turning right despite the fact that there was a car approaching from the opposite direction. One of these cases (0226) was not at an intersection. The truck was turning to enter a private driveway (*Fig. 7.7*). The remaining case involved a heavy vehicle of considerable length turning right from the leg of a 'T' junction into a busier road. This truck was struck by a car which approached from his right. The average speed of cars along this particular stretch of road is high, around 40 to 45 m.p.h. It is possible that the truck driver did not make sufficient allowance for the high traffic speed at this location.

7.40 We have now considered 22 of the 27 intersection-type truck versus car accidents. The remaining five accidents include one which has been described under the heading 'channelized intersections'. Two other cases involved a truck turning right. One of these accidents was essentially a rear end collision, for the truck was stationary, waiting to turn to the right, when it was struck from the rear by a car. This accident happened at night. The other accident involved a truck turning right and a car approaching from his right. The driver of the truck appeared to be most belligerent and possibly under the influence of alcohol. (We did not get close enough to smell his breath!). Another of these five accidents involved a car turning right across the path of a truck, virtually the reverse case of the previous accident.

7.41 The remaining accident in this group involved a truck entering a 'T' junction from the blind leg. The driver of the truck saw a small car approaching from his left at high speed and pulled over to the right hand side of the road to allow the car to pass. By this time, however, the driver of the small car had lost control of his vehicle and in the ensuing collision the car was in fact travelling sideways when it sideswiped the side of the truck with only minimal damage to both vehicles (*Fig. 10.15*). There was a similar collision, although not of an intersection type, in which a car rolled on a gradual bend and, while rolling, sideswiped a truck travelling in the opposite direction.

ACCIDENTS NOT AT AN INTERSECTION

7.42 We have already mentioned one of the accidents involving a car and a truck that did not happen at an intersection. This was case 0226 in which the truck turned right across the path of a car in an attempt to enter a private property.

7.43 Of the remaining five cases that did not happen at an intersection we have one that is similar to one of the multiple collisions. This involved a heavy vehicle backing out of a marshalling yard on to a busy road. This particular case happened at night. The vehicle was a semi-trailer with a long overhanging load on the trailer. Insufficient care was exercised when reversing on to the road, and a small sedan ran into the overhanging

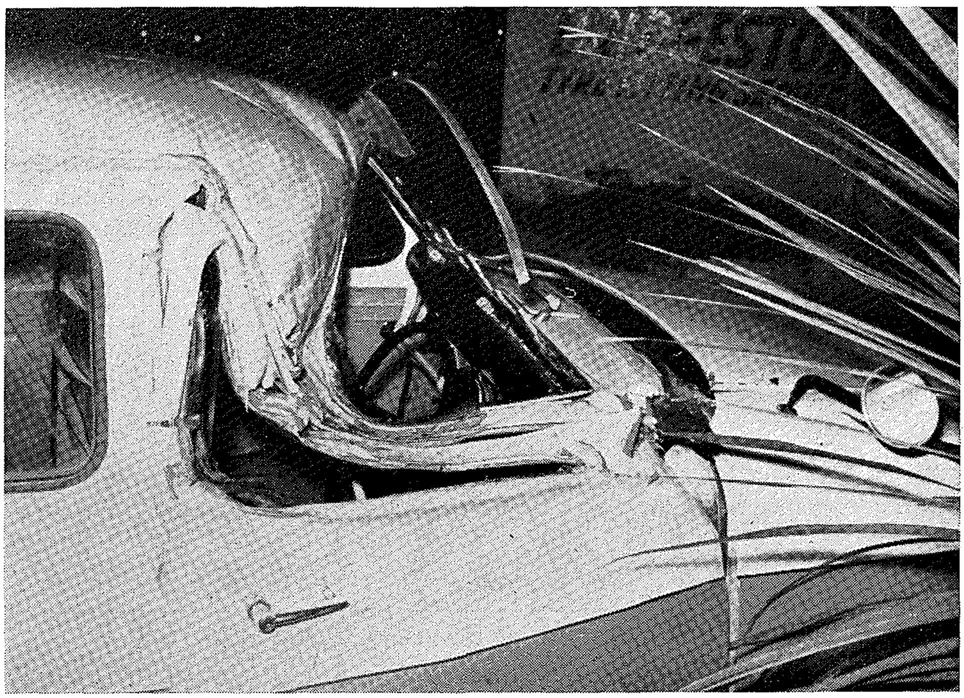


Fig. 7.8—This 1954 Standard '8' ran into the overhanging load of a sem-trailer which was reversing on to the roadway at night. The driver was concussed

load, which was projecting across the roadway (*Fig. 7.8*).

COLLISIONS WITH PARKED TRUCKS

7.44 There are two cases in this group of six accidents which involved a car running into the back of a stationary truck at night. In one of these cases a light truck-type utility was parked close to the side of the road and yet was struck by a small saloon car. Street-lighting at this point was virtually non-existent and the driver of the car, although showing no obvious signs of having been drinking, was found to have a blood alcohol level of over 0.08 per cent. As we mentioned in our discussion of single vehicle car accidents, the influence of alcohol appears to be very marked in cases which involve a collision with a parked vehicle.

7.45 The other case of this nature involved a car which drove into the back of a bus while it was stationary at a stop but still on the traffic lane. It would appear to be important for the drivers of these buses to ensure that their vehicles encroach no further than is absolutely necessary on the carriage way, particularly at night. It would also be safer for such buses to be equipped with very distinctive rear lights.

7.46 Of the two remaining cases, one involved a car driver attempting a 'U' turn at a place where visibility is restricted by a curve in the road. The driver of the car claims that he looked behind him and saw the road was clear and then proceeded to do a 'U' turn. He was struck by a light truck which suddenly appeared round the bend. The obvious comment here is that the car driver should not have attempted a 'U'-turn in this particular location, even though there is no sign forbidding him to do so.

7.47 The remaining accident was a side-swipe between a car and a truck travelling in the opposite direction. In actual fact the two vehicles themselves did not make contact but the driver had his arm hanging over the windowsill of the car and received a very severely injured right arm. (*Fig. 11. 12*). It would seem that this obvious exposure to injury should be sufficient to encourage people to keep their arms inside the car.

INJURIES TO TRUCK OCCUPANTS

7.48 22.5 per cent of all truck occupants in all accidents were injured, as shown in TABLE 7.4. None of the truck occupants involved in collisions with motor-cycles, pedal cycles and pedestrians was injured. The four truck occupants with moderate injuries all received concussion. One fell from the tray of a truck to the road, one driver was concussed when his van struck a car-type utility, and the drivers of the two trucks which collided in accident 0348, and who were both ejected, were both knocked unconscious. The two other persons in this last accident received only minor abrasions. All other injuries to truck occupants were minor abrasions, bruises and lacerations, to the face, scalp and limbs.

7.49 If the injuries of car and truck occupants are compared, for those accidents where both cars and trucks are involved it is found that the car occupants receive more (and more severe injuries) than truck occupants (see TABLE 7.5). This difference is quite marked, and the value of χ^2 suggests that it is not due to chance.

TABLE 7.4

INJURIES TO TRUCK OCCUPANTS

	Degree of Injury					
	Nil	Minor	Moderate	Severe	Very severe	Total
Truck occupants	66	15	4	0	0	85

TABLE 7.5

INJURIES TO OCCUPANTS IN TRUCK-CAR COLLISIONS

	Degree of Injury					
	Nil	Minor	Moderate	Severe	Very severe	Total
Truck occupants	42	13	1	0	0	56
Car occupants	17	36	24	5	0	82
Total	59	49	25	5	0	138

$\chi^2 = 44.90^{***}$

TABLE 7.6

INJURIES TO CAR OCCUPANTS

	Degree of Injury						
	Nil	Minor	Moderate	Severe	Very severe	Fatal	Total
Car occupants vs. trucks	17	36	24	5	0	0	82
Car occupants not vs. trucks, motor-cycles, pedal cycles, pedestrians	275	301	105	28	7	2	718
Total	292	337	129	33	7	2	800

$\chi^2 = 10.06^{***}$

7.50 Again, if the injuries of this group of car occupants are compared with those of car occupants involved in accidents which do not involve trucks, motor-cycles, pedal cycles and pedestrians, it is found that they again receive more (and more severe injuries). The value of χ^2 suggests that this difference is not due to chance (TABLE 7.6).

7.51 35.4 per cent of occupants of cars involved with trucks receive moderate or greater injury, while 19.8 per cent of the other group of car occupants and 1.8 per cent of truck occupants receive moderate or greater injury.

7.52 The decreasing degree of injury suggests that the persons concerned are subjected to decreasing intensity of injury-producing forces. That is, the forces to which truck occupants are subjected in collisions with cars are much less than the forces developed in collisions between cars, which are in turn much less than the forces developed in cars which collide with trucks.

INTRODUCTION

8.1 Cars form the greatest proportion of the motor vehicle population: 80 per cent (Census of Motor Vehicles, 1962). Consequently collisions beween two cars are the commonest type of car accident. In most of these collisions between two cars there is only one impact, both coming to rest without striking anything else. In some cases a car is involved in a subsequent collision, either with another motor vehicle or with a fixed object of some description.

8.2 The magnitude of these collisions varies greatly, making exact classification difficult, e.g. accident 0244 (*Fig. 8.1*).

● Case 0244

The front of a Peugeot (*Fig. 8.2*) struck the left side of a Ford Zephyr (*Fig. 8.3*) at a traffic light controlled intersection. The Zephyr was spun anti-clockwise through 270° and came to rest against the front of a Simca which had just moved off with the green light. The first collision resulted in injury to the driver of the Peugeot and to a rear seat passenger of the Zephyr. The collision with the Simca caused almost no damage to the cars, and no injury to the occupants.

8.3 Compare accident 0244 with the next example, accident 0046 (*Fig. 8.4*).

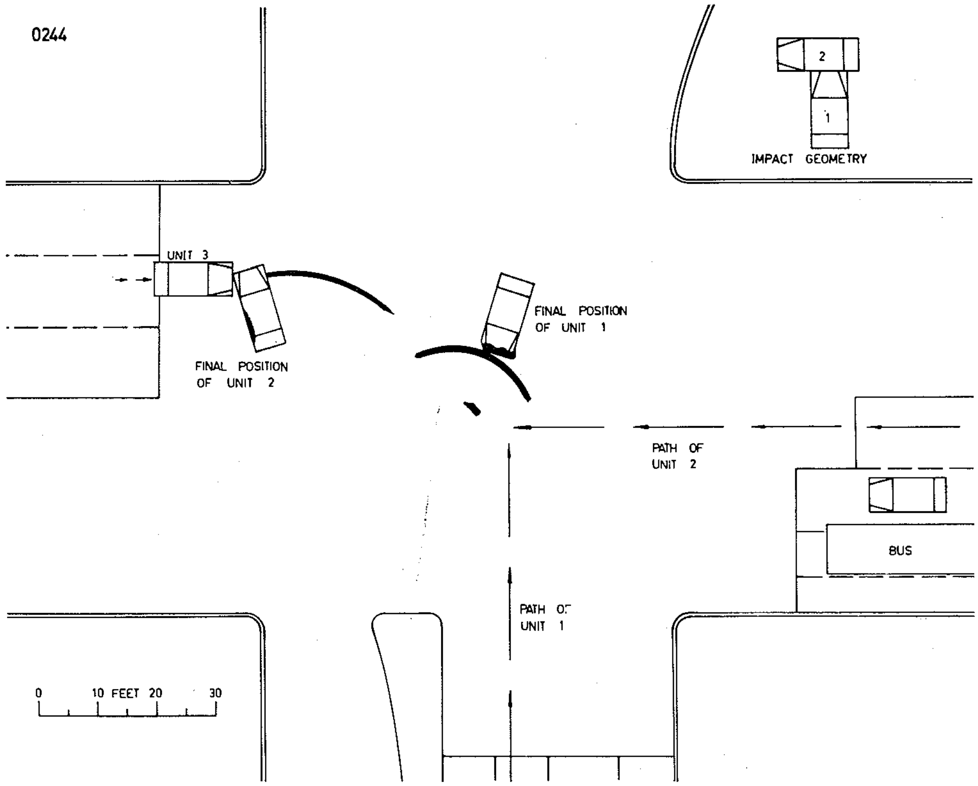


Fig. 8.1—Case 0244

Fig. 8.2—1958 Peugeot 403, after colliding with the Ford Zephyr shown in *Fig. 8.3*

Fig. 8.3—1959 Ford Zephyr, struck by the Peugeot shown in *Fig. 8.2*. Note that the rear door has come open

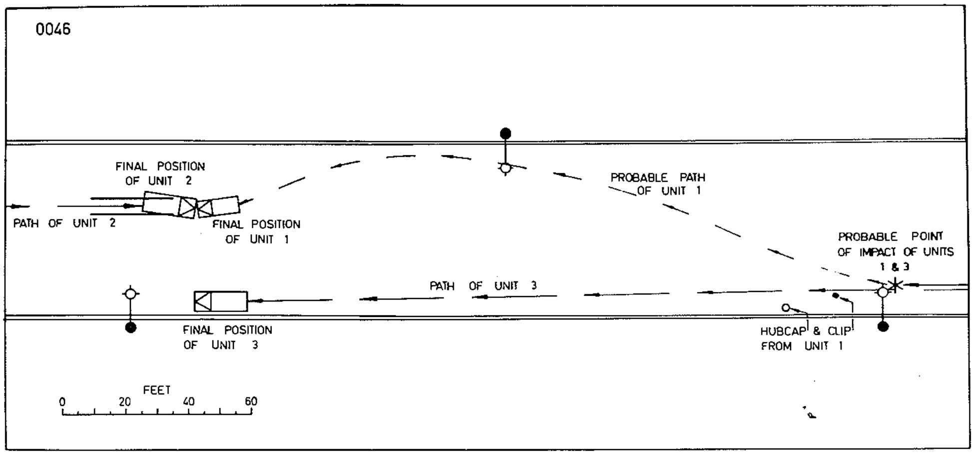


Fig. 8.4—Case 0046

Case 0046

A Volkswagen saloon, while overtaking a Humber Super Snipe saloon, lightly struck the right rear corner of the Humber with the left front wheel. The Volkswagen then veered across to the opposite side of the road where it struck a Ford Mainline utility head-on (*Fig. 8.5*). The damage to the Volkswagen was more severe than the damage to the Ford (*Fig. 8.6*). The driver of the Volkswagen suffered concussion, a fracture dislocation of the neck leading to complete paralysis, broken ribs and a fractured right thigh. On impact the steering column was forced back into the passenger compartment (*Fig. 9.15*). The driver struck the wheel and column with his chest and the area above the windscreen with his head.

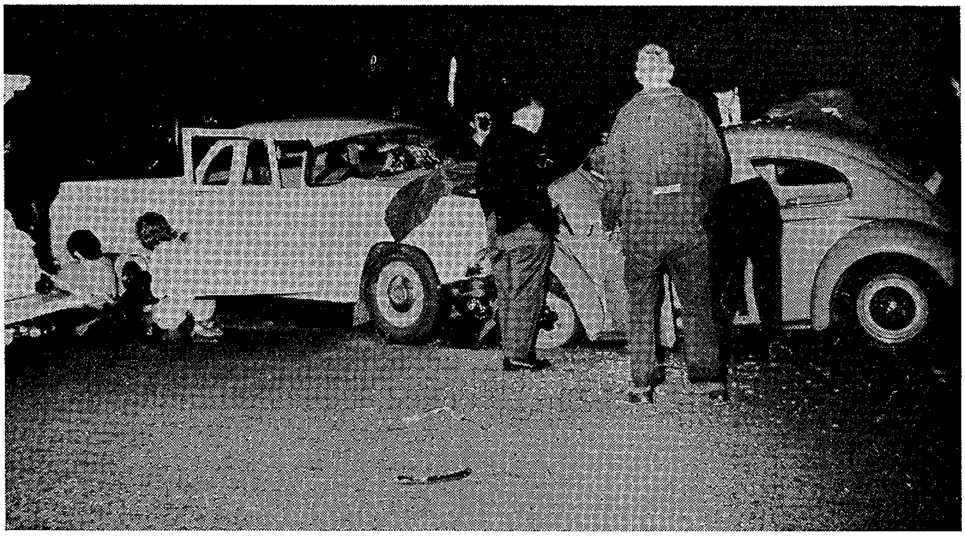


Fig. 8.5—Case 0046: collision between a 1955 Ford Mainline utility and a 1962 Volkswagen. The driver and the passenger of the utility are on the road beside their vehicle. The driver of the Volkswagen is still inside his car

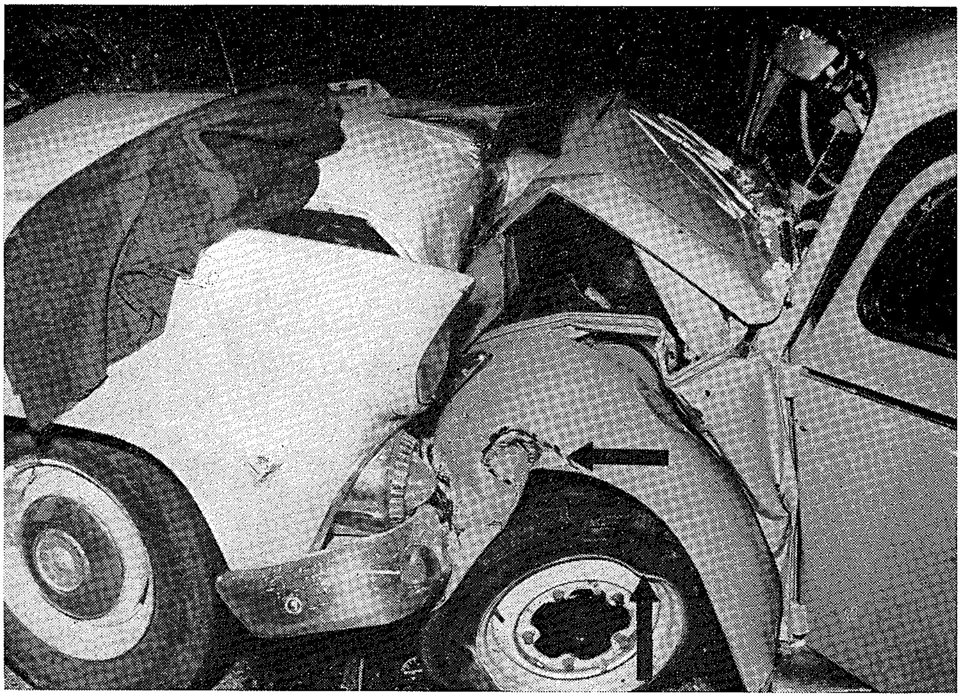


Fig. 8.6—Case 0046: arrows indicate the damage due to the initial collision between the Volkswagen and a Ford

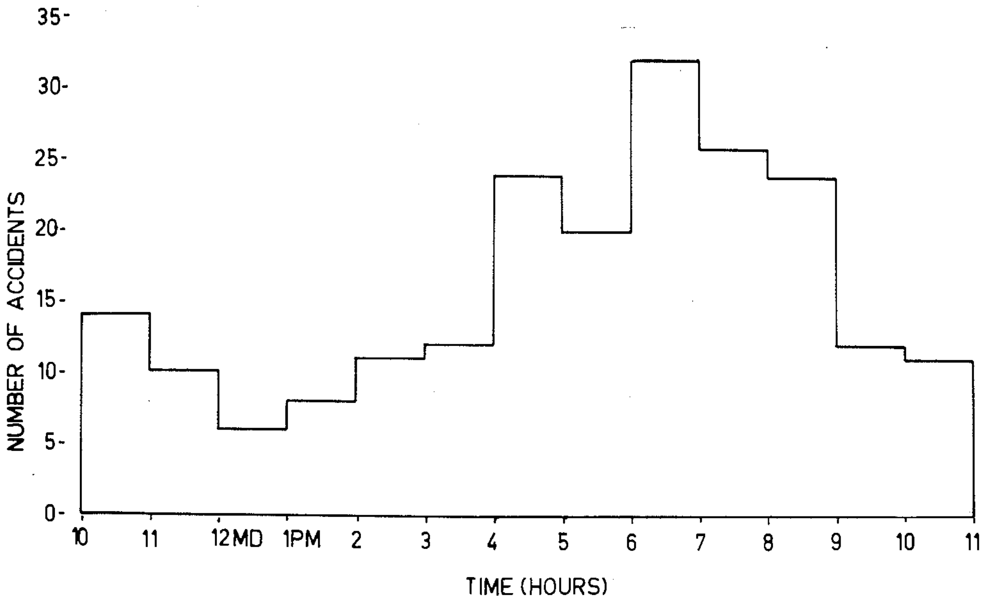


Fig. 8.7—Time distribution of accidents involving cars

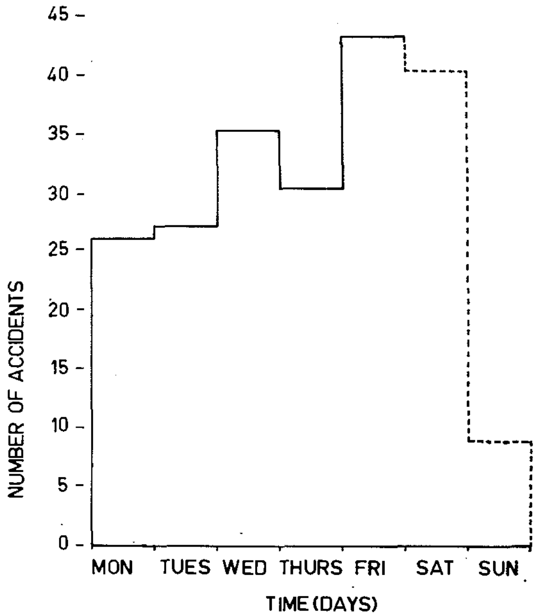


Fig. 8.8—Accidents involving cars for each day of the week

The passenger compartment of the Ford was relatively undamaged (*Fig. 9.18*). The driver suffered a fracture of the right knee cap when his knee hit a knob on the instrument panel. The left front seat passenger struck the windscreen and the top of the instrument panel with her face, fracturing her front teeth (*Fig. 11.18*).

8.4 The initial collision between the cars is more important in the first case, and of only minor importance in the second case where the second collision is more important. Where the effects of the car-to-car collision on personal injury have been specifically studied, such cases as these have been included in the same category as accidents in which only two vehicles were involved.

8.5 The following tabulation summarizes the types of car accidents that we covered in our survey. These categories are not necessarily exclusive and so the totals should be regarded as only an indication of the frequency of these various types of car accidents.

Type of Car Accident		No. of cases
Collision between two cars, no subsequent collision		108
Initial collision between two cars, subsequent collision with		
one or more motor vehicles	15	
utility pole	8	
tree	1	
building	4	
kerb	3	
ditch	1	32
Single car accidents		
collision with utility pole	8	
rollover only	8	
rollover followed by a collision	4	
collision with tree	6	
assorted fixed objects	3	
unloosed trailer	2	31
Collisions with parked vehicles		13

TIME DISTRIBUTION

8.6 The distribution in time of 210 accidents involving cars is shown in *Fig. 8.7* and *8.8*. These accidents include all car-to-car collisions, all single car accidents, and most of the collisions between cars and trucks. The distribution of accidents by time of day shows a peak around 6 p.m. which gradually falls off to 11 p.m. The distribution of accidents for each day of the week (*Fig. 8.8*) is interesting because, notwithstanding the fact that Saturday was only sampled half the number of times as Monday through Friday, there are almost as many accidents recorded. The height of the Saturday column should therefore be doubled, to approximate the proper relation of Saturday to the rest of the week. These accidents were almost evenly split between night (100) and day (110). In three quarters (155) of the 210 accidents an intersection played a significant part in the production of the accident. Only 27 occurred on wet roads.

AGE, SEX AND SEATED POSITION

8.7 *Fig. 8.9* shows the age distribution of all drivers, front seat passengers and rear

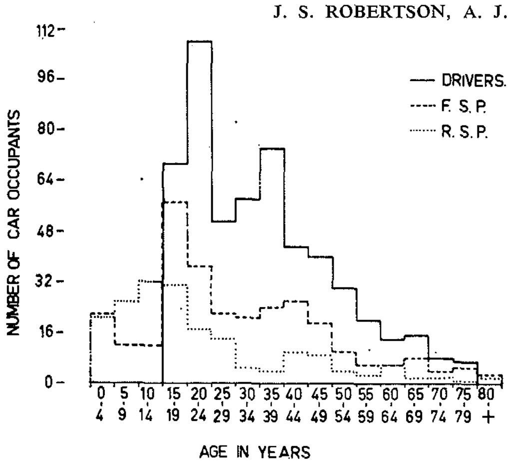


Fig. 8.9—Ages of car occupants

seat passengers. The most common age group of drivers involved is 20 to 24 years. Half of the drivers are less than 35 years old. There is a secondary peak at 35 to 39 years, after which the numbers gradually decrease with increasing age.

8.8 The numbers of drivers who had consumed alcohol are shown in TABLE 8.1, together with the percentages that these numbers form of total drivers in these age groups. About one-tenth of all drivers had obviously consumed alcohol, the greatest proportion being in the age range 40 to 49 years. This distribution of persons showing evidence of alcohol is rather similar to that of pedestrians.

8.9 The largest number of front seat passengers are in the 15 to 19 year age group. 63 per cent of rear seat passengers are less than 20 years old, with a peak at 10 to 14 years.

8.10 The sex and age distribution of the occupants in these seated positions is shown in TABLE 8.1a in the Appendix for the 1,020 persons for whom this information was known. Only one sixth of these car drivers are women. The most frequently involved age group for men is 20 to 24 years; for women it is 35 to 39 years. Among front seat passengers women (57 per cent) slightly outnumber men. But after age 35 years there are many more women than men. Rear seat passengers are almost equally divided between male and female, and are mostly young children.

DRIVING EXPERIENCE

8.11 The length of driving experience of the 265 drivers from whom this information was obtained, is set out below:

Less than 6 months	9
7 to 12 months	7
13 months to 5 years	66
6 to 10 years	63
11 to 20 years	59
21 to 40 years	53
More than 40 years	7

The rate of accident occurrence decreases rapidly with increasing experience after the first ten years. 31 per cent of the accidents happened to drivers who had been driving less than six years.

CAR TO CAR COLLISIONS

8.12 The commonest configuration in car to car collisions was the front of one car striking the side of another. The fact that Adelaide's street plan is based on a 90°

TABLE 8.1

DRIVERS WHO HAD CONSUMED ALCOHOL

	Age (Years)										
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69
No. of drivers with alcohol	6	13	6	5	11	9	8	2	2	2	1
Per cent of all drivers in each age group	8.7	12.0	11.8	8.6	14.9	20.9	20.0	6.7	10.0	14.3	6.6

TABLE 8.2

DISTANCES AT WHICH DRIVERS SAW OTHER CARS

Driver of	Saw the Other Car				
	In the distance	Close	Not at all	Not known	Total
Unit 1	15	60	4	25	104
Unit 2	17	44	11	32	104
	32	104	15	57	208

grid with large numbers of right-angled intersections accounts for the prevalence of the front to side configuration. This also has the important consequence that car occupants, because of this configuration, are injured by the sides of the interior of the car as often as by the front.

8.13 In these collisions between cars it was found that 79 per cent of the 151 drivers for whom the information was available did not see the other vehicle until it was too late to avoid a collision, as TABLE 8.2 shows.

8.14 Accident 0386 (*Fig. 8.10*) is an example of a collision between two cars. It is significant that the driver of the Holden looked only in one direction (right) before entering the intersection.

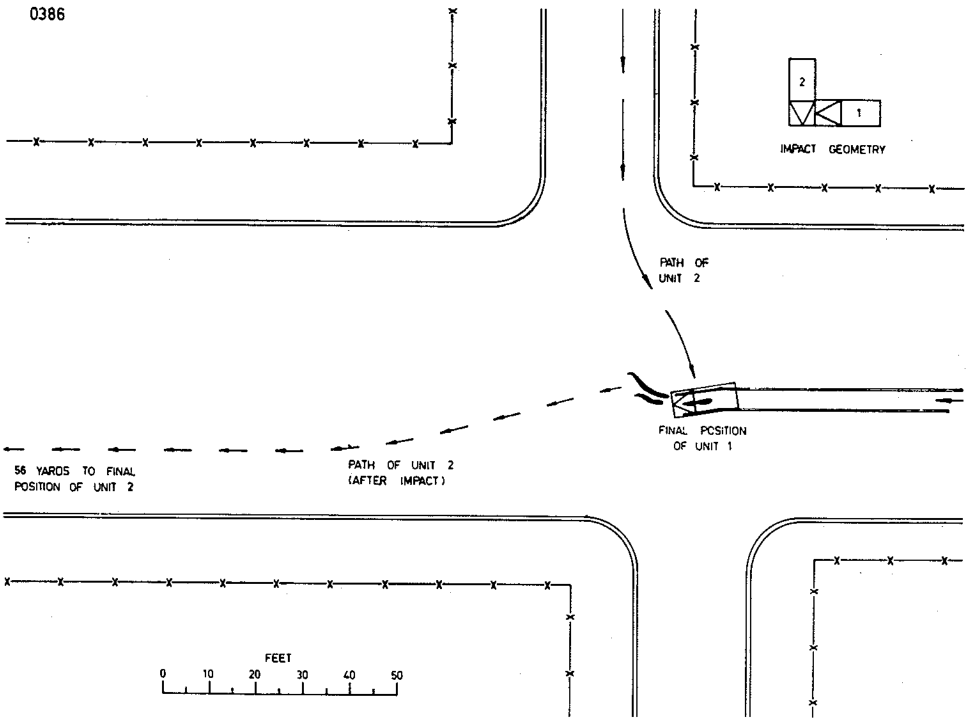


Fig. 8.10—Case 0386

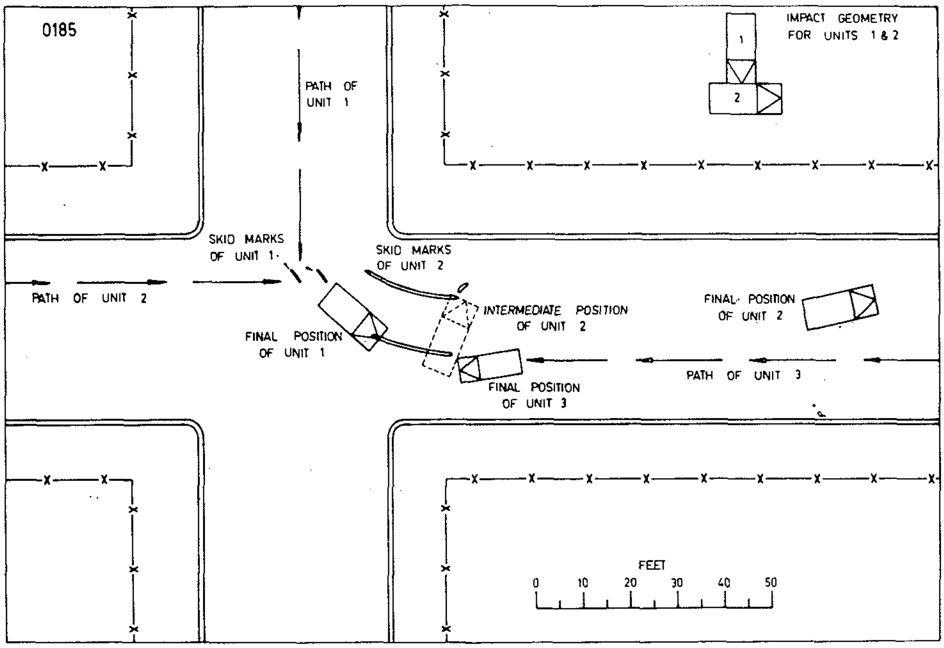


Fig. 8.11—Case 0185

● Case 0386

A Ford Falcon sedan was travelling on a very wide main road, when a Holden EH station sedan came out of a side street without stopping. The driver of the Holden had looked to his right as he entered the intersection, but looked to his left only immediately before the impact. The front of the Holden struck the right front wheel of the Falcon. The Holden was spun clockwise through 90° by the impact, and rolled off down the road with its brakes inoperative. The Falcon skidded 18 yards before the impact. The driver of the Falcon sustained an abrasion to his upper lip and a small laceration to his tongue. The driver of the Holden suffered bruises to his left forehead and left elbow.

8.15 The complex nature of a collision between two cars, followed by a subsequent collision, is illustrated by accident 0185 (*Fig. 8.11*).

● Case 0185

At a right-angled intersection with a good sight distance, a Ford Customline was struck on the centre of its left side by the front of a Standard Vanguard II. The Customline spun 90° anti-clockwise, and struck an Austin A40 which was approaching the intersection from the opposite direction. The original impact caused the right side doors of the Customline to come open and then the impact of the right rear corner with the Austin stopped the Customline's rotary motion, causing the two occupants to be ejected, one through the front door and one through the rear door. The Customline then spun 90° clockwise, coming to rest facing its original direction. The driver of the Vanguard could not remember the impacts or events immediately preceding the collision. He had a small abrasion on his right forehead. The driver of the Customline was concussed and had abrasions to his right shoulder, right buttocks, right hand and right knee, and his right forehead. He could not remember anything except the very start of the trip. The passenger of the Ford was seated in the centre of the rear seat. He sustained abrasions and small lacerations to the right side of his face, a fracture of his right shoulder blade and fractures of his right eighth, ninth, tenth and eleventh ribs. He also fractured the fourth and fifth metacarpal bones in his right hand. In both men the injuries were all on the right side of the body, which is consistent with the fact that they were ejected from the right side doors of the car and landed on the road. The driver of the Austin sustained a small abrasion to the bridge of her nose, bruising of the chest caused by the steering wheel, and bruises and abrasions to both knees caused by the instrument panel.

The impact on the side of the Customline caused it to spin sideways and also sprung open the doors on the opposite side. This sequence then set the stage for the ejection of the occupants which took place when the car stopped spinning, as it struck the other car. This accident illustrates three characteristics of the intersection collision: (a) the front of one car strikes the side of another car; (b) the impact on the side may spring open doors, particularly those which do not have safety door locks, and also (c) the impact may spin the car into the path of a third car. The subsequent collision may ensure the ejection of the occupants.

SINGLE CAR ACCIDENTS

8.16 Forty-four of the 408 accidents in this survey were essentially single car accidents. We include in this group 13 cases of cars running into parked vehicles, and two cases of trailers coming loose and hitting cars. The various types of accidents in this group are listed in para. 8.5. Some of these accidents had obvious and specific causes.

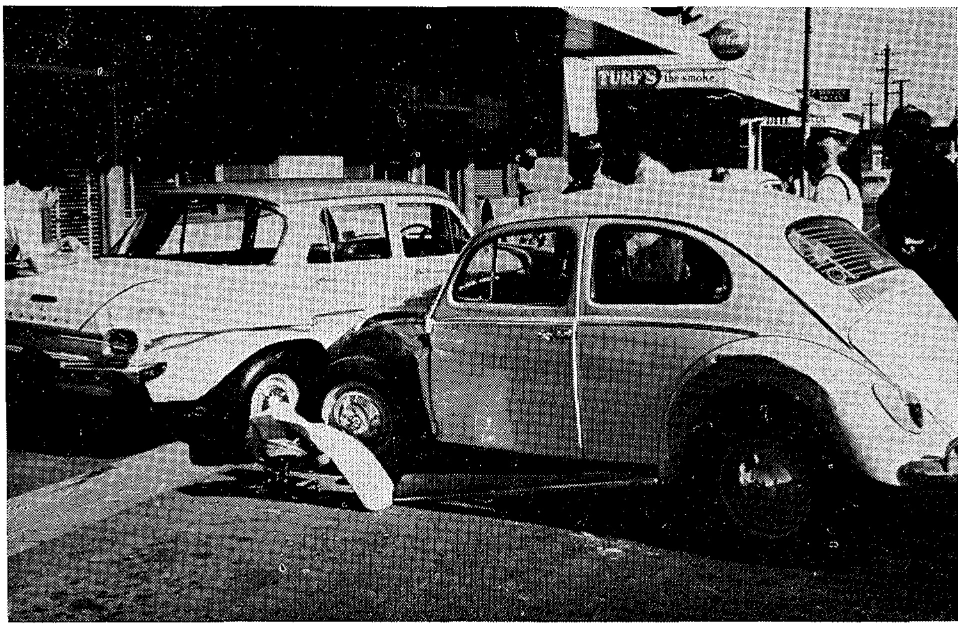


Fig. 8.12—A small child in this 1962 Volkswagen pushed the back of the driver's seat forwards. The driver lost control and the car sideswiped a parked car before hitting the Holden shown here. This Holden was pushed into yet another parked car

In two cases the driver collapsed at the wheel and each of the cars swerved off the roadway and hit a tree. Two other cases appeared to us to have been deliberate attempts to crash a car; in each case the motive may have been to win the sympathy or attention of another party. One driver lost control of a Volkswagen 1200 when a small child pushed the back of the driver's seat forwards (*Fig. 8.12*). Another driver mistook first gear for reverse and, instead of backing out of an off-street parking area, bounced forwards over a low concrete kerb, crossed a roadway and crashed into the side of a parked car. Two drivers claimed that they were distracted, one by a hat falling to the floor, the other by a moth flying into his eye. They both drove into the rear of parked cars. Finally there were the two accidents mentioned earlier which were caused by trailers breaking loose from their towing vehicle and colliding with other cars.

8.17 The failure of the safety chains on the towing attachments of each of these trailers points to the need for specifications for both the strength of such chains and the method of attaching them to both the trailer and the vehicle. It may also be desirable to make it an offence to tow a trailer which is not fitted with chains which meet such a specification. The condition of such chain is important. Thus *Fig. 8.13* shows the chain from a trailer in one of the accidents listed above. Notice that one link has been replaced with thin wire, and that the other links are almost worn through.

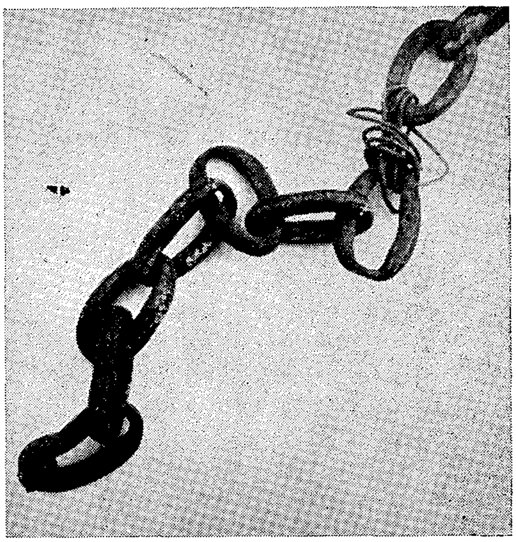


Fig. 8.13—Trailer safety chain, from a trailer which broke loose and crashed into a parked car

8.18 Apart from these specific causes the effect of alcohol is perhaps the most noteworthy feature of these single vehicle accidents (*Fig. 8.14* in Appendix B). Over one third — 16 in 44 — of these drivers had obviously consumed alcohol not long before their accident. The number of drivers actually affected by alcohol could have been higher than this. Towards the end of our survey we had the use of a simple device which indicates blood alcohol levels based on a breath sample. In one case the driver showed none of the customary effects of alcohol, no smell or obvious effects at all apart from rather slow movements. The breath test showed that this driver had consumed more than enough alcohol to cause a significant deterioration in driving ability. It is in accidents of this type, involving one driver only, that we would expect the role of alcohol as a causative factor to be most marked.

8.19 *Fig. 8.15* shows the distribution of these accidents by time of day. Those cases in which alcohol was obvious are also shown. While it is tempting to point to the sudden rise in accidents after 6 p.m., the time at which the hotels close, it is important to note that the proportion of cases involving alcohol remains very nearly constant until 11 p.m. We have marked with an 'S' those cases which occurred on a Saturday or a Sunday. These include the two cases in which the drivers had been drinking in the daytime.

8.20 The single car accident appears to be chiefly a night-time phenomenon. There were

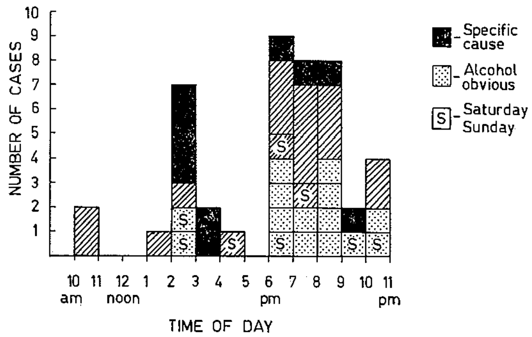


Fig. 8.15—Single car accidents by time of day

27 cases at night and 17 in the daytime. Seven of the 17 daytime accidents were rollovers, without a prior collision. There were five rollovers at night. Now it is reasonable to assume that whether one rolls a car over or not is unlikely to be closely related to lighting conditions. But the likelihood of collisions with poles, trees and parked cars may well be greater at night. Our figures certainly suggest that this is so. There were nine such collisions in the daytime and 21 at night. These consisted of 13 collisions with parked vehicles, eight with utility poles, six with trees, one with a roundabout, one with a rock garden on a median strip, and one with a series of fixed objects.

8.21 All but one of the collisions with parked vehicles were at night. The driver of the striking car in the one daytime accident recalled having glanced at his speedometer and then having looked up to see the parked car just before the impact. There was one night accident in which a faulty street light made it more difficult for the driver to see the parked car. In three other cases the street lighting was virtually nil. We are still left with one case in which the street was well lit and the driver sober (*Fig. 8.16*). Unfortunately we do not know the events leading up to this collision because the driver

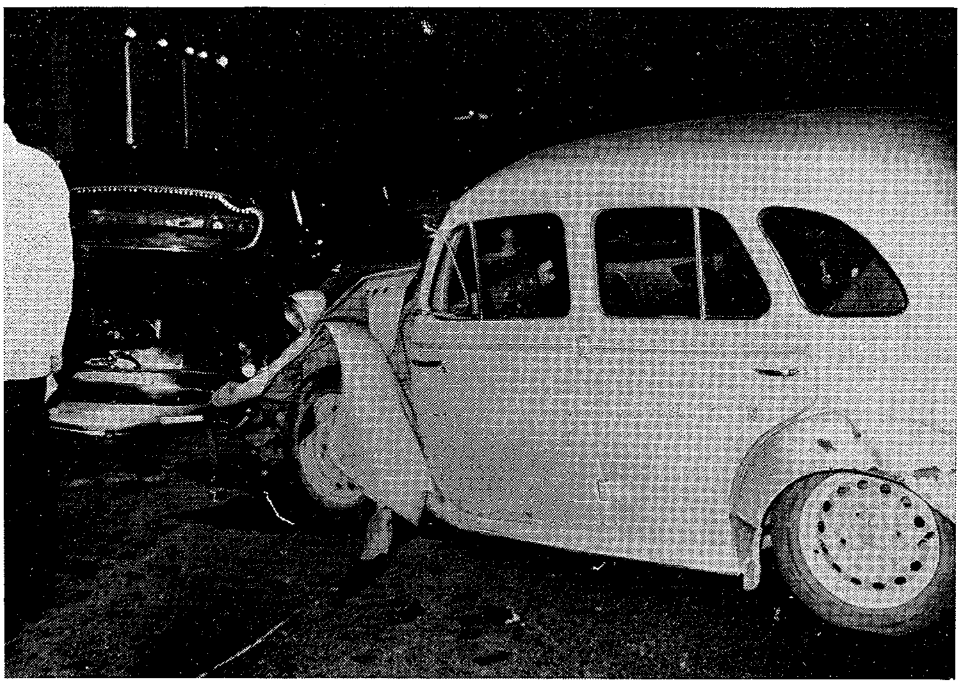


Fig. 8.16—A Vauxhall Wyvern after colliding with a parked car at night

was concussed and unable to remember. It may have been a similar case to the two detailed in para. 8.16 in which the drivers were distracted. Once again, the effect of alcohol appears to be very great. Five of these eight drivers had been drinking. One of them was hardly able to stand upright by himself.

8.22 The collision with a roundabout was a mysterious case. There was no indication of any attempt having been made to avoid a collision, such as skid marks due to braking, etc. The car struck the 18 in. high edge of the roundabout and rolled end over end. Once again the driver was concussed and unable to give any coherent explanation for the collision. A sloping rather than a vertical edge (*Fig. 8.17*) to the roundabout would certainly have reduced the damage to the vehicle and possibly the injuries to the driver. The existing vertical edging did not prevent the car from crashing onto the roadway on the far side of the roundabout, which is over 12 yards in diameter (*Fig. 8.18*). (*Fig. 11.9* and *11.10* also relate to this accident, see section 11.)

8.23 The driver whose car ran into a rock garden on a centre plantation of a divided highway had braked hard well before the impact in a successful attempt to avoid a pedestrian.

8.24 The collisions with trees call for little comment. Obviously if a car runs off the road it is likely that it may hit either a tree (*Fig. 8.19)* or a utility pole. If we were to choose further to denude our streets of trees, and to place all our power lines underground, the risk of this type of collision would be reduced, at the expense of damage to fences, etc. and possibly to pedestrians. A collision with a pole can result in severe damage to

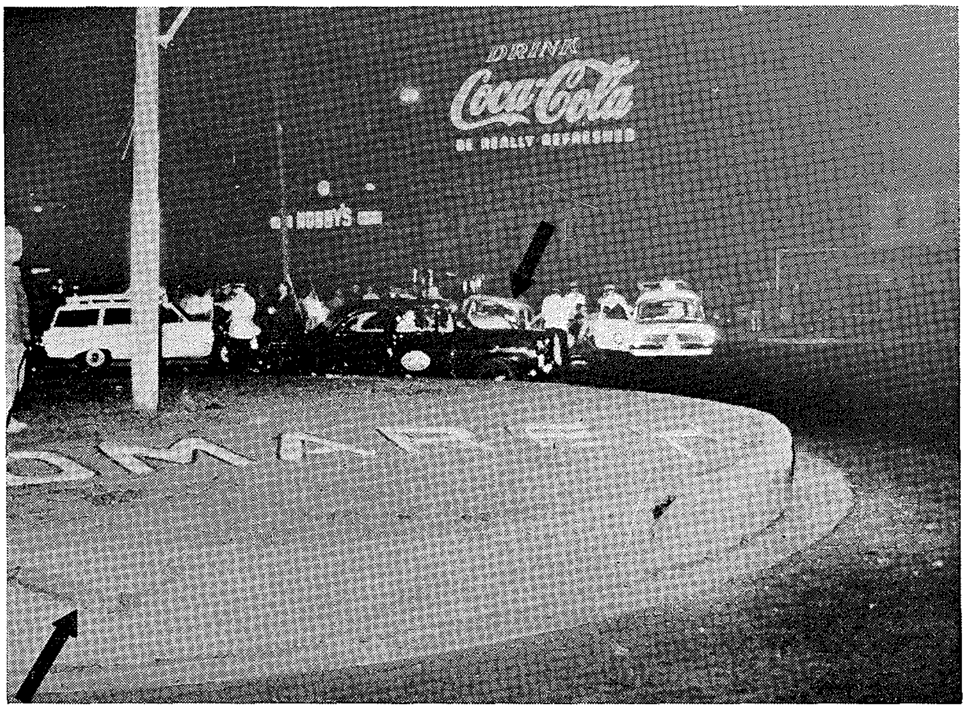


Fig. 8.17—Roundabout struck by the car shown in *Fig. 8.18*. The point of impact and the final position of the car are indicated by arrows

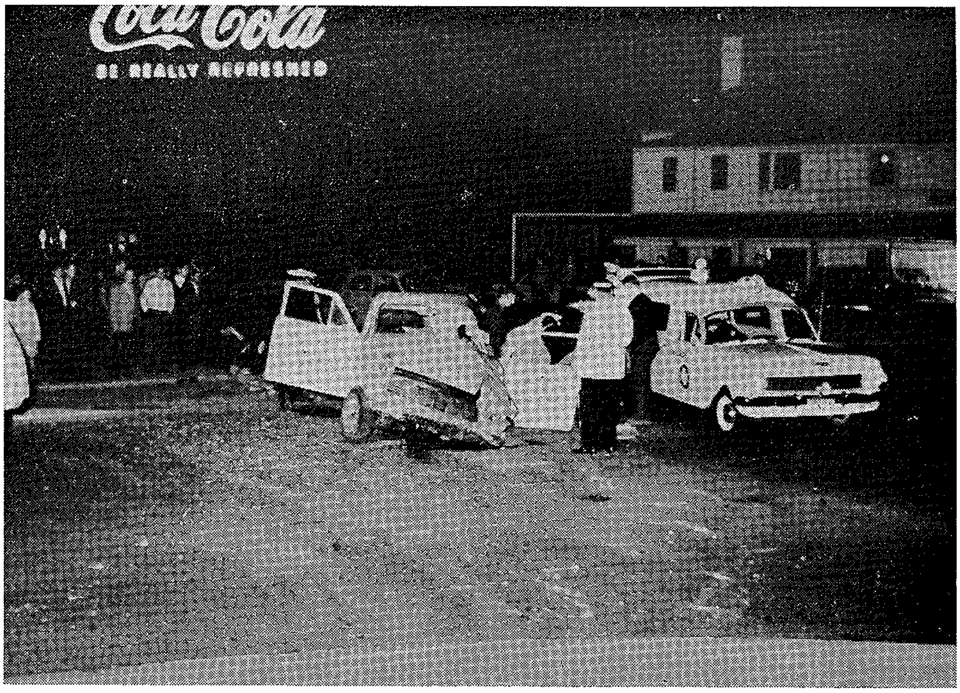


Fig. 8.18—1957 FE Holden after a collision with the roundabout shown in *Fig. 8.17*

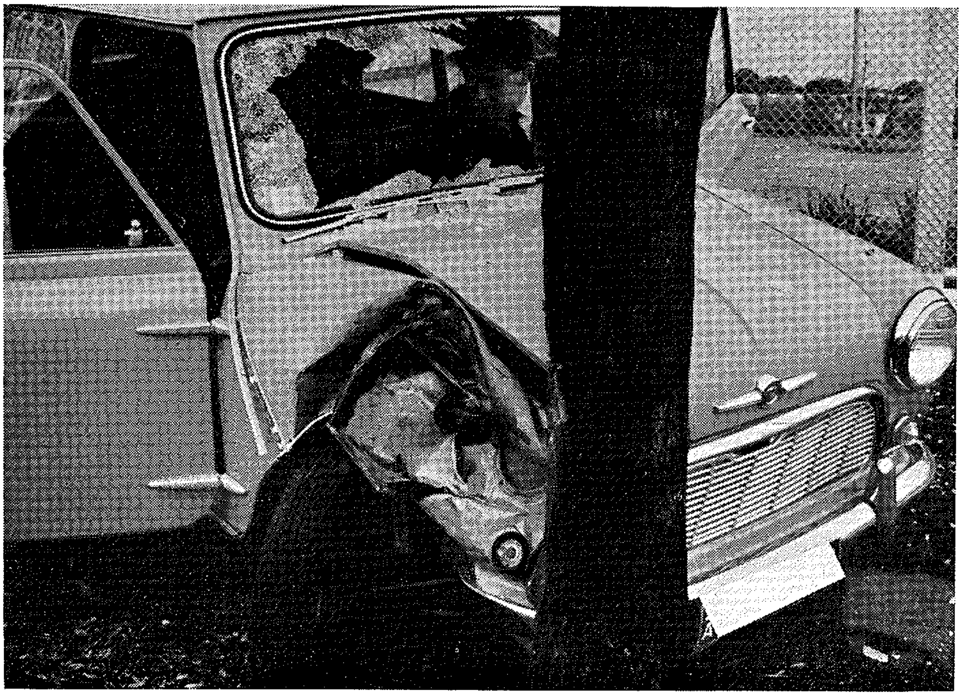


Fig. 8.19—The driver of the Morris 850 braked and swerved to the left to avoid hitting a dog. The car mounted the footpath and collided with this tree

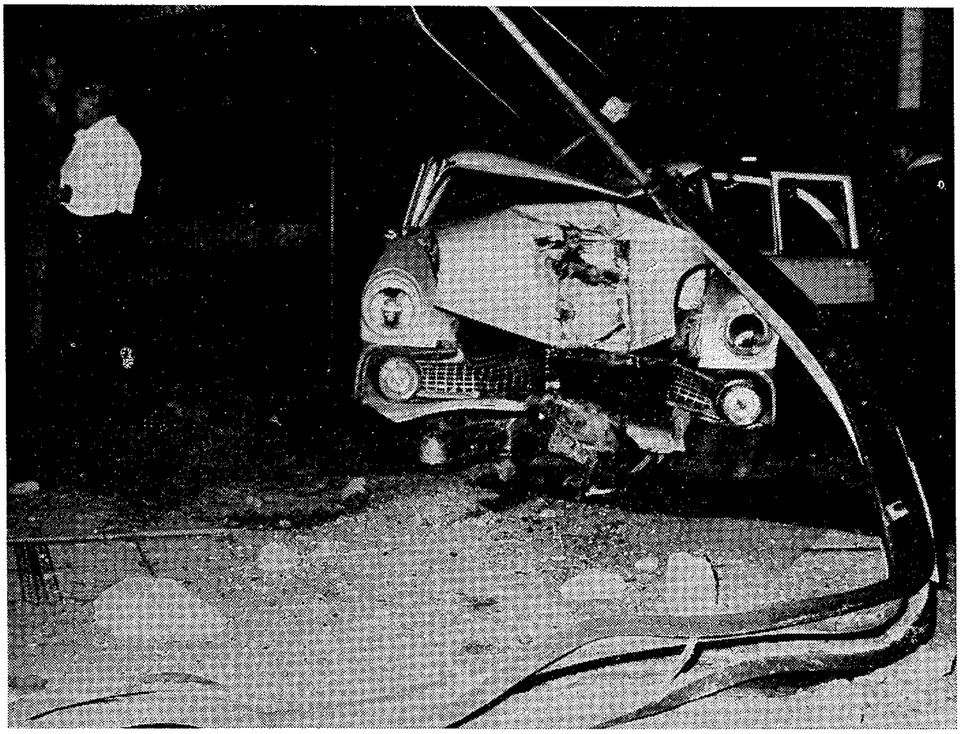


Fig. 8.20—1955 Ford Customline, after colliding with a steel and concrete utility pole. The base of the pole is in the bottom left corner. The car approached from the left (see also *Fig. 9.31*)

the vehicle and serious injuries to the occupants (*Fig. 8.20*). Utility poles can be modified to minimize the damage to a car which hits one (Ref. 15). One accident in this series, 0430, was partly due to an irregularity in the road alignment resulting in a line of utility poles being in the path of approaching traffic (*Fig. 8.21*). More effective street lighting and/or clearly visible markings on the poles may reduce the risk of collisions such as this one.

⊗ Case 0430

An M.G. Magnette saloon struck a utility pole with the front left corner (*Fig. 8.22*). Both occupants were affected by alcohol. The driver, a male aged 19 years, sustained concussion, lacerations to the bridge of his nose from the windscreen, an abrasion over his sternum from the steering wheel, and a deep laceration over his right knee and bruising of his left knee (instrument panel). The left front seat passenger, a male aged 26 years, sustained concussion and a deep laceration involving his left eyebrow and left forehead (from the windscreen). He also had a laceration to the left corner of his mouth, a bruise across his chest and left shoulder, and abrasions to both knees (instrument panel).

SINGLE CAR ROLLOVERS

8.25 Twelve cars rolled over without having been involved in an earlier collision. There are several factors which are worthy of special mention in these 12 accidents.

8.26 Speeds were much higher than the average speeds for all cars in our survey. The average travelling speed for this group was 35 to 40 m.p.h. The average speed on rollover was slightly less, about 35 m.p.h.

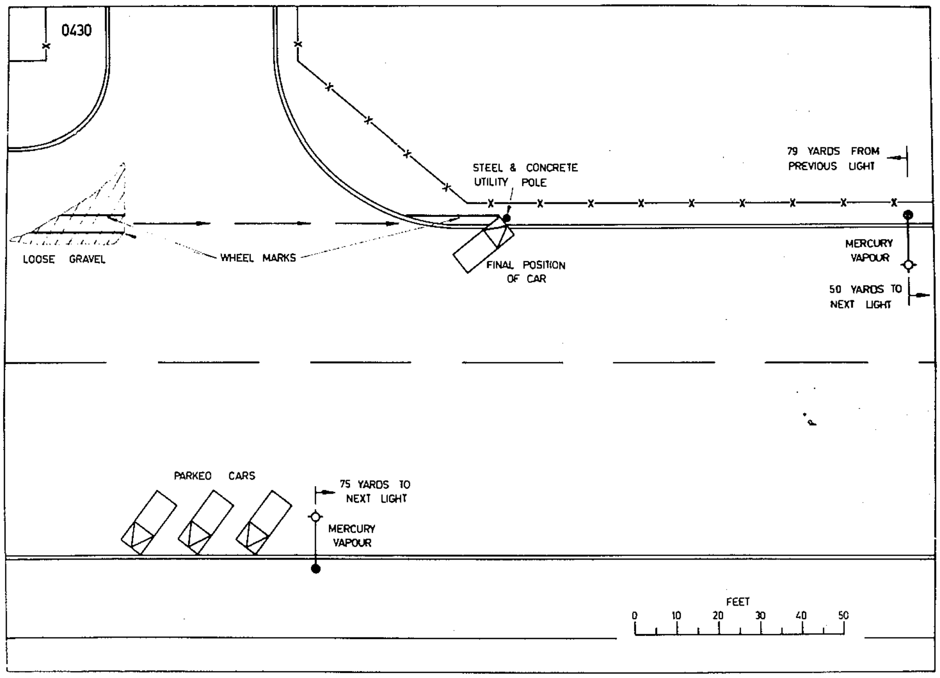


Fig. 8.21—*Case 0430*

Fig. 8.22—1954 M.G. Magnette after colliding with the utility pole shown (see also *Fig. 9.29, 11.7* and *11.17)*

Fig. 8.23—This Skoda rolled over after swerving from one side to the other on a straight road

(the corresponding figures for all cars in our survey are 27 m.p.h. and 21 m.p.h.).

8.27 Nine of these 12 drivers were under 25 years of age. The other three drivers were aged 33, 48 and 79 years. The younger drivers had an average of three years' driving experience, varying from as little as four months up to nine years.

8.28 The effect of age and inexperience is very marked in this type of accident. While recognizing that the number of cases here are very few, the young (under 25) driver is involved in three quarters of these accidents. Compare this with the age grouping of all car drivers who were involved in accidents covered by our survey, in which one third were under 25. This result is not unexpected if we accept that youth and inexperience can

Fig. 8.24—Police, ambulance and tow truck operators working to release the driver trapped in the vehicle shown in *Fig. 8.25* and *8.26*

produce a potentially dangerous combination of poor driving skill and underdeveloped awareness of road hazards.

8.29 The role of alcohol is also particularly marked because it has similar effects, in that it reduces the levels of skill and awareness in a driver, often with tragic consequences (*Fig. 11.1*). Four of the 12 drivers involved in the accident shown in *Fig. 11.1* had obviously been drinking not long before the accident occurred.

8.30 Nine drivers were alone in their cars. One car had one passenger, another had three and the remaining car had four passengers.

8.31 The vehicles are notable on two counts. First, half of these cars were manufactured before 1955. This may simply be a reflection of the age of the driver, i.e. young drivers may drive older and therefore cheaper cars. The other point, and one which is directly related to vehicle design, is that five of these 12 cars had independent rear suspension of the swing-axle type. These cars were two Volkswagen 1200 sedans, two Skoda sedans (*Fig. 8.23*), and one Renault Dauphine (*Fig. 10.6*). The drivers of these cars had mostly been driving for more than five years. One driver in fact claimed 45 years' driving experience.

8.32 The condition of the tyres on these cars was generally good. However, because all these accidents occurred on dry roads, the condition of the tyre tread would not have been very significant. Tyre pressures were measured in six of these cases. Two cars were found to have low pressures which would have reduced the stability of vehicles

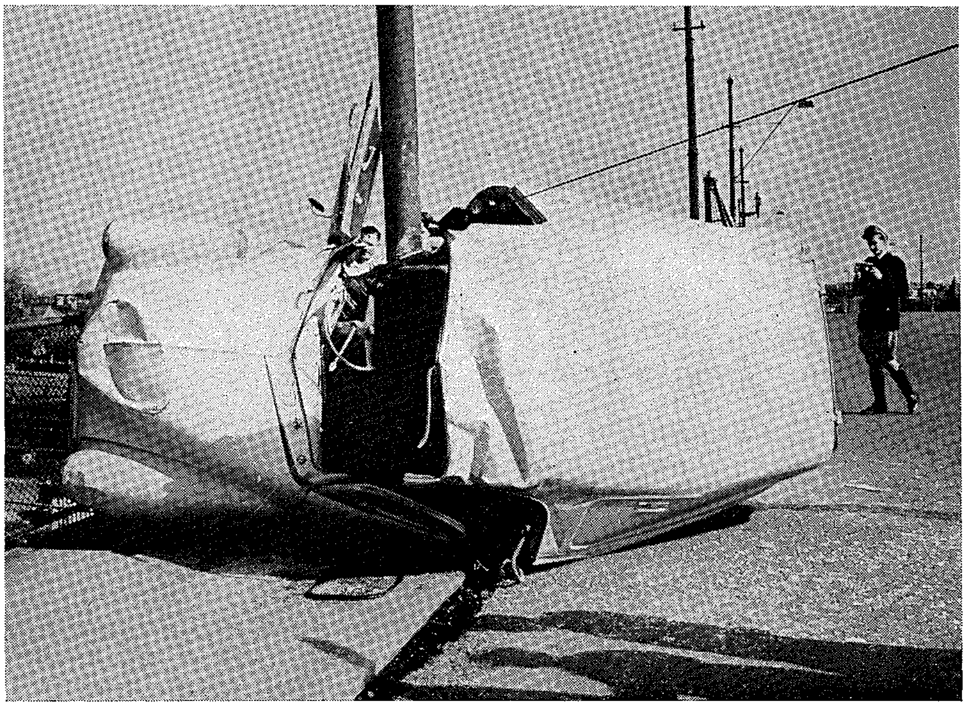


Fig. 8.25—This 1955 FJ Holden panel van rolled over and struck a steel utility pole. The front corner posts and the steering wheel were cut to extricate the driver from the damaged car

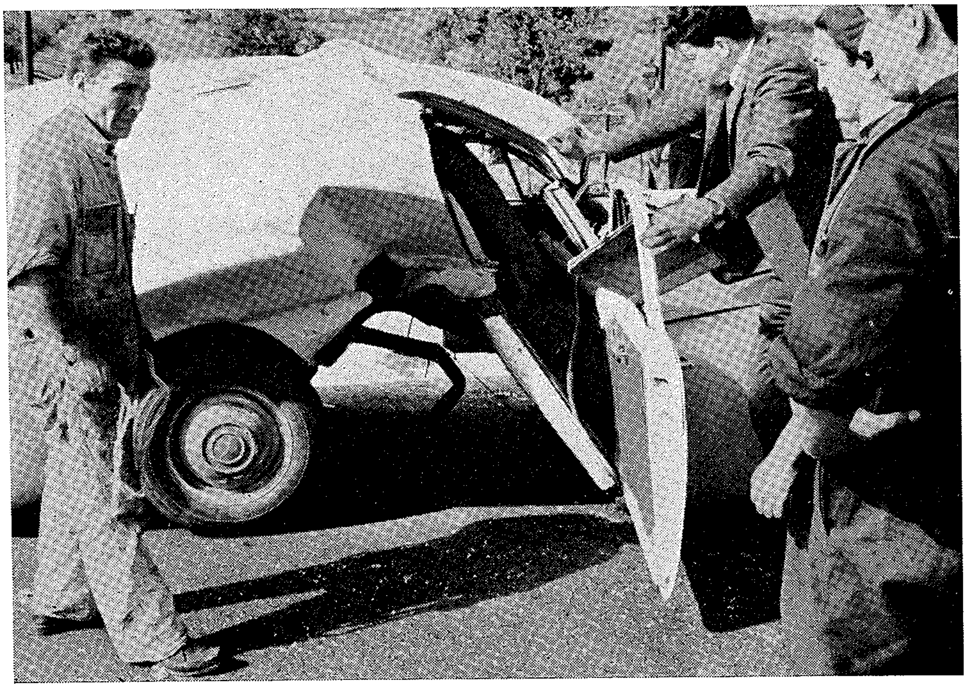


Fig. 8.26—The Holden panel van shown in *Fig. 8.25*

to a marked degree in one case (0314) (*Fig. 8.24, 8.25* and *8.26*).

● **Case 0314**

A 1955 FJ Holden panel van approached a bridge on a gradual left curve at a speed which may have been in the range 40 to 50 m.p.h. A slight bump in the road surface caused the vehicle to slew to the left. The driver was unable to bring the car back to the straight ahead position and it rolled over to the right. It continued to roll until it hit a steel utility pole with the underbody of the car. The deformation of the car at this point was 24 in. The driver, an 18-year old girl, was trapped by the legs between the undersurface of the instrument panel and the bottom of the seat. She was not released from the car until the front corner posts had been sawn through, the steering wheel cut away, and the door and instrument panel forced apart using portable hydraulic jacks. She suffered concussion, a minor fracture of one vertebra of the neck, and bruises and abrasions to both thighs.

The right rear tyre had a pressure of 10 p.s.i. The left rear was 20, the right front 24 and the left front 25 p.s.i. The low pressure in the right rear tyre may have been one of the main factors which resulted in this vehicle's rolling over. This was a commercial vehicle and it seems that this was one accident in which neglected maintenance cost a firm a vehicle and also injured an employee.

8.33 Apart from one car which ran off a track and rolled down a steep hillside, all these cars rolled over on dry bitumen roads. Rolling over when attempting to take a bend accounted for five accidents. Four cars rolled over when turning too quickly at intersections, two of them when swerving to avoid a second vehicle approaching from the right. The remaining two cases occurred almost inexplicably when the case car was overtaking another vehicle on a straight road.

MAKES AND MODELS OF CARS

9.1 Reference to the data code 2 in Appendix D will show the makes and models of cars which appeared in our survey. We have regrouped these according to the manufacturer of each car. This information is presented in *Fig. 9.1*. It can be seen that cars produced by General Motors Corporation account for nearly one half of all cars in the accidents in this survey. This is obviously a very much higher proportion than that of any other manufacturer. British Motor Corporation and the Ford Motor Company, with 16 per cent and 17 per cent respectively of the total, are the next largest groups.

9.2 Throughout this report we have tried to point out the very close relationship that exists between features of car design and the injuries that are received by both car occupants and other road users, e.g. pedestrians. We have, in some cases, pointed out features that do at present cause injury. If these features were to be changed, how would we estimate the possible reduction in the frequency of the related type of injury, as far as the whole population of road users is concerned?

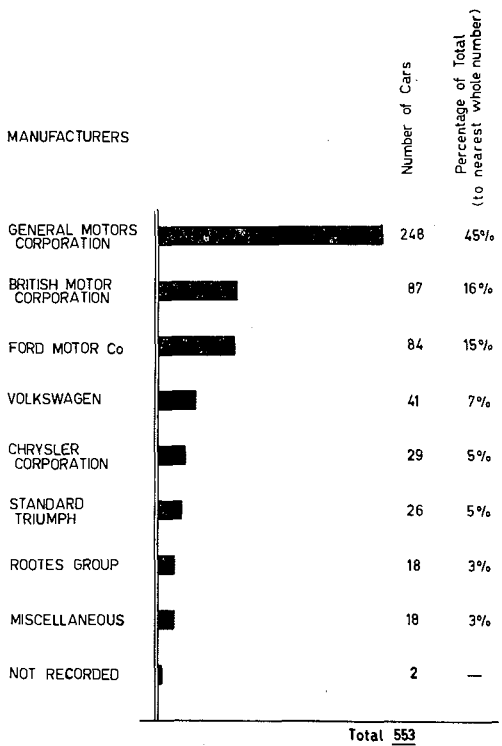


Fig. 9.1—Manufacturers of passengers cars

9.3 It is tempting to say that the effect would be proportional to the number of such models that have been changed compared to the total number of cars. But the measure that we are really seeking is the number of such models that are likely to be involved in accidents, for it is only in an accident that people are injured.

9.4 In TABLE 9.1 we relate the number of Holden cars (including station sedans, panel vans and utilities) in our survey to the number in the Adelaide metropolitan area in 1962. (Holden cars account for 84 per cent of all General Motors cars in our survey.) We also do this for all Ford and Volkswagen car-type vehicles. The Volkswagen 1200 is the only model from this manufacturer in our survey. There are, of course, many models which we have grouped together under 'Ford'. The figures listed for the metropolitan area are based on the Commonwealth Bureau of Census and Statistics Census of Motor Vehicles (1962). The χ^2 test shows that the distribution shown in TABLE 9.1 is most unlikely to be due to chance.

9.5 The meaning of TABLE 9.1 is easier to grasp if we present it in the form of percentages. These percentages are based on the total number of cars in our survey and in the metropolitan area, not merely on the total numbers of the three makes listed here. (See TABLE 9.2.) Holdens appear in the accidents covered by our survey slightly less frequently than they appear in the whole population of vehicles in Adelaide. Fords do not

TABLE 9.1

CARS IN SURVEY RELATED TO NUMBER IN ADELAIDE METROPOLITAN AREA, 1962

Make of Car	Number of Cars	
	TARU survey	Adelaide metropolitan area
Holden	213	53,718
Ford	77	24,588
Volkswagen	41	6,582

$\chi^2 = 15.2$***

appear as frequently as their percentage of the total number of cars suggests that they should. Volkswagens however seem to be involved in more accidents than their numbers suggest they should be.

9.6 We can see from these percentages that because the Holden is such a popular car its 'crashworthiness' is the factor which largely determines the nature of the injuries received by road users in one third of all the cars that are involved in accidents. Even slight improvements in the design of the Holden, such as the new door locks fitted to the HD model, will eventually affect about one third of all car occupants who are involved in an accident. We say 'eventually' because, of all the Holdens on our roads, only a small number are the latest HD model with the new door lock. As time passes however, the HD and subsequent models will become a larger proportion of the total number of Holdens in use in Adelaide. We are assuming (for the purpose of this discussion), that the Holden's percentage of the market remains substantially unchanged.

9.7 A change in the design of the Volkswagen, such as improved door locks or steering column, would potentially be much more effective than the proportion of Volkswagens on our roads would indicate. This is because these design changes will only be important when the car is involved in an accident. Before we are assailed by both the manufacturer and a horde of satisfied Volkswagen owners we must emphasize that we are only concerned here with showing that, for whatever reason or reasons, some makes and models are more likely to be involved in accidents than others. This may not necessarily be a reflection on the roadworthiness of that particular model of car. It may be that one particular type of driver, e.g. a young driver, favours that model, and the consequent accident involvement is more a reflection of the type of driver than of the characteristics of the car.

9.8 Whatever the reasons may be, the frequency with which a particular model of car is involved in accidents is the measure on which we must base any attempt to predict the potential reduction in death and injury which might follow a change to the design of that model. Similarly, those models which form the bulk of the cars which are involved

TABLE 9.2

CARS IN SURVEY RELATED TO PERCENTAGE OF CAR POPULATION

Make of Car	Percentage of All Cars	
	TARU survey	Adelaide metropolitan area
Holden	38.5%	39.6%
Ford	13.9%	18.1%
Volkswagen	7.4%	4.9%

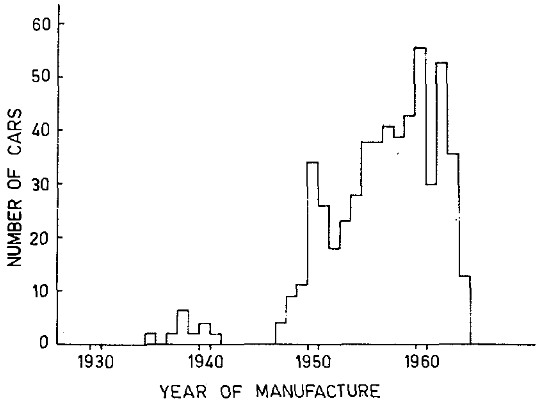


Fig. 9.2 — Year of manufacture of passenger cars

in accidents on our roads are those which we should look at with the most critical eye, for even very slight improvements in the 'crashworthiness' of these cars would mean a significant reduction in the frequency of injuries to road users.

YEAR OF MANUFACTURE

9.9 The year of manufacture of the cars that were involved in the accidents we attended is shown in *Fig. 9.2*. It can be seen that cars more than 20 years old account for only a very small proportion of the total. The peak is in the years 1960 to 1962, then falls to 1963 and 1964 because these were the two years in which we were attending accidents. Obviously we did not see any 1964 models in 1963.

9.10 The marked fall in the number of cars for the year 1961 is not because cars made that year were much safer than those made in the adjacent years. 1961 was a time of temporary economic recession in Australia and this may have affected the number of new cars registered that year. The annual increase in the total number of cars registered in South Australia did not change markedly from the increase in 1960 but


Fig. 9.3 — Two-car collision

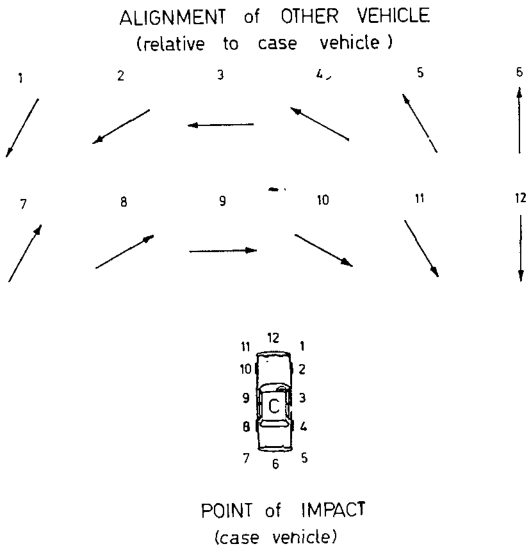


Fig. 9.4 — **Diagram of numerical code used to describe two car-collisions**

there may have been more older cars retained in use in 1961 than in 1960.

COLLISIONS BETWEEN CARS

9.11 Over one third (148 of 408) of the accidents covered by our survey were primarily collisions between two cars (*Fig. 9.3*). We say 'primarily' because in some of these accidents one of the cars was involved in a subsequent collision with another vehicle or with a fixed object. But the initial impact in all these cases was with another car.

9.12 To facilitate the description of these collisions between two cars we have developed a simple numerical code. We also refer to the particular car that we are considering as the 'case car'—marked with a C in *Fig. 9.4*. The alignment of the other car to the case car is described by allocating it to one of 12 positions which are set at 30 deg. intervals to the longitudinal axis of the case car, as shown in *Fig. 9.4*. The point of impact on the case car is described according to the following classification.

Right front corner	1
Right front wheel	2
Right side between wheels	3
Right rear wheel	4
Right rear corner	5
Centre rear	6
Left rear corner	7
Left rear wheel	8
Left side between wheels	9
Left front wheel	10
Left front corner	11
Centre front	12

Any impact with a second car can now be described by two sets of figures, the first set indicating the alignment of the other vehicle, the second set indicating the point of impact on the case vehicle. Some examples

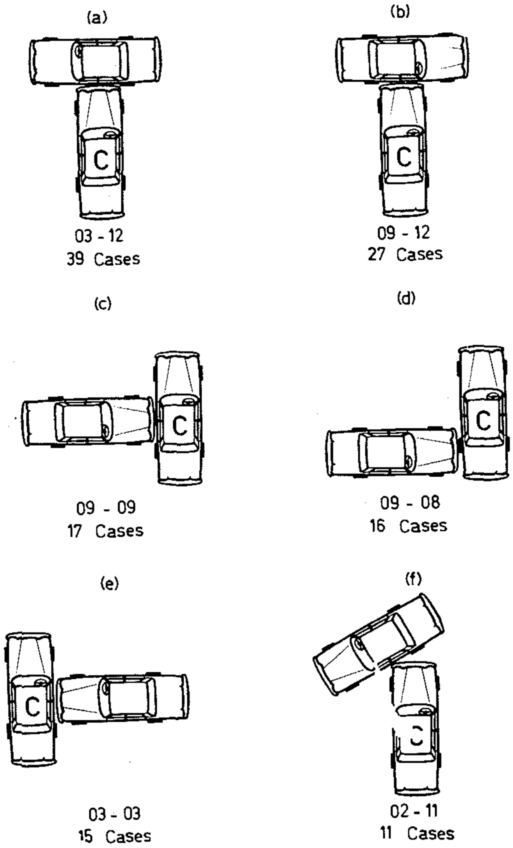


Fig. 9.5 — **Most frequent types of impact**

are given in *Fig. 9.5*. Remember that the first numbers refer to the alignment of the other car and the second numbers to the point of impact on the case car.

9.13 There are two warnings that we should make regarding the use of this convention. While these two numbers describe the alignment of the cars to each other and the point of impact on the case car, they do not necessarily give the point of impact on the other car. For example *Fig. 9.5* (*a*) could be drawn with the point of impact anywhere along the left side of the other car. The impact geometry would still be 03-12 for the case car. To describe the impact geometry completely in this case we would also have to give the point of impact on the other car, viz. point 09.

9.14 The second point which may be overlooked is that these numbers and the diagrams give only the impact geometry. They do not necessarily give the direction of the impact. With two cars the true direction of impact is along the line of their velocity relative to each other. Should the case car be stationary, the direction of impact is the same as the direction in which the other car is moving. Should the other car be stationary, the direction of impact is along the path of the case car. More commonly both cars are moving. If in *Fig. 9.5* (*a*) the case car is travelling at 20 m.p.h.

Point of Impact

Alignment of Other Car	1	2	3	4	5	6	7	8	9	10	11	12
1	2										3	
2	4	4	2								11	4
3	6	6	15	6							1	39
4	5	2	2		2						2	
5	4	1	1		1							1
6			1		5	12			1		4	13
7							1	2	1		3	1
8						2		2	2	1	6	
9							1	16	17	8	4	27
10	5							1	9	2	7	1
11									2	1		2
12	6											6

NUMBER OF CARS IN EACH CATEGORY

Fig. 9.6 — Impact geometry for two-car collisions

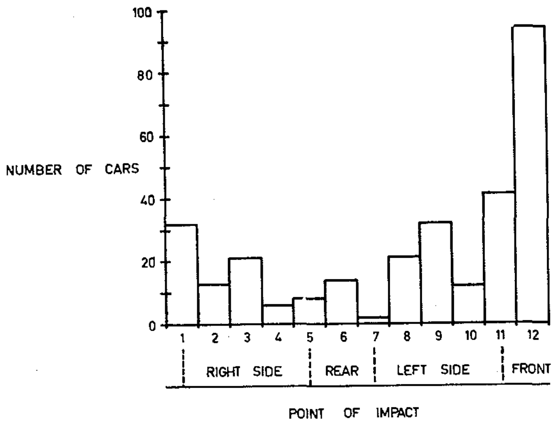


Fig. 9.7 — Points of impact in two-car collisions

and the other car at 34 m.p.h. then the direction of impact on the case car would be 02, and on the other car, 10.

9.15 This convention, which allows for 12 possible angles between the cars and 12 possible points of impact on the case car, gives us 144 different combinations. Some of these are unlikely, such as two cars reversing into each other (12-06). We therefore find that when we allocate each of the 296 cars in these 148 accidents to one or other of these 144 categories we use only 56 squares on *Fig. 9.6*. If we consider only those squares in which five or more cases are listed, we find that we reduce the number to 20 squares. These 20 squares contain 225 of the 296 individual cases. This is a rather roundabout way of saying that some types of impact occur more often than others.

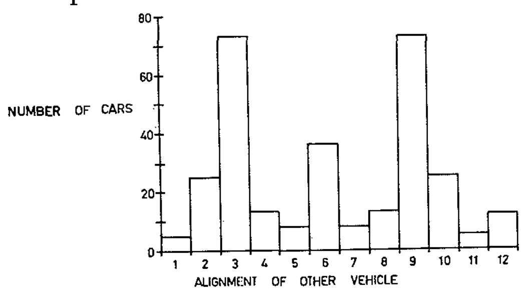


Fig. 9.8 — Alignments of other vehicles in two-car collisions

9.16 The totals for each row and column of *Fig. 9.6* are shown in the histograms of *Fig. 9.7* and *9.8*. The most frequent point of impact is on the centre of the front of the case car (point 12). The left rear corner of the case car receives the fewest impacts (point 7). The other vehicle is most likely to be aligned at right angles to the case car—alignments 3 and 9 of *Fig. 9.8*. There are comparatively few cases in which the other car is pointing in the opposite direction to the case car (alignment 12).

9.17 The six most frequent types of impact are shown in *Fig. 9.5*. The two most likely types of collision for a car are for it to strike, head on, the side of another car. The diagrams illustrating these two impacts, *Fig. 9.5 (a)* and *(b)*, show the case car striking the passenger compartment of the second car. While the actual point of impact can be anywhere along the side of the struck car, in fact almost all the impacts are in the region of the passenger compartment of the struck car. There are no such impacts on the right rear corner, point 5, and only one on the left rear, point 7. The next most common types of impact are those in which another car strikes the side of the case car. Remember that we are considering individual cars at the moment, not accidents. It is obvious that *Fig. 9.5 (c), (d)* and *(e)* are particular types of the accidents shown in *Fig. 9.5 (a)* and *(b)*. The impacts on the case car are very different however. In *(a)* and *(b)* it is a frontal impact. In *(c) (d)* and *(e)* it is a side impact at a particular point along the side of the car. Impact type *(f)* arises mainly from the other car turning across the path of the case car. As with cases *(a)* and *(b)* it is essentially a frontal impact for the case car.

9.18 Each of these six most frequent impact types are almost all intersection accidents. This is understandable in any metropolitan area, and particularly in Adelaide which consists almost entirely of a 'grid' of streets intersecting at right angles. Whatever

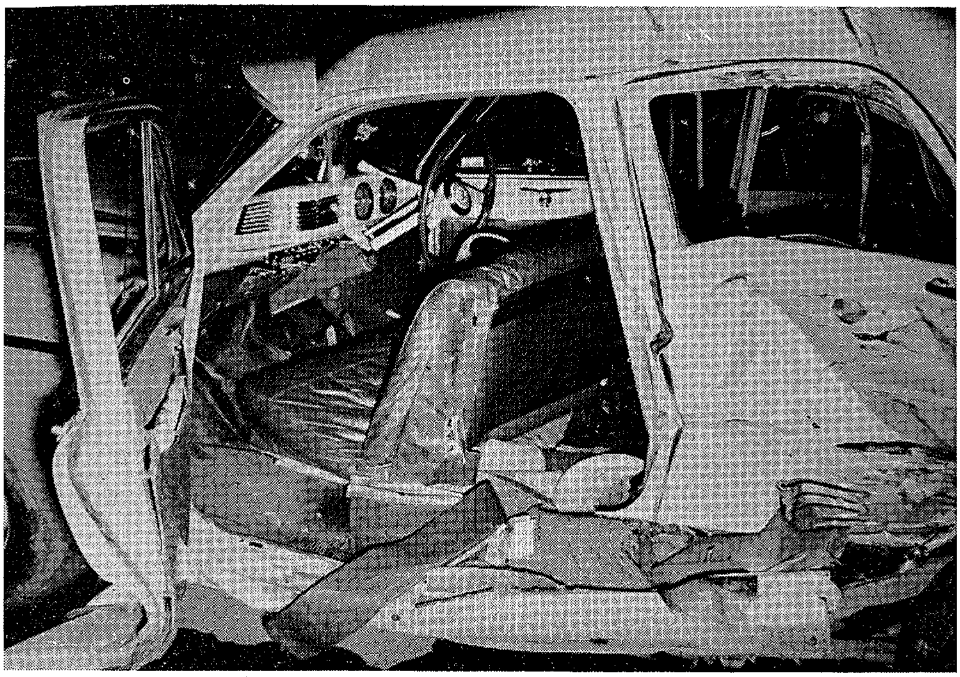


Fig. 9.9 — Impact on the side of the passenger compartment of a 1954 Vauxhall Wyvern

the reason, the fact remains that many of these impacts are on the side of the case car, including the sides of the passenger compartment. This has particular significance for both vehicle designers and for traffic engineers.

9.19 The sides and top of the passenger compartment are probably the most vulnerable parts of the structure of a car, as far as deformation of the passenger compartment is concerned (*Fig. 9.9*). The ends of the compartment are protected by the front and rear sections of the car, which will in many cases crumple on impact, leaving the passenger compartment relatively undamaged. A similar protective section at the sides is not possible with the conventional layout of the passenger car. The alternative is for the sides of the compartment to be made strong enough to withstand collision forces. If the door locks and hinges are designed to retain the doors in place as structural members in the event of a direct impact (Ref. 23), then this may be possible without very great changes in existing layouts.

9.20 The sides of the interior of the passenger compartment, which are generally the doors, could easily be made safer on many cars. It is not uncommon for the 'special' models of some cars to be fitted with arm rests on the doors, and the 'standard 'models to lack such conveniences. Unfortunately the people who choose the 'special' expose themselves to the risk of serious internal injuries if they are thrown against the arm rest on the door, as happens when a car is hit from the side. The driver who was thrown against the door shown in *Fig. 9.36* was lucky in this respect, for he was in a 'standard' model which had no arm rest.

9.21 At many locations it is possible for the traffic engineer to control the angles at which vehicles approach each other. One

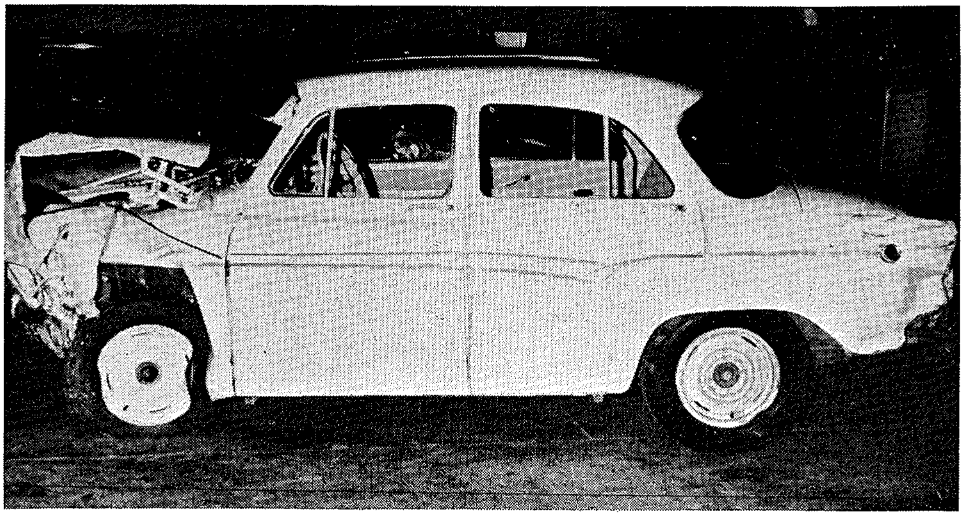


Fig. 9.10 — The damage to the rear of this Simca was caused by the initial collision with another car. The frontal damage resulted from a subsequent collision with the side of a hotel

way in which this is done is by the installation of suitably designed traffic islands. It is of course generally recognized that a rear end collision is likely to have less serious consequences than a head on collision under similar circumstances. But what of impacts on the sides of cars? We have noted that the side of the passenger compartment is a particularly vulnerable part of the structure of a car. Could it be that side-on impacts tend

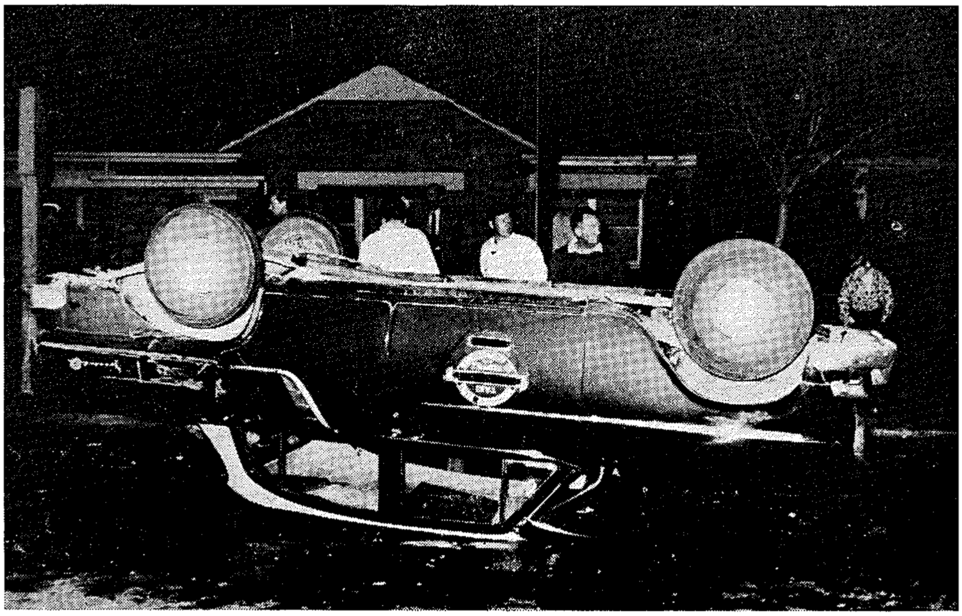


Fig. 9.11—This FC Holden taxi rolled over after being struck on the left side, behind the rear wheel, by the Holden shown in *Fig. 9.12*

to be as severe as those in which the cars hit head-on?

9.22 We have considered the relationship between the impact geometry and both the severity of injury to the occupants and the degree of damage to the car. For this first analysis we excluded those cars which were involved in subsequent collisions of a severity comparable to or greater than the initial collision. There is an argument in favour of including these cases because the risk of a subsequent collision may be related to the point and direction of the initial impact (*Fig. 9.10*). For this reason we did not exclude cars which rolled over after the initial impact (*Fig. 9.11* and *9.12*). We have found, on further investigation (see para. 9.28), that there is almost equal justification for retaining all cases involving a subsequent collision.

9.23 After excluding the cases mentioned above we calculated the average vehicle damage in each impact category. This was done by averaging the damage to each of the front, centre and rear sections, and then calculating the average overall damage from these three section damage averages. *Fig. 9.13* shows the variation of this average of overall vehicle damage with the geometry of the impact. The coding used is:

minor damage	2
moderate damage	3
severe damage	4

There is no category in which the average damage is extremely severe, nor is there any marked variation in the degree of vehicle damage between impact categories. An analysis of variance shows that there is in fact more variation in the degree of vehicle

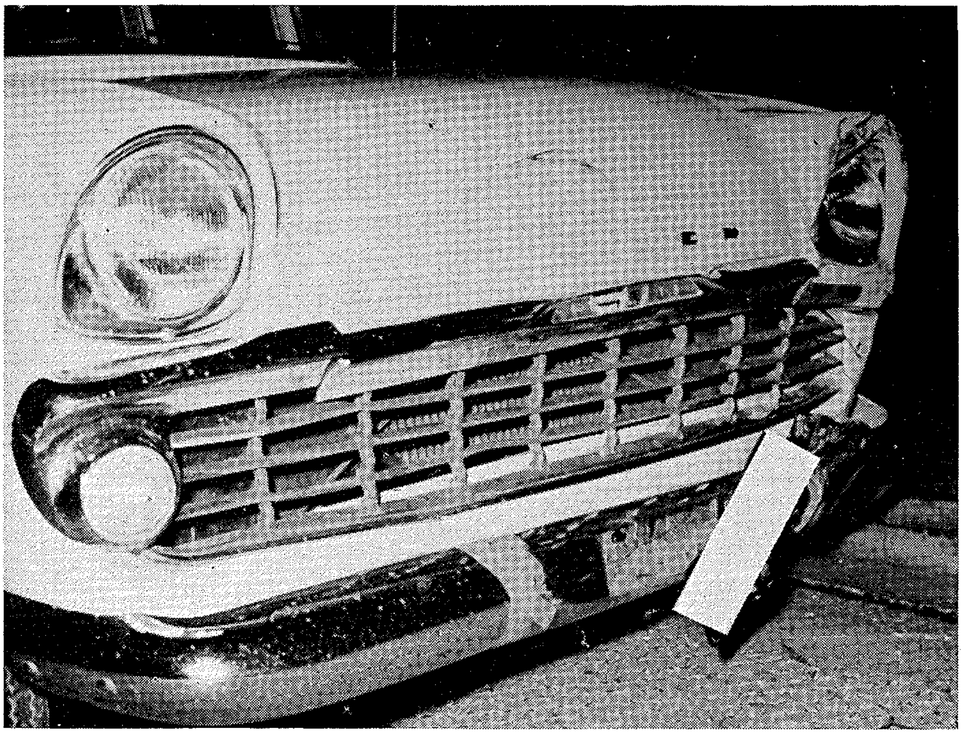


Fig. 9.12—Note the relatively small amount of damage to this car. The struck car (see *Fig. 9.11*) was spun anti-clockwise by the impact and rolled over

Point of Impact

Alignment of Other Car	1	2	3	4	5	6	7	8	9	10	11	12
1	4										3	
2	3	3	3								4	3
3	3	4	4	3							3	3
4	3	3	3		4						3	
5	3	3	3									2
6			2		3	4			3		4	3
7								3	4		3	3
8						3		3	3		3	
9								3	3	3	2	3
10	3							3	4	3	3	3
11									3	3		3
12	3											4

AVERAGE VEHICLE DAMAGE IN EACH CATEGORY

Fig. 9.13—Impact geometry and vehicle damage for two-car collisions

damage within impact categories than between categories. These variations within categories, i.e. differences in the degree of vehicle damage for the same type of impact, can obviously arise from differences in impact speeds and weights of vehicles. Furthermore the significance of each of these average damage ratings depends on the number of cases in each category. A guide to the number of cases is given in *Fig. 9.6*. This is only a guide because those cases which were excluded from the vehicle damage calculation have not been removed from this table. This has had a marked effect on the totals in only a few categories, such as square 03-03 where the number of cases has been reduced from 15 to 10 and square 06-05, from 5 to 2.

9.24 With the result obtained from this analysis, namely that there is some variation in the degree of vehicle damage which is related to the impact geometry, but not to a significant degree in the cases presented, we then related injury severity to impact geometry. The procedure here was very similar. Once again some cases were excluded. For example a parked car with no one in it is unlikely to tell us much about the risk of injury to car occupants. These exclusions were spread more evenly through the categories than was the case in the vehicle damage analysis. The most marked changes were in category 06-05 which had three cases removed, and 12-01, two cases. In an attempt to find a relationship that could be shown to

Point of Impact

Alignment of Other Car	1	2	3	4	5	6	7	8	9	10	11	12	
1	3										1·7		
2	1·4	1·8	3·3								1·9	1·6	
3	2	2·2	2·3	1·8							1·3	1·6	
4	1·5	1	2·5		2						2		
5	1·1	1·3	1									1	
6			1·5		1·8	1·4			1·5		1·9	2·2	
7								1·8	1		1·4	1·5	
8								1·8	2		1·5		
9								2·3	2·2	2·1	1·5	1·7	
10	1·5							2·4	1·9	2	1·8	2	
11									1	2		3	
12	2·3											3·3	

AVERAGE INJURY SEVERITY IN EACH CATEGORY

Fig. 9.14—Impact geometry and injury severity for two-car collisions

be significant we took our injury ratings to two figures, as shown in *Fig. 9.14*. The coding used in *Fig. 9.14* is:

no injury	1
minor injury	2
moderate injury	3
severe injury	4

The squares showing a rating of 1.3 or less all have only one or two cases and are therefore of doubtful significance. This also applies to some other squares (see *Fig. 9.6*). An analysis of variance showed that there was a significantly greater variation in injury severity within categories than between categories.

9.25 In addition to the above mentioned uncontrolled variables of impact speeds and vehicle weights, we have further complicating factors as far as the severity of injury is concerned, such as age, sex and seated position for each occupant. We have tried to minimize the effect of the number of occupants in a car by taking an average injury severity for each car and calculating the category average on this basis. This means that we have worked on an average injury rating for each car, not the rating for each individual. Otherwise a fully laden car would exert a disproportionate influence on the category average over a car having only one occupant.

9.26 We then reduced the number of impact categories to four, viz. frontal, right side, rear, left side. This meant, of course, that we increased the number of cases in each category but we also increased the variation in the type of impact within each category. These two effects seem to have largely balanced each other. The variation of injury severity within each group is less pronounced but is still larger than the variation between groups. In the case of the vehicle damage analysis, reducing the number of impact categories to four had virtually no effect on the variations both within and between categories.

9.27 It therefore appears that the effects of the uncontrolled variables must be reduced before useful results can be obtained. This will require particular care to ensure that the final analysis is performed on a body of data which is not so closely controlled, as it is no longer to be representative of the wide range of collisions between cars in traffic today.

Subsequent collisions and initial point of impact

9.28 To test for any relationship between the initial impact points on the case car and the risk of the case car being involved in a subsequent collision, we have grouped impacts into front, rear, and side. The results are as shown:

Point of impact	*Subsequent collision*	
	Yes	No
Front	6	125
Side	27	117
Rear	10	11

$$\chi^2 = 30.3^{***}$$

This means that the risk of being involved in a subsequent collision is almost negligible in frontal impacts, about one chance in five for side impacts, and an even chance for impacts on the rear of the car. The χ^2 value shows that this distribution is almost certainly not due to chance.

Subsequent rollover and initial point of impact

9.29 Grouping impacts into front, rear and side gives the following results:

Point of impact	*Subsequent rollover*	
	Yes	No
Front	3	128
Side	33	111
Rear	0	21

Combining front and rear into one category and comparing this with side impacts we get a χ^2 value of 28.429***. Once again this shows that the above distribution is not due to chance. Impacts on the side of the car are much more likely to cause it to roll over than front or rear-end impacts.

9.30 In neither of these two tests have we allowed for the alignment of the other vehicle, except when the impact was on one of the corners of the case car. We should mention in passing, however, that 20 of the 36 subsequent rollover cases were in three impact categories, viz. 03-03, 09-08 and 09-09.

DAMAGE TO THE INTERIOR OF THE CAR

9.31 It should be obvious that injuries to car occupants are almost invariably caused by contact with some part of the interior of the car. There are exceptions, of course, particularly the case of an occupant who is ejected from the car and who generally receives additional, often serious, injuries from striking the road. In the metropolitan traffic accident the great majority of car occupants remain inside the vehicle in an accident. We tried in each case to relate each injury to the part of the interior of the car which caused it. We also noted the damage to the interior of the car, and tried to determine whether this was a direct consequence of damage to the vehicle body or whether it was mainly due to the occupants being thrown around inside the car.

9.32 We present here our record of the incidence, and probable cause, of damage

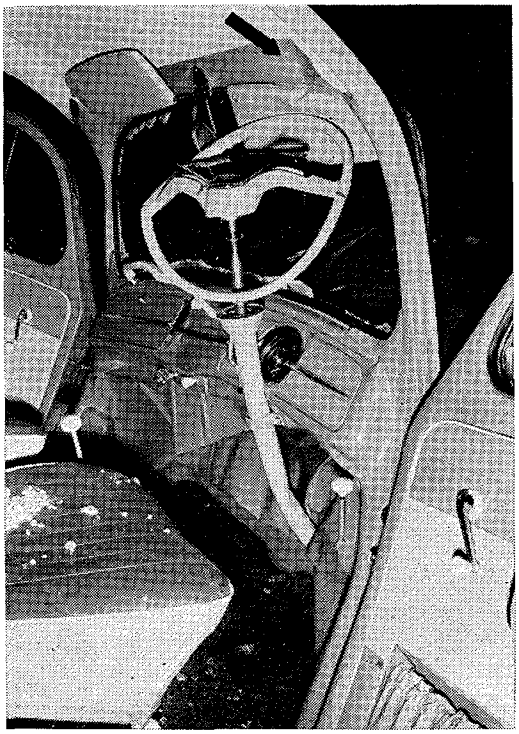


Fig. 9.15 — 1962 Volkswagen 1200 steering column forced back in a head-on collision with another car. Note also the dent in the header strip made by the driver's head, and the shoe trapped by the pedals

to four components: the steering wheel, the instrument panel, the rear vision mirror, and the front seat. Reference to code 2 (Appendix D) will show the categories we used in recording this information (columns 60, 61, 62 and 65).

9.33 Of the 553 cars in our survey there were 20 which were parked and had no occupants. A further 143 cars were excluded because they struck pedestrians, pedal cycles, or motor-cycles. In these accidents little or no damage is caused to the interior of the passenger compartment. This left a total of 390 cars.

Steering wheel

9.34 One hundred and twelve of the 390 cars we are considering (28.7 per cent) had the steering wheel damaged by an occupant, usually (but not always) the driver being thrown against it. In 62 cases the wheel was only slightly bent or cracked, but in 50 cases it was severely damaged. The spokes of the wheel sometimes failed, allowing the occupant to strike the far more solid hub of the wheel (*Fig. 9.15* and *9.16*). This impact with the hub can be reduced in severity or even avoided altogether by recessing the hub of the wheel. Such a design is often termed a 'dished' wheel. A case in which a wheel of this type has deflected the driver away from the hub is shown in *Fig. 9.17*. This particular wheel—the car is a 1957 model Ford Customline—has three spokes. This seems to be more effective than a wheel having only two spokes, e.g. *Fig. 9.15* and *9.16*, whether such a wheel is dished or not. It is surprising therefore that the latest models of Ford cars are fitted with a two-spoke wheel.

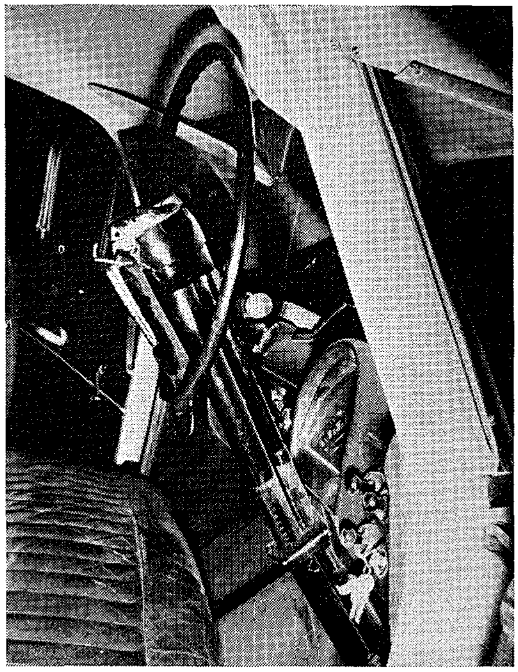


Fig. 9.16 — 1953 Ford Customline two-spoke steering wheel damaged by the driver being thrown against it. The collision, with a tree, has forced the steering column back 4 in.

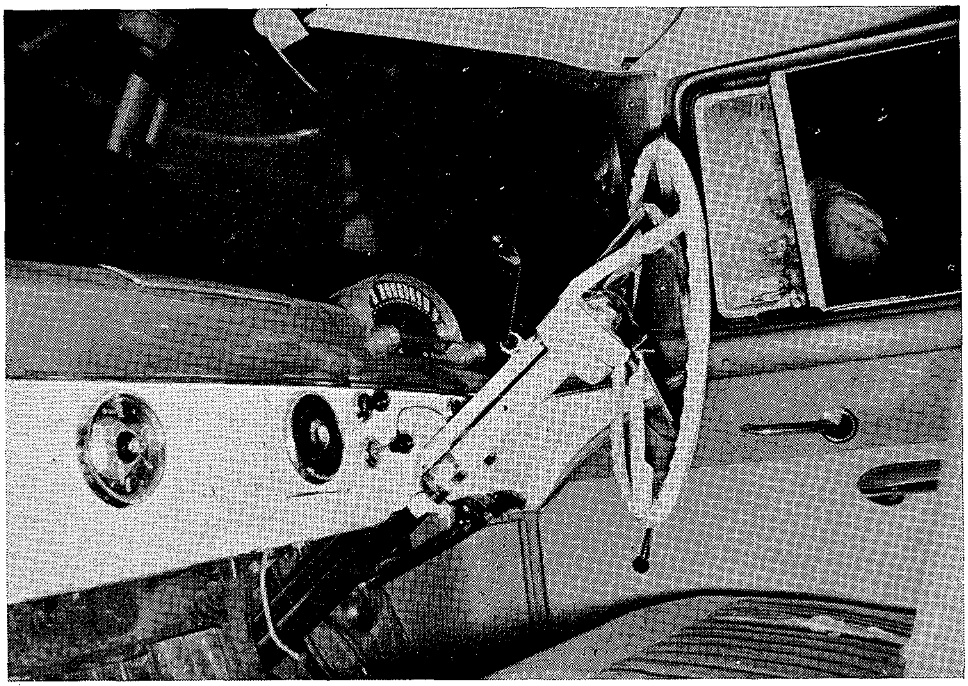


Fig. 9.17 — Three-spoke 'dished' wheel of a 1957 Ford Customline, damaged by the driver being thrown against it in a head-on collision with another car

9.35 We now compare the damage to steering wheels of both Holdens and Volkswagens (see TABLE 9.3). These two makes are chosen because they appeared frequently in the accidents covered by our survey and also because the design and arrangement of the interiors of these two makes of cars are different. The Holden has been considered in three model groups, first the early models up to and including the FJ series, then the FE, FC, FB and EK models, and finally the EJ and EH models. This table suggests that the steering wheel of a Volkswagen is more likely to be damaged by the occupant being thrown against it than is the case for any model of the Holden. The damage to the wheel is unlikely to be severe however. This may be because the wheel is close to the instrument panel and the occupant will be restrained by hitting the panel and the windscreen area as well as the steering wheel.

TABLE 9.3

COMPARISON OF DAMAGE TO STEERING WHEEL

Make and Model of Car	Damage to Steering Wheel (by Occupant Contact)			
	Minor	Severe	Total cars involved	Percentage damaged
Holden (FX, FJ)	3	4	39	35.2%
Holden (FE to EK)	17	15	91	18.0%
Holden (EJ, EH)	4	1	21	23.8%
Volkswagen 1200	11	2	31	42.0%
	35	22		

9.36 Note that it is not necessarily a good thing that the wheel should be only slightly damaged. If the driver is thrown against a wheel which bends easily he is less likely to be injured than he is if the wheel is very strong and rigid, unless he strikes the hub of the steering wheel.

9.37 In two of the 35 cases in TABLE 9.3, where the steering wheel received minor damage, two drivers sustained small abrasions to their lips from striking the upper rim of the steering wheel. In the other 33 cases we could not establish a definite relationship between the damage to the steering wheel and an injury, if any.

9.38 In the 22 cases of severe damage to the steering wheel there were 12 cases where no occupant injury could be related to the damage to the wheel. There were six cases of bruises to the chest, one laceration of a lip and two cases of fractured ribs. One case of severe facial lacerations and fractures occurred when the occupant struck the steering wheel hub. One of two cases of fractured ribs was in a Volkswagen; the other was in an FE model Holden. Therefore in this series of 57 cases the most severe injuries occurred when the occupant struck the hub of the steering wheel. All other contacts with the steering wheel produced little or no injury.

9.39 The illustrations to this section (*Fig. 9.15* and *9.16*) show that the steering column is sometimes pushed further back into the passenger compartment. (Note the mark on the column, shown in *Fig. 9.16,* adjacent to the mounting clamp on the instrument panel.) This is usually a consequence of an impact on the front of the car. There are some models which are not well designed in this regard. Of the cars we saw in these 408 accidents the one in which the steering column produced most severe injuries was the Volkswagen. This does not necessarily mean that the steering columns of some other models of cars are not also potentially injurious. We specify the Volkswagen because of the following case. The driver of the car shown in *Fig. 9.15* is now a quadraplegic as a result of the injuries he sustained in this accident. If the steering column of his car had not been forced back nearly 10 in., this driver might not have received such serious injuries. There is room for improvement in the design of this particular vehicle component.

9.40 Much of the trim, e.g., horn button or horn ring, on or around the steering wheel can aggravate injuries. We found some cases in which the horn ring had broken and the jagged end lacerated the driver's arm.

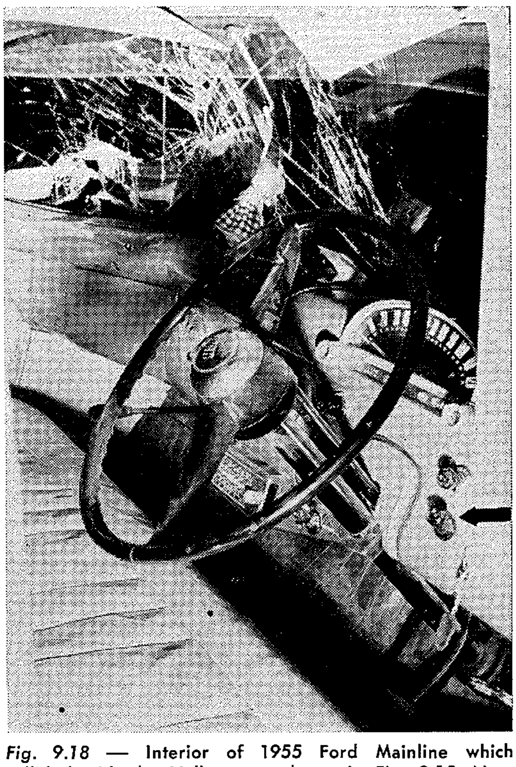


Fig. 9.18 — Interior of 1955 Ford Mainline which collided with the Volkswagen shown in *Fig. 9.15*. Note that the steering column has been forced back only half an inch. Arrow indicates control knob which fractured the driver's knee-cap

TABLE 9.4

COMPARISON OF DAMAGE TO INSTRUMENT PANEL

Model of Car	Damage to the Instrument Panel (by Occupant Contact)			
	Minor	Severe	Total number of cars	Per cent damaged to any damage
Holden FX, FJ	11	6	39	46.2%
Holden FE to EK	21	6	91	29.7%
Holden EJ, EH	6	0	21	23.9%
Volkswagen 1200	6	5	31	35.5%

Instrument panel

9.41 One hundred and thirty-six or 35 per cent of these 390 cars had the instrument panels damaged by the occupants being thrown against them. The panels of 100 cars received minor damage (bent knobs, etc.) and 36 were severely damaged (large dents). The bent control knob shown in *Fig. 9.18* is an example of minor damage. *Fig. 9.19* (Appendix B) illustrates severe damage to an instrument panel, and *Fig. 9.20* (Appendix B) the consequent injury.

9.42 We now compare the same three model groups of Holdens and the Volkswagen 1200, for the reasons stated earlier in this section (see TABLE 9.4). In the 44 cases of minor damage the injuries sustained were:

(a) 16 cases of superficial injuries to knees, shins and thighs,

b) 1 case where both knee caps were fractured on the lower edge of the instrument panel,

(c) 1 case where both lower legs were fractured on a home-made parcel shelf below the instrument panel.

In the 17 cases of severe damage there were:

(a) 2 cases where no injury could be related to the damage,

(b) 13 cases of superficial injuries,

(c) 2 fractures of the midshaft of the femur,

(d) 1 case of dislocation of the hip.

One of the cases of fracture of the femur and the dislocated hip occurred in the same car.

9.43 From this it appears that the majority of injuries caused by the instrument panel are minor, in accidents in the metropolitan area. These minor injuries could be minimized, and the more serious ones reduced in severity, if the instrument panel were designed to present a smooth, projection-free surface to the occupants, and to deform readily when struck.

9.44 A first step in the redesign of the instrument panel has been to add 'crash padding' in some cars. This has been shown to reduce the frequency of minor injuries caused by striking that particular part of the panel (Ref. 17). In some models it has not been located where the occupants most frequently hit the panel. In other cases the padding consists only of a thin layer of sponge rubber set over what feels to be a rigid metal section. Sponge rubber in this form may feel soft to the touch, but it can absorb only a negligible amount of the force of the impact of a person who is hurled against the panel. The most promising approach would seem to be to design the entire instrument panel area to crumple on impact, thereby minimizing the deceleration forces and the degree of injury sustained by the occupants.

Rear vision mirror

9.45 In 50 cases, or in 12.8 per cent of these 390 cars, an occupant hit the rear vision mirror. In nine cases there was no resultant damage to the mirror. In the other 41 cases the damage to the mirror varied from a bent standard to shattered glass and/

TABLE 9.5

COMPARISON OF DAMAGE TO REAR VISION MIRROR

Model of Car	Damage to the Rear Vision Mirror (by Occupant Contact)		
	Cases of damage	Total number of cars	Per cent damaged
Holden FX, FJ	3	39	7.7%
Holden FE to EK	3	91	3.3%
Holden EJ, EH	3	21	14.3%
Volkswagen 1200	7	31	22.5%

or a fractured standard which left a jagged end exposed.

9.46 When we compare the four groups of cars as before, we must note that here we are working with very few cases, there being only three cases for each of the groups of Holden models (see TABLE 9.5). We would suggest that the last two groups may have a higher rate of occupant contact with the rear vision mirror because the mirrors are closer to the occupants than they are in the models in the first two groups. However, a car having a driver and a passenger may be twice as likely to have an occupant hit the rear vision mirror as a car which has only one occupant, the driver. The average number of occupants in the front seats of all these 180 cars was close to 1.5 for the three groups of Holdens but was almost 1.8 for the Volkswagen. This variation alone is not sufficient to explain the higher rate of occupant contact with the rear vision mirror in the Volkswagen.

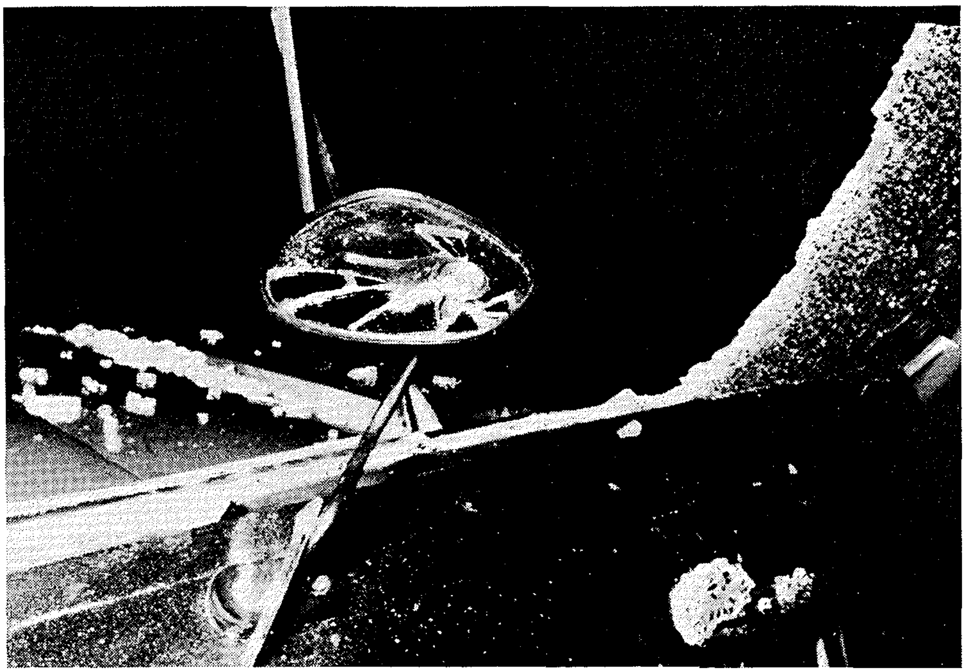


Fig. 9.21 — Rear vision mirror of a 1963 Renault R4, broken when struck by an occupant

TABLE 9.6

COMPARISON OF DAMAGE TO FRONT SEATS

Model of Car	Damage to Front Seat (Due to Inertia of Seat or Occupant Contact)		
	Cases of damage	Total number of cars	Per cent damaged
Holden FX, FJ	4	39	10.3%
Holden FE to EK	8	91	8.8%
Holden EJ, EH	2	21	9.5%
Volkswagen 1200	10	31	32.2%

9.47 The injuries in these 16 cases were mostly concussions and lacerations. The lacerations from the mirror itself were not very severe but they were around the forehead and eyes. Facial lacerations of any type may leave a permanent scar and possibly impair muscular control. This alone is sufficient to cause concern, without the additional hazard to a person's eyesight.

9.48 In one EJ model Holden the rear vision mirror standard fractured, leaving a jagged end still rigidly attached to the header area. This lacerated the driver's forehead. Attempts have been made to obviate this by mounting the mirror on a more flexible arm, but this does not prevent the mirror from breaking, e.g. *Fig. 9.21*. Mercedes Benz have designed the rear vision mirror to be readily knocked away from the mounting in the header area, complete with the mounting arm. Even this is only a partially effective solution. The effect on an occupant who hit this mirror at an (occupant) impact speed of, say, 20 m.p.h. would be no less than if this mirror and mounting arm assembly were thrown at the occupant's face at the same speed. The inertia of any assembly which is designed to be knocked away is very important.

9.49 The requirements for a safe rear vision mirror are therefore:

(a) glass which will not, when broken, expose sharp edges or small, sharp fragments;

(b) low inertia, both in regard to the mass of the mirror assembly and the force required to knock it aside.

9.50 We realize that these may be conflicting requirements, and that (b) in particular is limited by the need for vibration-free and sufficiently large mirrors. One means of achieving a reasonable field of view from a small mirror is to use a magnifying mirror, as is the case with some

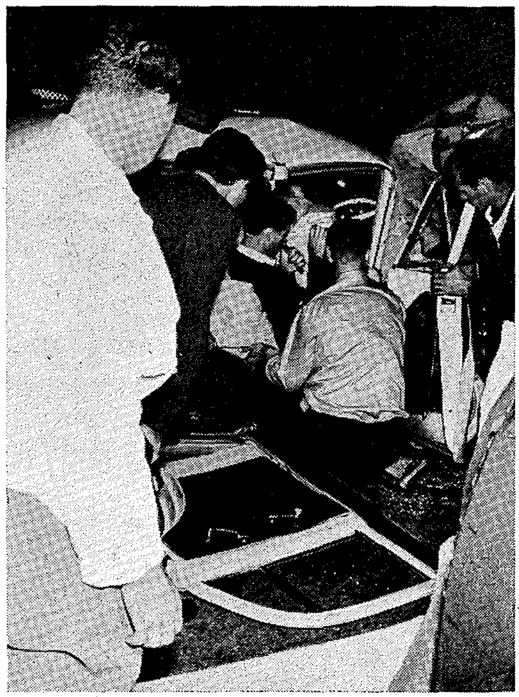


Fig. 9.22 — Driver trapped in an FX Holden by the front seat, which moved forward in the collision

Rover cars. This is not a satisfactory approach, for a magnifying mirror gives the illusion of much greater distance than is actually the case. This means that a following car will be much closer than is apparent when viewed in a rear vision mirror of this type. The ultimate solution is probably to develop external rear vision mirrors to the stage where it is not necessary to have one inside the passenger compartment.

Seats

9.51 Damage to the front seats of cars arose from two main causes. The less frequent cause was direct collision damage: 25 cases in the 390 cars, or 6.4 per cent. Seats were more often damaged by inertia forces of the seat itself and/or the occupants. There were 66 such cases, or 16.9 per cent of all these 390 cars.

9.52 In the comparison in TABLE 9.6 between the three model groups of Holdens and the Volkswagen we are comparing not only different models and manufacturers but also two basic types of seat, the full width bench seat (Holden) and the separate 'bucket' seats (Volkswagen). We are also only considering damage to the seat due to inertia forces or occupant contact. The Volkswagen is a lighter car than any model of the Holden, and therefore more likely to be subjected to higher decelerations in a collision with another car. But this difference alone cannot account for the poorer performance of the seat mountings of the Volkswagen.

9.53 Failure of the seat mountings, whether it is failure of the adjustment catch or complete failure of the mountings, means that the front seat occupants are forced by the front seat up against the instrument panel and steering wheel in a frontal impact. This additional force alone is bad enough, but in some cases, particularly with the 'bench' seat, the seat may become jammed, wedging the occupants up against the instrument panel. *Fig. 9.22* shows ambulance

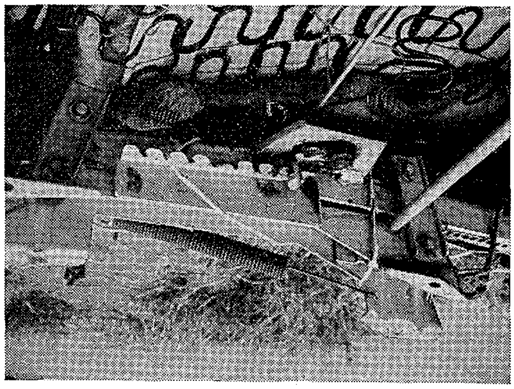


Fig. 9.23—Seat adjustment locking mechanism (passenger's side) of the 1952 FX Holden shown in *Fig. 9.22*

men, police and tow truck drivers working to release a driver who has been trapped in this way. The seat had come forwards and the damaged adjustment (*Fig. 9.23*) prevented it from being pushed back. The driver, who had a severe compound fracture

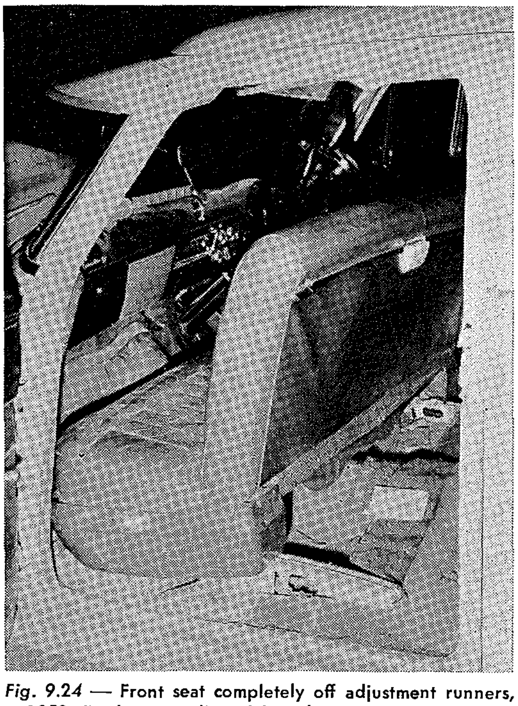


Fig. 9.24 — Front seat completely off adjustment runners, 1953 Ford Customline (also shown in *Fig. 9.16*)

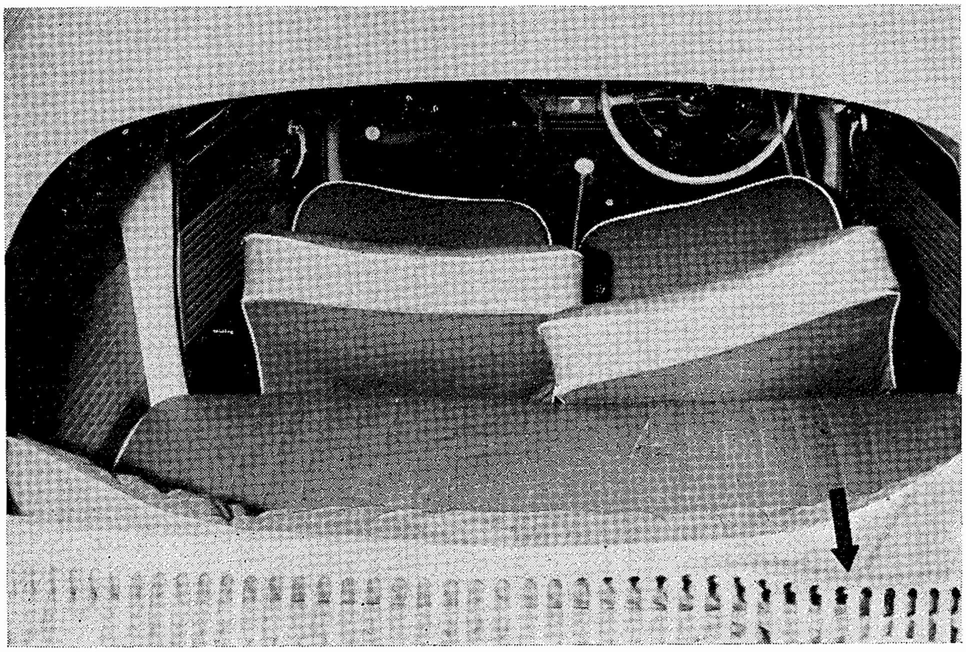


Fig. 9.25 — The front seat mountings of this 1960 Volkswagen failed when it was hit from the rear by another car. Note the damage to the back of the rear seat, and the dent (indicated by arrow) below the rear window, which was made by the driver's head

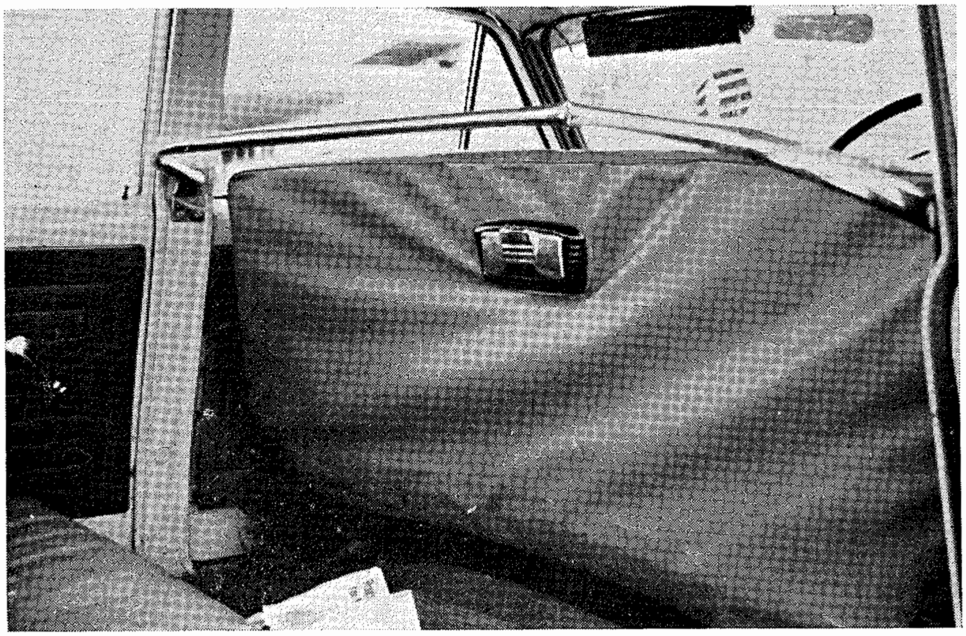


Fig. 9.26 — Handrail of a 1959 Holden taxi, struck by a rear seat passenger

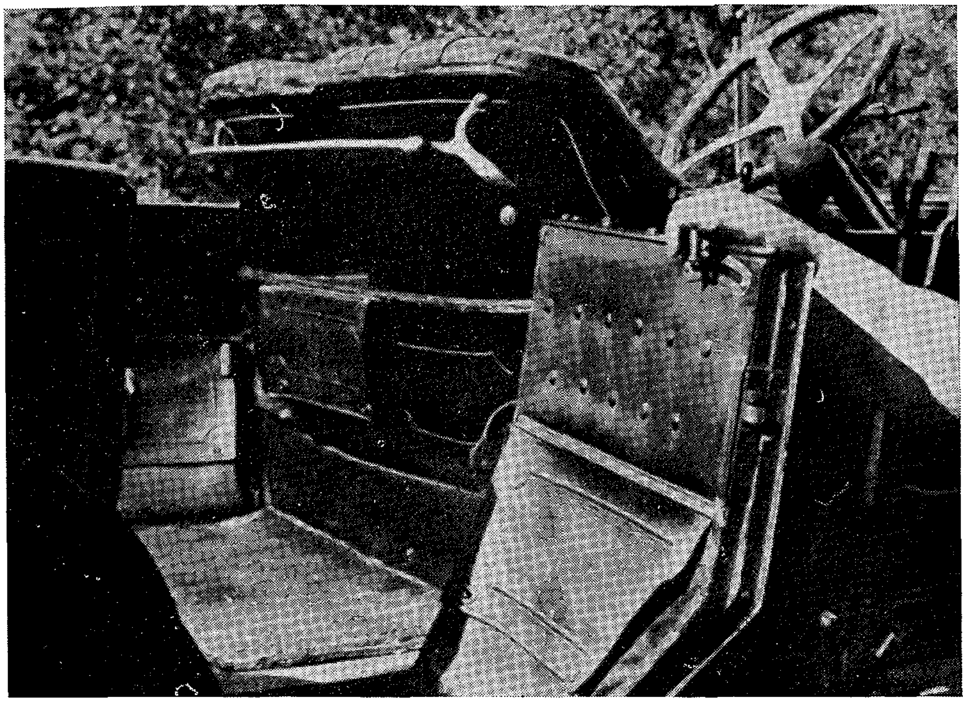


Fig. 9.27 — 'In 1910 the safety or packaging of the rear seat passengers was not considered very important compared with the exposure to severe weather. Heavy brass robe rails were attached to the seat back. (Figure 12 from Ref. 16)

of the right femur, was released after the seat had been unbolted from the floor of the car. The whole procedure took nearly three quarters of an hour. (This car is also shown in *Fig. 3.8* and *3.12*.) In some cases the complete seat will come off the adjustment runners (*Fig. 9.24*). While this is less likely to trap the occupants it obviously will increase the force of the impact with the instrument panel or steering wheel.

9.54 Rear end impacts also place a considerable load on the seat mountings. *Fig. 9.25* shows a case in which the mountings failed and the occupants were thrown against the back of the back seat and struck their heads on the rear window surround. The window was broken and the surround dented. The occupants were both concussed.

9.55 Passengers in the back seat will obviously hit the back of the front seat in frontal impacts. This is one way in which injuries can be directly attributed to the design of the seat and associated fittings. For some years it has been possible to buy Holdens that are fitted with a hand rail across the back of the front seat. This is, of course, directly in front of the rear seat passengers, who are thrown against it (*Fig. 9.26*). Perhaps consideration for the safety of car occupants has not advanced as far as *Fig. 9.27* and the quoted comment would have us believe (Ref. 16).

Glass

9.56 Injuries caused by window glass are discussed in the section on car occupants. Here we will describe the main types of window glass and note certain relevant features of each type.

9.57 Annealed plate glass is only found in older model cars. The lacerative potential

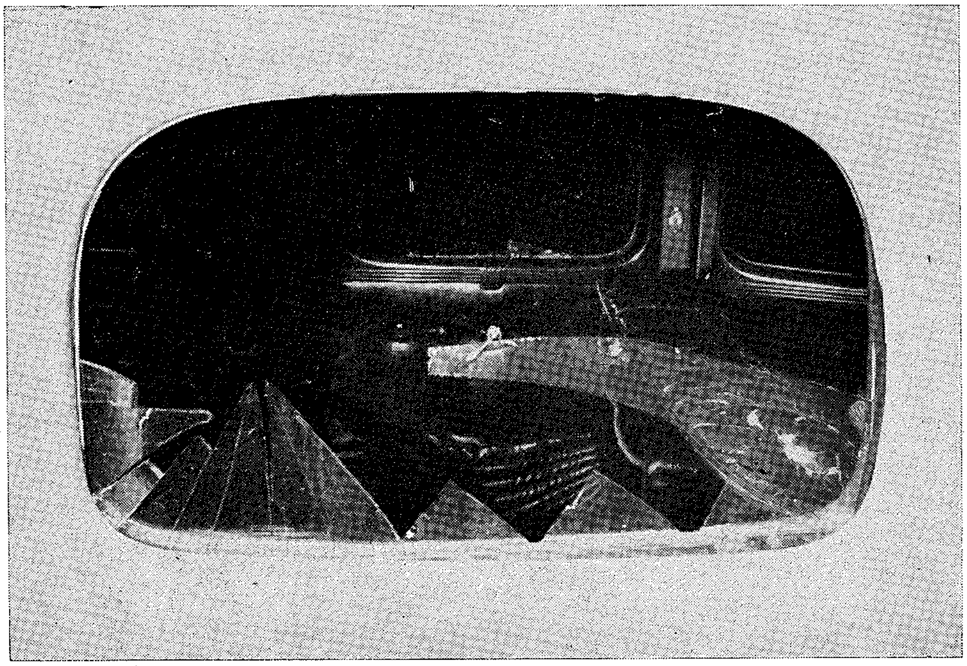


Fig. 9.28 — Annealed plate glass window of a pre-war Pontiac

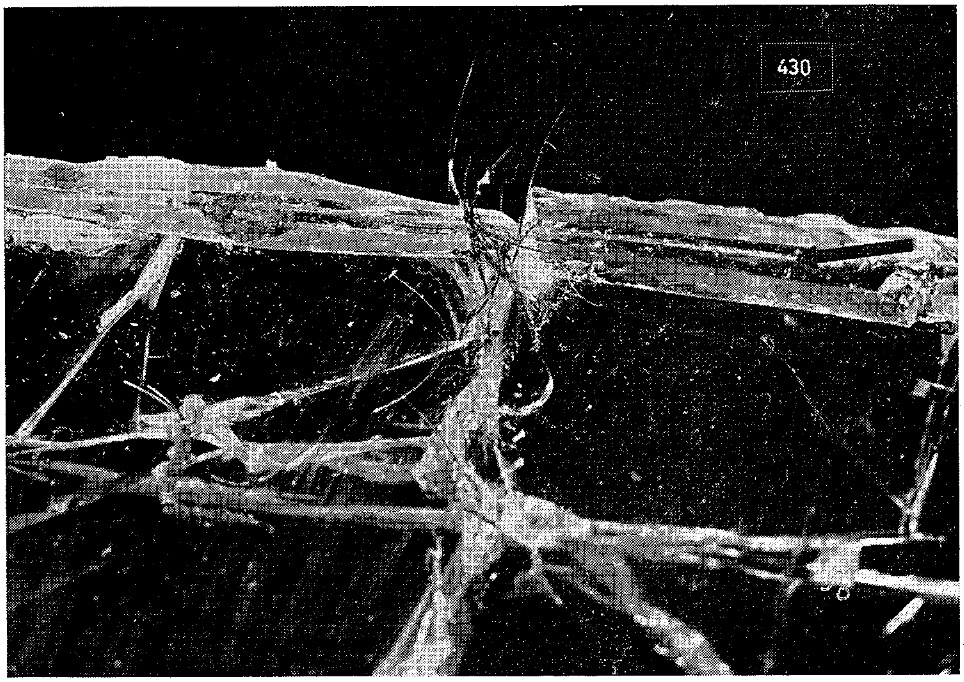


Fig. 9.29 — Laminated glass windscreen of a 1954 MG Magnette saloon, broken by the passenger's head; note hairs caught on sharp edges. Arrow indicates the interlayer between the two sheets of glass

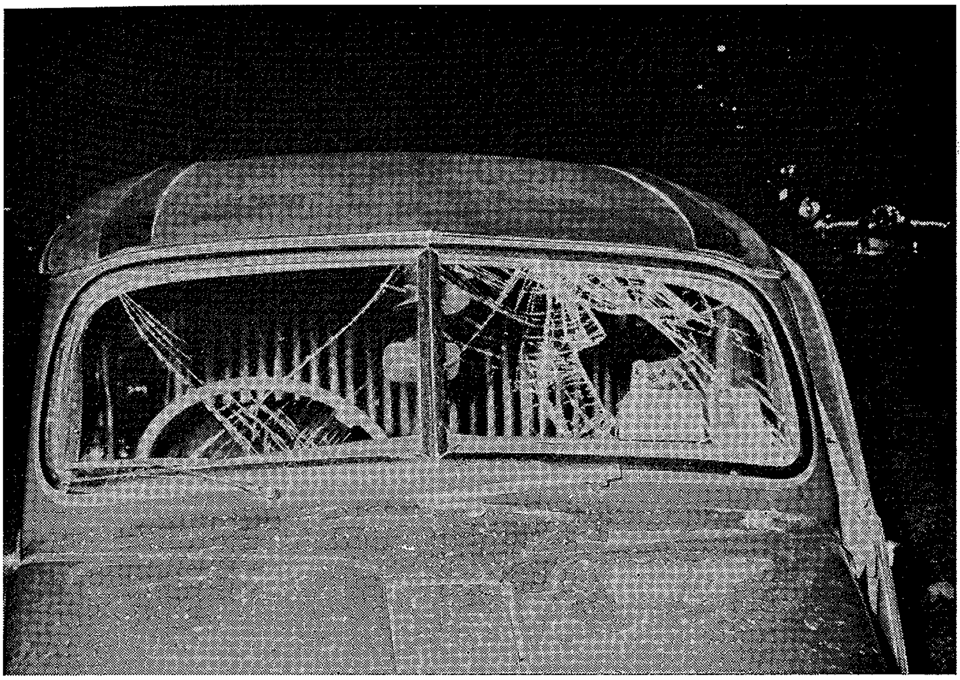


Fig. 9.30 — Laminated glass windscreen of a 1952 Riley. The fractures on the driver's side are due to deformation of the frame. Both driver and passenger struck the other half of the screen

of this type of glass is obvious (*Fig. 9.28*).

9.58 Laminated glass, which consists of two sheets of glass bonded together with a plastic interlayer, will still fracture in a similar manner to untreated plate glass (*Fig. 9.29*). The interlayer does reduce the chance of sharp edges being exposed unless the screen is actually penetrated. The properties of the interlayer are constantly being modified to improve the penetration resistance (Ref. 18). *Fig. 9.30* illustrates two types of damage to a laminated screen. On the driver's side, the left hand side of the picture, the glass has been cracked by distortion of the frame. Note that the cracks in the two sheets of glass are roughly at right angles to each other. On the passenger's side the screen has been penetrated. The driver had realized that a collision was inevitable and had reached across to try to hold her daughter back from the windscreen. The passenger was, of course, still thrown forwards and struck her forehead on the glass, at the same time forcing the driver's arm through the screen, which resulted in very severe lacerations to the full length of the forearm.

9.59 In Australia, toughened glass is far more commonly used than laminated glass, both for the side windows and for the windscreen. This glass is heat treated to ensure that, on impact, it will fracture into small pieces, none of which are likely to cause injury. There are some disadvantages with this type of glass, such as restricted visibility should the screen be broken by a stone and yet remain in place.

9.60 As far as injuries are concerned there is a greater risk of concussion than there is with laminated glass because toughened glass is stronger and therefore offers more resistance to an impact by a person's head. The risk of serious lacerations is greatly reduced however. The only excep-

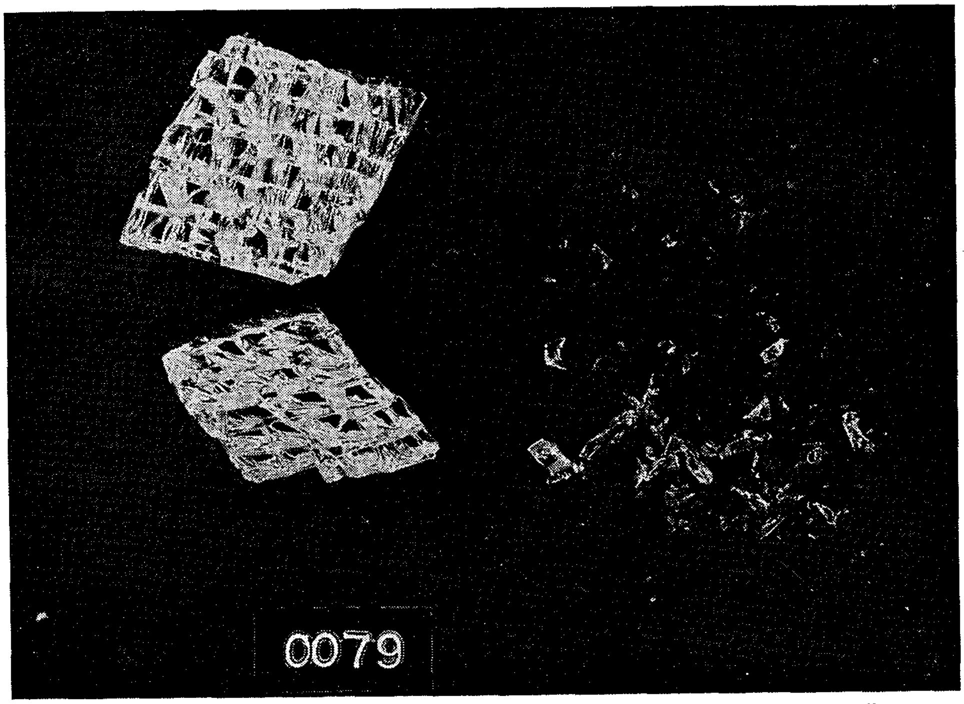


Fig. 9.32—Fragments of toughened glass from the shattered windscreen of a 1961 Volkswagen (Scale: 1.2 x full size)

tion to this statement is the case in which the toughened glass screen shatters and a jagged edge remains in the frame. *Fig. 9.31* (Appendix B) shows a typical example. In this case, which is also shown in *Fig. 8.22,* the screen was broken by the collision with the pole and the passenger was then thrown forwards, striking his forehead on the jagged edge of the glass remaining in the frame. It therefore appears that the method of mounting a toughened glass screen determines its lacerative potential. When fractured, the mounting should not retain glass fragments in such a way that it is possible for an occupant of the car to be injured by them.

9.61 There is one further small risk of injury from toughened glass which arises from the very small fragments that are often produced when the glass is fractured (*Fig. 9.32*). Should these small fragments, which can be showered around inside the car at quite high velocities, become embedded in an occupant, it can be very difficult both to find and to remove them. Despite these disadvantages toughened glass does seem to be less likely to inflict severe injuries than does laminated glass.

9.62 A further factor related to windscreens is the practice of tinting the glass to reduce glare. This is no doubt beneficial if the car is driven only in the daytime when visibility is good. At night the tinted screen will reduce visibility, which is often very poor even with a clear screen. We attended one night-time accident in which a car fitted with a tinted windscreen drove into the back of another car which was stationary waiting to turn right. Had the driver been able to see a little more clearly he might have realized that the vehicle ahead of him was stationary and, braked soon enough to avoid a collision.

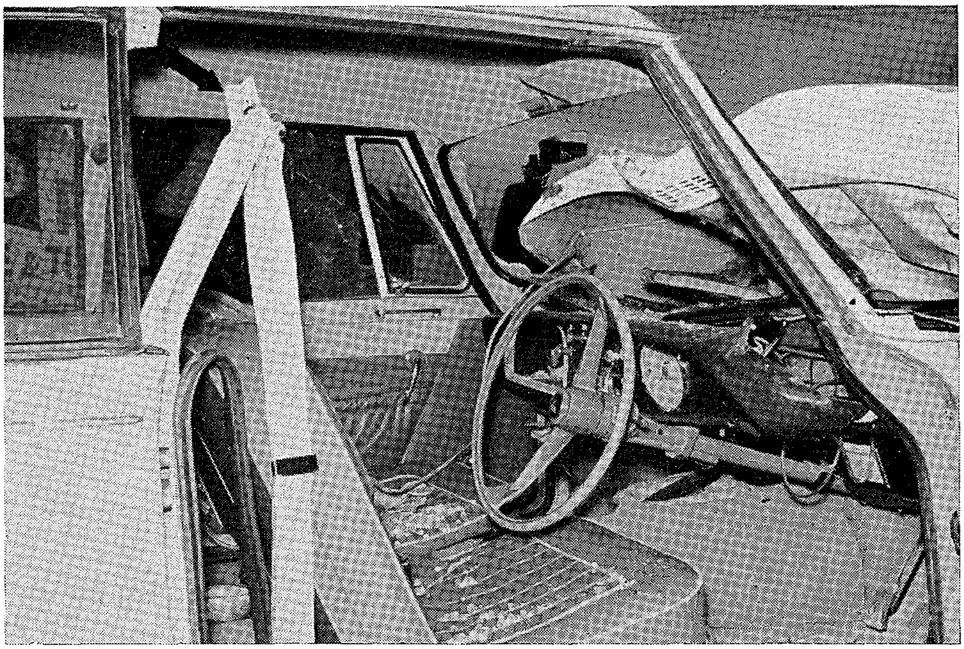


Fig. 9.33—Failure of seat belt mounting (arrow) on a 1960 Triumph Herald. Distortion of the mounting on the passenger's side is also indicated. This vehicle is also shown in *Fig. 7.8*

Seat belts and mounting points

9.63 In the discussion on seat belts (para. 11.63) we mention the failure of a mounting point for a belt. A close-up of the failed mounting is shown in *Fig. 9.33.* It can be seen that the load on the belt has caused the welds at the top of the centrepost to fail, allowing the post, mounting point and belt to come forward. This failure emphasizes the manufacturers' responsibility to provide sufficiently strong mounting points for seat belts. It is not enough to claim that if a hole is drilled in a particular position the centrepost will still be strong enough to withstand the impact loading from a seat belt. Such mounting points should be an integral part of the basic body frame.

9.64 We regret the reluctance of most Australian manufacturers to fit seat belts as original equipment in all cars. There is now very strong evidence to justify legislation requiring this. Such a measure has been taken in many states in the United States of America. This, together with Federal action, has resulted in virtually all passenger cars manufactured in the U.S.A. being fitted with seat belts as original equipment. The Australian subsidiaries of the three major American automobile manufacturers have not seen fit to follow their parent companies' example.

9.65 Legislation to make the fitting of seat belts compulsory in all new cars has been passed by the South Australian government, but has been put to one side and not implemented. Proclamation of this bill would be the most effective single action that this government could take to reduce the frequency of road traffic accident injuries and fatalities. The argument that people are more likely to wear seat belts if they themselves have had them installed in their car may be valid. But a study in the State of Wisconsin, U.S.A., has shown that, because legislation ensures that many more cars have belts in them, twice as many

Fig. 9.34—1960 Vauxhall Victor, struck on the right side by another car at an intersection. Both doors on the right side were sprung open

people will be wearing belts than would be the case without legislation (Ref. 19).

Door locks

9.66 The lock on a car door has the obvious function of keeping the door closed. In normal service it does its job well, and we no longer have to worry about doors flying open as the car takes a bend. Unfortunately doors often do come open when cars are involved in accidents (*Fig. 9.34*). In our survey we found that 8.6 per cent of all car doors came open. This includes all accidents involving cars. In many of these, e.g. pedestrian accidents, there is no additional loading on the door latch and doors rarely come open.

9.67 Now, there are many other mechanisms on a car that are also broken or fail in some way when the car is involved in an accident. So why do we draw attention to door locks in particular? The answer can be found elsewhere in this report (Section 11) and also in the work of the Automotive Crash Injury Research (A.C.I.R.) of the Cornell Aeronautical Laboratory. Ref. 20 is entitled *A study of automobile doors opening under crash conditions*. One of the conclusions was that for a car occupant 'ejection significantly increases the risk of moderate through fatal injuries.' In other words it is safer to stay inside the car. This was the beginning of the end for the term 'thrown clear'. But the end is not yet, for even today, over eleven years after this report was published, many people still talk about the 'dangers' of being 'trapped' in the car and the 'advantages' of being 'thrown clear'.

9.68 In a later article (Ref. 21) entitled *Ejection and automobile fatalities* it was

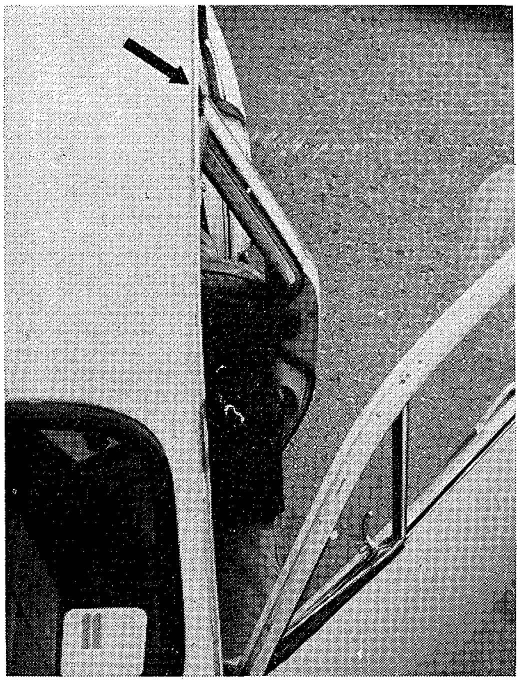


Fig. 9.35—This 1954 FJ Holden was struck on the right side by another car. The front seat transmitted the force of the impact across the car to the centre-post, which was pushed out as shown, the spot welds being partly torn away (arrow). The rear door had been removed previously

claimed that '25 per cent of all fatalities can be eliminated if ejection is completely prevented.' There would be a similar reduction in the severity of injuries to survivors of car accidents. We refer again to section 11 para. 56 of this report where we show that the risk of severe to fatal injury to car occupants involved in accidents in metropolitan Adelaide is increased 4.5 times if they are 'thrown clear'.

9.69 Implicit in the above discussion, and in the references quoted, is the assertion that occupants are ejected from their cars through open doors. We sometimes read in the daily press of people being 'hurled through the windscreen'. This may happen, but complete ejection from a car is almost always through a door which has come open.

9.70 This early work of the A.C.I.R., along with crash testing by vehicle manufacturers and the University of California at Los Angeles, prompted modifications to the door locks of cars manufactured in the U.S.A. from late 1955 onwards. *An evaluation of door lock effectiveness: pre 1956 vs. post 1955 automobiles* (Ref. 22), also by the A.C.I.R., showed that the new locks were saving about 800 lives each year. The frequency of occupant ejection was reduced by nearly 40 per cent. If all cars in use had been fitted with these improved door locks a saving of 1,800 lives annually might have resulted. These figures refer, of course, to the U.S.A. alone. Subsequent comparisons have been made between the performance of 1962 and 1963 automobile door latches and earlier designs (Ref. 23).

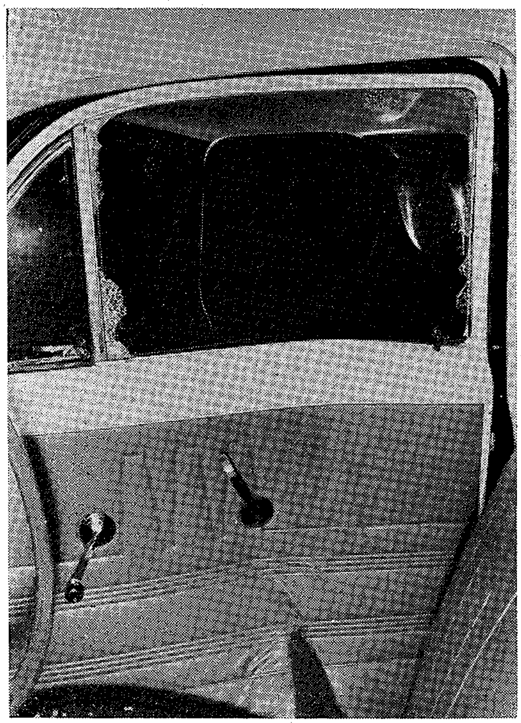


Fig. 9.36—1954 EH Holden which hit a high kerb with the right front corner when skidding sideways. Note shattered glass and buckled door panel, both caused by the driver being thrown against the door

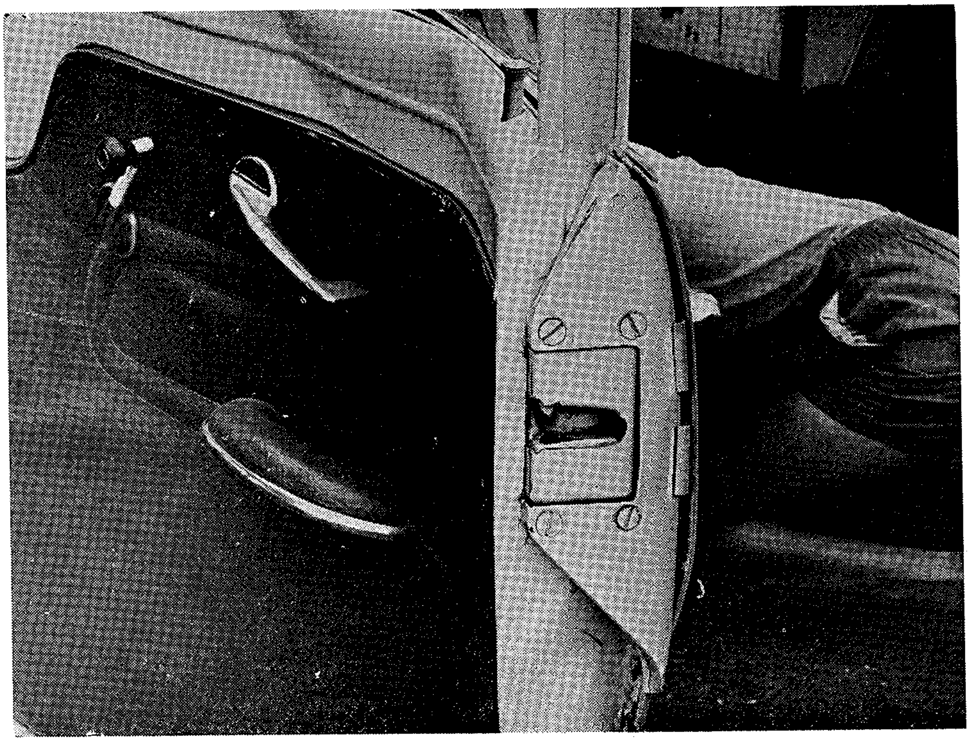


Fig. 9.37—Door latch of a 1956 FJ Holden

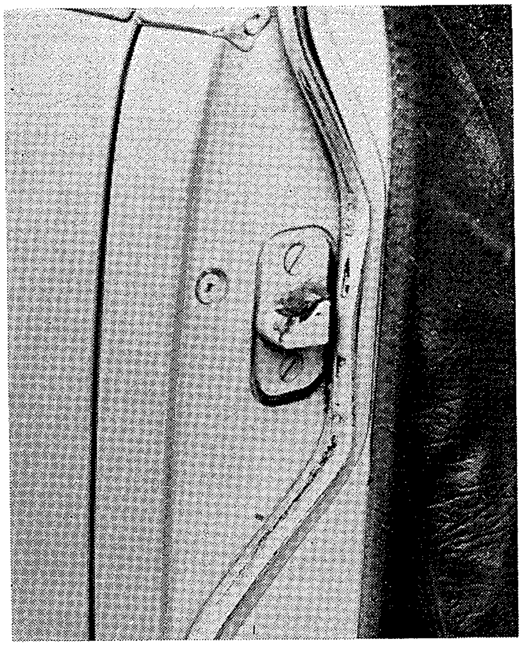


Fig. 9.38—Striker plate of a 1956 FJ Holden

9.71 This new generation of door locks had one basic aim: to hold the door closed no matter what loads might be imposed. The ways in which high loadings can be placed on door locks are many (Ref. 24). *Fig. 9.35* shows how the front seat can break loose and transmit the collision forces from a side-on impact to the far side of the car. The centre post has been forced out, and the door opened. Even the driver being hurled sideways against the door can result in considerable damage to the door frame and failure of the lock. In the case shown in *Fig. 9.36* the driver also shattered the side window with his head. He was fortunate that there was no arm rest fitted to the door, for rigid arm rests can cause serious internal injuries in cases such as this.

9.72 More frequently, however, the door lock is loaded by distortion of the body frame of the car or by direct impact on the door itself. *Fig. 9.37* and *9.38* show the

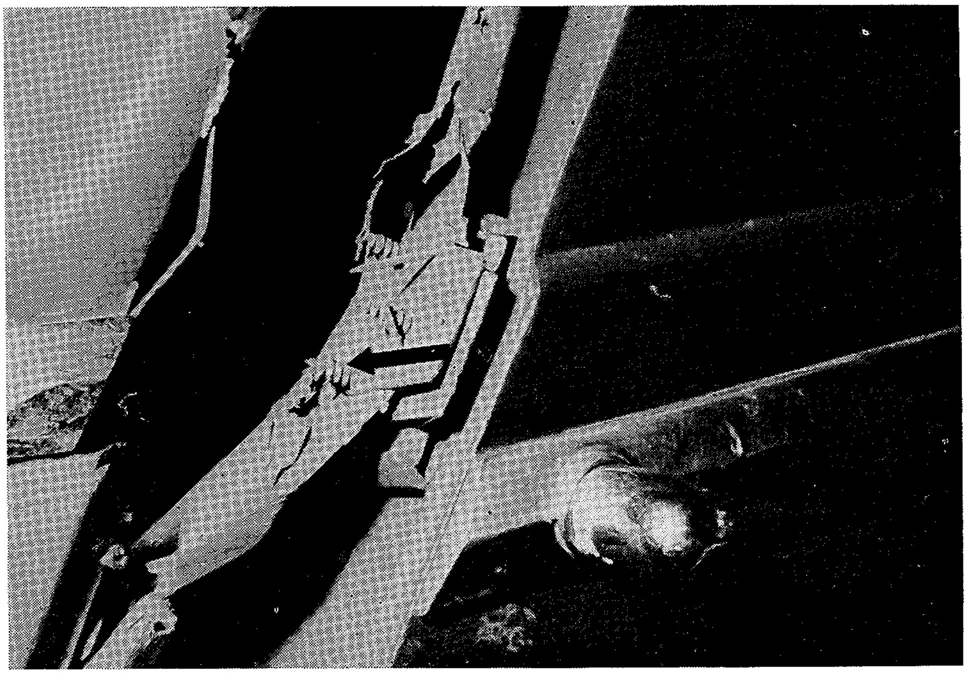


Fig. 9.39—Door lock failure on a 1952 Riley Saloon. Arrow indicates one of three wood-screws used to mount the striker plate to the body of the car

driver's door latch and striker of an FJ model Holden which was struck on the right front corner by another car at an intersection. The door has been damaged and the latch has been dragged forwards across the striker until the two separated and the door came open. This was one of the types of failure that the 'new generation' of door locks were designed to overcome.

9.73 Many manufacturers had previously provided some form of longitudinal restraint to reduce the chance of the two halves of the lock separating from each other. The initiative for such measures had generally come from embarrassing experiences such as a door springing open when the car hit a bump in the road. Consequently these devices were sadly inadequate when subjected to the much higher forces resulting from collisions or rollover. In some cases the mounting for the lock was even weaker than the lock itself (*Fig. 9.39*).

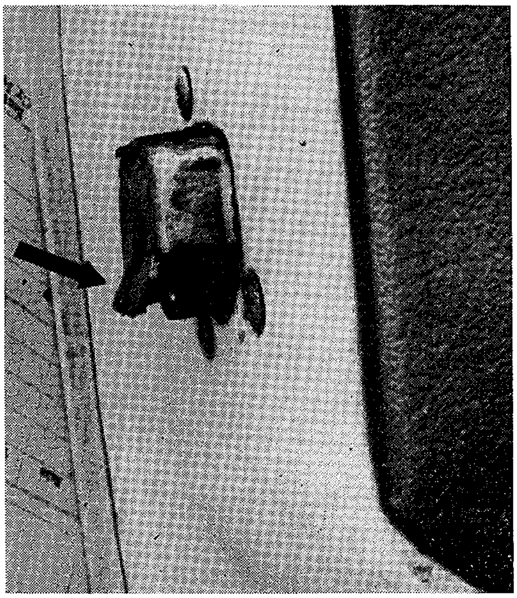


Fig. 9.40—Damaged door latch on a 1957 FE Holden. Arrow indicates bent flange. This type of latch superseded the one shown in *Fig. 9.37*

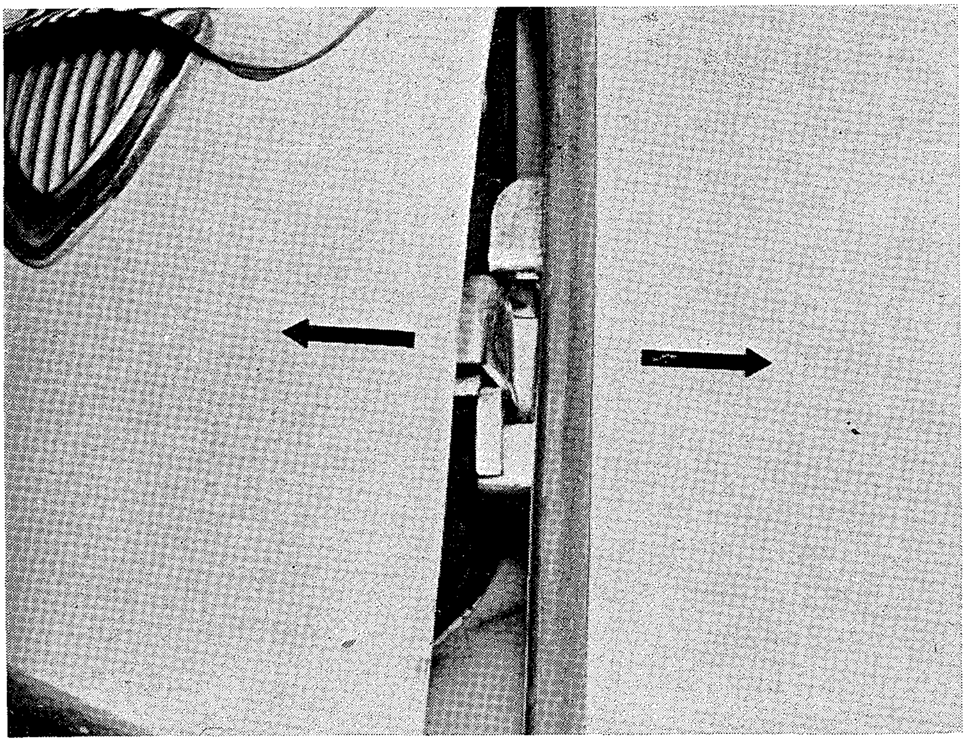


Fig. 9.41—1960 FB Holden door latch. The flange is bent, as in *Fig. 9.40*, but the latch is still engaged with the striker plate and the door has not opened. The forces on the lock, due to the distortion of the body frame of the car, are in the directions shown by the arrows.

9.74 The early attempts to design a lock to withstand collision forces met with varying degrees of success (Ref. 22). A common failing is shown in *Fig. 9.40*. Here a flange has been incorporated into the latch to prevent it from being pulled away from the striker. The flange was not strong enough and has bent, allowing the door to come open. A similar lock is shown in *Fig. 9.41*. Although badly distorted it is still engaged and has kept the door closed.

9.75 When recording the performance of door locks on the cars involved in accidents covered by our survey we noted also the type of lock. The results are shown in TABLE 9.7

9.76 To compare the performance of door locks which incorporate some form of longitudinal restraint with those which do not, we have tabulated them in TABLE 9.8, using the same notation as in TABLE 9.7. Expressed in percentages of the total number of doors, we can say that 5.5 per cent of those having type A locks came open, compared with 11.1 per cent of those having type B locks. In other words, door locks having some form of longitudinal restraint failed only half as frequently as those which lacked such a device. This result is almost certainly not due to chance.

9.77 There is one other somewhat surprising consequence of the improved type of door latch. Not only does it halve the risk of a door coming open but it also halves the risk of it being jammed shut in such a way that it cannot be opened. Parallel improvements in the stiffness of body shells may also have influenced this result in some

TABLE 9.7

CAR DOORS (AFTER THE ACCIDENT)

	Front Right Door		Front Left Door		Rear Right Door		Rear Left Door	
	A*	B**	A	B	A	B	A	B
Door remained closed:								
operates normally	169	181	166	172	163	142	159	149
does not operate normally	15	35	17	32	6	20	8	8
jammed shut	13	25	14	37	8	23	9	18
Door came open:								
operates normally	1	—	—	2	—	—	1	—
cannot shut, no damage to door	6	21	7	17	—	6	3	6
cannot shut, door damaged	8	15	10	24	6	4	3	15
Not elsewhere classified	—	2	—	—	1	2	—	—
Not applicable	—	—	—	—	31	91	31	92
Not recorded	7	15	5	10	4	6	5	6

*A: door lock incorporates some form of longitudinal restraint.

**B: door lock does not incorporate any form of longitudinal restraint.

cases. TABLE 9.9 lists the figures for doors which were jammed shut.

9.78 While the above results are statistically very significant, there is a great variation in the types of door locks, particularly in group A (those having some form of longitudinal restraint). We have included in this group even locks such as that shown in *Fig. 9.39.* In an attempt to define more clearly the differences in the behaviour of these two basic types of door lock we now consider two periods in the design of locks that have been used on the Holden car. Both locks have been shown, the earlier model in *Fig. 9.35, 9.37* and *9.38* and the later model in *Fig. 9.40* and *9.41.* This later type of lock was also fitted to the door shown in *Fig. 9.36.* The complete results are listed in TABLE 9.10.

9.79 Condensing TABLE 9.10 in the same way as before (see TABLE 9.11), we find that 4.8 per cent of the doors in group A came open and 8.9 per cent of those in group B. This confirms the conclusion drawn from TABLE 9.8: the new type of lock was an improvement. Simultaneous improvements in the rigidity of the vehicle body from one model to the next may also have lessened the loads placed on the door locks.

9.80 In fairness to General Motors Holdens we should mention here that a similar calculation based on the first half of our survey showed no difference at all in the performance of these two types of

TABLE 9.8

PERFORMANCE OF DOOR LOCKS

	Type of Door Locks (All Cars)	
	A	B
Door came open	45	110
All other cases	769	884

$\chi^2 = 17.5^{***}$ (p 0.01 = 6.6)

TABLE 9.9

INCIDENCE OF DOORS JAMMING SHUT

	Type of Door Lock (All Cars)	
	A	B
Door jammed shut	44	103
All other cases	770	891

$\chi^2 = 14.7^{***}$ (p 0.01 = 6.6)

TABLE 9.10

HOLDEN DOORS

	Front Right Door		Front Left Door		Rear Right Door		Rear Left Door	
	A*	B**	A	B	A	B	A	B
Door remained closed:								
operates normally	126	26	122	29	125	26	120	28
does not operate normally	12	8	13	8	2	3	5	1
jammed shut	9	5	10	5	8	5	8	1
Door came open:								
operates normally	1	—	—	—	—	—	—	—
cannot shut, no damage to door	5	4	6	3	—	—	2	3
cannot shut, door damaged	5	3	8	3	3	—	3	1
Not elsewhere classified	—	—	—	—	—	—	—	—
Not applicable	—	—	—	—	20	13	20	14†
Not recorded	3	2	2	—	3	1	3	—

*A: FE to EH models, all having type 'A' door locks.

**B: FX and FJ models, all having type 'B' door locks.

†The additional case in the last column of the 'not applicable' category is illustrated in Fig. 9.35. The left rear door had been removed before the accident.

lock. The result shown here is based on approximately twice the number of cases and, as the value of χ^2 shows, is unlikely to be due to chance. It is also in close agreement with a similar analysis based on General Motors cars in the U.S.A. (Ref. 22).

9.81 There is no significant difference in the types of accidents (e.g. single impact, rollover) or the types of collisions (e.g. pedestrian, moving vehicle) between the vehicles in groups A and B. There is therefore unlikely to be any consequent bias affecting the results presented in para. 9.79.

9.82 One other model which appeared often enough (41 cars) in our survey to make this type of investigation feasible was the Volkswagen 1200 sedan. This car has only two doors, the locks having no form of longitudinal restraint. 11 per cent of all Volkswagen doors came open in these accidents, e.g. *Fig. 9.42*. This is a little worse than the early model Holdens for which the figure was 8.9 per cent.

TABLE 9.11

PERFORMANCE OF HOLDEN DOOR LOCKS

	Type of Door Lock	
	A	B
Door came open	31	17
All other cases	560	145

$\chi^2 = 5.87^{**}$ p 0.02 = 5.41

9.83 Finally we must emphasize the extreme importance of this feature of the detail design of the passenger car. An effective door lock is a safety feature which is built into the car and is operating all the time. Its effectiveness is not dependent on the cooperation of the occupants of the car, as is the protection afforded by seat belts (Ref. 25). If the door locks of all new cars can be improved to the point at which it is no longer the lock but the hinges or even the door which fails, many lives will be saved and much needless suffering avoided. This stage has been reached on some cars (Ref. 23). But many manufacturers seem unconcerned about the safety of their customers in this regard.

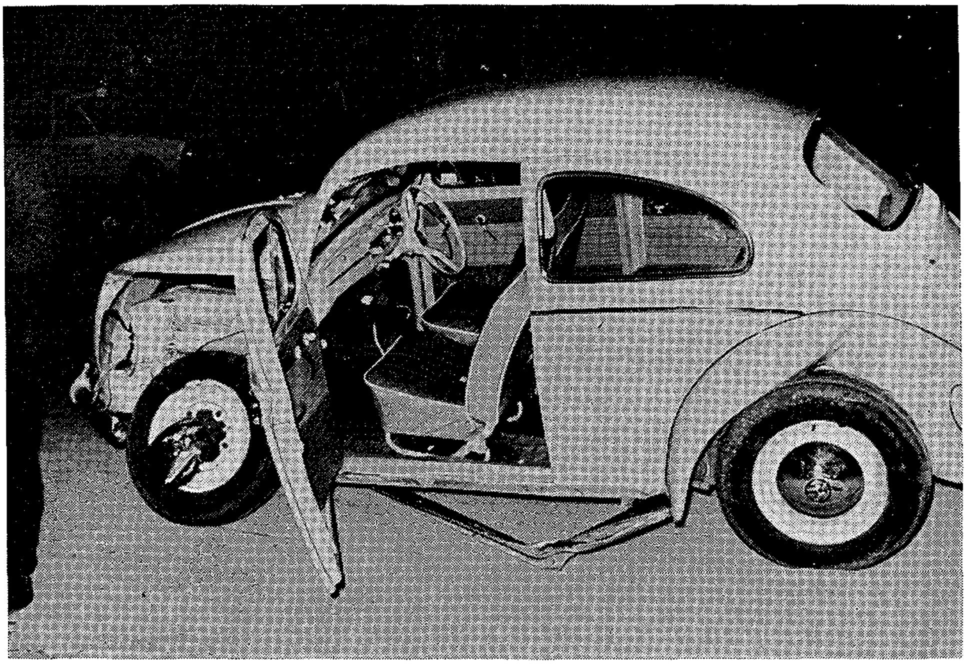


Fig. 9.42—The door of this 1960 Volkswagen came open during a collision with another car at an intersection

ROADWORTHINESS

9.84 Generally in this report we have been concerned with those features of vehicle design and condition which determine the 'crashworthiness' of the vehicle. This is a word which is being used to describe the performance of a vehicle as far as the protection of the occupants from injury in an accident is concerned. 'Roadworthiness' is a far more common word, although it too has grown up with the motor car. It refers, of course, to the handling and reliability of a vehicle and is dependent on both initial design and also on regular maintenance.

9.85 There are very few mandatory standards governing the design of motor vehicles. Indeed the motor vehicle industry is subject to little restriction as far as design codes are concerned; it occupies a very privileged position when compared to the aircraft industry, for example.

9.86 The role that initial design can play in the production of a roadworthy vehicle should be obvious. But just as some designs can be very good, so others can be rated as poor by comparison. Whether such designs can be claimed to be dangerous is a very contentious point which is the subject of a series of lawsuits in the U.S.A. at the present time. There are many who do not doubt that such claims are groundless, as the following excerpt from an editorial in the British motoring journal 'Autocar' indicates:

> 'If any car manufacturers, in any country, deliberately put a car on the market which by nature of its design was dangerous, and known to be so, they would deserve to be run out of business; but we are pretty sure that there are no manufacturers of that kind in the world today'. ('Autocar', 20 August, 1965.)

9.87 The critical point in such comment is the definition of the word 'dangerous'. For example, there are some cars which rely for their directional stability on having very much higher air pressure in the rear tyres than in the front. If the owner of such a car fails to follow the manufacturer's instructions in this regard and has an accident because his car does not handle correctly, who is responsible? At first sight it would appear to be the owner, but is it reasonable to assume that all drivers check the pressures in their tyres? Or, for that matter, is it reasonable to assume that all service station attendants know of the peculiar specifications of such cars? This example of the correct tyre pressures relates to both the initial design and also the maintenance of cars.

9.88 Generally the main concern has been to ensure that vehicles are maintained in a roadworthy condition. To this end many vehicle licensing authorities insist on regular checks of all motor vehicles, or of those which are more than a certain number of years old. A rather detailed discussion on the *Inspection of vehicles for roadworthiness, with special reference to methods and equipment,* is given in Ref. 26. There have been some studies of the effectiveness of these programmes in reducing the frequency of accident fatalities, e.g. Ref. 27.

9.89 Accurate estimation of the roadworthiness of a vehicle that has been involved in an accident is complicated by the often extensive collision damage. We lacked the authority and time to make a sufficiently detailed examination of the roadworthiness of each of the vehicles covered by our sur-

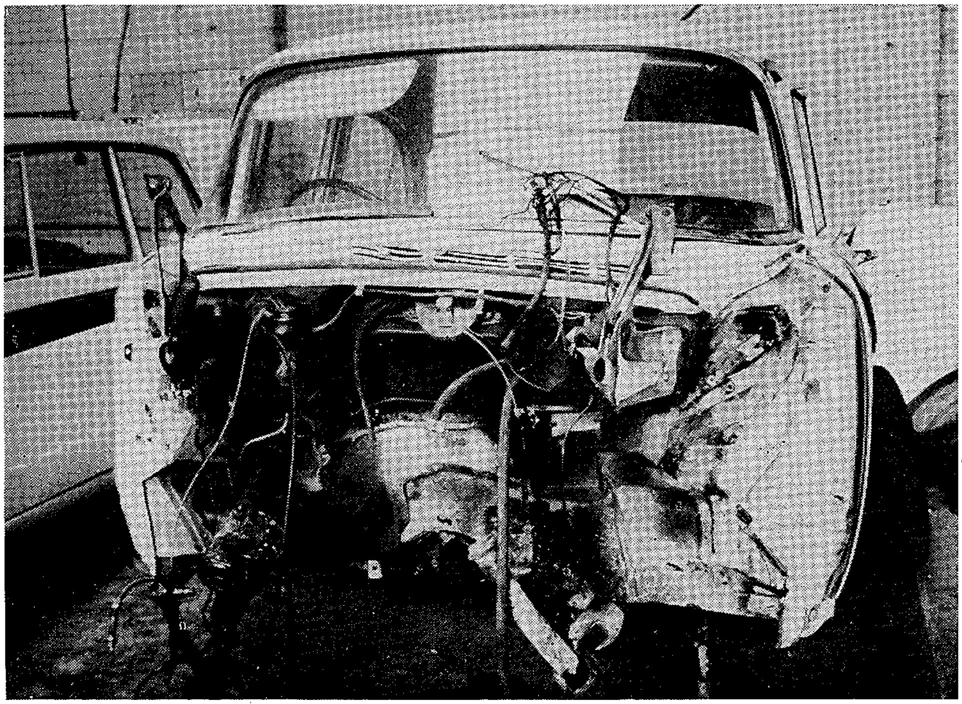


Fig. 9.43—The damaged FB Holden, shown in *Fig. 9.3,* stripped for repairs

vey. Therefore we must make it quite clear that we did not attempt what we would regard to be an adequate inspection of these vehicles for roadworthiness.

9.90 However there were only two cases, both single vehicle accidents, in which deficiencies in the roadworthiness of the vehicles were obviously of more than minor importance in the causation of the accident (these two cases represent 0.5 per cent of all accidents in the survey). This we believe reflects both the extremely complex nature of the metropolitan traffic accident, which can rarely be attributed to one specific cause, and the minor part that the roadworthiness of vehicles seems to play in such accident causation.

9.91 A programme of compulsory vehicle inspection should be sufficiently comprehensive at least to ensure that unroadworthy vehicles do not become more significant as a cause of accidents. But the considerable cost of such a programme must be related to the possible benefits. There are so many ways in which action can be taken to try to reduce the frequency of traffic accidents that some order of priority must be established if the maximum return is to be obtained from such efforts.

COST OF REPAIR

9.92 In the second year of this survey we tried to find out the actual cost of repair for each vehicle (see *Fig. 9.43*). We generally did this by recording both the registration number of the particular vehicle and the name of the towing service which removed it from the scene. This proved to be a far from foolproof method, for very often such vehicles would seem to 'disappear without trace'. Had we also noted the name of the owner of the car we might have been more successful, for the owner's name seemed to be the only record that was kept by some towing services. We tried to resist the temptation to assess the cost of repair on the spot, even in cases when there was not much chance of serious error.

9.93 We are able to present the cost of repair to 86 passenger cars (TABLE 9.2A). Half of these were severely damaged, and only two received minor damage. This is not representative of the whole picture of the degree of damage to cars in this series, and there is naturally little point in attempting to draw any conclusions about the average cost of repair on the basis of these 86 cases which are not representative of the whole. The bias towards the cases of severe damage arose because it proved to be very much easier to trace a car which had to be towed away from the scene of the accident than one which could be driven away. Furthermore, if a car receives only a small dent it is likely that it may never be repaired.

9.94 Attempts have previously been made to relate the cost of repair to impact velocity (Ref. 28) and also to relate it to the damage index devised by Moreland (Ref. 7 and 30). The cost of repair has also been taken as an indication of the degree of damage sustained by a vehicle (Ref. 31).

9.95 An inspection of TABLE 9.1A reveals the wide range of repair cost for the same degree of damage. For example, the cost of repair, for moderate damage, varied between limits of £A15 and £A450. This is mainly due to similar variations in the market value of the vehicles concerned. However, considerable differences in repair costs can exist even between cases involving similar cars with apparently similar degrees of damage (Ref. 28). This can be due to a greater amount of damage to the motor or transmission in one of the cars. Smaller differences arise from the quality of the repair work. Some insurance companies seem to insist on replacing damaged body panels with second hand panels from wrecked cars. These are naturally less expensive than new panels.

9.96 We have tried to minimize the effect of such variations by dividing the cost of

TABLE 9.12

VALVES FOR DIFFERENT DEGREES OF VEHICLE DAMAGE

Degree of Overall Damage	A/B	Range of A/B	No. of Cases
Minor	0.05	0.03-0.08	2
Moderate	0.24	0.09-1.00	35
Severe	0.62	0.28-1.00	44
Extremely severe	1.00	all 1.00	5

(Cars only: from Table 9.2A)

A = Cost of repair

B = Market value

repair (A) by the current market value of the vehicle (B). We have used a booklet published by a motoring journal as a guide in estimating the market values of these cars (Ref. 32). Some allowance has been made for the general condition of each vehicle. The market values for the two cases cited above were £A30 and £A2,400 respectively. These give 'cost of repair over market value' figures of 0.50 and 0.19. The average value for moderate damage is 0.24, based on 35 cases. The values for all degrees of vehicle damage are listed in TABLE 9.12. It will be appreciated that an upper limit of A/B = 1.00 is to be expected even with moderate damage. With only two exceptions among these 86 cars, a value of 1.00 represents a 'write off', i.e. the car was not repaired because the cost of repair would have exceeded the market value of the car.

9.97 The average values of A/B shown above are in the ratios 1:5:12:20 from minor through to extremely severe. If we compare these ratios with the median values of each range of our overall damage scale (para. 3.47) we find that there is a remarkably close correlation (see TABLE 9.13).

9.98 This shows that these two ways of rating the degree of damage to a car can give very similar results. We emphasize that these are two distinctly different methods. The fact that they agree so closely may perhaps be taken as some encouragement for the continued use of the present ratios between the median values of the damage ratings, viz. 1.5:5.0:11.0:22.5, for minor through to extremely severe damage on the overall damage scale. These ratios originally arose from an attempt to avoid anomalous results when basing the overall damage assessment on the three section damage ratings. For example, if the ratios were simply 1:2:3:4 for minor through to extremely severe, then moderate damage to two sections of the car would be given the same value as extremely severe damage to the passenger compartment. With the chosen ratings for section damage (para. 3.47), viz. 1:3:7:10, the former case has an overall damage value of 6, which is in the moderate

TABLE 9.13

VALUES OF A/B COMPARED WITH MEDIAN VALUES

Overall Damage Scale		Cost of Repair/Market Value (average values x 20)
	Median values	
Minor	1.5	1.0
Moderate	5.0	4.8
Severe	11.0	12.4
Extremely severe	22.5	20.0

TABLE 9.14

AVERAGE TIMES FOR REPAIRS

Degree of Overall Damage	Average Repair Time	No. of Cases
Minor	2 days	1
Moderate	2+ weeks	23
Severe	3½ weeks	16
Extremely severe	2+ months	1

overall damage range, and the latter case 10, which is in the severe overall damage range. Discrepancies can still arise with this system, but they do so less frequently than with the 1:2:3:4 ratios between classes of damage.

TIME TAKEN TO COMPLETE REPAIRS

9.99 In some cases we have been able to present the length of time taken to repair the vehicle. This appears to be subject to extraneous circumstances far more than does the cost of repair. For example, the dust scarcely settles around a taxi before repairs commence, whereas a vehicle used for private purposes may be untouched for a week or more. Repair times are listed for 41 cars in TABLE 9.1A. Naturally the length of time taken is related to the amount of damage. Average times are listed in TABLE 9.14.

SPEED

10.1 There is probably no more abused word in the road safety vocabulary than 'speed'. 'The speed that thrills is the speed that kills'. The converse is not necessarily true.

10.2 We tried to estimate both the travelling and impact speeds of all vehicles involved in the accidents which we attended. By 'travelling speed' we mean the speed of the vehicle before evasive action, if any, was taken by the driver. By 'impact speed' we mean the speed of this vehicle on impact. In cases in which there was no impact, e.g. rollover, we have taken the speed of the vehicle at rollover or, in the case of a motorcyclist, on falling from the machine. The travelling speed is usually greater than the impact speed because braking is the most common evasive action. The exceptions include vehicles which moved off from a standstill immediately before colliding with another car. The travelling speed of such vehicles is recorded as zero.

10.3 The ranges of travelling and impact speeds of all motor vehicles in our survey are shown in *Fig. 10.1.* The mean values are quite low: 27.0 m.p.h. and 20.5 m.p.h. The mean speeds for the 17 accidents which resulted in fatalities are higher: 36 m.p.h. and 31 m.p.h. If these mean values and the ranges of speeds are accurate, the effect of 'speeding' in the popular sense of the word is not very marked. This would mean that most accidents happen to people who are travelling well within the 35 m.p.h. speed limit. But how accurate are these recorded speeds?

10.4 The estimation of the speed of a vehicle after the event is beset with countless difficulties. Drivers' statements are unreliable, and those of witnesses often little better. This is not necessarily because of a wish to deceive or to avoid charges of speeding. Many drivers simply do not know how fast they are travelling without actually looking at the speedometer, and in an emergency there are more important things to be done. Probably the most frequent replies to our question 'how fast were you going?' were 'about 25' or 'not very fast'. There are other clues which are of considerable assistance, and perhaps the most useful of these are skid marks due to braking. We generally found that our final estimates of speeds were much higher than those of the drivers who had been involved in the accident. Despite this our mean values are still low when compared to the speeds of traffic streams on many metropolitan roads. This we believe to be a reflection of the fact that slow speeds can still be dangerous speeds in

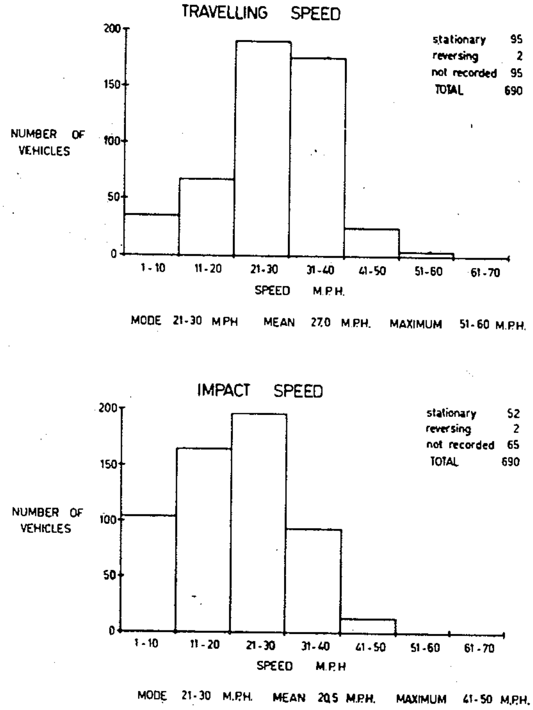


Fig. 10.1—**Motor vehicles: travelling speed and impact speed**

a metropolitan area. This is particularly true at intersections.

Critical speeds at intersections

10.5 In one week we attended two accidents which happened on the same through street. Each of these accidents was a collision between two cars at an intersection. While attempting to measure the positions of the skid marks which had been made by these cars we frequently had to jump aside to get out of the way of other cars that were speeding across these intersections. This made us wonder how many drivers could hope to avoid a collision, should a second vehicle suddenly appear along the intersecting road.

10.6 At the end of our survey we returned to 34 intersections at which we had previously attended accidents and, with the aid of a radar speed meter lent to us by the Highways and Local Government Department, were able to record approach and crossing speeds for 451 vehicles. As far as possible we returned to each intersection at the time of day and day of week which corresponded with the timing of the accident we had attended there. This gave us more than one set of readings at two intersections, where we had attended accidents at different times. As we had the use of the meter for one week only, we severely restricted our sample size at some intersections. In fact at one place we did not see a single vehicle in one hour. We had already measured the relevant sight distances, and being able to establish a minimum stopping distance from a given speed on a given surface, we proceeded with a calculation of critical speeds at these intersections. By critical speed we mean that speed at which a driver can either continue or slow down and avoid a collision with a vehicle approaching on his right. The method we have used to calculate the critical speeds is detailed in para. 10.10.

10.7 The results of these calculations are surprising. In no case is the safe speed greater than 37 m.p.h. and in one case it is less than 11 m.p.h. The actual speeds of the 451 vehicles we observed crossing these intersections varied from 55 m.p.h. to those of vehicles which came to a stop before proceeding to cross. Of these 451 vehicles 363, or 81 per cent were exceeding the critical speed. This means that only 19 per cent of these cars could hope to avoid all vehicles approaching from their right at these intersections. There are two immediate conclusions to be drawn from these results.

10.8 The first is that it is very easy in Adelaide to drive dangerously fast and yet not exceed the speed limit (35 m.p.h.). The driver who travels at a 'steady 30' is not a safe driver unless he also slows down when crossing intersections. As an example the safe speed on Duthy Street, which has the appearance of a major through road, is 13 m.p.h. at the intersection of Winchester Street. There are very few drivers who slow down to this speed or who even realize that a legal 30 m.p.h. is much too fast.

10.9 The second and far more significant conclusion is that the 'give way to the vehicle on the right' rule may be far from satisfactory in this city. With this rule a driver has to look for a moving vehicle on his right before he knows whether it is safe for him to continue across the intersection. It may be that most drivers do look, although we doubt it. The figures above show that, even if they do look, only one driver in five can hope to obey the rule to 'yield to the vehicle on the right' in all cases. This important matter needs much further impartial and careful study, for perhaps a major and minor road system of determining right of way would prove to be more in line with present driver behaviour. As a starting point, many more observations should be made, of a larger and carefully representative sample of intersections. It is possible that our sample could be somewhat biased, for it comprised intersections at which accidents actually happened; however, we believe that any such bias will be small.

Calculation of critical speeds

10.10 How fast can I approach an intersection and yet be sure that I can avoid a collision if a car should suddenly appear on my right? This is a question which we hope most drivers ask themselves at some time. Our survey of accidents and speeds across intersections suggests that few drivers have arrived at the correct answer, or that, if they have, they choose to ignore it.

10.11 We have taken here a general example of a four-way intersection (*Fig. 10.2*). It has an obstruction to vision, e.g. a wall, hedge, etc., on the relevant corner. Our case car is driven by driver D_1. As he approaches the intersection he can see further and further along the street on his right. If he is careful, and a little fortunate also, he will be looking to his right and will see the second car, driven by driver D_2, at the instant that it appears from behind the obstruction to vision. Driver D_1 has now to make up his mind what to do. Should he slow down and let D_2 pass across in front of him? This is what is required by law in South Australia, viz. yield to the vehicle on the right. If D_2 is a long way back from the intersection D_1 may decide that he can get across first without risking a collision. These are the two principal alternatives. There is, of course, a third alternative, and that is to collide with D_2.

10.12 We may make it easier for the reader to follow the method we have used to estimate critical approach speeds if we consider first the collision case. Referring again to

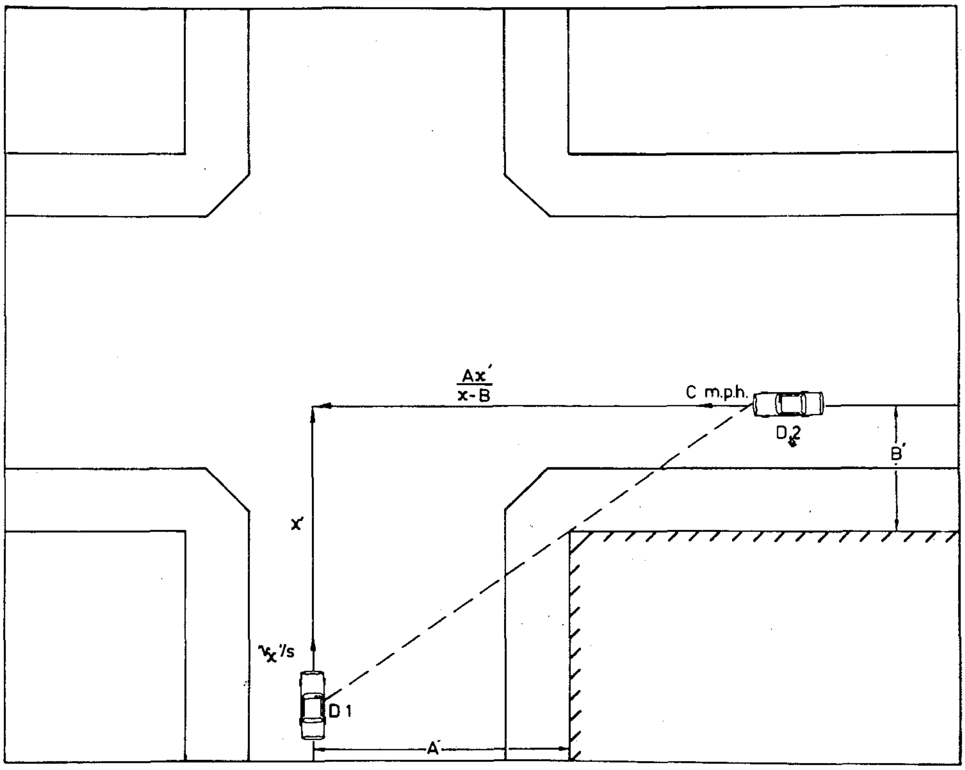


Fig. 10.2— General example of a four-way intersection

Fig. 10.2, we have D_1 travelling at v_X ft/sec when a distance X feet back from the path of D_2. The layout of the intersection stipulates that D_2 can be no further back from the path of D_1 than AX/(X-B) ft if D_1 is to be able to see him. If we set D_2 at AX/(X-B) ft back from the path of D_1 and assume him to be travelling at a steady speed of C m.p.h., we can readily find v_X, the speed of D_1, which will ensure that D_1 and D_2 will collide. We do this by allowing each vehicle the same time to reach the conflict point. D_1 will take X/v_x sec;

$$D_2 \text{ will take } \frac{AX}{(X-B)} \times \frac{1}{C} \times \frac{15}{22} \text{ sec}$$

(note that v_x is in ft/sec and C in m.p.h.). Therefore

$$v_x = X \times \frac{(X-B)}{(AX)} \times C \times \frac{22}{15} \text{ ft/sec} \qquad (1)$$

This means that, at any distance X feet back from the path of D_2, we can stipulate a steady speed v_x which will ensure that D_1 and D_2 collide. This is not desirable. We really want to know the value of v_X which will ensure that D_1 and D_2 do not collide.

10.13 Consider first the case in which D_1 decides to slow down or stop and let D_2 pass. We allow for this by defining v_X as the maximum speed from which D_1 can stop within X ft. This means that at any point distant X ft back from the path of D_2 the driver D_1 is travelling slowly enough to be able to stop his vehicle without encroaching on the path of D_2.

10.14 There are two additional factors involved here. The first is the braking performance of D_1's vehicle. We have found that in an emergency stop with locked wheels the braking performance depends mainly on the coefficient of friction between the tyre and the road surface. For our present purpose we may assume a constant retardation, R, for all vehicles for a given surface. This figure, in terms of stopping distance from 30 m.p.h., varies between 11 and 22 yd on dry bitumen, according to the physical characteristics of the particular road surface.

10.15 The second factor is the time taken by driver D_1 to see the other vehicle and to decide whether to stop or to continue on. If he decides to stop, this time is measured up to the instant that he applies the brakes. This whole interval we have taken as his reaction time, T. In each case we have assumed this to be 1 sec. We do not think this value is too large. It is true that under favourable circumstances, e.g. on a 'Miles' trainer, a person may recognize a hazard and apply the brake within 0.4 sec. In traffic when the driver must also look ahead and to his left he may not be looking to his right when D_2 first appears from behind the obstruction to vision. Casual observation of driver behaviour at intersections suggests that many drivers do not attempt to look to their right. For these reasons we believe that an effective reaction time of one second is unlikely to be too short.

10.16 Using the above notation we have

$$v_x^2 = 2R \times [X - v_x T]$$

(R in ft/sec/sec) which reduces to

$$v_x = -RT + \sqrt{R^2T^2 + 2RX} \text{ ft/sec} \qquad (2)$$

Note that we have not allowed for any clearance between D_1 and the path of D_2. This would need to be only 3 or 4 ft and would have only a small effect on the value of v_X in most cases, since X is much greater than 3 ft.

10.17 When considering the remaining alternative, viz. D_1 passing across in front of D_2, it is reasonable to allow some clearance, S (ft). We have allowed a constant value of 15 ft for S. This is measured back from driver D_1. We now have driver D_2 distant AX/(X-B) ft back from the path of D_1 and travelling towards the intersection

TABLE 10.1

LOCATION OF THE ACCIDENTS WHERE SPEED STUDIES WERE MADE

Accident No.	Suburb	Direction and Intersection
62	Adelaide	S on BROWN and Wright
155	Adelaide	E on GILBERT and Brown
73	Adelaide	E on HINDLEY and Gray
35	Adelaide	S on HUTT and South
77	Adelaide	S on HUTT and South
61	Clarence Park	S on EAST and Forest
292	Colonel Light Gardens	W on ROCHESTER and West Parkway
156	Cowandilla	W on COWANDILLA RD. and Turner Street
386	Croydon Park	N on SHILLABEER and Overland
412	Daw Park	E on MORGAN and Winston
162	Findon	E on RESERVE and Drummond
204	Glenelg	E on AUGUSTA and Gordon
315	Glenelg	E on CLIFF and McGilp
158	Hindmarsh	W on ADAMS and Manton
124	Hyde Park	E on COMMERCIAL ROAD and Westall Street
236	Kent Town	S on GOODEN and Rundle
318	Kent Town	S on GOODEN and Rundle
359*	Kent Town	S on GOODEN and Rundle
401	Malvern	N on DUTHY and Fairford
157	Malvern	N on DUTHY and Sheffield
223	Malvern	S on DUTHY and Winchester
346	Malvern	N on RUGBY and Fairford
191	Malvern	N on RUGBY and Wattle
117	North Adelaide	N on LEFEVRE and Ward
295	Norwood	S on EDWARD and William
297	Norwood	N on SYDENHAM and William
217	Payneham South	E on COORARA and James
284	Portland	N on LANGHAM and Wellington
196	Prospect	N on PROSPECT TERRACE and Gloucester
29	Royal Park	N on CROWN and Pine
106	Somerton	N on SCARBOROUGH and Cudmore
134	St. Morris	W on SEVENTH AVENUE and Green Street
240	Toorak Gardens	N on GILES and Kensington Road
185	Wayville	W on YOUNG and Joslin
31	Woodville Gardens	E on FIFTH AVENUE and Liberty Grove
382	Woodville South	S on OVAL and Cedar
348	Wattle Park	N on PENFOLD and Kensington

* Note: 318 differs from 359 in that the sight distance is restricted by parked cars (See para. 7.28)

point at C m.p.h. We arrive at an equation similar to eqn (1)

$$v_X = (X + S) \times \frac{(X - B)}{(AX)} \times \frac{22C}{15} \text{ft/sec} \quad (3)$$

Substituting for v_x from eqn (2)

$$-RT + \sqrt{R^2T^2 + 2RX}$$
$$= (X + S) \times \frac{(X - B)}{(AX)} \times \frac{22C}{15}$$

This is a quartic in X and is more difficult to handle than the following method.

Take a larger value, C_1, for the approach speed of D_2, e.g.

$$C_1 = C + 10 \text{ m.p.h.}$$

Then in eqn (1)

$$v_X = X \times \frac{(X - B)}{(AX)} \times \frac{22C_1}{15} \quad (4)$$

For the clearance distance to be S as stipulated we must have

$$v_X = (X + S) \times \frac{(X - B)}{(AX)} \times \frac{22C}{15} \quad (3)$$

TABLE 10.2

RESULTS OF MEASUREMENTS

Accident No.	Critical Speed (m.p.h.)	Total No.	No. Above Critical Speed	Highest Speed Recorded	Per Cent above Critical Speed	Per Cent above 35 m.p.h.	Assumed Speed of Car on Other Road	Highest Speed Recorded on Other Road	No. of Cases Recorded on Other Road
62	22.3	9	7	35	78	0	40	32	11
155	11.7	17	17	33	100	0	35	30	21
73	13.5	13	13	32	100	0	35	23	7
35	23.7	22	22	43	100	32	40	35	14
77	23.7	22	20	40	91	18	40	37	9
61	24.5	8	8	45	100	12.5	35	35	8
292	23.7	0	—	—	—	—	35	22	2
156	13.4	25	25	25	100	52	35	—	0
386	14.2	17	17	50	100	77	35	22	1
412	24.4	4	4	30	100	—	45	38	14
162	11.6	3	3	32	100	—	40	40	7
204	21.3	5	3	25	60	—	40	38	22
315	14.1	7	7	42	100	29	35	32	11
158	36.9	15	1	38	7	7	35	38	10
124	10.7	5	5	23	100	—	45	40	11
236	20.3	23	22	40	96	4	40	36	24
318	19.9	16	16	40	100	6	45	40	14
359	33.1	23	0	33	0	—	45	40	24
401	23.6	19	17	35	90	—	35	21	2
157	19.9	12	12	41	100	42	35	27	2
223	13.3	24	24	47	100	29	40	39	9
346	24.4	6	4	35	66	—	40	32	11
191	23.1	8	4	28	50	—	45	44	8
117	33.6	24	0	32	0	—	35	33	26
295	17.9	19	19	35	100	—	40	35	19
297	14.7	14	13	31	93	—	40	40	19
217	13.0	11	11	44	100	2	35	16	1
284	12.0	0	—	—	—	—	35	24	3
196	12.2	1	1	20	100	—	40	40	15
29	14.2	3	3	29	100	—	35	25	5
106	13.8	11	11	40	100	2	35	35	13
134	12.0	21	21	35	100	—	30	—	0
240	25.2	8	4	38	50	1	50	45	26
348	32.0	13	4	40	31	15	45	37	13
185	18.2	16	16	38	50	12.5	40	27	4
31	21.3	2	1	26	100	—	40	38	10
382	11.3	5	5	30	100	—	35	30	5
		451	363		81	14			401

Highest critical speed: 36.9 m.p.h.
Lowest critical speed: 10.7 m.p.h.

Our procedure is therefore to choose $C_1 = C + 10$, solve eqn (4) for X and hence v_X. Then calculate

$$C_2 = \frac{15AXv_X}{22(X - B)(X + S)}$$

Should $C_2 = C$ then the problem is solved and the value obtained for v_X is the required one. If $C_2 \neq C$, then we multiply C by C/C_2, obtaining a new 'corrected' value of C_1. Repetitions of this procedure will result in C_2 approaching the value of C. When $|C_2\text{-}C| \leqslant 0.5$, the corresponding values of X and v_X have been taken to be sufficiently accurate for the present purpose. Any error in v_X will be less than 0.5 m.p.h.

10.18 We have ignored the effect of D_1 accelerating in an attempt to avoid a collision. The values of X we have obtained, taken together with the corresponding values of v_X, allow a time of about 2 sec in which D_1 can accelerate. This will commonly make a difference of less than 5 ft in the distance D_1 travels. Even with a car having a high performance, this increase is not likely to be more than 15 ft. There is also the sobering thought that driver D_2 may try to accelerate past D_1. We have assumed a steady speed of approach for D_2.

10.19 We should emphasize here that although our calculation of critical speeds assumes an upper limit for the speed of the vehicle on the right, in no case in which the speeds of 15 or more such vehicles were obtained was our estimate in error by more than 5 m.p.h.*

10.20 TABLES 10.1 and 10.2 show the location of the accidents where speed studies were made and the results of the measurements.

ACCIDENTS AT A SIGNALIZED INTERSECTION

10.21 Curiously enough, the intersection which we attended most frequently in the course of our survey was controlled by traffic lights. We refer to Gepps Cross, which is situated near the northern boundary of the Adelaide metropolitan area (*Fig. 10.3*).

10.22 The history of this intersection is interesting. The present layout was set down and traffic lights began operating on July 17, 1959. The source of all knowledge, the barman of the hotel at this corner, assured us that there were many more accidents at the intersection after the lights had been installed. Unfortunately accident records are not available for the period before 1961, so we cannot check on the accuracy of this information. The records for 1961 to 1964 are shown in TABLE 10.3. The last column on the right refers to one particular type of collision now to be described. The phasing of the lights allows traffic to proceed north from M.R.2 into M.R.6 and M.R.2. It also allows traffic from M.R.2 to proceed south along M.R.2 or to bear right along Grand Junction Road. This means that there is a right of way situation between two streams of traffic, both of which have a green light. The alignment of their paths is such that there is frequently a third car travelling north on M.R.2 and bearing right to continue along M.R.2, which obscures the other two cars from each other.

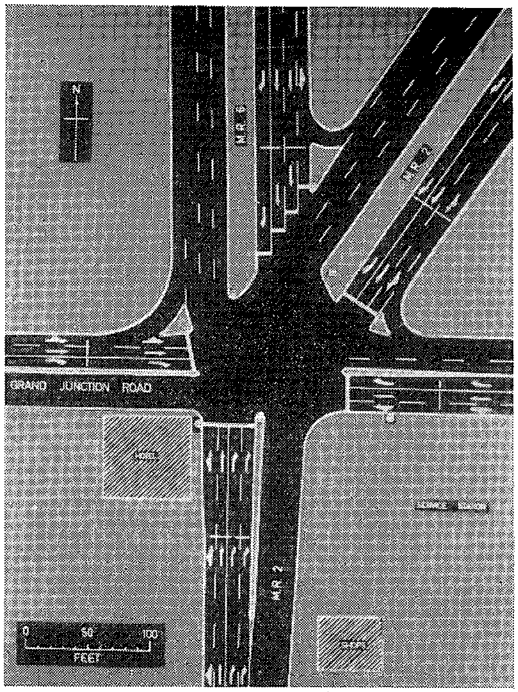


Fig. 10.3—Gepps Cross

*We wish to acknowledge the assistance of Mr. R. Kirby of the Department of Mathematics of the University of Adelaide in the derivation of this method.

TABLE 10.3

GEPPS CROSS

Year	Total Accidents Reported	Personal Injury Accidents	Collisions
1961	83	17	16
1962	89	7	21
1963	118	22	34
1964	143	25	39

10.23 The particular type of collision that results can produce serious injuries and severe vehicle damage. Over the 4 years listed above, this feature of the phasing of the lights accounted for one quarter — 110 —of all the accidents at this intersection. The severity of these accidents was such that they form half of all the personal injury accidents and account for half of the total value of property damage over this 4-year period. In 1964 the property damage from all 143 accidents was estimated to have been £15,000.

10.24 We attended six accidents at this intersection. Each one of these accidents can be directly attributed to deficiencies in the phasing of the traffic lights. Three cases were of the type described above, e.g. case 0320.

- **Case 0320**

A Volkswagen 1200 sedan was stationary, facing south, at the traffic lights on M.R.2. When the lights changed to green this car moved off and began to bear right to continue on along Grand Junction Road. An FE Holden sedan entered the intersection from the south at about 30 m.p.h. after the lights had turned green. This car was proceeding straight ahead, to enter M.R.6. Neither driver saw the other car until just before the left front corner of the Holden struck the left side and rear wheel of the Volkswagen, which was moving at about 20 m.p.h. The Volkswagen was spun twice by the impact and the front seat passenger, a 48-year old woman, was ejected. She was concussed, received many abrasions, and injured the small vertebrae at the base of her spine. The passenger in the left rear seat, a 19-year-old girl, received concussion, abrasions and bruises. The driver's face was lacerated on the left side. The 20-year old man driving the Holden was not injured. The damage to the left side of the Volkswagen is shown in *Fig. 10.4*. This accident happened on a fine, clear night.

10.25 The remaining three cases arose from the amber period allowing vehicles insufficient time to clear the intersection. Consider vehicles travelling west along Grand Junction Road (*Fig. 10.3*). The distance from the stop line to the far side of the intersection, plus the length of a car, is 135 ft. The amber period is 3 sec. There is no all-red phase. To cover 135 ft in 3 sec demands a minimum speed of 32 m.p.h. But a driver must be able, on seeing the green change to amber, either to stop before the intersection or cross over within the amber period. In this case, if a driver is travelling fast enough to cross the intersection, he is travelling too fast to stop should the amber phase begin when he is still some distance back from the stop line. With this phasing of the lights the condition is always present in which it is impossible for a driver to cross the intersection without risking a collision with a vehicle moving off from the southern leg of M.R.2; e.g. case 0239.

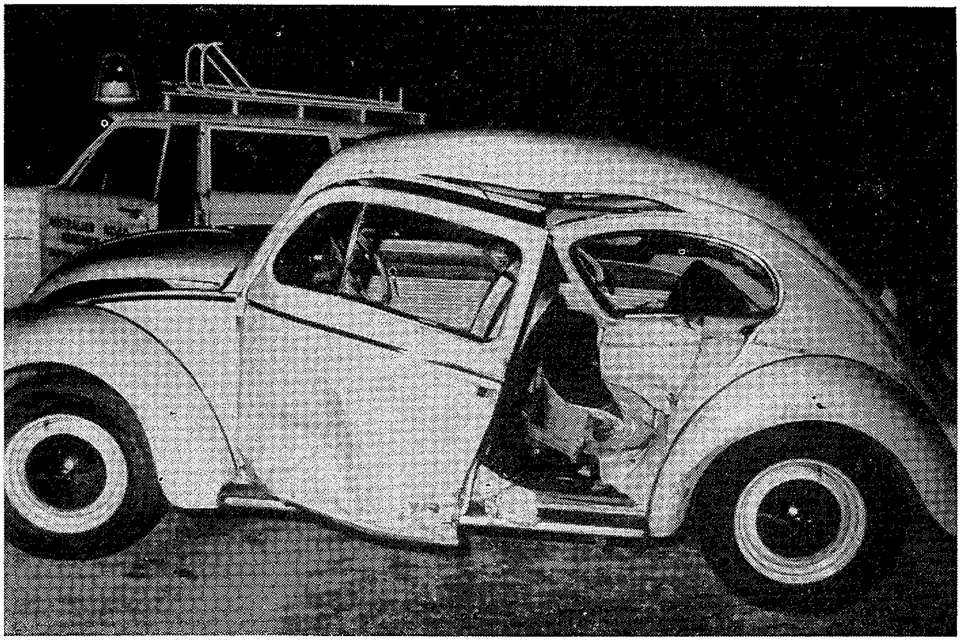


Fig. 10.4—The Volkswagen 1200 sedan from accident 0320

● **Case 0239**

A truck carrying a load of peaches, total weight 8 tons, was travelling west along Grand Junction Road at about 20 m.p.h. After entering the intersection the lights changed to amber and then to red. A motor-scooter moved off from the southern leg of M.R.2 (see *Fig. 10.5*). Although it was mid-day the rider could not see this truck because there was another truck alongside him on his right on M.R.2. The scooter hit under the left side of the tray of the truck and was run over by the rear wheels. The rider, a 32-year old man, received a fractured rib and multiple abrasions. His pillion passenger, a 30-year old woman, received abrasions and a deep laceration to the right knee. They were both wearing safety helmets. The driver of the truck was not injured. The truck was immobilized in what was rather a 'David and Goliath' sequence. As the left rear wheels passed over the scooter the rear spring broke, allowing the wheels to act as a roller between the bottom of the tray and the road. This dragged the rear axle back far enough for the tail shaft to pull out of the splines at the gearbox. The free end of the shaft then snagged on the road surface.

10.26 A similar situation exists for vehicles travelling south from M.R.6 into M.R.2. Here the distance from the stop line in the left hand lane to the south side of east bound traffic on Grand Junction Road is 165 ft. The situation is similar to that described above.

10.27 It is, of course, true to say that had the motorists been more observant and taken greater care these accidents may not have happened. But a similar remark applies to those responsible for the phasing of these lights. Unfortunately serious under-

Fig. 10.5—Gepps Cross: view looking west along Grand Junction Road. Arrows indicate wrecked motor-scooter and immobilized truck (accident 0239).

staffing of this section of the Highways Department means that the work of contractors who install traffic lights very often cannot be checked for some months or even years.

SKIDDING AND ACCIDENTS

10.28 Considerable emphasis is often placed on the relationship between skidding and accidents (Ref. 33). Skidding can result from cornering too rapidly (*Fig. 10.6*) and is also a feature of the post-impact motions of a car involved in a collision (*Fig. 10.7, 10.8* and *10.9*). There is, of course, always

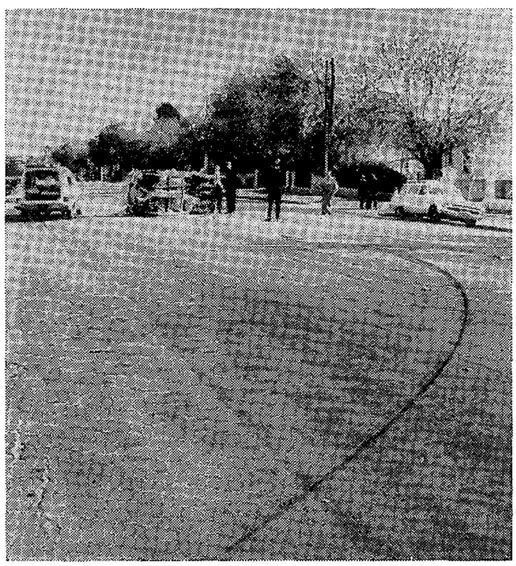


Fig. 10.6—The driver of this 1962 Renault Dauphine swerved to the left to avoid a vehicle on his right at an intersection. His car skidded and rolled over.

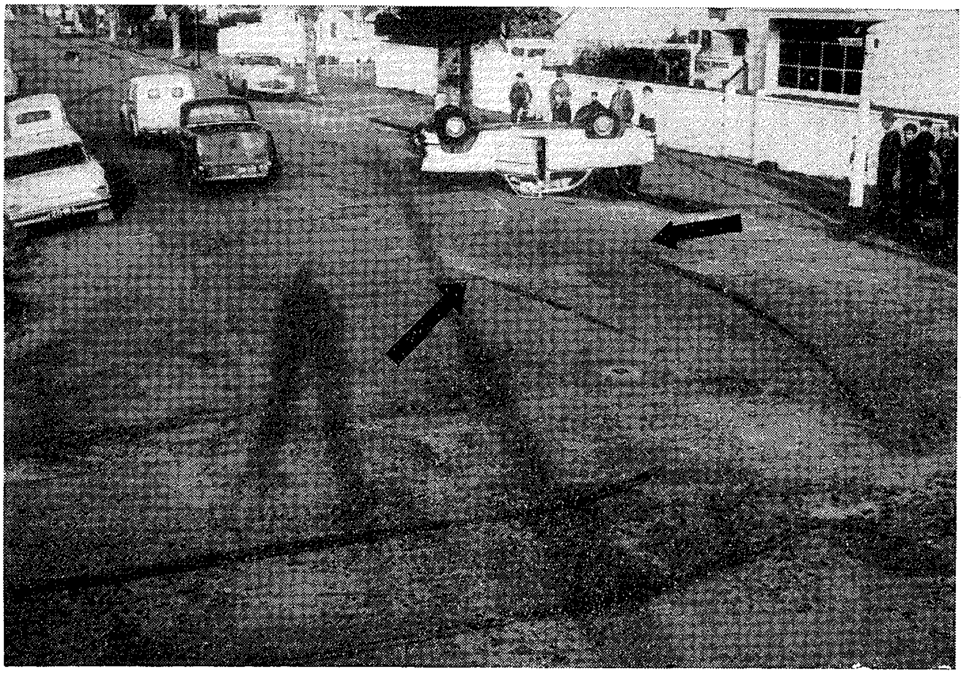


Fig. 10.7—The arrows indicate the ends of the skid marks made by the 1959 Ford Zephyr as it slid sideways before rolling over and after being struck on the left side by another car. The braking skid marks of the other car can be clearly seen

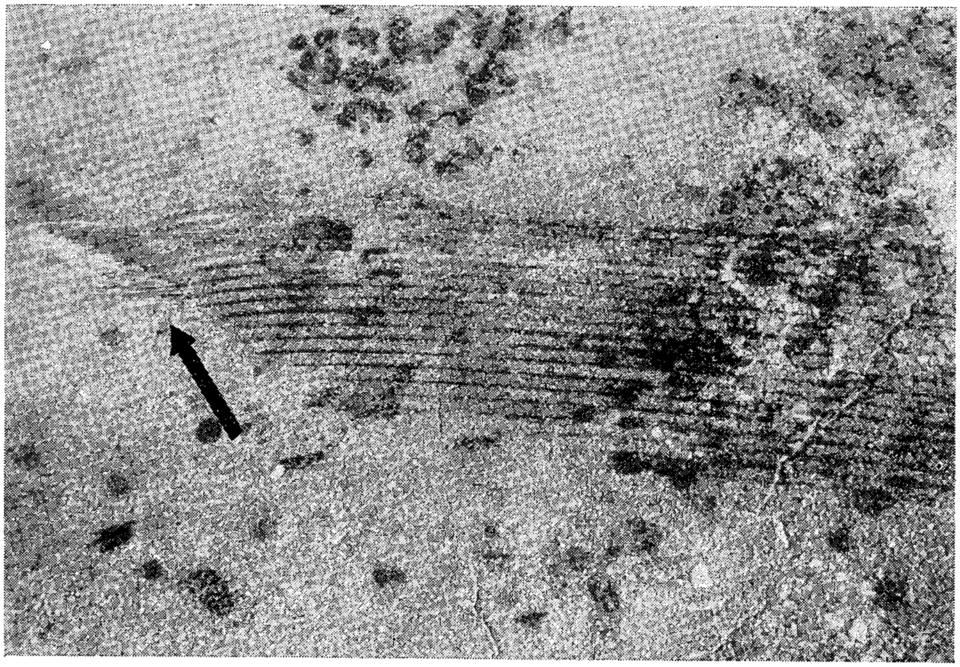


Fig. 10.8—The end of the skid mark shown by the right hand arrow in *Fig. 10.7*. The direction of travel here was from right to left. The arrow indicates a gouge mark made by the wheel rim

a small amount of sliding taking place between the tyres and the road, chiefly when cornering. In this section we are concentrating on skidding due to braking (*Fig. 10.10*).

10.29 When the road wheels of a moving car stop turning, the vehicle is sliding or skidding over the road surface. This has two important consequences. First, all steering control is lost. Second, the effective braking force is reduced because the force of friction between a rolling wheel and the road surface is greater than that for a sliding wheel. In other words, a skidding vehicle will take longer to stop from a given speed, and will not respond to the steering controls as long as all wheels are not rotating.

10.30 In an emergency, when it is necessary to stop in as short a distance as possible, it is therefore desirable not to lock the wheels, to achieve maximum braking and retain effective steering control. There are devices which will permit a driver to brake as hard as he can and yet not lock the wheels (Ref. 34). These have not yet found ready acceptance by the automobile industry. There may be some drivers who, in an emergency, can stop a car in the most efficient manner, i.e. braking as hard as possible without locking the wheels. We suspect that such people are few and that virtually all drivers will brake so hard that their vehicle is likely to skid in an emergency stop. The skid marks shown in *Fig. 10.11* were made by an experienced racing driver. In this survey we recorded the frequency of skidding due to braking and the type and condition of the road surface. Of the 623 motor vehicles for which this information was recorded, 180 skidded when braking. This does not mean that all of the remaining 443 vehicles were not also braking. Some of them doubtless were, but they did not skid.

Road surface

10.31 Whether or not the wheels lock depends, of course, on the skid resistance of the road surface. It is very easy indeed to skid on a surface covered with melting ice. It is much more difficult, fortunately, to do so on a dry concrete or sealed surface. All of the 180 vehicles which skidded were on bitumen roads. This is to be expected because, with only one or two exceptions, this was the only type of road surface encountered in this survey. The term 'bitumen surface' is at the best a rather vague one. It encompasses surfaces which vary in nature from the machine-laid 'hot mix' to the poorly maintained macadam-based surface found in many suburban side-streets.

10.32 Consider for the present only a clean dry bitumen road. There can be a great variation in the skid resistance of this type of road surface. We were able to confirm this at many accident locations by performing skid tests with our own vehicle. These tests were usually a series of two or three locked wheel skids from a steady 30 m.p.h. to a standstill. We repeated the test at each location until at least two values were obtained for stopping distance which were within 10 per cent of each other. Obviously a test of this nature can only be performed safely in very light traffic and where there are few pedestrians. This often meant that we had to return to the accident scene at an 'off-peak' period.

10.33 Under locked wheel skidding conditions the coefficient of friction between the tyre and the road surface is virtually the only factor determining stopping distance. Our tests gave stopping distances, from 30 m.p.h., varying from 11 to 22 yd on dry, clean bitumen. We realize that road test reports quote shorter stopping distances for braking from 30 m.p.h. On the same surface as that on which we achieved an 11

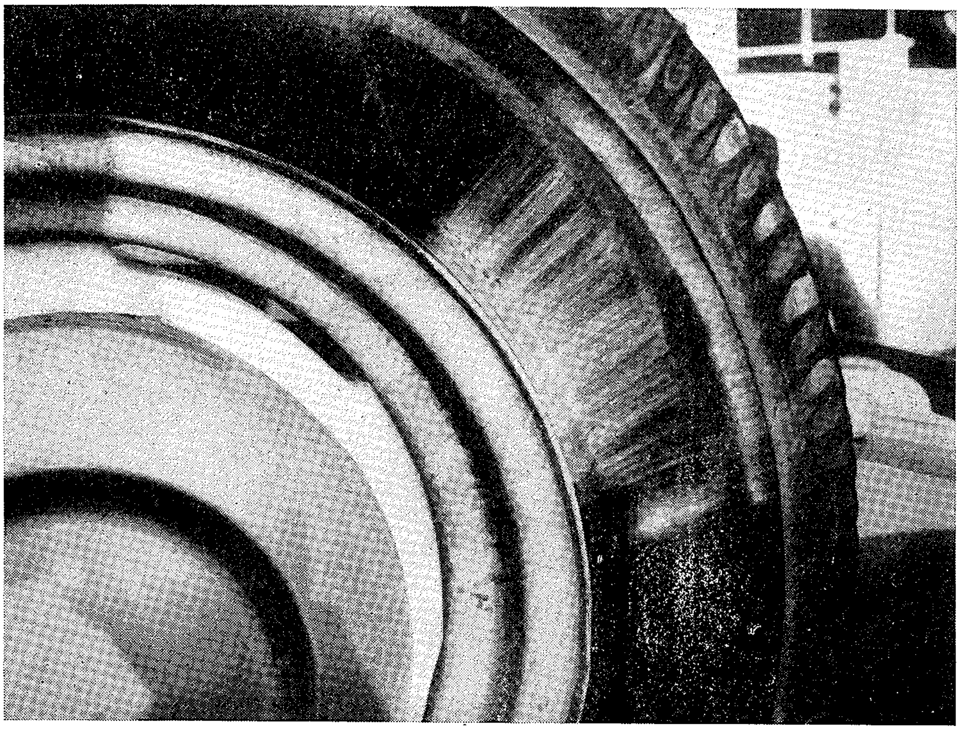


Fig. 10.9—Abraded wall of tyre which made the skid mark shown in *Fig. 10.8*

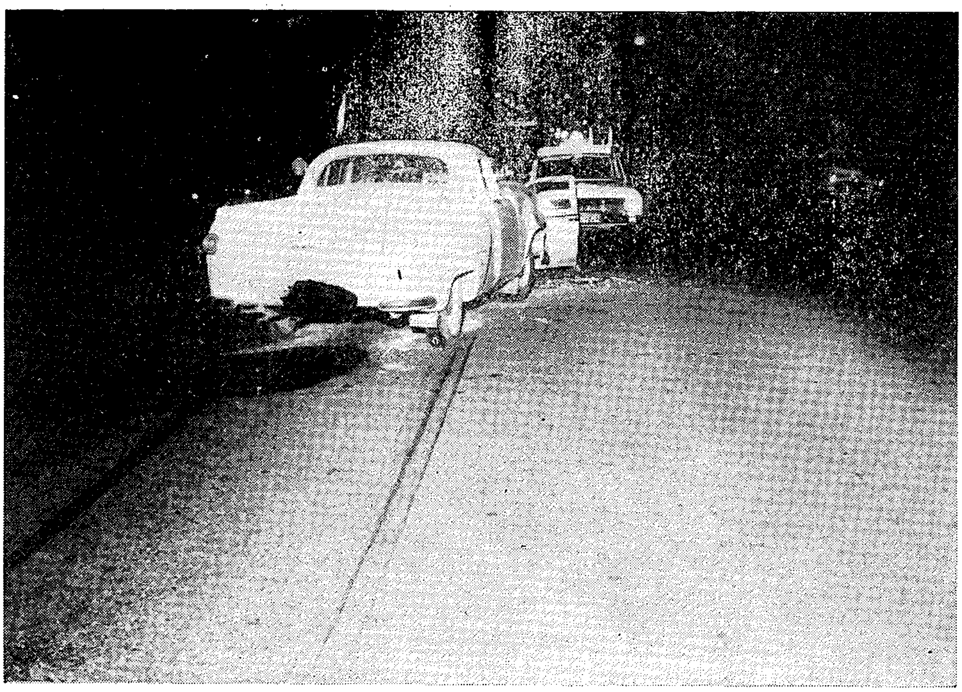


Fig. 10.10—Skid marks due to braking. This accident is also shown in *Fig. 8.4*

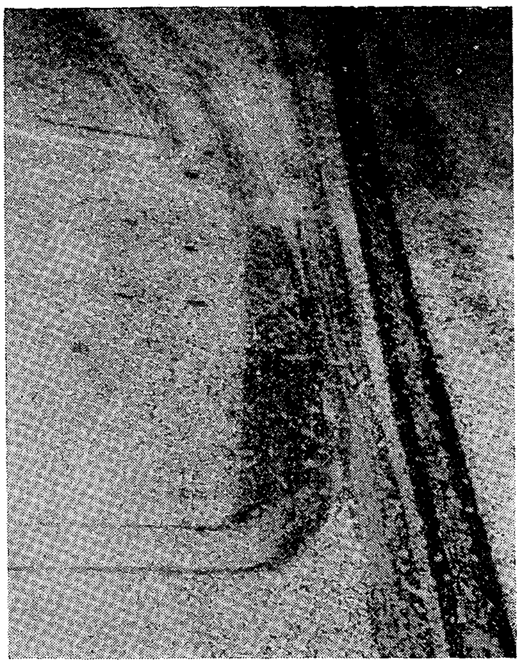


Fig. 10.11—The skid marks referred to in para. 10.30 are those on the right. The car which approached from the left was pushed sideways by the impact

yard skid length a shorter stopping distance could only be achieved if the wheels did not lock. Under the circumstances of a road test the driver knows in advance that he must stop, and may well be able to do so without locking the wheels. Once again, we doubt whether this would be the case in an emergency stop in traffic or at an intersection.

10.34 A stopping distance of 22 yards from 30 m.p.h. on a dry, clean bitumen surface is most surprising. The particular surface is shown in *Fig. 10.12* and *10.13*. The poor skid resistance is apparently due to the large aggregate being coated with bitumen, which is melted by the heat generated by the tyre sliding over it. The resulting skid mark is a molten tar mark and not an abraded rubber mark. The vehicle is in fact sliding on molten tar. We understand that this surface is a basecourse for the final layer of hot mix. As there often seems to be a delay of some months before the final layer is applied we suggest that signs be displayed warning motorists of the slippery surface.

10.35 Mention should be made in this section of the skid resistance of white road markings. The white paint that is commonly used for road markings has a skid resistance that is much less than that of a bitumen road surface. While it is most unlikely that the area of paint will be such that a vehicle

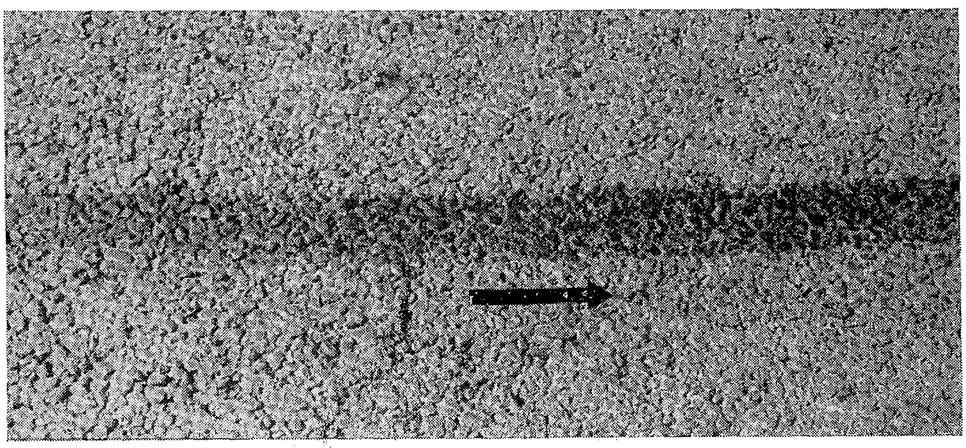


Fig. 10.12—The braking skid mark referred to in para. 10.34. The arrow indicates the direction of travel

Fig. 10.13—Detailed view of the skid mark and road surface shown in *Fig. 10.12*. The tape measure shows inches

will skid to a standstill on the painted surface alone, it is possible for even one wheel to skid on a painted marking and for this skid to continue onto the bitumen surface. In other words the painted area can initiate a skid in much the same way as a patch of oil on the road. Ref. 35 gives a discussion of the skid resistance of various road-marking materials.

10.36 Even a dry road surface will have its skid resistance reduced if it is covered with a layer of loose material. This was not very common; only 16 vehicles out of more than 600 were on such a surface, but 10 of these 16 vehicles skidded on the loose material. Some of these cases could have been avoided altogether if regular road maintenance had included the removal of loose material, e.g. by a street sweeping machine. The significance of skidding on loose material is accentuated when we look at the frequency of skidding on wet roads.

Weather conditions

10.37 The average annual rainfall in Adelaide is 21 in. This tends to come in short sharp falls of rain. The roads are therefore not wet as frequently as would be the case in an area of similar annual rainfall where light showers are more common. Much of the work that has been done in other countries on skid resistance has concentrated on wet pavements (Ref. 36 and 37).

10.38 Exactly one-eighth of the accidents in this survey occurred on wet roads. The ratio is very nearly the same when calculated on a vehicle basis. There were 75 motor vehicles travelling on wet roads at the time of their accidents, but only ten of these were recorded as having skidded. In

16 cases we were unable to tell whether skidding had occurred. We learned that while skid marks may not be obvious on a wet road, very often they will appear as the road dries out. Taking only the recorded cases of skidding on wet roads we find that in fact there are just as many cases of skidding on loose material. This highlights the importance of keeping sealed roads free from loose gravel and other material.

10.39 Temperature effects in Adelaide do not appear to be critical. The possibility of ice forming on the road surface is very remote. The softening of road tars in midsummer may be more of a problem. We have no example of this, but we did not investigate any accidents during the hottest months. The exceptionally long stopping distance of 22 yards from 30 m.p.h. was recorded when the road surface temperature was 80°F.

Tyres

10.40 Considerable emphasis is placed on the relationship between the condition of a vehicle's tyres and the risk of skidding, and hence being involved in an accident. Many insurance assessors will question damage claims if the tyres of the particular vehicle are not in 'good' condition. TABLES 10.4 and 10.5 relate the condition of the tread of the tyres of motor vehicles in our survey to the incidence of skidding due to braking (excluding those cases in which we were unable to tell whether skidding had occurred or not). In this assessment we have taken a 'good' tyre to be one with a well defined tread pattern, the depth of tread being at least 1/10th of an inch. If even one tyre on the vehicle could not be classified as 'good' we have placed that vehicle in the 'worn' tyre category.

10.41 Looking at each of the three columns of figures in TABLES 10.4 and 10.5 we see that more vehicles with good tyres (94) skidded than did those with worn tyres (67). This was so even for skidding on wet roads, although here the numbers are small (7:3). It is tempting to deduce from this that it is better to have worn tyres if one wishes to minimize the risk of skidding. This, of course, is not so, but further consideration

TABLE 10.4

SKIDDING DUE TO BRAKING

	Road Surface		
	Wet	Dry	Totals
Vehicles with good tyres	7	87	94
Vehicles with worn tyres	3	64	67
Condition of tyres not recorded			19
Total			180

TABLE 10.5

NO SKIDDING DUE TO BRAKING

	Road Surface		
	Wet	Dry	Totals
Vehicles with good tyres	25	159	184
Vehicles with worn tyres	23	166	189
Condition of tyres not recorded			70
Total			443

of these figures will suggest that tyres in poor condition play a much smaller role in metropolitan accidents than is commonly supposed.

10.42 The first point we must make is that we do not know how many vehicles were in fact braking. If we knew this, and also knew how many had good tyres and how many had poor tyres, we could then compare these figures with TABLE 10.4. This would enable us to form some estimate of how much difference the condition of a vehicle's tyres makes to whether or not it skids when braking. The second point is that even if we could do this we are still assuming that other conditions are constant. This is not so. As we have seen, the skid resistance of even dry clean bitumen surfaces can vary by as much as 100 per cent.

10.43 The recent development of high hysteresis rubber which improves the non-skid performance of a tyre is unlikely to have biased these figures at all. Such tyres were only just coming on to the market in Adelaide during the last year of our survey.

10.44 The risk of a tyre 'hydroplaning' is related to the design and condition of the tread. The phenomenon is chiefly associated with high speeds on very wet roads and is unlikely to be a significant factor in metropolitan accidents.

10.45 Bearing in mind these very important qualifications we can now look at TABLE 10.5. This table shows us that of those vehicles which did not skid there are almost equal numbers of vehicles with good tyres as with worn tyres. This indicates that there is unlikely to be a bias in TABLE 10.4 arising from there being more vehicles with good tyres. Why then have more vehicles with good tyres skidded than have those with worn tyres? Possible reasons to explain this curious result have been mentioned. But these other factors would have to be shown to be very significant indeed before one could justly claim that worn tyres play a major role in the causation of metropolitan traffic accidents.

Information from skid marks

10.46 Skid marks on the road convey much more information than merely an indication that a vehicle has skidded. *Fig. 10.11* shows that one car has been knocked sideways on impact.

10.47 We have assumed that the coefficient of friction between a skidding tyre and a uniform road surface is independent of both the weight and speed of the vehicle. This has enabled us to relate the length of our test skids to those of a vehicle involved in an accident and so calculate the speed lost by that vehicle in the skid. This will give us a complete picture only in accidents in which any collision is of a minor nature as far as the skidding vehicle is concerned, e.g. a collision between a car and a pedestrian. In some pedestrian accidents we were able to calculate the speed of the vehicle when the wheels started to skid and its speed when it hit the pedestrian, the point of impact being located by scuff marks made by the pedestrian's shoes, as long as the vehicle did skid to a stop. Collisions between vehicles usually restricted us to estimating the difference between travelling and impact speeds, i.e. the speed lost by skidding before the actual collision.

10.48 The position of the wheels on impact is often very clearly defined (*Fig. 10.14*). As we have mentioned above, all steering control is lost when a vehicle skids. If all four wheels lock a car will continue straight ahead. The only deviation, if any, will be due to the car sliding down the camber of the road or to irregularities in the road surface. The sharp deviation in the skid marks running down from the top of *Fig. 10.14* is due to the impact of a bus from the left of the picture. Note that the deviation in the skid marks made by the bus is slight when compared to that of the other

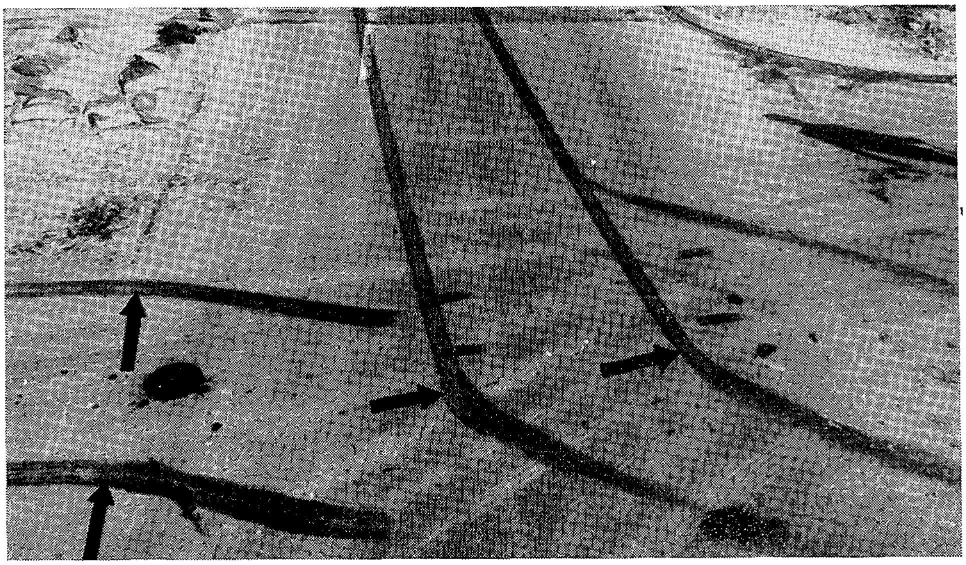


Fig. 10.14—Collision between a bus and a car. The arrows indicate the positions of the front wheels of the car and bus on impact

set of skid marks, which were made by a car. Under certain conditions it is possible to relate the momenta of the vehicles on impact by measuring the angle through which the skid marks have been deflected. We say 'under certain conditions' because there are many variables, such as the point of impact on the struck car, which can influence the magnitude of this deflection.

10.49 The post-impact path of a car may also be clearly shown by its skid marks. In *Fig. 10.14* the car, which was struck on the right side, has been pushed sideways while still retaining some forward motion. The resulting path is as shown. Note that the back wheels, which were tracking behind the front wheels before the impact, have followed paths that are parallel to but separate from the front wheels after impact. If the track and wheelbase of the car are known it is possible to determine the position of the car at any point along its skid marks. This can be of great assistance when trying to find out what was happening to a car at the moment when, for example, an occupant was ejected. This method has enabled us to show that ejection of a car occupant, through a door of the car, often occurs as the car slides sideways after a collision.

10.50 If skidding does not take place on all four wheels the vehicle may tend to yaw away from the initial direction of travel. This is the case when only the rear wheels skid. The following case is an excellent illustration of this.

● **Case 0423**

A 21-year old male driving a Morris Mini Minor along a suburban street saw a truck enter the street some distance ahead. The car driver braked hard, locking the rear wheels. In an excellent demonstration that the coefficient of sliding friction is less than that of rolling friction, the car yawed to the right and was actually travelling sideways as it sideswiped the truck (see *Fig. 10.15*). The impact encouraged the rotation of the car, which spun through a full turn before coming to rest. The driver sustained a lacer-

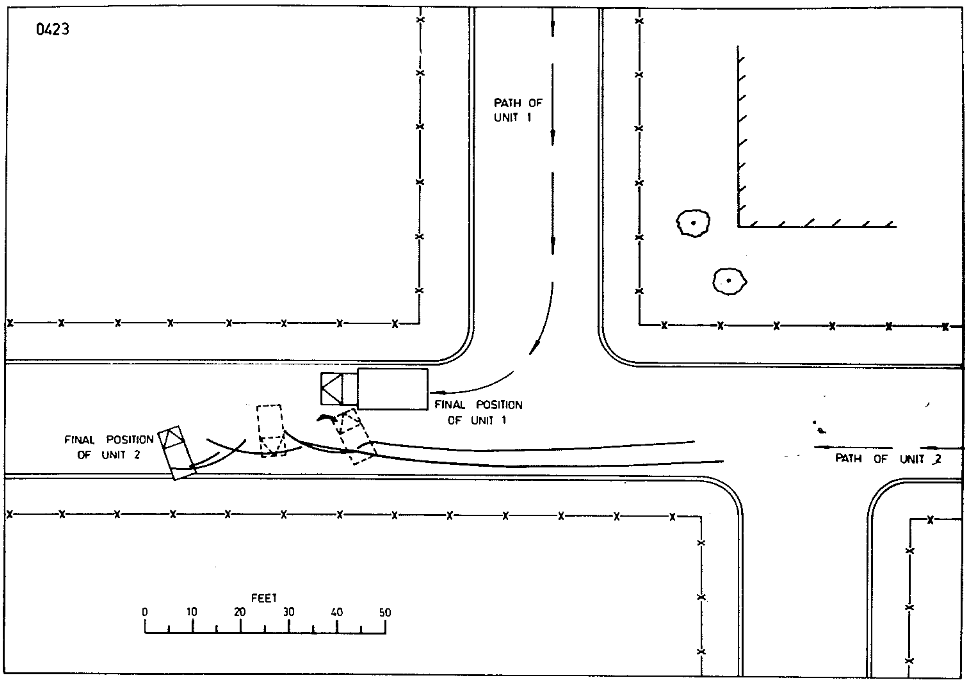


Fig. 10.15—Case 0423

ated forehead and a bruised arm. His initial speed would have been in the range of 50 to 60 m.p.h. The safe speed at this intersection is less than 20 m.p.h. He confided to us that he was having a replacement cylinder head prepared which, when fitted, would make his car 'really fly'.

Summary on skidding and accidents

10.51 We have tried to show that skidding is affected by many factors which are consequently themselves related to the causation of traffic accidents. Probably the most significant of these factors is the skid resistance of the road surface itself. There is room for a great deal of improvement both by avoiding the use, even for limited periods, of surfaces which are known to have a poor skid resistance and also by reducing the great variations in skid resistance which exist between different but apparently similar surfaces.

ACCIDENTS AT INTERSECTIONS

10.52 TABLE 10.6 lists the location of the car accidents that did not involve any other type of vehicle or a pedestrian. Once again we must point out that the layout of the streets in the Adelaide metropolitan area is such that there are very many intersections which are joined by wide, straight roads.

10.53 The accidents at intersections are particularly interesting when we look at the numbers happening at stop signs and traffic lights. Taken together (there were 17 car accidents at stop signs and 25 at traffic lights), these two groups of accidents account for 42 out of the 129 accidents at intersections. We now go on to discuss all the accidents in our survey which occurred at stop signs and traffic lights.

Stop signs

10.54 The stop sign (*Fig. 10-16*) naturally requires a driver to stop, but having stop-

TABLE 10.6

LOCATION OF CAR ACCIDENTS NOT INVOLVING PEDESTRIANS OR OTHER TYPES OF VEHICLE

Location of Accident	Number of Accidents	Percentage
At an intersection	129	70.5
Within 20 yd before an intersection	4	2.2
Within 20 yd after an intersection	10	5.5
Not at an intersection	40	21.8
Total	183	100
Total *intersection-type* accidents	131	70.5

ped, this vehicle then has right of way over traffic approaching from the left. Twenty-five of 129 accidents at intersections in our series were at intersections where there were stop signs. Three of these 25 cases are of no particular interest as far as behaviour at stop signs is concerned. These were cases where a vehicle was stationary at a stop sign when hit by another car which had been involved in a previous collision.

10.55 Nine vehicles that had stopped as required at a stop sign collided with a vehicle on the intersecting road. This vehicle was approaching from the right in five cases, and from the left in the other four cases. There are two points to mention here. One is the role of a third vehicle which creates a 'blind spot' for the driver moving off from the stop sign. Either these drivers did not realize that a vehicle might be hid-

Fig. 10.16—Stop signs: this semi-trailer was unable to slow down sufficiently to avoid hitting the car which had moved off from the stop sign (arrow) on the far side

den behind the third car or they decided, foolishly, to take a chance that the road was clear. The other point is that some drivers do not seem to appreciate that, if they move off suddenly from a stop sign, approaching traffic may not be able to stop in time to avoid a collision.

10.56 In 11 of these 25 accidents we are certain that one vehicle did not stop at the stop sign. There are a further two cases in which we suspect that this was so. One of these 11 cases resulted in the death of a passenger in the car which drove through the stop sign. At some locations a single stop sign on the left side of the roadway may not be adequate. An overtaking vehicle may not be able to see the sign because it is obscured by the overtaken vehicle. At intersections where the roadway has been widened, e.g. for a bus stop, the sign may well be to one side of driver's line of sight. In such circumstances an additional sign on the right hand side of the road, or on a median, may reduce the risk of error.

Warning signs

10.57 Of the warning signs that are used in this area the most common is probably the cross roads warning sign. We presume that cross road warning signs are erected at a busy intersection because the risk of

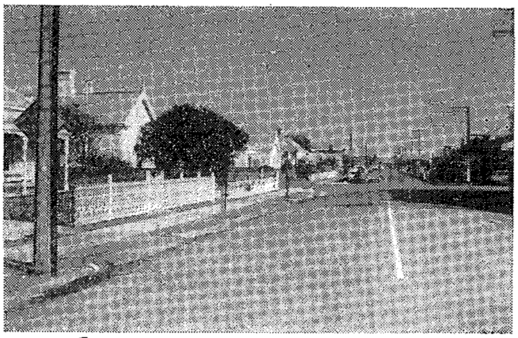


Fig. 10.17—Note the cross-road warning sign hidden by the utility pole. The car in the distance had just been pushed back onto its wheels after being rolled over in a collision

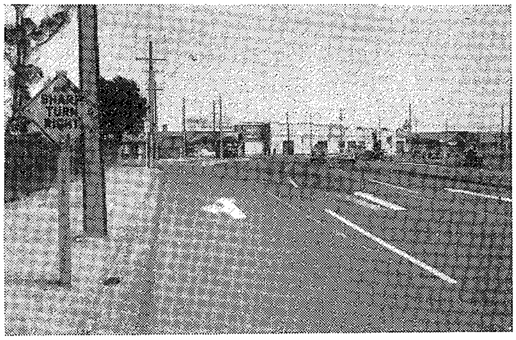


Fig. 10.18—Warning sign left in position after changes to the road layout

a collision there is greater than is the case at a less frequented intersection. How heavy must the traffic be, or how many accidents must take place, before an intersection warrants warning signs? Do intersections that lack such signs demand less care on the part of the motorist?

10.58 Maintenance of signs is important, and this includes such details as cutting back foliage to ensure that the sign is not hidden from the motorist. A far more confusing situation for the motorist is shown in *Fig. 10.17,* in which a utility pole has been placed directly in front of a cross road warning sign (the car at the intersection had just been rolled back onto its wheels after a collision).

10.59 Redundant signs are also obviously undesirable, e.g. *Fig. 10.18.* If drivers become accustomed to ignoring a sign such as this they may tend not to pay attention to more important signs.

Traffic lights

10.60 Thirty-seven of these 408 accidents were at traffic lights. We have discussed accidents at one particular signalized intersection but we list here the general types of accidents at traffic lights. These accidents consisted of two main groups. In one group both vehicles were proceeding straight across the intersection. In the other group of accidents one vehicle was turning right. The few remaining cases were collisions with pedestrians and one of the types of accident which we have discussed in relation to the Gepps Cross intersection (para. 10.21).

10.61 There were 16 collisions in which both vehicles were proceeding straight across the intersection. The most common feature in these 16 accidents was a collision between two vehicles during or at the end of the amber phase of the lights. An all-red phase seems to be the only way to minimize this type of collision. In our view the consequent reduction in traffic flow is a fair price to pay for increased safety.

10.62 Three of the accidents in this group were at Gepps Cross and have been discussed in detail elsewhere in this section. There were two cases in which a driver mistook a green 'turn left' arrow for the green light for 'straight ahead'. Casual observation suggests that most drivers realize their mistake and stop before proceeding further across the intersection, but these cases show that there are exceptions. There may be improvements that could be made to the arrangement of traffic lights in such situations to minimize the risk of wrong interpretation. Finally, there was one accident which may have been partly caused by the late afternoon sun shining straight into the traffic lights, making it very difficult to decide which of the three lights was illuminated. If such extraneous light could be absorbed rather than reflected by the traffic light this chance of error would be eliminated.

10.63 The second main group of accidents at traffic lights involved a vehicle turning right across the path of another vehicle approaching the intersection from the opposite direction. This is the classic type of motor-cycle accident in our series, and five of these 15 accidents involved a motorcycle which was hit by a turning vehicle. In one case, which has been described in the section on motor-cycle accidents, the driver's statement suggested that the lights may have been on split-phase operation, i.e. the car turning right had the red light come on while the motor-scooter still had a green light. This can easily cause confusion, which may result in a severe collision. Whenever there is a conflict between the efficiency of the traffic flow and the safety of road users, as there is at this intersection (West Terrace and Currie Street), we believe that safety should take precedence over efficiency.

10.64 At one other intersection (Prospect Road and the Main North Road) the arrangement of the lights suggested to drivers turning right, across traffic from Prospect Road to enter the Main North Road, that they had the green light to proceed against oncoming traffic whereas in fact they did not.

INJURIES TO CAR OCCUPANTS

11.1 There were 1,029 car occupants seated in the 542 cars involved in our survey. This is an occupancy rate of 1.9 persons per car.

11.2 The 228 occupants of cars which collided with pedestrians, pedal cycles, and motor-cycles were injured much less than those involved in collisions with other cars, trucks and fixed objects, and in rollover accidents. The injuries to each group are set out in TABLE 11.1. From this table it can be seen that 2.63 per cent of car occupants involved in collisions with pedestrians, pedal cycles and motor-cycles were injured to some degree, whereas 63.2 per cent of car occupants involved in the other more severe collisions were injured.

11.3 In the collisions with pedestrians, pedal cyclists etc., two drivers received small lacerations to the face when they were struck by fragments of tempered glass from the side windows which were broken by a pedal cyclist (case 0328) and a motor-cyclist (case 0087). In another case (0115) a motor-cycle and sidecar struck the side of a car at an intersection. The car rolled over, and the driver sustained a central corneal abrasion to his left eye, cause not known. In accident 0374 a utility ran into the rear of a cyclist, killing him, and then swerved across the road, striking a steel and concrete utility pole. The three occupants were ejected. The driver, a male aged 40 years, suffered concussion, a fracture of the left scapula and compression fractures of the 8th, 11th and 12th thoracic vertebrae. The centre front seat passenger, a 4-year old male, suffered concussion and lacerations of the left eyelids, and the left front seat passenger, a female aged 34 years, sustained concussion and facial abrasions, fractures of the right 10th and 11th ribs, and lacerations of both shins. None of the other 221 persons involved in collisions with pedestrians, pedal cycles, and motor-cycles, were injured at all.

11.4 There were only two deaths among car occupants. In case 0369 a 13-year old boy was seated under a canopy in the tray

TABLE 11.1

INJURIES TO CAR OCCUPANTS

	Degree of Injury							
	Nil	Minor	Moderate	Severe	Very severe	Fatal	Not recorded	Total
Occupants of cars colliding with motor-cycle, pedal cycle, pedestrian	221	2	3	1	0	0	1	228
Occupants of cars colliding with cars, trucks, fixed objects and rollover	292	335	126	32	7	2	7	801
Total	513	337	129	33	7	2	8	1,029

of an Austin A40 utility which rolled over on a bend and struck a tree (*Fig. 11.1*). The boy was found alongside the tree and died soon afterwards from head and chest injuries which were probably sustained when he hit the tree. In case 0235 a 27-year old woman, the left front seat passenger of a Morris Minor which was struck on its left front door by a large car, sustained head and chest injuries and died some days later. Her 3-year old son, who was seated on her lap at the time, suffered concussion and small lacerations to the head.

11.5 We will now consider the occupants of cars which had the more severe collisions — with cars, trucks, fixed objects and those with rollover only. TABLE 11.2 shows the distribution and degree of injury by body area. Each person is counted once in each body area. The number of persons injured in each body area to each degree of injury is expressed as a percentage of the total number of persons injured. Injuries to the head are most common, followed by lower limb, upper limb, thorax, abdomen, and spine and pelvis. However, most of the limb injuries are minor (abrasions and bruises), as are about two thirds of the head injuries. Expressed differently, 26.1 per cent of head injuries are moderate to fatal in degree, as are 6.2 per cent of thoracic injuries, 1.0 per cent of abdominal injuries, 2.0 per cent of injuries to the spine and pelvis, 3.8 per cent of upper limb injuries and 3.4 per cent of lower limb injuries. This means that head injuries make up almost half of the injuries which war-

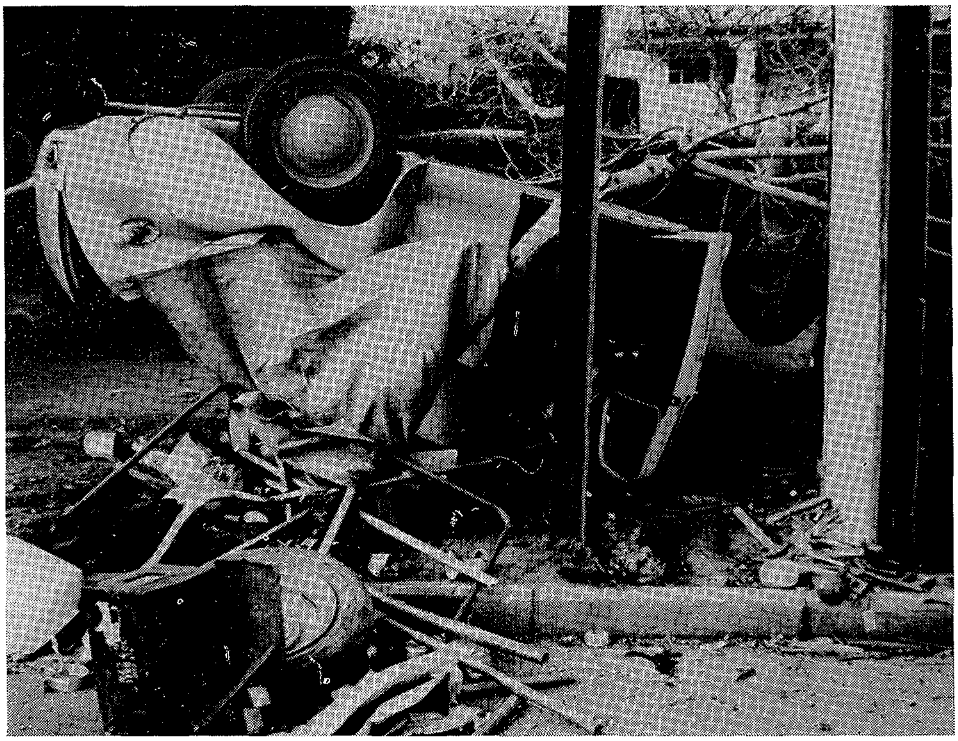


Fig. 11.1—A passenger in the back of this 1951 Austin A40 utility was killed when it overturned and struck a tree

TABLE 11.2

DISTRIBUTION AND DEGREE OF INJURY BY BODY AREA

	Head and neck	Thorax	Abdomen	Spine and pelvis	Upper limb	Lower limb
	No. %	No. %	No. %	No. %	No. %	No. %
Minor	220 (44.0)	66 (13.2)	13 (2.6)	0 (0)	135 (26.9)	246 (49.0)
Moderate	116 (23.1)	24 (4.8)	2 (0.4)	3 (0.6)	10 (2.0)	6 (1.2)
Severe	9 (1.8)	5 (1.0)	1 (0.2)	5 (1.0)	7 (1.4)	7 (1.4)
Very severe	4 (0.8)	1 (0.2)	1 (0.2)	2 (0.4)	2 (0.4)	4 (0.8)
Fatal	2 (0.4)	1 (0.2)	1 (0.2)	0 (0)	0 (0)	0 (0)
Total	351 (70.1)	97 (19.4)	18 (3.6)	10 (2.0)	154 (30.7)	263 (52.4)

rant admission to hospital, or cause death.

INJURIES TO EACH BODY AREA

11.6 We will now discuss particular injuries to each part of the body. Again, we do not include the occupants of cars which struck pedestrians, pedal cyclists or motorcyclists, for they were very rarely injured.

Head injuries

11.7 As we have seen previously, head injuries are the most common injury received in car accidents, 351 persons receiving head and neck injuries. Fifteen of these also received neck injuries. Each person is counted only once for soft tissue injuries in each area, but each skeletal injury and concussion is counted separately, i.e. one person may have more than one skeletal injury. These injuries are set out as follows.

The column at the far right shows the percentage of persons with head injuries (N = 351).

Soft tissue injuries of the face		265	75.5%
lacerations	120		
bruises	88		
abrasions	57		
Fractures of the face		18	5.1%
nose	8		
maxilla	4		
teeth	5		
mandible	1		
Concussion		121	34.5%
Soft tissue injuries of the scalp		67	19.2%
lacerations	33		
bruises	31		
abrasions	3		
Fractures of the skull		2	0.06%
mastoid and petrous temporal bone	1		
base of skull	1		

One hundred and twenty (or 34.2 per cent) of the persons with head injuries sustained lacerations to the face. These lacerations are important cosmetically, for they will cause some degree of disfigurement, and they need expert treatment to minimize the residual scarring.

11.8 There are some characteristic lacerations produced by certain structures inside the car. Sunvisor hinges (*Fig. 11.2*) cause a 'U' shaped laceration, at or above the hairline (*Fig. 11.3*). The rear vision mirror is usually struck by the forehead, nose and upper cheek, producing a series of small lacerations as the plate glass shatters into fragments (*Fig. 11.4*). When a car occupant strikes a tempered glass windscreen with sufficient force to break it, he usually receives small shallow lacerations from the small fragments of glass. If his head, after the initial impact which breaks the glass, travels downwards towards the lower edge of the windscreen, he breaks out the glass fragments remaining in the frame,

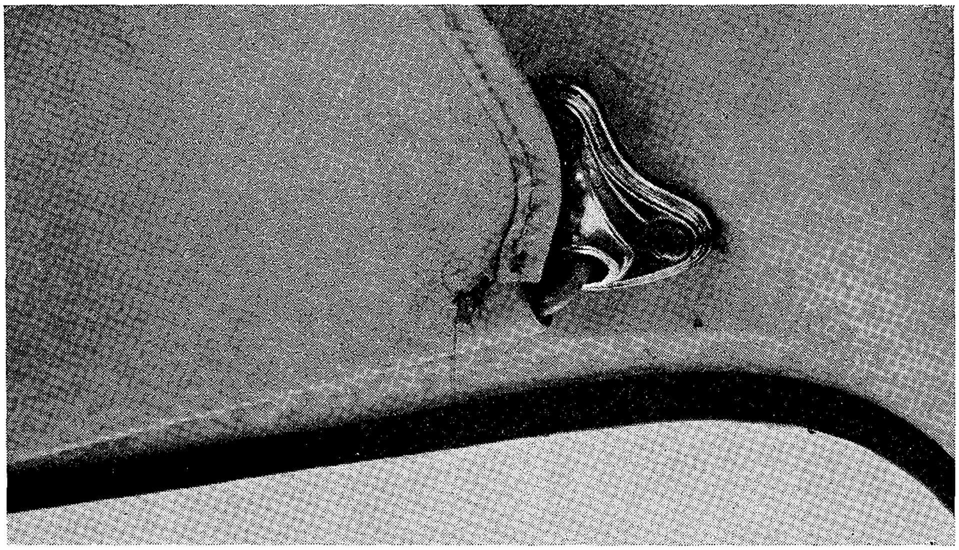


Fig. 11.2—Sunvisor hinge: note skin and hair caught in lining

producing lacerations to the lower surface of the chin (*Fig. 11.5*) and a characteristic shape to the hole in the windscreen (*Fig. 11.6*).

11.9 Impact with a laminated glass windscreen seems to produce severe lacerations if the glass is penetrated by the head (*Fig. 11.7*), the face being cut by the sharp edges exposed. If the laminated glass is not penetrated (*Fig. 11.8*) the lacerations are smaller and less severe. The three cases of lacerations to the face from laminated glass all involved the eyebrow and forehead, an important area cosmetically. There were few fractures of the facial bones. The worst was in a woman who was struck on the face by the hub of the steering wheel (*Fig. 11.9*). This produced severe lacerations of the forehead, nose, cheek, mouth and chin, with a depressed fracture of the right maxilla (*Fig. 11.10*). Another girl fractured her lower jaw in several places, again on striking the steering wheel hub.

Fig. 11.3—Laceration in driver's forehead, produced by sunvisor hinge shown in *Fig. 11.2*

11.10 One hundred and twenty-one persons (34.6 per cent) suffered concussion. That is, more than one third of those suffering head injuries would require hospitalization for this cause alone. 19.1 per cent of persons sustained soft tissue injuries of the scalp, and 2 per cent suffered fractured skulls.

Windscreens

11.11 Head injury from striking the windscreen is quite common (see TABLE 11.3). There were 48 cases where the car occu-

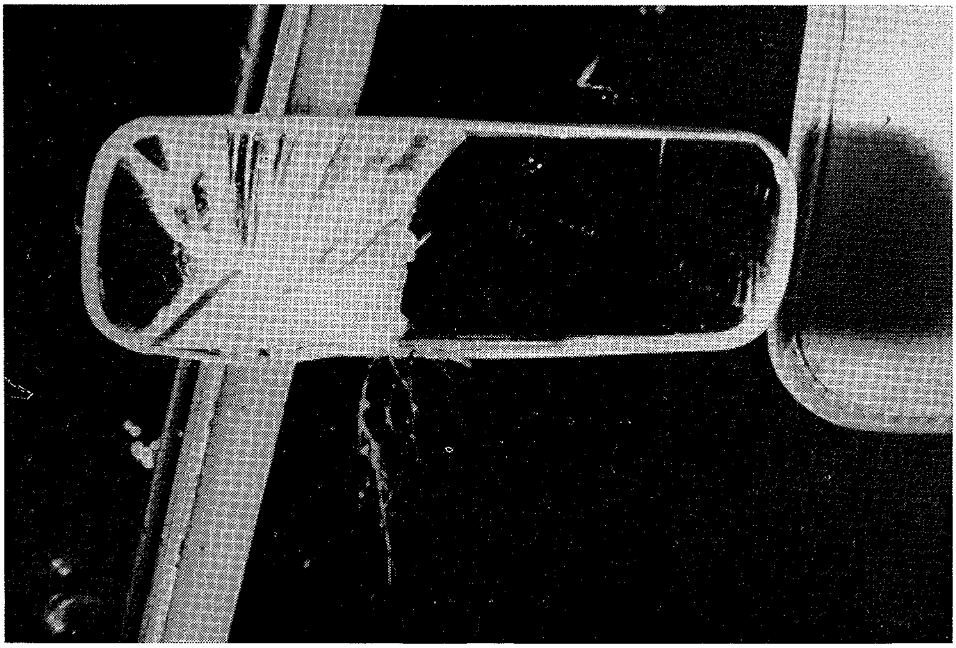


Fig. 11.4—Rear vision mirror struck by face of front seat passenger. Note characteristic fracture of glass and hairs and skin adhering to frame

Fig. 11.5—Lacerations to chin and right ear produced by impact with tempered windscreen

Fig. 11.6—Characteristic shape of hole in tempered glass windscreen after impact by occupant's head

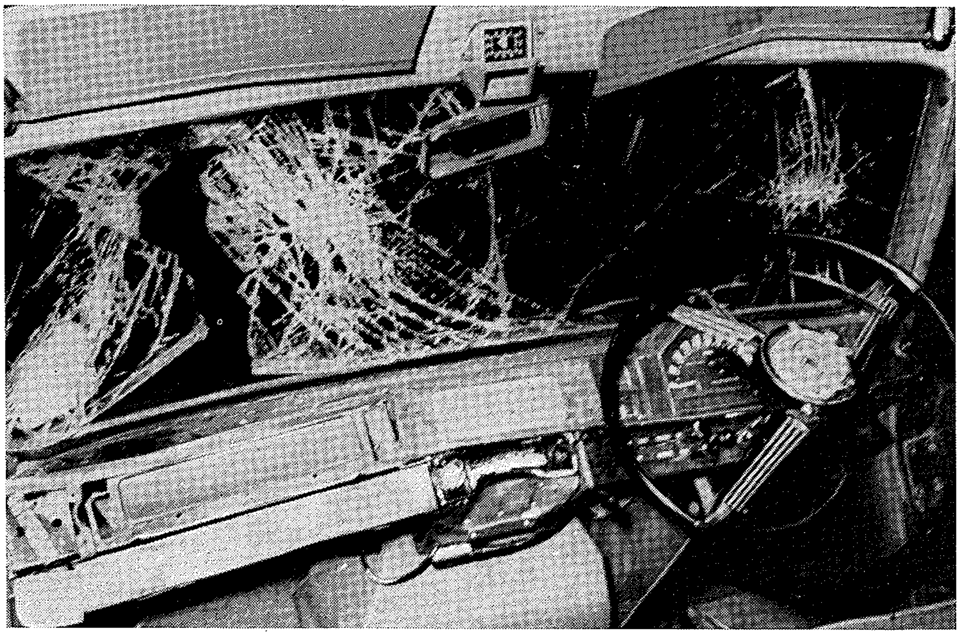


Fig. 11.7—Case 0430: laminated glass windscreen penetrated by passenger's head, resulting in severe lacerations of forehead

Fig. 11.8—Laminated glass windscreen not penetrated by occupant's head; minor lacerations of the face resulted

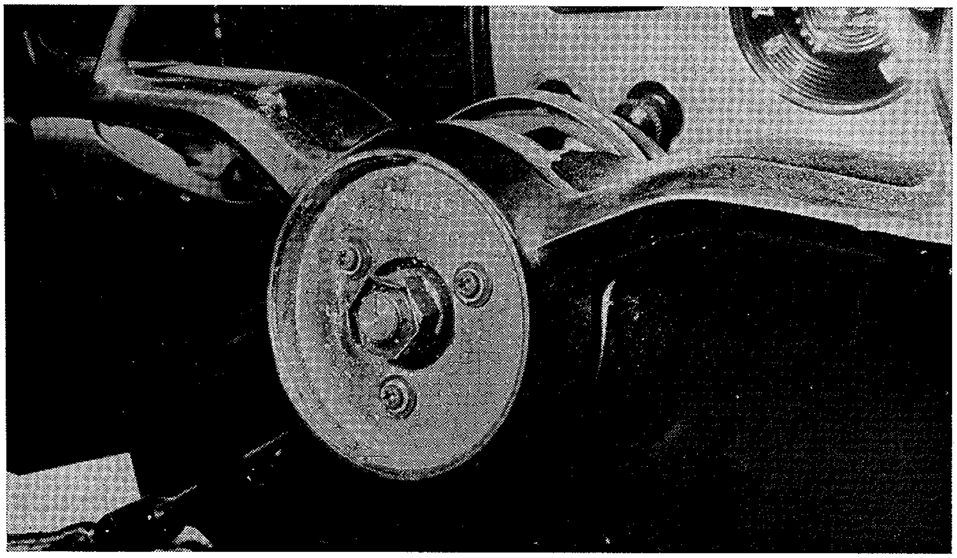


Fig. 11.9—Exposed steering wheel hub; note flecks of flesh

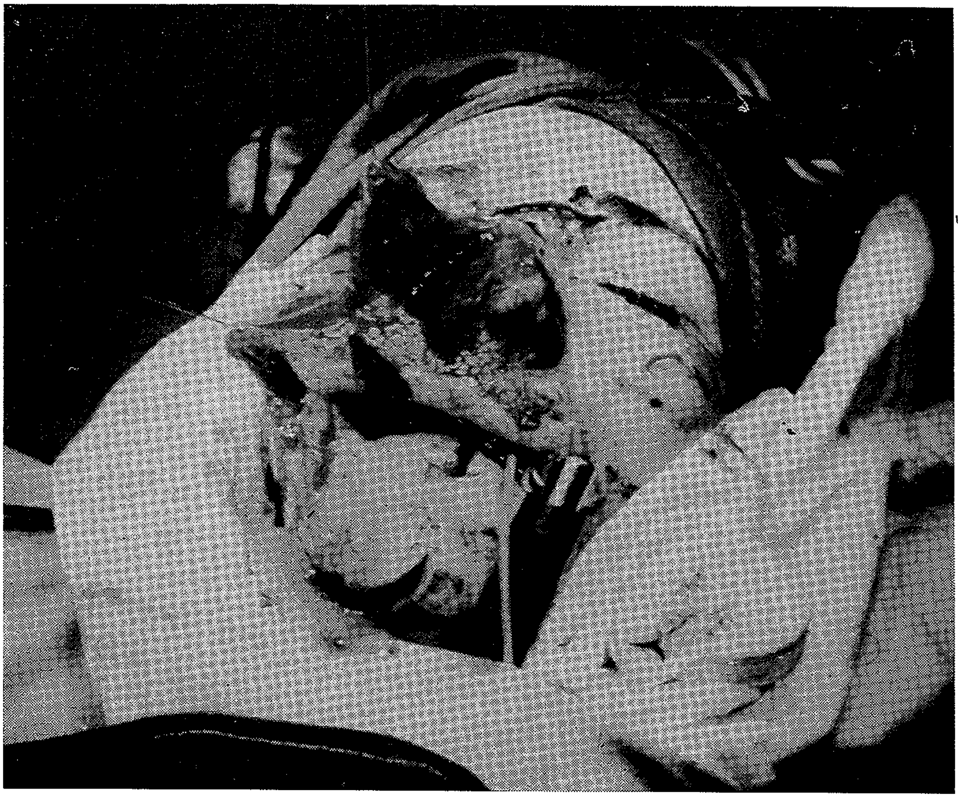


Fig. 11.10—Severe lacerations of the face resulting from impact with steering wheel shown in *Fig. 11.9*

pant's head definitely struck the glass of the windscreen. Forty-three windscreens were of tempered glass, and five of laminated glass. The cases involving tempered glass windscreens were divided into those in which the windscreen was broken and those in which it remained intact. The totals in TABLE 11.3 do not sum, for some cases had more than one injury. Only one soft tissue injury is recorded for each case.

TABLE 11.3

HEAD IMPACTS WITH WINDSCREEN

	Tempered Glass		Laminated Glass
	Broken	Not Broken	(Broken)*
Total cases	24	19	5
Concussion	10	5	3
Broken teeth	1	0	0
Soft tissue injury of the face			
Lacerations	19	2	3
Bruises	1	11	1
Abrasions	4	5	1
No injury	0	1	0

*All the laminated glass windscreens fractured.

11.12 The higher incidence of concussion (42 per cent) in cases where the tempered glass was broken, compared with cases where the glass was unbroken (26 per cent), suggests that these impacts were of greater severity than in the cases of unbroken glass. However, a χ^2 test of significance shows that the difference in incidence of concussion could be due to chance.

11.13 It is obvious from TABLE 11.3 that broken tempered windscreens produce more lacerations than intact windscreens. The latter cause a large number of bruises. The number of cases of laminated windscreens is small and the injuries sustained seem to be of the same order as those produced by broken tempered windscreens. It is worthy of note that at least one person struck a tempered glass windscreen without sustaining injury and without fracturing the windscreen.

Neck injuries

11.14 These are not very common, only 15 cases occurring. Eight of these cases were soft tissue 'strains', five of which were due to impact from the rear of the car. There were three cases with superficial bruises or abrasions of the neck. One girl (in case 0322) aged 6 years, a rear seat passenger, struck her throat on the top of the back of the front seat. She had some difficulty in swallowing but no other injury. In case 0357 a 38-year old man, a front seat passenger, developed a large haematoma of the neck which started on the right side. The size of the haematoma caused him some discomfort in swallowing. We could not determine what object he struck, but since the impact was from the right front he could have struck the steering wheel rim.

11.15 There were two injuries of the spine. In case 0046 a 35-year old man driving a Volkswagen struck another car head on. His head struck the sunvisor, leaving a dent, and his chest struck the steering column, which moved up in front of him nearly 10 in. He suffered a fracture dislocation of the cervical spine at C4/5 with considerable displacement and with complete transection of the spinal cord (*Fig. 11.11*) and consequent permanent quadriplegia. The other case (0314) involved an 18-year old girl driving a van which rolled over and struck a utility pole with its under surface. She complained of impairment of sensation in her right arm and was found to have a fracture of a transverse process of the 6th cervical vertebra.

Fig. 11.11—Case 0046: fracture dislocation of cervical spine of driver

Thoracic injuries

11.16 The commonest thoracic injuries are superficial abrasions and bruises, as shown in the following table.

Superficial injuries	65
abrasions	9
bruises	54
lacerations	2
Skeletal injuries	40

fractured ribs	25
fractured clavicle	11
fractured scapula	4
Internal thoracic injuries (All were lung injuries)	5

All the internal injuries were associated with fractured ribs. Two of these cases died, but only one, who had a lacerated lung, had a fatal lung injury. The other cases had various degrees of haemothorax and pneumothorax. Fractured ribs are the commonest and probably the most important skeletal thoracic injury because of their influence on respiratory movements. Surprisingly few internal injuries are associated with the fractures. In only five of 25 cases, or 20 per cent, was there evidence of some pulmonary damage. There were no cardiovascular lesions at all.

Injuries of the abdomen

11.17 Superficial injuries are mostly (13 cases) abrasions and bruises of the back in the lumbar region. There were three cases with bruises over the iliac crests on the front of the abdomen.

11.18 There were three cases of internal injury. Two of these car occupants died. One had lacerations of the spleen and left kidney, and the other a laceration of the left kidney and a rupture of the junction of the aorta and left renal artery. In the third case, a 17-year old girl sustained a contusion of the left kidney which settled down after several days' bed rest. Two women who were about six months pregnant seemed to come to no harm (obstetrically speaking) in their accidents.

Injuries of the spine and pelvis

11.19 There were six cases with fracture of the pelvis and two cases of fracture of the lumbar transverse processes. These latter two cases, together with the two fractures of the cervical spine, were the only injuries to the spinal column we encountered.

11.20 In one case of pelvic fracture the details of the fracture were not recorded, but of the others, three involved fractures of the pubic rami, one a fracture of the acetabulum, and there was one fracture of the coccyx. This last fracture was sustained by a woman who was ejected and probably landed in a sitting position. The acetabular fracture occurred when the driver's left knee struck the parcel shelf as his car was struck from the front. The head of the femur fractured the posterior wall of the acetabulum as the driver's body decelerated.

Injuries of the upper limb

11.21 Superficial injuries predominate, being mostly bruises and abrasions, with some lacerations of varying severity. There were 15 fractures of the upper limb and one sprain of the left little finger. The fractures were as follows:

Phalanges		2
Metacarpals		4 (2 compound)
Radius and ulna		5
midshaft	1	
at wrist	3	
neck of radius	1	
Elbow		2 (both compound)
Humerus		3
midshaft	1	
neck	2	

11.22 In case 0294 the 50-year old driver of a car suffered a compound fracture when his elbow, which was resting on the window sill and protruding from the car, struck the tray of a truck travelling in the opposite direction. There was complete loss of the lower end of the humerus and the upper end of the radius and ulna (*Fig. 11.12*). The other case of fracture of the elbow involved a 41-year old woman driver who put out her left arm to prevent her daughter from striking the windscreen as her car hit a tree. The daughter carried her mother's

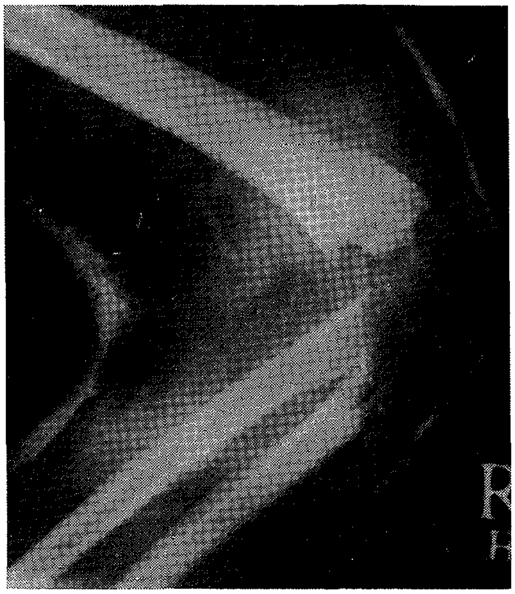


Fig. 11.12—Compound fracture of right elbow, with complete loss of bone and joint, after impact with tray of truck

arm through the laminated windscreen causing hyperextension of the elbow with fracture of the olecranon, together with a deep laceration of the ulnar border of the forearm.

Injuries of the lower limb

11.23 Superficial injuries were by far the most common injuries to the lower limb. The majority of these injuries were abrasions and bruises of the knee and lower leg caused by striking the lower edge of the instrument panel, the edge of the instrument panel and the edge of the parcel shelf. There were 13 fractures in 11 persons. One person suffered fractures of both patellae, and one had fractures of the upper ends of both tibiae.

Superficial injuries		260
abrasions	134	
bruises	102	
lacerations	24	
Skeletal injuries		13
Posterior dislocation of hip	1	
Fracture of the femur	3	
midshaft	2 (1 compound)	
subtrochanteric	1	
Fracture of the patella	4	
Fractures of the tibia	3	
condyles	2	
malleoli	1	
Fractures of bones of the foot	2	
metatarsal	1	
navicular and medial euneiform	1	

11.24 The subtrochanteric fracture of the femur was the only skeletal injury which was not associated with a frontal impact. In this case the impact was on the door next to which the driver was seated. All the other fractures occurred in frontal impacts which forced the car occupant forwards, into the instrument panel. This impact with the instrument panel causes a variety of fractures along the length of the upper leg. The patellae were fractured against the sharp lower edge of the instrument panel (*Fig. 11.13* and *11.14*). The passenger's weight, greatly increased by the deceleration of the impact of the knee with the instrument panel, acted on the femur in its long axis, causing it to fail in compression (the two midshaft fractures), or forced the head of the femur out of the acetabulum in a posterior dislocation (one case). This sequence of fractures was first reported by Smillie (Ref. 48).

11.25 The case of bilateral fractures of both tibial condyles occurred, again in a frontal impact, when the upper end of the passenger's lower legs struck the edge of a substantial parcel shelf. In this case the tibia, and not the patella, bore the brunt of the impact. The fractures of the ankle (1 case) and foot (2 cases) occurred in frontal impacts, where the deformation of the front of the car was considerable, and the fractures were caused by the impact being transmitted by the floor of the car to the driver's foot.

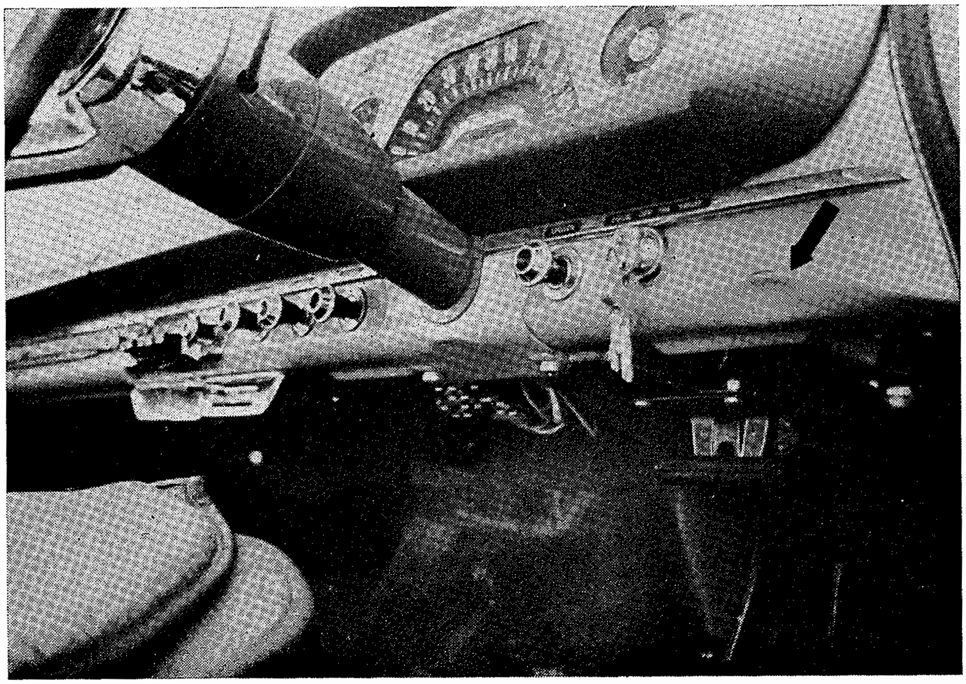
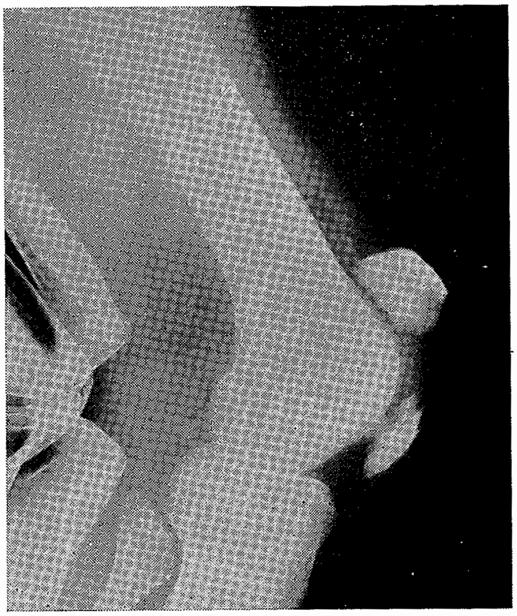


Fig. 11.13—Frontal impact: note dent in lower edge of instrument panel (arrow), produced by impact with driver's knee



CAUSES OF INJURY

11.26 The basic cause of injury in car collisions is the energy exchange occurring when the moving car occupant strikes the stationary (or nearly so) car interior. By careful inspection of the cars after impacts we have determined in many cases just what objects the occupants struck when their injury was produced. In some cases there were many impacts and it was impossible to determine the specific parts of the interior struck, but in a large number of cases there was evidence in the form of dents, grease marks, blood, hair or skin to mark the point of impact. TABLE 11.4 shows the areas of the car interior struck, together with the body areas injured by the impact.

Fig. 11.14—Fracture of patella, result of impact with instrument panel shown in *Fig. 11.13*

TABLE 11.4

CAUSE OF INJURY BODY AREAS VERSUS INJURED

	All Injuries						
	Head and neck	Thorax	Abdomen	Spine and pelvis	Upper limb	Lower limb	Total
Windscreen	58	0	0	0	5	3	66
Corner post	12	0	0	1	1	0	14
Door	60	30	6	2	38	24	160
Instrument panel	9	8	0	0	3	150	170
Steering wheel and column	18	22	0	0	5	2	47
Front seat	12	3	2	0	1	18	36
Header area and rear vision mirror	55	0	0	1	0	0	56
Ejection, partial or complete	12	4	3	2	12	8	41
Other	14	8	1	2	2	4	31
Not known	101	22	6	2	87	54	272
Total	351	97	18	10	154	263	893

11.27 The areas of the car interior were defined and named as follows:

(a) Windscreen: the windscreen glass and frame surrounding it, including flying glass fragments.

(b) Corner post: front left and right — area between windscreen frame and adjacent door frame.

(c) Door: includes window glass and surrounding frame.

(d) Instrument panel: includes parcel shelves beneath the instrument panel, and hand brake levers and other controls located below the instrument panel.

(e) Steering wheel and column: includes horn ring.

(f) Front seat: includes both top and bottom of the back of the front seat.

(g) Header area: area of roof immediately above the windscreen, including the rear vision mirror and interior sun-visors.

(h) Ejection: may be partial, e.g. driver's arm caught between car and road as the car rolls over, or complete.

(i) Other: anything else.

(j) Not known: cause of injury not determined.

11.28 Arranged in order of frequency of causing injury to all body areas; the causes are listed as follows:

	No. of injuries
Instrument panel	170
Door and frame	160
Windscreen and frame	66
Header area and rear vision mirror	56
Steering wheel and steering column	47
Ejection, partial or complete	41
Front seat	36
Other	31
Corner post	14
Not known	272

The door, windscreen and header area are mainly responsible for head injuries, the door and the steering column for thoracic injuries, the door and ejection for abdominal and upper limb injuries, and the instrument panel and door for lower limb injuries. The lower limb injuries caused by the windscreen were abrasions produced by flying fragments of tempered glass.

TABLE 11.5

CAUSE OF INJURY BODY AREAS VERSUS INJURED

	Moderate and Greater Injury						
	Head and neck	Thorax	Abdomen	Spine and pelvis	Upper limb	Lower limb	Total
Windscreen	23	0	0	0	1	0	24
Corner post	3	0	0	1	0	0	4
Door	28	14	2	2	4	1	51
Instrument panel	3	0	0	0	0	15	18
Steering wheel and column	7	4	0	0	0	0	11
Front seat	3	1	0	0	0	0	4
Header area and rear vision mirror	16	0	0	1	0	0	17
Ejection, partial or complete	7	3	1	2	3	0	16
Other	5	4	1	2	1	1	14
Not known	36	5	1	2	10	0	54
Total	131	31	5	10	19	17	213

11.29 The order of precedence changes markedly if only injuries of moderate or greater severity are considered. TABLE 11.5 shows the cause of injury by body area for moderate or greater injuries.

11.30 Arranging the causes by order of frequency we obtain the list shown in TABLE 11.6. It will be noted that the door is by far the greatest cause of moderate or greater injuries, especially to the head and thorax. It is followed by the windscreen (head injuries almost entirely), instrument panel (lower limb injuries), header area and rear vision mirror (head injuries) and ejection (which causes injuries to all body areas except the lower limb). The steering wheel and column (cause of injuries to head and thorax) now takes sixth place. Only 13 per cent of injuries caused by the instrument panel are moderate or greater, compared with 30 to 40 per cent moderate or greater injuries caused by the door, windscreen, header area, and ejection.

Direction of impact and seated position, related to the cause of injury

11.31 *Fig. 11.15* shows how the proportion of drivers and front seat passengers injured varies with impacts on the front and either side of the car. In front impacts passengers are injured more often than drivers,

TABLE 11.6

CAUSES IN ORDER OF FREQUENCY

	No. of Moderate and Greater Injuries	Per cent of All Injuries Caused by this Area
Door	51	32
Windscreen	24	37
Instrument panel	18	13
Header area and rear vision mirror	17	31
Ejection partial or complete	16	39
Other	14	45
Steering wheel and column	11	23
Front seat	4	11
Corner post	4	24
Not known	54	20

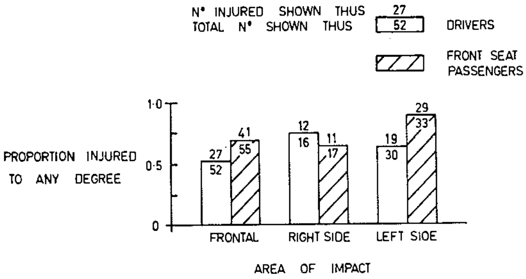


Fig. 11.15—Injury versus seated position versus area of impact

in impacts on the right side drivers are injured more often than passengers, and in impacts on the left side, front seat passengers are injured more often than drivers.

11.32 The direction of impact has a considerable bearing on what areas of the car interior cause injury to each part of the body. The seated position of the occupant is another factor which influences the production of injuries: for example the driver is close to the steering wheel, which is a possible danger in frontal impacts, but in impacts from the right side the other front seat occupants are at risk from the steering wheel.

11.33 To examine these relationships further, all single impact car-to-car collisions, i.e. cases where the vehicle-to-vehicle impact was the main cause of injury, were selected. Included are some cases where there was a third but trivial impact with another car or a fixed object, but this impact had no influence on the injuries produced. The persons involved in these collisions were further subdivided into groups according to whether the impact on their vehicles was mainly frontal, from the right side, or from the left side. TABLES 11.1A, 11.2A and 11.3A in the Appendix show the causes of injury to each body area for all drivers and left front seat passengers in these three groups. Centre front and rear seat passengers are not included, for the sake of simplicity.

11.34 TABLES 11.7, 11.8 and 11.9 summarize the chief causes of injury for frontal, left side and right side impacts.

11.35 From these tables it appears that the car occupant's body, in the seated posi-

TABLE 11.7

FRONTAL IMPACTS: CHIEF CAUSES OF INJURY

Body Area	Front Seat Passengers (55 at Risk)			Drivers (98 at Risk)		
	No. of injuries for each cause		Total No. of injuries to body area	No. of injuries for each cause		Total No. of injuries to body area
Head	Windscreen	17	32	Header	13	40
	Header	9		Steering wheel	6	
				Windscreen	5	
				Door	5	
Thorax	Instrument panel	3	4	Steering wheel	8	8
Abdomen	—			Door	1	1
Spine and pelvis	—			Header	1	1
Upper limb	Corner post	3	14	Door	6	15
Lower limb	Instrument panel	28	30	Instrument panel	26	32

TABLE 11.8

RIGHT SIDE IMPACTS: CHIEF CAUSES OF INJURY

Body area	Front Seat Passengers (17 at Risk)		Drivers (26 at Risk)	
	No. of injuries for each cause	Total No. of injuries to body area	No. of injuries for each cause	Total No. of injuries to body area
Head	Header 3 Instrument panel 2	9	Door 9	14
Thorax	Instrument panel 1 Front seat 1	3	Door 5	6
Abdomen	—	0	—	0
Spine and pelvis	—	0	Door 1	1
Upper limb	Steering wheel 2	4	Door 3	7
Lower limb	Instrument panel 4	7	Instrument panel 5 Door 4	12

tion, strikes those parts of the interior of the car which lie closest to it, in the direction of the impact. In frontal impacts the heads of both driver and front seat passenger strike the header area, but the driver also strikes the steering wheel, and so does

TABLE 11.9

LEFT SIDE IMPACTS: CHIEF CAUSES OF INJURY

Body area	Front seat passengers (33 at Risk)		Drivers (54 at Risk)	
	No. of injuries for each cause	Total No. of injuries to body area	No. of injuries for each cause	Total No. of injuries to body area
Head	Door 9 Ejection 3	22	Windscreen 4 Door 3 Header 3	23
Thorax	Door 5	7	Door 2	6
Abdomen	Door 1	1	Ejection 1	2
Spine and pelvis	Door 1 Ejection 1	2	—	0
Upper limb	Ejection 3 Corner post 2	9	Ejection 1 Instrument panel 1	14
Lower limb	Ejection 3 Instrument panel 3 Door 2	13	Instrument panel 6	15

not strike the windscreen as often as the front seat passenger. The driver's chest strikes the steering wheel; the passenger's chest strikes the instrument panel. The movements of arms were rarely able to be determined. The legs of both drivers and front seat passengers strike the instrument panel.

11.36 In right side impacts the driver is injured in all body areas by the door, but the front seat passenger strikes the header area and instrument panel with head and thorax, and strikes the steering wheel with upper limbs. The lower limbs again strike the instrument panel.

11.37 In left side impacts the left front seat passenger is injured in almost all areas by the door. Also ejection becomes a cause of injury for the head and upper and lower limbs. Drivers, thrown to the left and forwards strike the left side of the windscreen and header area. They may also strike the left door. The instrument panel is still the prime cause of injury to lower limbs.

11.38 *Fig. 11.16* shows the number of impacts to each area of the interior of the car. Most of the head impacts are around the top of the windscreen, the sun-visors, header area, rear vision mirror and the top of the door. There are only three head impacts on the instrument panel. Impacts on the face and lower edge of the instrument panel are almost entirely from the knees, which also strike the parcel shelf. The front of the chest strikes the lower edge of the steering wheel and the sides of the chest and the arms strike the lower door, as do the hips and pelvis. Rear seat passengers strike their heads on the top of the back of the front seat and their shins on the lower part.

KINEMATICS

11.39 The kinematics of unrestrained car occupants in collisions have been investigated by Dye (Ref. 38), who used articulated plane figures in a laboratory simulation of a cockpit, and Severy et al (Ref. 39, 40, 41 and 42) who used anthropometric dummies in controlled instrumented collisions. Buttner and Friedhoff (Ref. 43 and 44) describe injuries produced by the

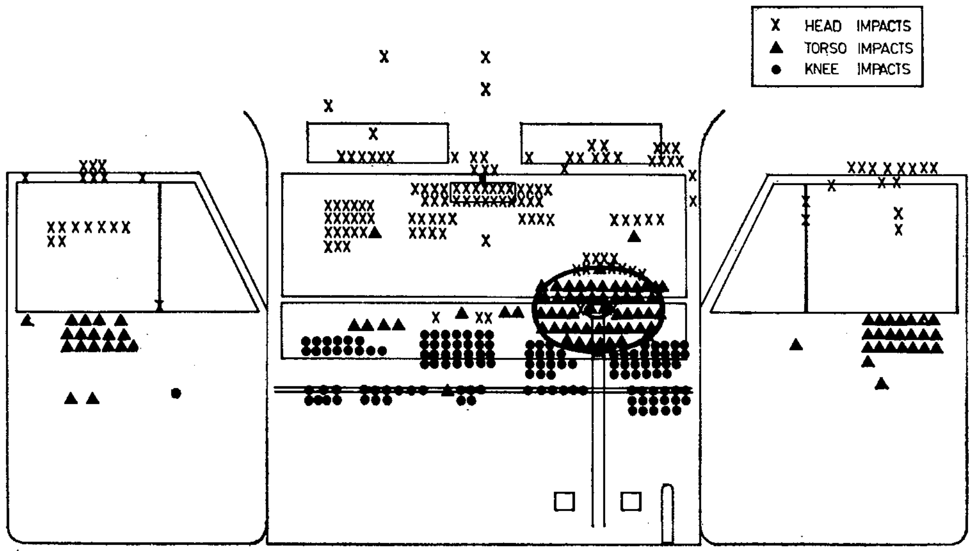


Fig. 11.16—Position of body impacts on interior of car

steering wheel and the instrument panel, and suggest mechanisms by which they could have been produced.

11.40 The previous consideration of the injuries and the areas of the car interior impacted by the car occupants suggests the following series of movements, at impact.

11.41 In a frontal impact, the front seat occupant moves forwards in the seated position until his knees reach the instrument panel. Depending on the relative height of the knee and instrument panel the knee strikes the lower edge (*Fig. 11.13*), or passes underneath, where it may strike various control levers, radios, fuse racks, etc., which have sharp metal edges (*Fig. 11.17*).

11.42 Next the body must pivot about the knee, which is relatively fixed to the instrument panel, with the trunk and head moving forwards and upwards towards the upper half of the windscreen and the header area. This is where evidence of head impacts is found: on the sunvisor hinges (*Fig. 11.2*), the rear vision mirror (*Fig. 11.4*) and the windscreen. From here the head and trunk must fall downward because the windscreen glass is broken out downwards (*Fig. 11.6*), and teeth are broken on the top of the instrument panel (*Fig. 11.18*).

11.43 The driver strikes the steering wheel with his chest as he moves forwards and upwards, and sometimes strikes its upper edge with his face. We found that chest injuries were infrequent, despite much deformation of the steering wheels, even in non-dished designs. The driver's head still hit the header area if the impact forced him to one side of the steering wheel. The act of braking at impact will increase the loading on the bones of the leg considerably; this may increase the risk of fracture

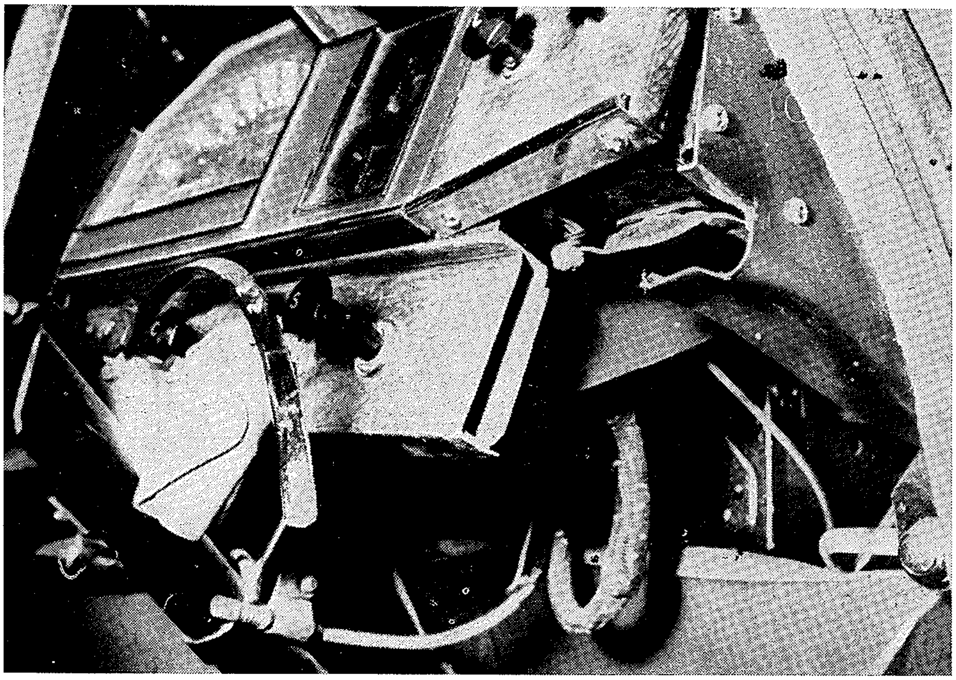


Fig. 11.17—Case 0430: frontal impact. Note many sharp metal edges under instrument panel.

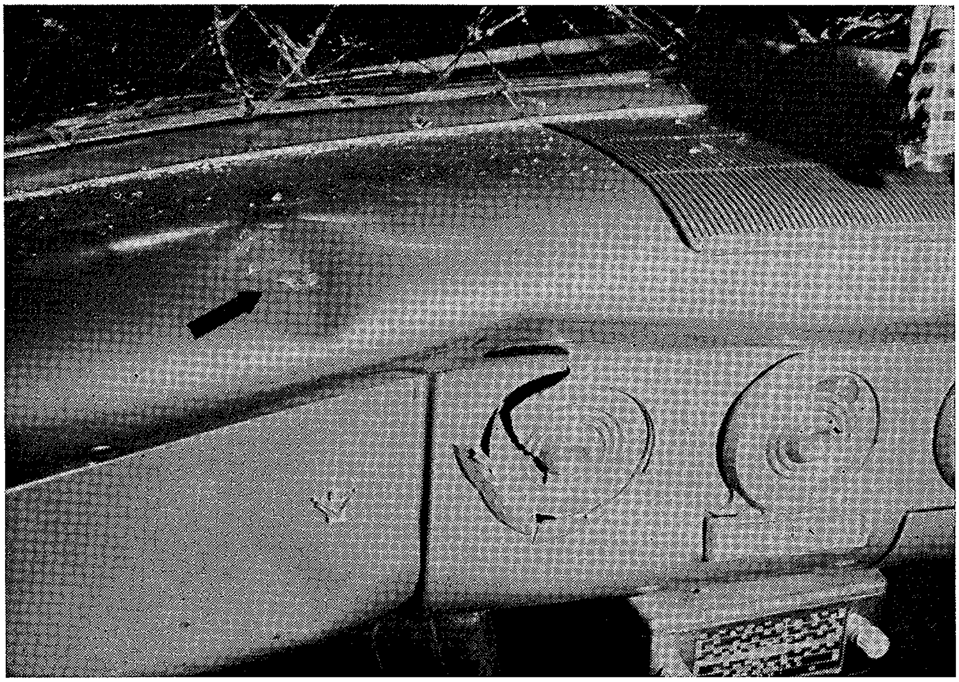


Fig. 11.18—Case 0046: frontal impact. Passenger's knee struck face of instrument panel, and his face and teeth struck top of instrument panel (arrow). Note teeth marks

occurring, e.g. the patella in impacts on the lower edge of the instrument panel. Volkswagen drivers are especially at risk in frontal impacts, for the steering box extends in front of any other structural member, and forces the steering column upwards and backwards, towards the driver, before any other part of the car is deformed. The driver is thus very liable to chest injuries.

11.44 In two collisions with fixed objects the driver, instead of moving upwards and forwards to strike his head on the header area, moved forwards and downwards (relative to the car) and struck his face on the hub of the steering wheel, inflicting severe injuries.

11.45 In side impacts, the occupant closest to the impact strikes the door directly. His head strikes the window glass, or the thinly covered rolled metal edges above the doors. The upper arm and thorax strike the lower window sill and the arm-rests when fitted. The window winders and internal door handles do not seem to be in the areas struck by occupants in side impacts. The hip and thigh strike the door below the door handle and window control. In side impacts, the occupants on the opposite side are thrown across the car at impact. The left front seat passenger in right side impacts typically travels forwards and to the right, striking his head on the right side of the windscreen or the rear vision mirror, and his chest on the left edge of the steering wheel. In left side impacts the driver strikes his head on the left side of the windscreen, and his chest on the instrument panel. One driver, whose car was struck from the left front, remembers striking his head on the roof above the left door, then bouncing back behind the wheel, which he was still holding.

11.46 It is difficult to determine exactly what happens to rear seat passengers, but in frontal impacts they strike their knees on the front seats, and possibly their heads on the top of the back of the front seats. In side impacts they strike the doors rather like the front seat occupants.

Seated position and degree of injury

11.47 We have seen that the opportunities for being injured vary from seat to seat around the car. The degree of injury received also varies with seated position, as seen in TABLE 11.10. The one 'other' occupant mentioned in TABLE 11.10 was a 16-year old boy in the tray of a utility which rolled and struck a tree. All other car occupants were seated inside the passenger compartment of cars. From the table, 64 per cent of drivers were injured to some degree — 75 per cent of front seat passengers and 45 per cent of rear seat passengers.

11.48 The figures in TABLE 11.10 are regrouped in TABLE 11.11, omitting 'not knowns'. The value of χ^2 means that it is highly unlikely that this distribution would occur by chance, and that there is therefore probably a real difference in risk of injury in each of the seated positions. Another pertinent fact is that while there are few women drivers, almost two-thirds of front seat passengers are women. The commonest injuries to car occupants are head and leg injuries, both of which are important areas cosmetically for women. Therefore women are placed in the situation where they are exposed to the risk of being injured more often than men, and the injuries they receive will possibly be more serious in effect.

DEGREE OF INJURY AND VEHICLE DAMAGE

11.49 We believe that there is a relationship between the injury sustained by a car occupant and the degree of damage sus-

TABLE 11.10

CAR OCCUPANTS: DEGREE OF INJURY

	Nil	Minor	Moderate	Severe	Very severe	Fatal	Not known	Total
Drivers	143	169	57	16	6	0	4	395
Front seat passengers	59	117	50	10	1	1	3	241
Rear seat passengers	90	49	19	6	0	0	0	164
Other	0	0	0	0	0	1	0	1
Total	292	335	126	32	7	2	7	801

TABLE 11.11

DISTRIBUTION OF INJURIES

	No Injury	Minor and Greater Injury	Total
Drivers	143	248	391
Front seat passengers	59	179	238
Rear seat passengers + other	90	75	165
Total	292	502	794

$\chi^2 = 37.119^{**}$

tained by the car. The amount of damage produced by a specific collision will depend on many factors, including the weight and speed of each car (if a two-car collision) the strength of the deformed parts, and the relation of the position and direction of impact to the centre of gravity of each vehicle. These are the main factors which determine the size of the force which acts on the car, and therefore also on the occupants. The force which deforms the car is transmitted to the car occupants and may injure them.

11.50 We have shown that there is a difference in injury potential between the driver's seat, the other front seats and the rear seat. TABLES 11.4A to 11.6A in the Appendix show the degree of injury sustained by persons in each of these three seated positions for each degree of vehicle damage. Linear regressions were calculated to determine the relationship between degree of injury and vehicle damage for each seated position. Each degree of vehicle damage was given the value of the mid-point of the range of values for that degree of damage.

11.51 The analyses of variance are set out in the Appendix (TABLE 11.7A) and show very significant linear regressions between vehicle damage and degree of injury. The regression lines are plotted in *Fig. 11.19,* which also shows the mean degree of injury for each degree of vehicle damage. The differences between the slopes of the regression lines were found to be not significant. The difference in position of the regression lines suggests that front seat passengers receive more severe injuries than drivers, who in turn receive more severe injuries than rear seat passengers.

11.52 *Fig. 11.20* shows the percentage of occupants of each seated position injured to any degree, for each degree of vehicle damage. Front seat passengers are injured more often than drivers, and rear seat passengers are injured least of all. The differences between seated positions become smaller with increasing vehicle damage.

EJECTION

11.53 Thirty-five of the 1,029 car occupants involved in all accidents were ejected. This is an ejection rate of 3.4 per cent. The severity of the injuries sustained, compared with those of occupants who remained in the car, is shown in TABLE 11.12.

11.54 Grouping the data in TABLE 11.12 we have the results shown in TABLE 11.13. The value of χ^2 means that the differences in injury severity are unlikely to be due to chance, and that there is therefore probably a real difference in the occurrence and severity of injury between those ejected and those not ejected.

11.55 Those ejected were injured more often and sustained more severe injuries when injured than car occupants not

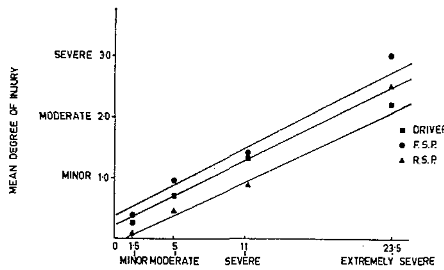


Fig. 11.19—Car occupants: degree of injury versus vehicle damage.

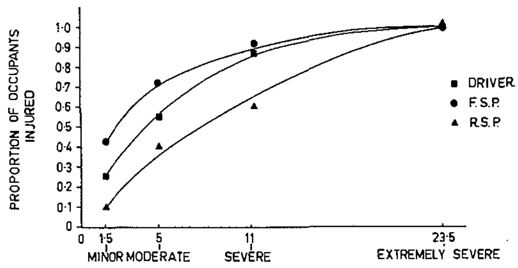


Fig. 11.20—Car occupants: proportion injured versus vehicle damage

ejected. 97 per cent of those ejected were injured, compared with 48 per cent of those not ejected. 47 per cent of the ejected had moderate or greater injury, while 16 per cent of those not ejected were injured to the same degree. The difference is even more marked for those with severe or greater degree of injury: 18 per cent of the ejected and 4 per cent of those not ejected.

11.56 The ratio of the proportions of those ejected, and not ejected, in each injury grouping are as shown in TABLE 11.14. The difference in the proportion of each group injured in each class of injury severity increases markedly as the severity of the injuries increases. Those ejected received severe to fatal injuries 4.5 times as often as those not ejected.

11.57 Ejection is associated with spinning of the car, rather than rollover. The ejection often occurred when the car stopped suddenly, the occupants being projected through the opened doors (e.g. case 0185). The impact on the side of the car, which sets it spinning, also springs open the doors on the opposite side of the car, through which the ejection takes place.

SEAT BELTS

11.58 Fifty-eight of 1,029 car occupants

TABLE 11.12

INJURIES TO EJECTED AND NOT EJECTED CAR OCCUPANTS

	Injury Severity							
	Nil	Minor	Moderate	Severe	Very severe	Fatal	Not recorded	Total
Car occupants ejected	1	17	10	4	1	1	1	35
Car occupants not ejected	512	320	119	29	6	1	7	994
Total	513	337	129	33	7	2	8	1,029

TABLE 11.13

DEGREE OF INJURY TO EJECTED AND NOT EJECTED CAR OCCUPANTS

	Injury Severity		
	Nil and minor	Moderate and greater	Total
Ejected	18	16	34
Not ejected	832	155	987
Total	850	171	1,021

$\chi^2 = 23.174$***

TABLE 11.14

RATIO OF PROPORTIONS OF EJECTED AND NOT EJECTED CAR OCCUPANTS IN EACH INJURY GROUPING

	All Injuries	Moderate and Greater Injury	Severe and Greater Injury
Ejected : not ejected	(0.97:0.48) 2:1	(0.47:0.16) 3:1	(0.18:0.04) 4.5:1

had seat belts available and 24 were actually wearing them. There were 16 cases where the information about seat belts was not recorded. Therefore 5.6 per cent of car occupants had seat belts available, and 43 per cent of these occupants were wearing the belt when they had their accident. The types of belt fitted were as follows:

Lap	13
Lap and sash	42
Diagonal	2
Not recorded	1
Total	58

11.59 The injuries received by those wearing seat belts were compared with those car occupants not wearing seat belts, in accidents not involving pedestrians, pedal cycles and motor-cycles (see TABLE 11.15). 50 per cent of those wearing seat belts were injured, and 49.7 per cent of those not wearing seat belts. For moderate and greater injuries 12.5 per cent of those wearing seat belts were injured, compared with 16.9 per cent of those not wearing seat belts.

11.60 These figures show little difference, but the numbers are small. More data are needed.

11.61 During the course of our survey we periodically counted cars (travelling on main roads) fitted with visible seat belts, i.e. shoulder straps. The number of cars fitted with seat belts in these spot checks rose from 3 per cent at the beginning of our survey in 1963 to almost 15 per cent at the end in 1964. In a recent count (mid-1965), 25 per cent of cars were fitted with seat belts. In all cases about 60 per cent of occupants with belts available were wearing them. These figures may be low, for we could not include cars fitted with lap belts only.

11.62 We have several cases where the wearing of seat belts undoubtedly prevented injury. In two cases (0170 and 0301) a Mini Minor ran into the back of a stationary Morris Convertible. In the first case the driver, not wearing a seat belt, broke the windscreen with his head, sustaining concussion and lacerations of the face. In the other case the car sustained damage very similar to that of the first car (*Fig. 11.21* and *11.22*), but the driver was wearing a diagonal seat belt and suffered only momentary breathlessness and bruising of the chest. These two collisions were virtually identical, the only difference being in the wearing of the seat belt and consequent prevention of injury in the second case.

11.63 In one other case previously reported (Ref. 45), a small car collided head-on with a truck (*Fig. 7.7*). Both occupants were wearing lap and diagonal seat belts, and despite the fact that the upper mounting points failed, both occupants suffered only small abrasions to the face and concussion. These cases, together with our few figures, are sufficient to make us feel that seat belts are of considerable value in preventing injury.

TABLE 11.15

INJURIES TO CAR OCCUPANTS WEARING AND NOT WEARING SEAT BELTS

	Injury						
	Nil	Minor	Moderate	Severe	Very severe	Fatal	Total
Seat belts worn	12	9	3	0	0	0	24
Seat belts not worn	501	328	126	33	7	2	997

Fig. 11.21—Mini Minor struck stationary car. The driver, not wearing a seat belt, broke the windscreen with his head

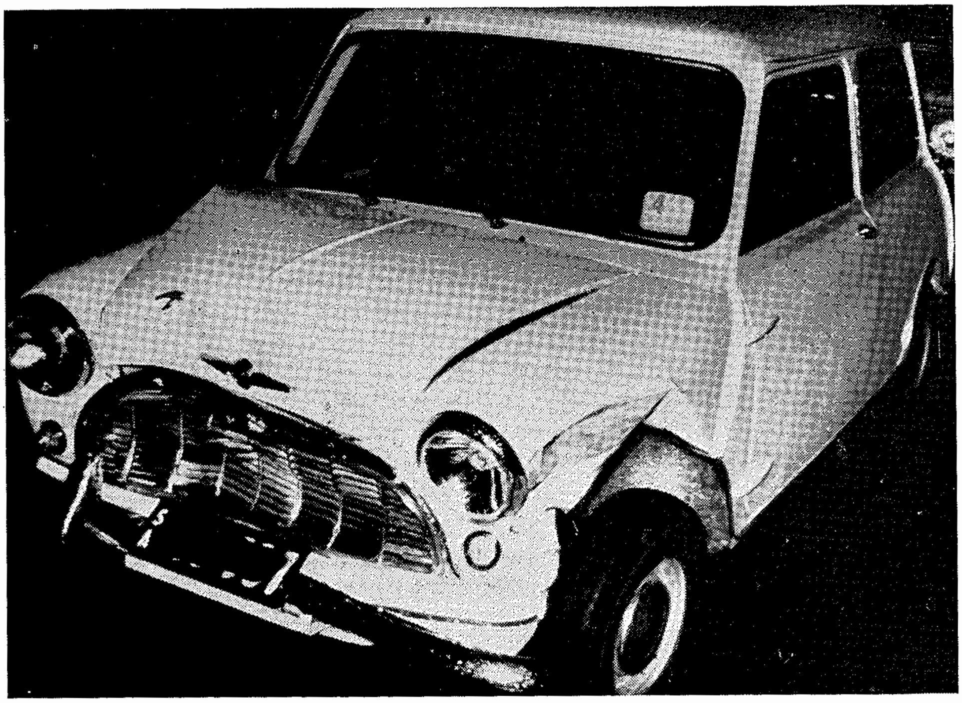


Fig. 11.22—Mini Minor struck stationary car. Damage was similar to that shown in *Fig. 11.21*. The driver, who was wearing a seat belt, was not injured

ALCOHOL

11.64 In this survey we noted whether a person involved in an accident showed signs of recent ingestion of alcohol. We did not perform clinical tests of intoxication but noted the smell of alcohol on the breath, the stance and gait, and the general behaviour of the person concerned. We did not attempt to assess the degree of intoxication, but merely noted the presence or absence of alcohol as indicated by our rather gross tests. This results (we believe) in a considerable underestimate of the number of drivers who had actually consumed alcohol before driving, but in the absence of a compulsory alcohol test, sanctioned by law, we could do no better.

11.65 TABLE 11.16 shows the number of drivers (37 per cent) showed evidence of dence of ingestion of alcohol. 5.5 per cent of drivers involved in collisions with motorcycles, pedal cycles, and pedestrians showed evidence of alcohol, compared with 15.2 per cent of other drivers. This makes a total fraction of 12.5 per cent showing evidence of alcohol. In single vehicle accidents, where the driver alone is presumably responsible for the accident, 16 of the 43 drivers (37 per cent) showed evidence of the presence of alcohol.

11.66 About the same fraction of pedestrians (15.8 per cent) as drivers showed the presence of alcohol, but the percentage for pedal cyclists and motor-cyclists was much less (4 per cent). Research in the U.S.A. (Ref. 46) has shown that alcohol does increase the risk of involvement in accidents, and that the risk increases as increasing amounts are consumed.

11.67 Of the 66 drivers who showed some evidence of the presence of alcohol, six were charged with driving under the influence of liquor or a drug. Twenty-three of the others were admitted to hospital because of injuries — mostly concussion and superficial head injuries. The remaining 37 who were involved in accidents for which they were in some measure responsible, and who showed signs of being affected to some degree by alcohol, were not considered to be so much affected as to warrant a charge of 'driving under the influence'. In the absence of accurate estimations of blood or breath alcohol levels it is not possible to say how many of these 37 drivers had their faculties impaired to a significant degree.

ADMISSIONS TO HOSPITAL

11.68 More than half of the car occupants did not require any treatment at all.

	No. of persons
No treatment required	662
First aid treatment only	8
Attended casualty department and were discharged	203
Admitted to hospital and discharged	148
Admitted to hospital and died	2
Died before reaching hospital	2
Not recorded	4
Total	1,029

11.69 Three hundred and fifty-three persons (34.4 per cent) attended a hospital; 203 of these attendances were by persons who were allowed to leave after treatment in a casualty department, while 150 persons were admitted. Of those admitted, two died while in hospital, and the others had an average stay of 4.8 days.

Length of stay in hospital in days	No. of cases
0- 1	61
1- 2	33
3- 5	19
6-10	14
11-15	5
16-20	2
21-25	1
26-30	0
more than 30	10
Total	145

TABLE 11.16

DRIVERS AND PRESENCE OF ALCOHOL

	Alcohol Present			
	No	Yes	Not known	Total
Drivers of cars which struck pedestrians, pedal cycles, motor-cycles	138	8	1	147
Drivers of cars which struck other cars, trucks, fixed objects, or rolled over	330	59	6	395
Total	468	67	7	542

11.70 There were four deaths. Two of the car occupants died of the injuries sustained in their accidents. A 27-year old woman in case 0235 died after 15 days in hospital, and a 13-year old boy died before reaching hospital (case 0369). In both of the other two cases the case car struck a tree when the driver collapsed at the wheel. In one case (0330) a 79-year old male died some hours after the accident of congestive cardiac failure and pulmonary oedema. Post mortem examination revealed much coronary atheroma and an old myocardial infarct. In the other case, a 55-year old man complained of praecordial pain, then collapsed at the wheel. He died at the scene. No post-mortem examination was done. In neither of these cases was anyone else injured, although the cars both swerved across the road to the wrong side and struck trees.

11.71 Thus, 150 (29 per cent) of the 508 car occupants injured required admission, 42.5 per cent of these staying at least one night. Another 40 per cent of injured car occupants required casualty treatment only, while the remainder required no treatment at all.

SECTION 12 — CAR ACCIDENTS: FURTHER STATISTICAL STUDIES

INTRODUCTION

12.1 In course of this work a good deal of detailed quantitative information was assembled about the factors concerned in collisions. It therefore seemed desirable and important to explore these data statistically in greater depth, to try to learn something of their mutual relationships so as to determine what vehicular and circumstantial factors correlate with injuries. Only collisions between cars were considered in this analysis.

RELATIONSHIPS AMONG TWENTY VARIATES

12.2 The following 20 variates were selected for detailed correlation analysis:

1. Degree of injury: overall
2. Degree of injury: head
3. Degree of injury: thorax
4. Degree of injury: abdomen
5. Degree of injury: spine and pelvis
6. Degree of injury: upper limb
7. Degree of injury: lower limb
8. Rollover
9. Damage to front of vehicle
10. Damage to compartment
11. Damage to rear of vehicle
12. Vehicle damage
13. Deformation at p.p.i. (principal point of impact)
14. Speed of vehicle
15. Weight of vehicle
16. Sex
17. Age
18. Accident severity
19. Weight of other vehicle
20. Speed of other vehicle

12.3 Most of these were recorded as ranked scores, as set out in our data codes (see Appendix D). Some, such as vehicle speeds, were estimates of varying precision. Others, such as the extent of vehicle damage, were scores compiled by a process described elsewhere (see para. 3.41), while others again, such as sex (male) or rollover, were scored as present or absent and assigned the numerical values 1 or 2. The object of the analysis, it may be emphasized, was to determine what variates correlate with the various categories of injury; or in other words to examine the extent to which other variates could be used as predictors of the degree of injury to the victim.

12.4 It should be noted that the variates used are not independent. Variates 1 to 7 are all aspects of body injury, and are therefore related. All other variates except 16 and 17 are related to vehicle damage in one way or another. Variates 16 and 17 — age and sex — vary with seated position, i.e. drivers are mostly male, average age about 35 years. More than half of front seat passengers are female, average age about 30 years, and rear seat passengers are 50 per cent males, and their average age is about 18 years. All these factors must be taken into account when interpreting results.

SIMPLE CORRELATIONS

12.5 We began by compiling a series of simple linear correlation matrices for *all occupants,* and for *drivers, front seat passengers* and *rear seat passengers* respectively. The 190 separate values are set out in TABLES 12.1A to 12.4A. Because so many correlations were investigated simultaneously, conservative tests of significance were used. These were as follows:

* $p = 0.01$, $t = 2.60$, least significant correlation $\pm$ 0.1734

** $p = 0.005$, $t = 3.50$, least significant correlation $\pm$ 0.2307

*** $p = 0.001$, $t = 3.96$, least significant correlation $\pm$ 0.2591

12.6 If a lower level of significance is chosen, two variates in a large matrix may by chance appear to be significantly correlated when in reality no association exists. In all analyses of this kind it is important to keep in mind that a significant correlation between two variates does not imply that they are casually connected. In TABLE 12.1A, which considers all occupants, there are many significant correlations. Thus the overall severity of injury (variate 1) is correlated with every other variate except the speed of the other vehicle (variate 20). However, the correlation with age is not so strong as many others, nor is that with damage to the front of the vehicle. Head injury is correlated with all other variates except abdominal injury, rollover and age. Thoracic injury is not correlated with abdominal injury, rollover, damage to the front or rear of the vehicle, the deformation, speed and weight of the vehicle, or with the speed of the other vehicle. In fact, a detailed study of TABLE 12.1A, and of those for the different categories of participants, shows many interesting correlations, and indicates many points for further specific enquiry.

12.7 No attempt will be made at present to compare these categories of participants in detail, for those interested may easily do this for themselves. Any specific points arising from such enquiries, and for which the raw data need to be consulted, should be referred to the authors, who will gladly furnish the necessary information.

MULTIPLE REGRESSIONS

12.8 From simple correlations, the next step was to go on to examine multiple regressions of various factors on the variates expressing degree of injury, both overall and regional. These studies required rather extensive computation, and their results are tabulated in TABLES 12.5A to 12.8A.

12.9 For *all occupants* it will be seen that six variates make significant contributions to the degree of overall injury: they are damage to the front of the vehicle, damage to the passenger compartment, the deformation of the vehicle, sex, age and the weight of the other vehicle. However, age, vehicle deformation and the weight of the other vehicle do not give significant information about head injuries, though sex does do so. Sex and age also help to account for thoracic injuries.

12.10 On comparing drivers with front seat passengers, we see that damage to the front of the vehicle and to the passenger compartment are important in both as contributing to the overall degree of injury, whereas age is important in this respect for passengers but not for drivers. On the other hand, now that we are taking many variates together, we find that the damage to the front of the vehicle does not contribute significantly to head injury in drivers, but is highly correlated with it in passengers.

12.11 Once again, a detailed analysis of the many interesting features of these tables is unnecessary, for specific questions for further study almost suggest themselves. Here we give only the tables and we hope that readers seeking more details will get in touch with us.

FACTOR ANALYSIS

12.12 It will be appreciated that the analyses discussed in this section partly concern the statistics of the mutual correlations of ranked scores. This kind of problem occurs very often in psychological experiments, when a large number of subjects may each be scored for many attributes. To cope with this type of situation a variety of methods have been developed. These fall into two main classes: one is principal component analysis (Ref. 49 and 50), while the other is factor analysis (Ref. 51). Modern computers have greatly lightened the labour of applying these methods, so that even though it seemed likely that they would have no advantages over the more conventional methods of multiple regression, it was decided to perform a factor analysis on the matrix of 20 variates in our car-car collisions. The maximum likelihood method was used in preference to the centroid method, for the easier computations of the latter are of no moment when a computer is available. The factor loadings showed that — except for the first factor, which seemed to give some measure of the general severity of the accident — all the factors were bipolar and not easy to identify. Accordingly this kind of analysis was not pursued further.

12.13 In general we may say that our understanding of what takes place in collisions between two cars is not yet sufficiently advanced to enable us to select independent variates. Until we are able to do this there appears to be little point in attempting to demonstrate the degree of correlation between variates by using advanced statistical methods.

SECTION 13 — CONCLUSION

13.1 It should be clear to the reader who has persisted thus far with our account that during this project we have recorded a great deal of information about traffic accidents in the City of Adelaide. Even so, although this report has gone into considerable detail, the time at our disposal has not allowed us to analyse or to describe all that we would have wished. We believe however that we have uncovered most of the worthwhile nuggets in our data.

LIMITATIONS OF THIS STUDY

13.2 We must emphasize again the limitations of the study and the dangers of extrapolating from our findings without due regard to these limitations. These dangers are greater on the vehicular and traffic environmental aspects than on matters concerned with the causes and production of injuries.

13.3 *First*: We used an 'ambulance definition', and our findings therefore apply only to that fraction of the total traffic accidents to which ambulances were called. We found that in Adelaide the ambulance tends to be notified even for relatively minor accidents. This may not be so in other cities.

13.4 *Second*: Our findings apply in detail only to a particular city, and they can therefore be related with real confidence, so far as the highways and traffic aspects are concerned, only to Adelaide traffic conditions. For example, this city, with its flat terrain and rectangular grid of streets, has a high proportion of intersection collisions. Other cities, with more hills and more winding roads, may show a smaller proportion. Again, Adelaide streets are often wide, and there are very few legalized pedestrian crossings, so that the circumstances of our pedestrian accidents are likely to differ from those in other cities. We have also uncovered many specific instances of environmental failure. These findings, and those relating to the highways and traffic aspects of our accidents, will be of most interest to our own traffic engineers.

13.5 *Third*: Our research covered only the years 1963 and 1964, and the general relevance of our findings will in some ways slowly decline with time, as vehicles change, roads are developed and improved, and methods of handling vehicles (and their occupants) and pedestrians are also improved. We hope that our findings may have some influence in these developments.

13.6 *Fourth*: What we have been studying are the relatively uncommon failures in the complex road transport system, for accidents are uncommon when viewed in the setting of the vast numbers of daily possibilities that exist for conflict between vehicle and vehicle, and vehicle and pedestrian. We have had some success in discovering *what* happens in accidents, but have penetrated less deeply into *why* accidents happen, especially into the causes of human failure. It is true that we did not set out to explore specifically the human factors in causation, and in consequence we can say relatively little about them. This would have required at least a trained social worker, and more heed should have been given (by J.S.R.) to those colleagues who wished at the beginning for such a worker to be included in the team. It is gratifying that in a subsequent study in Brisbane this omission has been rectified.

13.7 *Fifth*: One particular aspect of human failure, namely the contribution of alcohol to accident causation, could not be adequately studied because we lacked the legal power to do so. In our view this is the most pressing need in the whole field of accident investigation in Australia today.

13.8 *Sixth*: There was some bias in our sample, and it is particularly unfortunate that we did not sample weekend accidents late at night, when traffic volume is low and the risk of accident is much greater than average. More careful planning would have prevented this unfortunate omission.

13.9 *Seventh*: On the medical side our data have fewer limitations, and are of more general relevance and permanent value. The trajectories of pedestrians, pedal cyclists and motor-cyclists when struck by cars of the same type are likely to be very much the same everywhere in accidents of comparable magnitude, and so are their injuries. Injuries to car occupants are likely also to be similar in comparable accidents wherever they occur. Our contribution has been useful in that we have been able to relate specific injuries to their causes in very many instances, and to provide data on which safer design of vehicles, vehicle components and protective helmets could be based. We hope that the responsible authorities will use them for this purpose.

THE NEED FOR CONTINUING SURVEILLANCE

13.10 During our work on the roads we informed our traffic engineers about accidents at particular places to which we thought their attention should be drawn, either because of some environmental feature such as obstruction to vision, or because of some other circumstance needing attention, such as the phasing of traffic lights. Therefore we consider that a mobile unit such as ours should be a permanent feature of the highways scene in every capital city. Although it need not work to an intensive plan like ours it should be on the roads one or two days each week, at different times. It should be manned by an engineer from the state highways department, and if this task could be rotated among the junior staff of that department it would be of great educational value in bringing home to them early in their careers that accidents are messy and often tragic happenings which are not adequately represented by coloured pins on a map. Accidents constitute a serious endemic disease which is not under control, and therefore they should be kept under continuing surveillance, for roads and vehicles change over the years, so that what is true now may not necessarily be true in a few years' time.

13.11 Along with such a mobile unit, continuing efforts should be made to ensure that accident reports reach the highways authorities as quickly as possible, so that 'black spots' where accidents are frequent can be rapidly identified and the appropriate remedial action set in motion without delay; for delay in these matters costs lives, and also money.

CORRELATION WITH OTHER STUDIES

13.12 We have mentioned above the dangers of extrapolating too freely, especially in matters of highway and traffic engineering, from our sample made at a particular time and place, to Australia as a whole for an indefinite time to come. It was the clear recognition of this danger that led the Human Factors Committee to recommend to the Australian Road Research Board that a comparable study should be carried out in another Australian city. With the co-operation of the National Health and Medical Research Council, and of the Queensland Main Roads Department, this was done in Brisbane, and the report of that unit, which was directed by Mr. K. G. Jamieson, is shortly to appear. Besides avoiding some of our mistakes in planning and execution, the Brisbane unit included a social worker, whose report should be of the utmost interest and value.

13.13 However, we still have no good information about rural accidents, for both the existing units have studied urban and suburban accidents. It is true that the latter predominate, as Thorpe (Ref. 29) has shown for Victoria, but accidents 'in the bush' still make up a very significant fraction of the whole, and it is likely that their circumstances will be quite different from those occurring in built-up areas. More thought should therefore be given to the possibility of somehow setting up a detailed study in the country.

FINAL REMARKS

13.14 Although the work of this survey has been demanding it has been intensely interesting, and in some ways we are sorry that it is now completed. Analysis of the data took much longer than we had expected, but in many respects this was a pioneering study, and we had to feel our way through our material. However, we hope that it will provide a body of useful facts for highways and traffic authorities, town planners, vehicle designers, legislators, hospital administrators and safety educators. Counter-measures against accidents must be based on facts if they are to be effective, and in this country, which has one of the worst road accident records in the world, there is a great need for a more realistic and more intensive attack on the road accident toll. Our descendants will very likely marvel at our seeming indifference for so long to a casualty list which year after year has been on the scale of that of a small war, and at our inability to agree to take any serious and concerted action about it. And yet there are signs that public concern is growing rapidly, and therefore we hope that the picture will soon change for the better. If we have provided some facts on which rational and effective counter-measures can be based — and we believe we have — we shall be well content.

TABLE 2.1A

DAILY DISTRIBUTION OF FATAL ROAD ACCIDENTS IN ADELAIDE ACCORDING TO TIME OF DAY (1962)

Day of Week \ Time	Mid -01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	N.R.	Total
Sunday	4	1	1	0	0	2	0	0	0	1	2	0	1	1	4	3	0	2	6	3	4	2	1	2	1	41
Monday	0	0	1	0	0	1	1	2	2	0	3	1	0	3	3	3	5	0	9	4	1	2	2	1	0	44
Tuesday	1	0	3	0	0	0	3	4	0	1	0	1	1	1	1	2	3	6	8	2	2	0	1	1	0	41
Wednesday	0	0	0	1	0	0	1	0	4	2	0	0	3	0	2	4	3	4	12	6	2	1	2	4	1	52
Thursday	1	0	1	0	0	0	1	4	2	0	0	0	0	1	3	1	1	4	6	4	1	1	0	2	0	33
Friday	0	0	1	1	0	0	2	4	0	0	0	1	2	3	2	1	5	7	10	4	4	4	3	5	0	59
Saturday	2	3	0	2	0	1	3	2	1	0	4	1	0	3	2	2	7	2	37	22	6	2	2	7	0	111
N.R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
TOTAL	8	4	7	4	0	4	11	16	9	4	9	4	7	12	17	16	24	25	88	45	20	12	11	22	3	382

TABLE 3.1A

TIME AND REGIONAL DISTRIBUTION OF ACCIDENTS REPORTED TO THE AMBULANCE, ADELAIDE
JANUARY TO JUNE, 1962

Time of Day	Area 1			Area 2			Area 3			Area 4			Area 5			Total
	J-M*	A-J†	Total	J-M	A-J	Total	J-M	A-J	Total	J-M	A-J	Total	J-M	A-J	Total	
MN 12																
1	5	7	12	2	3	5	4	7	11	0	5	5	1	1	2	35
2	2	3	5	1	4	5	3	0	3	0	2	2	1	2	3	18
3	1	4	5	1	1	2	0	1	1	2	0	2	2	0	2	12
4	0	1	1	0	1	1	2	0	2	0	0	0	0	0	0	4
5	0	1	1	1	0	1	0	0	0	1	0	1	0	0	0	3
6	1	1	2	1	0	1	0	1	1	1	0	1	0	1	1	6
7	2	3	5	1	0	1	1	0	1	0	1	1	0	0	0	8
8	4	11	15	3	7	10	3	10	13	3	3	6	3	7	10	54
9	4	5	9	3	7	10	4	3	7	2	4	6	1	3	4	36
10	6	3	9	3	2	5	3	2	5	1	4	5	1	2	3	27
11	3	3	6	6	5	11	2	6	8	5	2	7	4	9	13	45
MD 12	9	4	13	3	4	7	0	5	5	1	3	4	6	0	6	35
1	5	9	14	5	2	7	4	5	9	4	2	6	5	5	10	46
2	5	8	13	3	5	8	7	2	9	2	2	4	8	1	9	43
3	8	7	15	2	3	5	9	5	14	2	3	5	2	6	8	47
4	5	6	11	6	7	13	6	10	16	3	2	5	8	1	9	54
5	18	30	48	9	13	22	10	6	16	8	4	12	10	10	20	118
6	25	20	45	12	12	24	13	13	26	5	9	14	10	4	14	123
7	24	28	52	16	12	28	14	16	30	3	9	12	8	12	20	142
8	19	15	34	13	16	29	12	10	22	6	4	10	10	3	13	108
9	8	6	14	5	6	11	4	5	9	4	4	8	6	7	13	55
10	7	5	12	3	1	4	5	3	8	3	2	5	5	5	10	39
11	6	3	9	7	6	13	1	4	5	1	4	5	3	3	6	38
MN 12	4	4	8	3	3	6	2	4	6	1	1	2	5	6	11	33
	171	187	358	109	120	229	109	118	227	57	70	128	99	88	187	1,129

* January to March period
† April to June period.

TABLE 3.2A

DAILY DISTRIBUTION OF ACCIDENTS REPORTED TO THE AMBULANCE, JANUARY TO JUNE, 1962

Day of Week	Area 1			Area 2			Area 3			Area 4			Area 5			Total
	J-M*	A-J†	Total	J-M	A-J	Total	J-M	A-J	Total	J-M	A-J	Total	J-M	A-J	Total	
Monday	15	20	35	18	13	31	10	10	20	9	6	15	15	8	25	124
Tuesday	18	22	40	9	19	28	9	17	26	5	15	20	9	11	20	134
Wednesday	22	21	43	11	20	31	16	9	25	9	7	16	12	10	22	137
Thursday	25	36	61	14	14	28	10	14	24	3	9	12	15	13	28	153
Friday	25	27	52	18	17	35	12	20	32	14	12	26	15	16	31	166
Saturday	44	41	85	22	23	45	30	29	59	10	15	25	19	22	41	256
Sunday	19	20	39	17	14	31	21	19	40	8	6	14	13	7	20	144
Total			355			229			226			128			185	1,123

* January to March. † April to June.

TABLE 3.3A

QUARTERLY TOTALS OF ACCIDENTS (1963)

Time	1st quarter	4th quarter	Total of 1st and 4th quarter	2nd quarter	3rd quarter	Total of 2nd and 3rd quarter
12-2 a.m.	25	46	71	41	35	76
2-4	10	13	23	10	8	18
4-6	10	8	18	6	7	13
6-8	30	38	68	35	34	69
8-10	24	45	69	50	44	94
10-12 MD	41	38	79	35	34	69
12-2 p.m.	38	48	86	39	40	79
2-4	33	66	99	51	66	117
4-5	35	52	87	61	66	127
5-6	44	55	99	78	54	132
6-7	50	71	121	94	77	171
7-8	26	58	84	52	54	106
8-10	40	63	103	51	47	98
10-12 MN	26	59	95	45	39	84
Total	442	660	1,102	648	605	1,253

1st quarter versus 4th quarter = 14.978 N.S.*
2nd quarter versus 3rd quarter = 8.535 N.S.
(1 + 4) versus (2 + 3) = 21.537 N.S.

* (Here and subsequently, 'N.S.' indicates a probability greater than 0.05 that the samples are drawn from the same population)

TABLE 3.4A

TRAFFIC ACCIDENT RESEARCH UNIT WORKING SCHEDULE BASED ON A 20-WEEK CYCLE

Week No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Monday	L	O	E	L	E	E	L	E	L	O	L	L	E	L	E	E	L	E	L	E
Tuesday	E	E	L	O	L	E	L	L	E	E	L	E	L	O	L	E	L	E	E	L
Wednesday	L	E	L	L	E	O	E	E	L	E	L	E	L	E	L	O	L	E	E	L
Thursday	E	L	E	E	L	E	L	O	L	L	E	L	E	E	E	L	E	L	L	O
Friday	L	E	L	E	L	L	E	L	E	E	E	O	L	E	L	L	E	O	L	E
Saturday	O	L	O	E	O	L	O	E	O	L	O	E	O	L	O	E	O	L	O	E
Sunday	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O

E = Early = 10.00 a.m.- 5.45 p.m.
L = Late = 5.45 p.m.-11.00 p.m.
O = Off duty

TABLE 3.5A

NUMBER OF ACCIDENTS ATTENDED

Day of Week	Early Period: Number of accidents attended 0	1	2	3	4	Early Period: Sub-total of accidents	Early Period: Sub-total of working periods	Late Period: Number of accidents attended 0	1	2	3	4	Late Period: Sub-total of accidents	Late Period: Sub-total of working periods	Grand total of accidents	Total working periods
Monday	5	16	4	0	0	24	25	8	8	8	0	0	24	24	48	49
Tuesday	5	12	8	3	0	37	28	9	12	2	1	0	19	24	56	52
Wednesday	0	15	9	2	0	39	26	6	16	9	0	0	34	31	73	57
Thursday	4	7	7	2	0	27	20	8	11	8	3	1	40	31	67	51
Friday	2	10	11	5	2	55	30	1	10	9	2	0	34	22	89	52
Saturday	0	6	4	3	0	23	13	0	2	8	7	0	39	17	62	30*
Sunday	0	2	2	0	0	6	4	0	2	1	1	0	7	4	13	8*
Total accidents	0	68	90	45	8	211		0	61	90	42	4	197		408	
Total working periods	16	68	45	15	2		146	32	61	45	14	1		153		299

*Note: After a short initial period only alternate Saturdays were 'on duty', and no Sundays.

TABLE 3.6A

ADELAIDE METROPOLITAN AREA—SOME 12-HOUR TRAFFIC COUNTS

Location	Date	Total Count	Total Increase	Increase (%)
1	5.4.63. 10.7.64.	49,666 51,292	1,626	3.27%
2	15.5.63. 9.7.64.	45,338 51,805	6,467	14.26%
3	30.1.63. 12.5.64.	35,046 36,916	1,870	5.34%
4	16.4.63. 29.7.64.	27,308 31,656	4,348	15.92%
5	4.7.63. 21.8.64.	28,294 35,164	6,870	24.28%
6	31.1.63. 3.6.64.	27,984 30,438	2,454	8.77%
7	21.3.63. 5.6.64.	20,008 23,436	3,428	17.13%
8	22.5.63. 17.8.64.	79,088 84,754	5,666	7.16%
9	9.9.63. 28.10.64.	41,194 42,682	1,488	3.61%
10	12.3.63. 17.6.64.	22,880 26,364	3,484	15.23%
Total 1963 count Total 1964 count		376,806 414,507	37,701	10.01%

TABLE 3.7A

REGIONAL DISTRIBUTION OF ACCIDENTS (1963)

Number of Accidents	North of the River		South of the River	
	Early period	Late period	Early period	Late period
0	53	81	41	72
1	61	52	52	49
2	46	34	56	32
3	11	13	18	15
4	10	0	11	10
5	0	1	1	3
6	0	0	2	0
Mean	1.249	0.906	1.540	1.117
variance	1.226	1.002	1.560	1.638

TABLE 3.8A

EXPECTATIONS (POISSONIAN) FOR AT LEAST ONE ACCIDENT (1963)

	North of the River		South of the River		Whole City	
	Early	Late	Early	Late	Early	Late
Monday	0.65	0.50	0.74	0.61	0.91	0.81
Tuesday	0.67	0.48	0.69	0.51	0.90	0.75
Wednesday	0.65	0.50	0.75	0.55	0.90	0.77
Thursday	0.69	0.70	0.71	0.60	0.90	0.88
Friday	0.64	0.72	0.81	0.85	0.93	0.95
Saturday	0.85	0.75	0.91	0.88	0.98	0.96
Sunday	0.72	0.30	0.80	0.47	0.94	0.64

TABLE 3.9A

ACCIDENTS ATTENDED IN THE PERIOD FEBRUARY 3 TO AUGUST 28, 1964

		Early Period								Late Period					Total
		10-11 a.m.	11-12 a.m.	12-1 p.m.	1-2 p.m.	2-3 p.m.	3-4 p.m.	4-5 p.m.	5-5.45 p.m.	5.45-7 p.m.	7-8 p.m.	8-9 p.m.	9-10 p.m.	10-11 p.m.	
Monday	All accidents	5	1	3	0	0	3	11	7	13	9	7	3	2	64
	Accidents attended	4	1	1	0	0	3	4	4	5	3	5	2	0	32
	Percentage	*80*	*100*	*33*	*0*	*0*	*100*	*36*	*57*	*38*	*33*	*71*	*67*	*0*	*50*
Tuesday	All accidents	2	2	4	6	2	1	8	11	6	5	9	2	2	60
	Accidents attended	2	1	2	4	0	1	4	6	2	3	4	2	1	32
	Percentage	*100*	*50*	*50*	*67*	*0*	*100*	*50*	*55*	*33*	*60*	*44*	*100*	*50*	*53*
Wednesday	All accidents	1	4	5	2	2	5	8	11	8	9	3	1	2	61
	Accidents attended	1	4	5	0	0	4	4	7	3	4	2	0	2	36
	Percentage	*100*	*100*	*100*	*0*	*0*	*80*	*50*	*64*	*38*	*44*	*67*	*0*	*100*	*59*
Thursday	All accidents	2	1	2	4	1	3	3	6	14	10	7	3	4	60
	Accidents attended	2	1	1	3	1	2	1	5	5	2	3	2	2	30
	Percentage	*100*	*100*	*50*	*75*	*100*	*67*	*33*	*83*	*36*	*20*	*43*	*67*	*50*	*50*
Friday	All accidents	2	2	8	3	1	7	16	12	15	14	8	6	5	98
	Accidents attended	1	1	6	2	1	5	6	4	7	4	5	3	1	47
	Percentage	*50*	*50*	*75*	*67*	*100*	*71*	*38*	*33*	*47*	*29*	*63*	*50*	*20*	*48*
Saturday	All accidents	4	1	6	1	7	2	1	5	15	10	5	3	1	61
	Accidents attended	0	1	3	1	4	1	0	5	5	5	2	2	1	30
	Percentage	*0*	*100*	*50*	*100*	*57*	*50*	*0*	*100*	*33*	*50*	*40*	*67*	*100*	*49*
Total	All accidents	16	11	28	16	13	21	47	52	71	57	39	18	16	404
	Accidents attended	10	9	18	10	6	16	19	31	27	21	21	11	7	207
	Percentage	*73*	*82*	*64*	*63*	*46*	*76*	*40*	*60*	*38*	*37*	*54*	*61*	*44*	*51*

TABLE 4.1A

AGE AND SEX OF DRIVERS OF VEHICLES STRIKING PEDESTRIANS

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	Total
Male	11	16(2)	14	10(1)	10	2	5(1)	1	—	1	1	1	72(4)
Female	1	2	1	—	2	—	1	—	—	—	—	1	8
Total	12	18	15	10	12	2	6	1	—	1	1	2	80(4)

(Figures in parentheses indicate drivers affected by alcohol)

TABLE 5.1A

PEDAL CYCLE ACCIDENTS: AGE OF CYCLIST BY TIME OF DAY

Time of Day	Age in Years																		Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	
a.m. 10.01-11.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11.01-12.00	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
p.m. 12.01- 1.00	—	—	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	3
1.01- 2.00	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2
2.01- 3.00	—	—	—	1	1	—	—	1	—	—	—	—	—	—	—	—	—	—	3
3.01- 4.00	—	—	2	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	4
4.01- 5.00	—	4	2	1	—	—	—	—	—	2	1	—	—	—	—	—	—	—	10
5.01- 6.00	—	1	5	1	—	—	1	—	—	—	—	—	1	1	—	—	—	—	10
6.01- 7.00	—	—	—	2	—	—	—	2	—	1	—	—	—	—	—	—	—	—	5
7.01- 8.00	—	—	1	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	3
8.01- 9.00	—	—	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	3
9.01-10.00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	5	13	8	1	2	1	4	1	4	2	—	1	1	—	—	—	1	44

TABLE 6.1A

MOTOR-CYCLISTS: AGE VERSUS EXPERIENCE

Age in Years	Experience: Months 6	7	Years 13/12-5	6-10	11-20	21-30	31-40	40+	N.R.	Total
15-19	4	5	15						1	25
20-24	1		7	1						9
15-29		1	2	2	3				1	9
30-34	2		2	2	3				1	10
35-39					2				1	3
40-44				1	2					3
45-49						1			2	3
50-54										0
55-59							1			1
60-64				1				1		2
65-69			1						1	2
N.R.									1	1
Total	7	6	27	7	10	1	1	1	7	67

TABLE 6.2A

MOVEMENT OF MOTOR-CYCLE VERSUS TYPE OF OTHER VEHICLE

Other Vehicle	Movement of Motor-cycle: Proceeding straight ahead	Proceeding straight ahead overtaking	Turning right	Turning left	U-turn	Total
Car	38	6	2	0	1	47
Truck	3	0	0	1	0	4
Pedal cycle	0	1	1	0	0	2
Pedestrian	5	2	0	0	0	7
Nil	6	0	0	0	0	6
Total	52	9	3	1	1	66

TABLE 6.3A

TPYE OF OTHER VEHICLE VERSUS ITS MOVEMENT

Other Vehicle	Movement of Other Vehicle: Proceeding straight ahead	Proceeding straight ahead overtaking	Turn right	Turn left	U-turn	Total
Car	10	4	23	2	8	47
Truck	4	0	0	0	0	4
Pedal cycle	1	0	1	0	0	2
Total	15	4	24	2	8	53

TABLE 6.4A

DEGREE OF INJURY

	Degree of Injury					
	Nil	Minor	Moderate	Severe	Very severe	Total
Motor-scooter						
Front impact	3	5	5 (3)	5	1	19 (3 pillion)
Side impact	—	1	1	3	1	5
Motor-cycle						
Front impact	—	9	2	1	1	13
Side impact	—	8 (1)	1	5 (1)	—	14 (2 pillion)
Total	3	23 (1)	9 (3)	14 (1)	3	51 (5 pillion)

TABLE 6.5A

FRONT IMPACTS

Body Area	No. Injured in Each Body Area	
	Motor-scooter riders	Motor-cycle riders
Head	11	6
Thorax	2	1
Abdomen	1	0
Spine and pelvis	0	0
Upper limb	6	6
Lower limb	16	11

TABLE 6.6A

SIDE IMPACTS

Body Area	No. Injured in Each Body Area	
	Motor-scooter riders	Motor-cycle riders
Head	2	8
Thorax	0	2
Abdomen	1	0
Spine and pelvis	0	0
Upper limb	3	4
Lower limb	5	13

TABLE 8.1A

CAR OCCUPANTS: AGE, SEX AND SEATED POSITION

Age in Years	Drivers		Front Seat Passenger		Rear Seat Passenger	
	Male	Female	Male	Female	Male	Female
0- 4			11	11	11	10
5- 9			8	4	14	12
10-14			5	7	10	22
15-19	60	9	26	31	18	13
20-24	97	11	21	16	10	7
25-29	47	4	9	13	9	5
30-34	53	5	10	11	1	4
35-39	61	13	9	15	4	0
40-44	37	6	9	17	3	7
45-49	32	8	4	15	6	3
50-54	27	3	3	7	1	3
55-59	15	5	1	5	1	2
60-64	13	1	0	6	1	5
65-69	12	3	2	6	0	2
70-74	7	1	2	2	0	2
75-79	6	1	1	4	1	0
80+	0	0	1	2	0	2
Total	467	70	122	172	90	99

TABLE 9.1A

COST OF REPAIR (CARS ONLY)

Accident No.	Make and Model	Year of Manu-facture	Section Damage	Cost of Repair (A)	Market Value (B)	A/B	Time to Repair
MINOR DAMAGE:							
0264	Holden EJ sedan	1963	2.1.1.	£ 30	£900	0.03	—
0286	Holden EK utility	1962	2.1.1.	£ 55	£700	0.08	2 days
Total and Average:				£ 85	£1,600	0.05	2 days
MODERATE DAMAGE:							
0232	Vauxhall Cresta sedan	1961	1.2.3.	£186	£925	0.20	2 weeks
0233	Holden FJ sedan	1956	2.3.3.	£ 80	£350	0.23	—
0249	Ford Zephyr sedan I	1955	1.3.2.	£ 90	£300	0.33	3 weeks
0257	Holden FB taxi	1961	3.2.1.	£200	£650	0.31	—
0264	Bedford panel van	1947	2.2.2.	£ 15	£ 30	0.50	—
0267	Holden FJ van	1955	3.2.3.	£258	£300	0.86	—
0269	Holden FE sedan	1957	3.2.1.	£200	£475	0.42	—
0272	Holden EJ sedan	1963	3.1.1.	£152	£900	0.17	1 week
0284	Morris Oxford utility	1952	3.2.1.	Write off	£100	—	—
0286	Morris '850' sedan	1964	3.2.3.	£195	£690	0.28	3 weeks
0288	Austin A50 sedan	1955	3.2.2.	£160	£275	0.58	3 weeks
0288	Volkswagen 1200 sedan	1962	3.1.1.	£ 93	£795	0.12	2 weeks
0288	Holden EH station sedan	1963	3.1.1.	£133	£1,000	0.13	2 weeks
0290	Holden FB sedan	1960	3.1.1.	£ 66	£675	0.10	1 week
0291	Standard Vanguard sedan	1950	3.1.1.	£ 47	£125	0.38	2 weeks
0295	Holden FB St. sedan	1959	3.1.1.	£177	£700	0.25	1 week
0307	Mercedes 220 SE	1963	3.1.1.	£450	£2,400	0.19	1 month
0308	Vauxhall Wyvern	1953	3.2.1.	£126	£200	0.63	5 weeks
0322	Volkswagen 1200 sedan	1963	3.1.1.	£115	£775	0.15	2 weeks
0326	Triumph Mayflower sedan	1951	3.2.1.	Write off	£100	—	—
0327	Holden EK sedan	1962	3.2.1.	£275	£825	0.33	3 weeks
0338	Morris 1100 sedan	1964	1.3.3.	£150	£900	0.17	2 weeks
0340	Holden EJ taxi	1963	3.1.1.	£ 75	£875	0.09	—
0340	Ford Falcon St. sedan	1960	2.3.1.	£100	£650	0.15	—
0342	Riley sports convertible	1951	3.1.1.	Write off	£225	—	—
0346	Holden FJ panel van	1956	3.1.1.	Write off	£300	—	—
0372	Holden FB sedan	1960	3.1.1.	£120	£675	0.18	1½ weeks
0378	Holden FB sedan	1960	2.3.1.	£150	£675	0.22	3 weeks
0387	Holden EK sedan	1961	1.3.3.	£ 94	£775	0.12	1 week
0400	Morris '850' sedan	1961	3.2.1.	£177	£500	0.35	3 weeks
0404	Ford Zephyr II sedan	1959	3.2.1.	£ 70	£640	0.11	—
0411	Holden EH sedan	1963	3.1.1.	£150	£950	0.16	1 week
0416	Renault R4	1963	3.3.1.	£180	£600	0.30	5 weeks
0429	Holden EH taxi	1964	3.2.2.	£186	£925	0.20	2½ weeks
0431	Holden FB sedan	1960	3.1.1.	£ 91	£675	0.13	3½ days
Total and Average:				£5,286	£21,955	0.24	2+ weeks

Section damage code:

Nil	1
Minor	2
Moderate	3
Severe	4
Extremely severe	5

(e.g.: 4.2.1. represents severe frontal damage, **minor** passenger compartment damage, **nil** damage to rear section.)

TABLE 9.1A (cont.)

Accident No.	Make and Model	Year of Manu-facture	Section Damage	Cost of Repair (A)	Market Value (B)	A/B	Time to Repair
SEVERE DAMAGE:							
0227	Holden FE sedan	1957	2.3.4.	£325	£475	0.68	—
0228	Rover	1951	4.2.2.	£200	£200	1.0	—
0235	Morris Minor sedan	1950	2.4.3.	Write off	£125	—	—
0240	Standard Vanguard II	1955	4.3.2.	Write off	£275	—	—
0244	Ford Zephyr II taxi	1959	2.4.2.	£263	£600	0.44	—
0246	Ford Zephyr II utility	1960	2.4.3.	£300	£650	0.46	—
0246	Holden FE sedan	1957	4.2.1.	£233	£475	0.49	—
0261	Jaguar Mk VII	1954	4.4.1.	Write off	£450	—	—
0261	Holden FB sedan	1960	4.3.1.	£450	£675	0.67	—
0266	Skoda station sedan	1950	2.4.2.	Write off	£ 40	—	—
0269	Jaguar Mk V	1949	4.2.1.	£150	£200	0.75	—
0269	Austin A40 panel van	1954	4.3.2.	Write off	£180	—	—
0270	Hillman	1951	3.4.1.	Write off	£ 90	—	—
0272	Hillman station sedan	1958	3.3.3.	£230	£425	0.54	3½ weeks
0275	Ford Falcon sedan	1963	4.3.1.	£227	£825	0.28	—
0275	Ford Customline	1954	4.3.2.	Write off	£350	—	—
0275	Holden FC sedan	1958	4.4.1.	£480	£550	0.87	1 month
0277	Ford Falcon sedan	1964	4.2.2.	£290	£900	0.32	1 month
0277	Ford Customline	1953	4.2.2.	Write off	£225	—	—
0278	Standard Cadet	1955	4.3.1.	Write off	£150	—	—
0280	Ford Customline	1953	4.3.3.	Write off	£225	—	—
0282	Rover	1951	4.2.1.	£ 85	£170	0.50	4 weeks
0283	Holden FE sedan	1957	2.4.2.	£308	£475	0.65	17 days
0286	Austin A30 sedan	1955	3.3.3.	£116	£190	0.61	3 weeks
0287	Pontiac sedan	1951	3.4.1.	Write off	£200	—	—
0291	Ford Anglia	1956	2.4.3.	£182	£240	0.76	1 month
0293	Vauxhall Velox	1962	4.3.1.	£257	£925	0.28	3 weeks
0300	Holden FC sedan	1959	4.2.3.	£450	£625	0.72	4 weeks
0307	Holden EK sedan	1961	2.4.1.	£300	£775	0.39	1 month
0312	Standard '8'	1954	2.5.1.	Write off	£100	—	—
0319	Ford Zephyr II	1959	4.2.1.	£450	£640	0.70	3 weeks
0326	Dodge sedan	1950	2.4.3.	Write off	£130	—	—
0327	Vauxhall Victor	1960	3.4.3.	£209	£600	0.35	1 week
0345	Ford Customline	1953	4.3.1.	Write off	£225	—	—
0345	Pontiac	1937	1.4.3.	Write off	£ 30	—	—
0346	Morris Minor	1957	3.4.1.	Write off	£375	—	—
0355	Volkswagen 1200 sedan	1960	4.3.3.	£304	£650	0.47	3 months
0357	Holden FB sedan	1960	4.3.1.	£400	£675	0.59	—
0373	Austin A40 sedan	1950	2.4.2.	Write off	£ 90	—	—
0394	Morris 850 sedan	1961	4.3.2.	£300	£500	0.60	4 weeks
0405	Ford Prefect sedan	1950	4.2.1.	Write off	£ 60	—	—
0408	Chrysler sedan	1937	4.2.1.	Write off	£ 30	—	—
0412	Holden FC taxi	1959	2.4.3.	£300	£575	0.52	3 weeks
0417	Holden EK utility	1962	4.2.3.	£286	£795	0.36	1½ weeks
Totals and average				£10,159	£16,365	0.62	3½ weeks

Section damage code:

Nil	1
Minor	2
Moderate	3
Severe	4
Extremely severe	5

(e.g.: 4.2.1. represents severe frontal damage, minor passenger compartment damage, nil damage to rear section.)

TABLE 9.1A (cont.)

Accident No.	Make and Model	Year of	Section Damage	Cost of Repair (A)	Market Value (B)	A/B	Time of Repair
EXTREMELY SEVERE DAMAGE:							
0252	Holden FE sedan	1957	4.4.3.	Write off	£475	—	—
0279	Holden FC sedan	1958	4.4.2.	Write off	£550	—	—
0289	Fiat 1100 sedan	1959	2.5.4.	£550	£550	1.00	2 months
0314	Holden FJ panel van	1955	3.5.4.	Write off	£250	—	—
0364	Sunbeam Talbot '80'	1949	2.4.4.	Write off	£100	—	—
Totals and average:				£1,875	£1,875	1.00	2 months

Section damage code:

Nil	1
Minor	2
Moderate	3
Severe	4
Exteremely severe	5

(e.g.: 4.2.1. represents severe frontal damage, minor passenger compartment damage, nil damage to rear section.)

TABLE 11.1A

CAUSE OF INJURY TO EACH BODY AREA OF DRIVERS AND LEFT FRONT SEAT PASSENGERS IN SINGLE IMPACT CAR/CAR COLLISIONS (FRONTAL IMPACT)

	Wind-screen	Centre Post	Door	Instrument Panel	Steering Wheel and Column	Front Seat	Header Area	Ejection		Not Recorded	Total
Head											
Driver	5 (2)	3	5 (1)	—	6 (2)	—	13 (4)	—	—	8 (3)	40 (12)
Front seat passenger	17 (2)	1	—	1	1	—	9 (3)	—	1	2 (1)	32 (6)
	22 (4)	4	5 (1)	1	7 (2)	—	22 (7)	—	1	10 (4)	72 (18)
Thorax											
Driver	—	—	—	—	8 (1)	—	—	—	—	—	8 (1)
Front seat passenger	—	—	—	3	—	—	—	—	—	1	4
	—	—	—	3	8 (1)	—	—	—	—	1	12 (1)
Abdomen											
Driver	—	—	1	—	—	—	—	—	—	—	1
Front seat passenger	—	—	—	—	—	—	—	—	—	—	0
	—	—	1	—	—	—	—	—	—	—	1
Spine and Pelvis											
Driver	—	—	—	—	—	—	1	—	—	—	1
Front seat passenger	—	—	—	—	—	—	—	—	—	—	0
	—	—	—	—	—	—	1	—	—	—	1
Upper limb											
Driver	—	1	6 (1)	1	—	—	—	—	—	7	15 (1)
Front seat passenger	1	3	1	—	—	—	—	—	—	9	14
	1	4	7 (1)	1	—	—	—	—	—	16	29 (1)
Lower limb											
Driver	1	—	1	26 (3)	—	—	—	—	1	3	32 (3)
Front seat passenger	—	—	—	28 (2)	—	—	—	—	—	2	30 (2)
	1	—	1	54 (5)	—	—	—	—	1	5	62 (5)
Total											
Driver	6 (2)	4	13 (2)	27 (3)	14 (3)	0	14 (4)	0	1	18 (3)	97 (17)
Front seat passenger	18 (2)	4	1	32 (2)	1	0	9 (3)	0	1	14 (1)	80 (8)
Grand total	24 (4)	8	14 (2)	59 (5)	15 (3)	0	23 (7)	0	2	32 (4)	177 (25)

(Figures in brackets indicate moderate and greater injuries.)

TABLE 11.2A

CAUSE OF INJURY TO EACH BODY AREA OF DRIVERS AND LEFT FRONT SEAT PASSENGERS ONLY IN SINGLE IMPACT CAR/CAR COLLISIONS (RIGHT SIDE IMPACTS)

	Wind-screen	Centre Post	Door	Instrument Panel	Steering Wheel and Column	Front Seat	Header Area	Ejection	Other	Not Recorded	Total
Head											
Driver	—	1	9 (4)	—	—	—	1	—	—	3	14 (4)
Front seat passenger	—	—	—	2	—	—	3	—	—	4 (1)	9 (1)
	—	1	9 (4)	2	—	—	4	—	—	7 (1)	23 (4)
Thorax											
Driver	—	—	5 (2)	—	—	—	—	—	—	1	6 (2)
Front seat passenger	—	—	—	1	—	1 (1)	—	—	1	—	3 (1)
	—	—	5 (2)	1	—	1 (1)	—	—	1	1	9 (3)
Abdomen											
Driver	—	—	—	—	—	—	—	—	—	—	0
Front seat passenger	—	—	—	—	—	—	—	—	—	—	0
Spine and pelvis											
Driver	—	—	1	—	—	—	—	—	—	—	1
Front seat passenger	—	—	—	—	—	—	—	—	—	—	0
	—	—	1	—	—	—	—	—	—	—	1
Upper limb											
Driver	—	—	3 (1)	—	1	—	—	—	—	3	7 (1)
Front seat passenger	—	—	—	—	2	—	—	—	—	2	4
	—	—	3 (1)	—	3	—	—	—	—	5	11 (1)
Lower limb											
Driver	—	—	4 (1)	5 (1)	—	—	—	—	—	3	12 (2)
Front seat passenger	1	—	1	4	—	—	—	—	—	1	7
	1	—	5 (1)	9 (1)	—	—	—	—	—	4	19 (2)
Total											
Driver	0	1	22 (8)	5 (1)	1	0	1	0	0	10 (1)	40 (10)
Front seat passenger	1	—	1	7	2	1 (1)	3	0	1	7	23 (1)
Grand total	1	1	23 (8)	12 (1)	3	1 (1)	4	0	1	17 (1)	63 (11)

(Figures in brackets indicate moderate and greater injuries.)

TABLE 11.3A

CAUSE OF INJURY TO EACH BODY AREA OF DRIVERS AND LEFT FRONT SEAT PASSENGERS ONLY IN SINGLE IMPACT CAR/CAR COLLISIONS (LEFT SIDE IMPACTS)

	Wind-screen	Centre Post	Door	Instru-ment Panel	Steering Wheel and Column	Front Seat	Header Area	Ejection	Other	Not Recorded	Total
Head											
Driver	4	1	3 (3)	—	—	—	3	—	1	11 (1)	23 (4)
Front seat passenger	—	1	9 (3)	2 (1)	—	—	—	3 (2)	—	7 (1)	22 (7)
	4	2	12 (6)	2 (1)	—	—	3	3 (2)	1	18 (2)	45 (11)
Thorax											
Driver	—	—	2 (2)	1	—	1	—	—	—	2 (1)	6 (3)
Front seat passenger	—	—	5 (2)	—	—	—	—	1 (1)	—	1 (1)	7 (4)
	—	—	7 (4)	1	—	1	—	1 (1)	—	3 (2)	13 (7)
Abdomen											
Driver	—	—	—	—	—	—	—	1	—	1 (1)	2 (1)
Front seat passenger	—	—	1 (1)	—	—	—	—	—	—	—	1 (1)
	—	—	1 (1)	—	—	—	—	1	—	1 (1)	3 (2)
Spine and pelvis											
Driver	—	—	—	—	—	—	—	—	—	—	0
Front seat passenger	—	—	1 (1)	—	—	—	—	1 (1)	—	—	2 (2)
	—	—	1 (1)	—	—	—	—	1 (1)	—	—	2 (2)
Upper limb											
Driver	—	—	—	1	—	—	—	1 (1)	—	12 (1)	14 (2)
Front seat passenger	—	2	—	—	—	—	—	3	—	4 (1)	9 (1)
	—	2	—	1	—	—	—	4 (1)	—	16 (2)	23 (3)
Lower Limb											
Driver	—	—	1	6	—	—	—	1	—	7	15
Front seat passenger	—	—	2	3	—	—	—	3	1	4	13
	—	—	3	9	—	—	—	4	1	11	28
Total											
Driver	4	1	6 (5)	8	0	1	3	3 (1)	1	33 (4)	60 (10)
Front seat passenger	0	3	18 (7)	5 (1)	0	0	0	11 (4)	1	16 (3)	54 (15)
Grand total	4	4	24 (12)	13 (1)	0	1	3	14 (5)	2	49 (7)	114 (25)

(Figures in brackets indicate moderate and greater injuries.)

TABLE 11.4A

VEHICLE DAMAGE VERSUS DRIVER'S INJURIES

Driver's Injuries	Vehicle Damage					
	Minor	Moderate	Severe	Extremely severe	Not recorded	Total
Nil	39	87	17	—	—	143
Minor	12	83	71	3	—	169
Moderate	—	20	34	3	—	57
Severe	1	5	7	3	—	16
Very severe	—	—	5	1	—	6
Fatal	—	—	—	—	—	—
Not recorded	—	2	1	—	1	4
Total	52	197	135	10	1	395

TABLE 11.5A

VEHICLE DAMAGE VERSUS FRONT SEAT PASSENGER'S INJURIES

Front Seat Passenger's Injuries	Vehicle Damage					
	Minor	Moderate	Severe	Extremely severe	Not recorded	Total
Nil	21	30	8	—	—	59
Minor	15	61	41	—	—	117
Moderate	—	18	30	2	—	50
Severe	—	3	6	1	—	10
Very severe	—	1	—	—	—	1
Fatal	—	—	—	1	—	1
Not recorded	—	3	—	—	—	3
Total	36	116	85	4	—	241

TABLE 11.6A

VEHICLE DAMAGE VERSUS REAR SEAT PASSENGER'S INJURIES

Rear Seat Passenger's Injuries	Vehicle Damage					
	Minor	Moderate	Severe	Extremely severe	Not recorded	Total
Nil	17	47	26	—	—	90
Minor	2	25	22	—	—	49
Moderate	—	3	14	2	—	19
Severe	—	2	2	2	—	6
Very severe	—	—	—	—	—	—
Fatal	—	—	—	—	—	—
Not recorded	—	—	—	—	—	—
Total	19	77	64	4	—	164

TABLE 11.7A

CAR OCCUPANTS: LINEAR REGRESSIONS OF MEAN DEGREE OF INJURY ON VEHICLE DAMAGE

391 Drivers degree of injury x vehicle damage				
Variance	D.F.	S.S.	M.S.	V.R.
Regression	1	68.236694	68.236694	107.706***
Deviation	389	246.448750	0.633544	
Total	390	314.685440		
Y = 0.221096 + 0.097230 X				
R = 0.4656				
238 Front seat passenger degree of injury x vehicle damage				
Variance	D.F.	S.S.	M.S.	V.R.
Regression	1	38.301952	38.301952	67.288***
Deviation	236	134.336730	0.569223	
Total	237	172.638680		
Y = 0.397085 + 0.097993 X				
R = 0.4710				
164 Rear seat passenger degree of injury x vehicle damage				
Variance	D.F.	S.S.	M.S.	V.R.
Regression	1	23.341138	23.341138	42.758***
Deviation	162	88.433270	0.545884	
Total	163	111.774400		
Y = —0.014508 + 0.088633 X				
R.0.4569				
Comparison of the slopes of the regression lines				
	D.F.	S.S.	M.S.	V.R.
Combined regression	1	129.6935		
Between regression	2	0.1863	0.0931	0.1562 N.S.
Total regression	3	129.8798		
Pooled regression	787	469.2188	0.5962	

TABLE 12.1A

412 — ALL OCCUPANTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.0000	***	***	**	***	***	***	**	*	***	***	***	***	***	***	**	*	***	***	
2	0.7048	1.0000	***		***	***	***		***	***	*	***	***	**	***	**		***	**	
3	0.4443	0.2716	1.0000		***		***			***		***				**	***	*	**	
4	0.1419	-0.0390	-0.0288	1.0000						**										
5	0.3825	0.1663	0.2148	-0.0128	1.0000	***	*			**					**				*	
6	0.4010	0.1946	0.0413	-0.0432	0.2340	1.0000	***	***		***		**			*			*	***	
7	0.5529	0.3286	0.2373	0.0227	0.1251	0.1941	1.0000		***	***		***	***	***	*			***	***	
8	0.1428	0.0681	0.0479	-0.0316	0.0196	0.1728	0.0185	1.0000	*	***	***	***	*	***	**		*	***	***	*
9	0.1257	0.1641	-0.0006	0.0333	-0.0434	0.0513	0.2728	-0.1236	1.0000		***	***	***	***			**	***	**	***
10	0.4135	0.3065	0.2290	0.1464	0.1506	0.1687	0.2323	0.4143	-0.0763	1.0000	***	***	***	***	***			***	***	
11	0.1720	0.1177	0.0979	0.0153	0.0733	0.0561	0.0366	0.3295	-0.3819	0.4524	1.0000	***			**		***	***		
12	0.3857	0.3298	0.1723	0.0935	0.0954	0.1486	0.3107	0.2750	0.4524	0.6612	0.3499	1.0000	***	***	**			***	***	***
13	0.2156	0.1883	0.0622	0.0690	0.0756	0.0590	0.2840	-0.1016	0.4240	0.2024	-0.0234	0.4677	1.0000	***	*		**	***		**
14	0.1780	0.1414	0.0586	0.0347	-0.0012	0.0657	0.2226	0.2225	0.3523	0.2732	0.0581	0.4212	0.3071	1.0000			*	***		
15	-0.1900	-0.1791	-0.0292	-0.0018	-0.1309	-0.1152	-0.1190	-0.1462	-0.0384	-0.2223	-0.1599	-0.1537	-0.1129	-0.0039	1.0000			*	***	
16	0.1380	0.1343	0.1358	0.0514	0.0820	-0.0157	0.0874	-0.0035	-0.0374	0.0596	0.0053	-0.0080	-0.0063	-0.0795	-0.0346	1.0000				
17	0.1025	0.0588	0.2219	-0.0228	0.0648	0.0884	0.0849	0.1228	-0.1498	0.0997	0.1815	-0.0353	-0.1430	-0.1059	0.0154	-0.0255	1.0000		***	**
18	0.2503	0.2126	0.0995	0.0785	0.0456	0.1038	0.2226	0.2528	0.3122	0.3822	0.1768	0.5620	0.2602	0.4594	0.1030	-0.0171	-0.0609	1.0000		***
19	0.2571	0.1437	0.1514	0.0195	0.1035	0.1707	0.1786	0.2850	0.1301	0.2496	0.0627	0.2250	-0.0232	0.0018	-0.1960	0.0683	0.1692	0.0236	1.0000	*
20	0.0854	0.0750	0.0511	-0.0062	-0.0248	0.0110	0.0823	-0.1039	0.1829	0.0596	0.0132	0.2595	0.1468	0.0672	0.0329	-0.0052	-0.1345	0.2005	-0.0998	1.0000

TABLE 12.2A

192 — DRIVERS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.0000	***	***	*	***	***	***		**	***		***	***	***	**			***	**	
2	0.6626	1.0000	***		**		***		**	***		***	***	**	*			**		
3	0.4952	0.4141	1.0000		***		***		**	**		***	**	*				*		
4	0.1831	-0.0339	-0.0269	1.0000												*				
5	0.4305	0.2328	0.3288	-0.0115	1.0000	***	***						*		**					
6	0.4277	0.1199	0.0357	-0.0405	0.3704	1.0000		***		**		*			*			*		
7	0.6563	0.3085	0.4175	0.0511	0.2510	0.0439	1.0000		**	***		***	***	**				***		
8	0.1397	0.0770	0.0260	-0.0330	-0.0449	0.2926	-0.0304	1.0000	*	***	***	***		**	*			***		
9	0.2206	0.2040	0.1963	0.1070	0.0454	0.0061	0.2188	-0.1499	1.0000		***	***	***	***			**	***	*	
10	0.3917	0.2498	0.2155	0.1279	0.1289	0.1986	0.3044	0.4634	-0.0616	1.0000	***	***	**	**	**			***	***	
11	0.1019	0.0841	-0.0081	-0.0588	-0.0151	0.0550	0.0859	0.3081	-0.3993	0.4219	1.0000	***			*					
12	0.4391	0.3184	0.2764	0.0728	0.0953	0.1478	0.3780	0.2969	0.4915	0.6373	0.2976	1.0000	***	***	*			***	***	*
13	0.3445	0.2837	0.2014	0.1208	0.1783	0.0128	0.3891	-0.1170	0.4299	0.2168	-0.0444	0.4711	1.0000	***			*	**		
14	0.2475	0.2072	0.1853	-0.0442	0.0615	0.0874	0.2291	0.2091	0.3657	0.2279	-0.0258	0.3812	0.2747	1.0000		*		***	***	
15	-0.1912	-0.1687	0.0232	-0.0307	-0.2199	-0.1481	-0.0657	-0.1776	-0.0532	-0.1987	-0.1634	-0.1765	-0.1259	-0.0292	1.0000	**			*	
16	0.1011	0.0276	0.0699	0.1829	0.0977	0.0346	0.0911	0.0759	-0.0447	0.0639	0.0269	0.0024	0.0012	-0.1576	-0.1918	1.0000				
17	-0.0717	0.0033	0.1050	-0.0932	0.0485	-0.0394	-0.0056	0.0809	-0.1953	0.1404	0.1425	-0.0418	-0.1851	-0.1101	0.0745	0.1025	1.0000		*	
18	0.3170	0.1986	0.1734	0.0762	0.0466	0.1774	0.2682	0.2991	0.3363	0.3556	0.1073	0.5436	0.2224	0.4267	0.0961	-0.0581	0.1751	1.0000	*	*
19	0.1915	0.1023	0.0959	0.0678	0.1331	0.1030	0.1700	0.2452	0.1244	0.2889	0.0615	0.2698	0.0517	0.0617	-0.1637	0.0932	-0.0260	0.1451	1.0000	
20	0.1190	0.0482	0.1404	0.0015	-0.0329	0.0176	0.0920	-0.1113	0.0828	0.0215	0.0828	0.1774	0.0816	-0.0053	-0.0109	0.0058	-0.0415	0.1568	-0.0782	1.0000

TABLE 12.3A

130 — FRONT SEAT PASSENGERS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.0000	***	***		**	***	***		**	***		***		**			*	*	***	
2	0.7188	1.0000				**	***		***	***		***		*				***		
3	0.4276	0.1689	1.0000							***						*	**		*	
4	0.0043	0.0374	-0.0311	1.0000																
5	0.2547	0.1150	-0.0432	-0.0108	1.0000			**		*										
6	0.3484	0.2405	0.0316	-0.0461	0.0260	1.0000	***		*			*	*						*	
7	0.4910	0.4106	0.0927	0.0762	-0.0121	0.4074	1.0000		***	*		***	**	***	*			**	*	
8	0.1286	-0.0398	0.1355	-0.0240	0.2562	0.0244	0.0412	1.0000		***	***	**		**				**	***	
9	0.2398	0.2949	-0.0838	-0.0291	-0.0109	0.1880	0.4272	-0.1005	1.0000		***	***	***	***				***		
10	0.3990	0.3367	0.3230	0.1480	0.2059	0.1548	0.2188	0.3705	0.0134	1.0000	***	***	*	***	*			***	*	
11	0.1440	0.1099	0.1717	0.0989	0.0960	-0.0126	-0.0065	0.3577	-0.3168	0.4354	1.0000	***					*	**		
12	0.3686	0.3990	0.1524	0.1009	0.1404	0.1895	0.3449	0.2327	0.5147	0.6624	0.3658	1.0000	***	***				***		*
13	0.1387	0.1135	-0.0039	0.0116	0.0162	0.1824	0.2395	-0.1027	0.4089	0.1781	-0.0287	0.4406	1.0000	*				*		
14	0.2585	0.1922	0.0803	0.0503	0.0251	0.1304	0.3333	0.2392	0.3291	0.3423	0.1607	0.4241	0.2233	1.0000				***		
15	-0.1636	-0.0754	-0.0401	-0.0233	-0.0102	-0.0872	-0.2185	-0.1269	-0.0950	-0.1879	-0.1283	-0.1465	-0.1641	-0.0531	1.0000				**	
16	0.1231	0.1385	0.1835	0.0685	0.0953	-0.0599	0.0412	0.0245	0.0091	-0.0028	0.0696	-0.0333	-0.0119	-0.0223	0.0621	1.0000				
17	0.2180	0.0882	0.2627	0.0578	0.0967	0.1531	0.1465	0.1703	-0.1188	0.0182	0.2058	0.0063	-0.0687	-0.0582	0.1264	0.1168	1.0000		*	*
18	0.2197	0.2887	0.1185	0.0759	0.1056	0.0716	0.2686	0.2350	0.3516	0.3939	0.2479	0.5486	0.2057	0.4537	0.0522	-0.0692	-0.0043	1.0000		
19	0.2835	0.1286	0.2200	-0.0313	0.0679	0.2104	0.2047	0.3164	0.1177	0.1806	0.0035	0.1462	-0.0264	-0.0481	-0.2311	0.0480	0.2204	-0.0431	1.0000	
20	0.0353	0.0575	0.0148	-0.0081	-0.0112	0.0363	0.1077	-0.0806	0.1561	0.0109	0.0311	0.2259	0.0888	0.0233	0.0682	-0.0160	-0.2208	0.1569	-0.1502	1.0000

TABLE 12.4A

90 — REAR SEAT PASSENGERS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.0000	***	***		***	***	*		*	***	***	***				**		*	***	
2	0.7658	1.0000				*		*		***	*	**			**	*			*	
3	0.3551	0.1507	1.0000		***				**		**			*			***			
4	0.1888	-0.0842	-0.0255	1.0000																
5	0.4510	0.1273	0.4574	-0.0215	1.0000	*			**		*									
6	0.4012	0.2452	-0.0518	-0.0415	0.2377	1.0000				*	**								**	
7	0.2628	0.1426	-0.0830	-0.0664	-0.0701	-0.0265	1.0000									***				
8	0.1934	0.2452	-0.0518	0.0415	-0.0438	0.0706	0.1905	1.0000		***	***	**		*					***	
9	-0.2291	-0.1121	-0.2845	-0.1081	-0.2719	-0.1328	0.1961	-0.0893	1.0000	*	***	*	***	***				*		***
10	0.5481	0.4210	0.1248	0.2042	0.1467	0.2259	0.1344	0.3773	-0.2354	1.0000	***	***		*	***			***	**	
11	0.4055	0.2420	0.2766	0.1348	0.2565	0.2740	-0.0460	0.3369	-0.4332	0.5574	1.0000	***					*	*		
12	0.3819	0.3048	0.0265	0.1483	0.0447	0.1785	0.1380	0.3016	0.2676	0.7114	0.4698	1.0000	***	***				***	**	***
13	0.0811	0.1606	-0.0975	-0.0021	-0.1024	-0.0594	0.1090	-0.0594	0.4372	0.1962	0.0363	0.4971	1.0000	***				***		***
14	-0.0048	-0.0022	-0.2469	0.1878	-0.1929	-0.0488	0.1287	0.2525	0.3662	0.2462	0.1060	0.4823	0.5248	1.0000				***		*
15	-0.1769	-0.3200	-0.0848	0.0519	-0.0716	0.0012	-0.0260	-0.1032	0.0601	-0.3408	-0.2014	-0.1561	-0.0318	0.1121	1.0000					
16	0.2761	0.2261	0.1561	-0.0673	0.1318	0.0028	0.3480	0.0028	-0.1605	0.1207	0.0589	-0.0100	-0.0467	-0.1256	0.0207	1.0000				
17	0.1622	0.0643	0.3545	0.0513	0.0845	0.1290	0.0436	0.1137	-0.1242	-0.0144	0.2112	-0.0258	-0.1668	-0.1023	-0.1519	0.0259	1.0000			
18	0.2279	0.1773	-0.0520	0.0906	-0.0207	0.0562	0.1156	0.1843	0.2105	0.4073	0.2334	0.6130	0.4194	0.5183	0.1576	0.1027	-0.1468	1.0000		**
19	0.3499	0.2324	0.0816	-0.0369	0.0959	0.2960	0.1138	0.3703	0.1689	0.2968	0.1684	0.2978	-0.1887	-0.0110	-0.1977	0.0856	-0.0821	-0.0968	1.0000	
20	0.1138	0.1645	-0.0463	-0.0242	-0.0256	-0.0306	-0.0646	-0.1051	0.3991	0.1786	-0.1273	0.4718	0.3684	0.2641	0.0532	-0.1536	-0.0891	0.3306	-0.0572	1.0000

TABLE 12.5A

ALL OCCUPANTS (412)

Variate	Variate											R	V.R.
	8	9	10	11	12	13	14	15	16	17	19		
1		*	***			**			**	*	**	0.50	21.9
2		***	***						**	N.S.		0.39	18.0
3			***						**	***		0.34	17.5
6	**										**	0.21	9.8
7		***	***			**			N.S.	**	N.S.	0.43	15.4

Variate 1 = Overall injury
2 = Injury to head
3 = Thorax
6 = Upper limb
7 = Lower limb
8 = Rollover
9 = Damage to front
10 = Damage to compartment
11 = Damage to rear

Variate 12 = Vehicle damage
13 = Deformation at principal point of impact
14 = Speed at impact
15 = Weight of vehicle
16 = Sex
17 = Age
19 = Weight of other vehicle
R = Multiple regression coefficient
V.R. = Variance ratio

TABLE 12.6A

DRIVERS (192)

Variate	Variate											R	V.R.
	8	9	10	11	12	13	14	15	16	17	19		
1		*	***			**						0.49	20.2
2		N.S.	**			*						0.37	9.7
3		*	*			N.S.				N.S.		0.34	5.9
6	***											0.29	17.9
7	N.S.		***			***						0.46	17.2

Variate 1 = Overall injury
2 = Injury to head
3 = Thorax
6 = Upper limb
7 = Lower limb
8 = Rollover
9 = Damage to front
10 = Damage to compartment
11 = Damage to rear

Variate 12 = Vehicle damage
13 = Deformation at principal point of impact
14 = Speed at impact
15 = Weight of vehicle
16 = Sex
17 = Age
19 = Weight of other vehicle
R = Multiple regression coefficient
V.R. = Variance ratio

TABLE 12.7A

FRONT SEAT PASSENGERS (130)

Variate	Variate											R	V.R.
	8	9	10	11	12	13	14	15	16	17	19		
1		***	***							**		0.52	15.7
3	N.S.	***	***									0.47	11.8
2			***						N.S.	**		0.44	10.1
6		*	N.S.							*		0.30	4.1
7		***	*					*		**		0.54	13.0

Variate 1 = Overall injury
2 = Injury to head
3 = Thorax
6 = Upper limb
7 = Lower limb
8 = Rollover
9 = Damage to front
10 = Damage to compartment
11 = Damage to rear

Variate 12 = Vehicle damage
13 = Deformation at principal point of impact
14 = Speed at impact
15 = Weight of vehicle
16 = Sex
17 = Age
19 = Weight of other vehicle
R = Multiple regression coefficient
V.R. = Variance ratio

TABLE 12.8A

REAR SEAT PASSENGERS (90)

Variate	Variate											R	V.R.
	8	9	10	11	12	13	14	15	16	17	19		
1		*	**			N.S.			*	N.S.	**	0.66	10.8
2						*		**	**		N.S.	0.47	5.9
3				*						**		0.41	8.8
6				*							**	0.37	7.0
7	*	**							***			0.48	8.7

Variate 1 = Overall injury
2 = Injury to head
3 = Thorax
6 = Upper limb
7 = Lower limb
8 = Rollover
9 = Damage to front
10 = Damage to compartment
11 = Damage to rear

Variate 12 = Vehicle damage
13 = Deformation at principal point of impact
14 = Speed at impact
15 = Weight of vehicle
16 = Sex
17 = Age
19 = Weight of other vehicle
R = Multiple regression coefficient
V.R. = Variance ratio

Appendix B

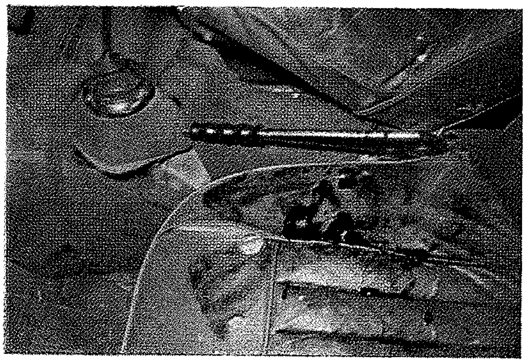


Fig. 8.14—The consequences of drinking and driving: the beer bottle top and blood on the seat of the car (see also p. 176)

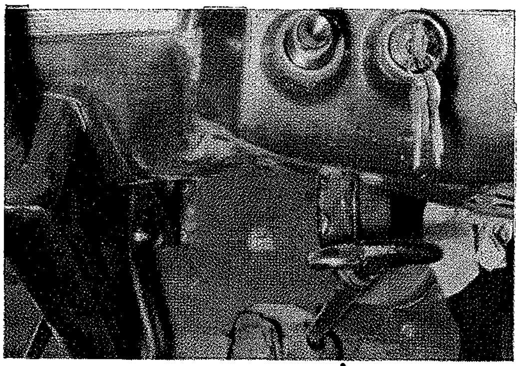


Fig. 9.19—Dent made by the driver's knee in the instrument panel of the Ford Customline shown in *Fig. 9.16* (see also p. 200)

Fig. 9.20—Injuries caused by striking the instrument panel shown in *Fig. 9.19* (see also p. 200)

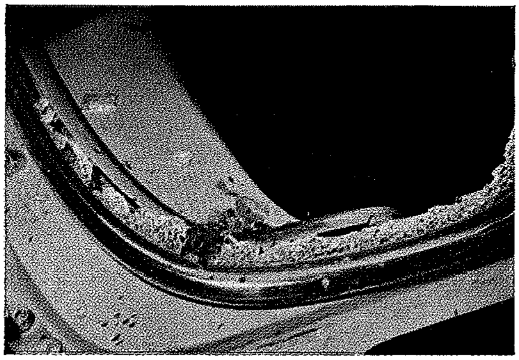


Fig. 9.31—Jagged edge of the toughened glass retained in the frame after the windscreen of this 1955 Ford Customline had been broken. The passenger struck his forehead on this edge (see also p. 208)

APPENDIX C (See also section 4)

ADULT PEDESTRIANS STRUCK BY THE FRONTS OF PASSENGER CARS

ANALYSIS OF VARIANCE AND DERIVATION OF INJURY/SPEED CURVES

X = impact speed (m.p.h.); Y = injury severity; fatal injury: Y = 5;
minor injury: Y = 1.

(a) *All 32 cases*

Variation	Degrees of Freedom	Sums of Squares	Mean Square	Variance Ratio
Regression	1	0.506353	0.506353	17.172***
Deviation	30	0.884608	0.029486	
Total	31	1.390961		

$$\log Y = -0.249281 + 0.516291 \log X$$
$$R = 0.6033$$

(b) *Six cases each involving a Volkswagen 1200 car*

Variation	Degrees of Freedom	Sums of Squares	Mean Square	Variance Ratio
Regression	1	0.244628	0.244628	7.843*
Deviation	4	0.124749	0.031187	
Total	5	0.369377		

$$\log Y = -1.415187 + 1.324670 \log X$$
$$R = 0.8138$$

(c) *Six cases each involving a Ford Falcon car*

Variation	Degrees of Freedom	Sums of Squares	Mean Square	Variance Ratio
Regression	1	0.000354	0.000354	0.008 N.S.
Deviation	4	0.174682	0.043670	
Total	5	0.175036		

$$\log Y = 0.310145 + 0.026359 \log X$$
$$R = 0.0450$$

The values of R (the correlation coefficient) and the variance ratio suggest that the number of cases is too small for a firm conclusion to be drawn.

CHECK ON THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE SLOPES OF THE SPEED/INJURY CURVES FOR VW 1200 AND FORD FALCON

(a) *VW 1200*

$$\text{S.e. (b)} = \sqrt{\frac{\text{residual variance}}{(\log \overline{X} - \log X)^2}} = \sqrt{\frac{0.03119}{0.1394}} = 0.47$$

$$b_{VW} = 1.32 \pm (2.78 \times 0.47) = 1.32 \pm 1.31$$

(b) *Ford Falcon*

$$\text{S.e. (b)} = \sqrt{\frac{0.04367}{0.5103}} = 0.29$$

$$b_F = 0.026 \pm (2.78 \times 0.29) = 0.026 \pm 0.85$$

$$\text{S.e. } (b_{VW} - b_F) = \sqrt{\text{var } (b_{VW}) + \text{var } (b_F)}$$

$$= \sqrt{0.223 + 0.0856}$$

$$= 0.555$$

$$t_8 = \frac{b_{VW} - b_F}{\text{S.e. } (b_{VW} - b_F)} = \frac{1.299}{0.555}$$

$$t_8 = 2.34$$

Significant at 5% level; $t_8 = 2.31$

APPENDIX D

CODE No. 1 — CIRCUMSTANCES AND INJURY CARD

1–4 *Accident No.*

0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

5 *Type of card*
1 Circumstances and injury card

6 *Day of week*
1 Monday
2 Tuesday
3 Wednesday
4 Thursday
5 Friday
6 Saturday
7 Sunday

7–8 *Time in hours*
01 12.01- 1.00 a.m.
02 1.01- 2.00 a.m.
03 2.01- 3.00 a.m.
04 3.01- 4.00 a.m.
05 4.01- 5.00 a.m.
06 5.01- 6.00 a.m.
07 6.01- 7.00 a.m.
08 7.01- 8.00 a.m.
09 8.01- 9.00 a.m.
10 9.01-10.00 a.m.
11 10.01-11.00 a.m.
12 11.01-12.00 noon
13 12.01 p.m.-1.00 p.m.
14 1.01- 2.00 p.m.
15 2.01- 3.00 p.m.
16 3.01- 4.00 p.m.
17 4.01- 5.00 p.m.
18 5.01- 6.00 p.m.
19 6.01- 7.00 p.m.
20 7.01- 8.00 p.m.
21 8.01- 9.00 p.m.
22 9.01-10.00 p.m.
23 10.01-11.00 p.m.
24 11.01-12.00 midnight

9–10 *Month of year*
01 January
02 February
03 March
04 April
05 May
06 June
07 July
08 August
09 September
10 October
11 November
12 December

11 *Year* (code last digit of year)
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9
0 0

12 *Weather conditions*
1 Day
2 Night

13 *Road conditions*
1 Dry
2 Wet

14 *Road characteristics*
1 At intersection
2 Not at intersection

15 *Road characteristics*
1 View open
2 View obscured

16 *Road characteristics*
1 Straight
2 Curved
9 Not applicable

17 *No. of vehicles in this accident*
1 1
2 2
3 3
4 4
5 5
6 6

18 *No. of persons in this accident*
1 1
2 2
3 3
4 4
5 5
6 6
7 7

8 8
9 9+

19 *Type of accident*
1 No collision
2 Collision

20 *Type of collision*
1 With moving vehicle
2 With stationary vehicle
3 With pedestrian
4 With fixed object
5 With moving object (not a pedestrian or motor vehicle)

21 *Unit 1 — type of vehicle*
1 Car
2
3 Light truck
4 Heavy truck and bus
5 Car with trailer
6 Motor-cycle, motor-scooter
7 Pedal cycle
8 Motor-cycle with sidecar, 3-wheel car
9 Pedestrian

22 *Unit 1 — type of car*
1 2-door sedan
2 4-door sedan
3 Tourer, hood up
4 Tourer, hood down
9 Not applicable

23 *Unit 1 — make of car*
1 Holden
2 Ford
3 Morris/Austin
4 Volkswagen
5 Chrysler
6 Hillman
7 Vauxhall
8 Fiat
9 Others

24 *Unit 1 — rollover*
1 No
2 Yes

25 *Unit 1 — degree of vehicle damage*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Extreme

26 *Unit 2 — type of vehicle*
1 Car
2
3 Light truck
4 Heavy truck and bus
5 Car with trailer
6 Motor-cycle, motor-scooter
7 Pedal cycle
8 Motor-cycle with sidecar, 3-wheel car
9 Pedestrian

27 *Unit 2 — type of car*
1 2-door sedan
2 4-door sedan
3 Tourer, hood up
4 Tourer, hood down
9 Not applicable

28 *Unit 2 — make of car*
1 Holden
2 Ford
3 Morris/Austin
4 Volkswagen
5 Chrysler
6 Hillman
7 Vauxhall
8 Fiat
9 Others

29 *Unit 2 — rollover*
1 No
2 Yes

30 *Unit 2 — degree of vehicle damage*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Extreme

31 *Principal other vehicle — its unit number*
3 3
4 4
5 5
6 6
7 7
8 8

32 *Principal other vehicle — type of vehicle*
1 Car
2
3 Light truck
4 Heavy truck and bus
5 Car with trailer
6 Motor-cycle, motor-scooter
7 Pedal cycle
8 Motor-cycle with sidecar, 3-wheel car
9 Pedestrian

33 *Principal other vehicle — type of car*
1 2-door sedan
2 4-door sedan
3 Tourer, hood up
4 Tourer, hood down

34 *Principal other vehicle — make of car*
1 Holden
2 Ford
3 Morris/Austin
4 Volkswagen
5 Chrysler
6 Hillman
7 Vauxhall
8 Fiat
9 Others

35 *Principal other vehicle — rollover*
1 No
2 Yes

36 *Principal other vehicle — degree of vehicle damage*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Extreme

37 *Accident severity*
1 Minor
2 Moderate
3 Severe
4 Very severe

38 *Unit No. of vehicle containing participant concerned*
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9

39 *Type of participant*
1 Car occupant
2 Motor-cycle or scooter rider or passenger
3 Pedal cyclist
4 Pedestrian

40 *Direction of impact for vehicles*
1 Head-on
2 From right front
3 At right angle from right
4 From right rear
5 Direction from rear
6 From left rear
7 At right angle from left
8 From left front
9 Not applicable

40 *Movement of this unit (if pedestrian) prior to accident*
1 Crossing road at marked pedestrian crossing
2 Crossing road, not at marked pedestrian crossing
3 Walking along road, facing oncoming traffic
4 Walking along road, back to oncoming traffic
5 Not on road
6 Playing on road
7 Other
8
9

41 *Speed at impact*
1 Stationary
2 1-10 m.p.h.
3 11-20 m.p.h.
4 21-30 m.p.h.
5 31-40 m.p.h.
6 41-50 m.p.h.
7 51-60 m.p.h.
8 61+ m.p.h.
9 Reversing

42 *Door opened* (If any door opened, was it the door of the compartment occupied by this person?)
1 No
2 Yes

43 *Type of door locks — longitudinal restraint*
1 No
2 Yes

44 *Survivability* (for compartment occupied by this person)
1 Definitely survivable
2 Questionably survivable
3 Not survivable
9 Not applicable (pedestrian, cyclist)

45 *Ejection*
1 No
2 Yes
3 Not applicable (cyclist)

46–7 *Age in years*
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9
0 0

48 *Sex*
1 Male
2 Female

49 *Seated position*
1 Driver or rider
2 Centre front
3 Left front
4 Rear right
5 Centre rear
6 Left rear
7 Other auto seating
8 Pillion passenger
9 Sidecar passenger

50 *Degree of injury (overall assessment)*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Fatal

51 *Injuries to head and neck (excluding spine)*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Fatal

52 *Cause of injury to head and neck — for car occupant — code*
1 Windshield and frame
2 Corner post area left and right
3 Door including handles, glass and frame
4 Instrument panel area
5 Steering column wheel and horn rim
6 Front seat
7 Header area, including mirror
8 Striking ground or fixed object
9 Other

52 *For motor-cyclists, pedal cyclists, and pedestrians*
1 Striking ground or fixed object
2 Struck by front of vehicle
3 Striking top of bonnet or mud-guard
4 Striking windscreen
5 Struck by side of vehicle
6 Striking part of own vehicle
7 Other

53 *Injury to thorax*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Fatal

54 *Cause of injury to thorax*
(As for column 52)

55 *Injury to abdomen (excluding spine)*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Fatal

56 *Cause of injury to abdomen*
(As for column 52)

57 *Injuries to spine and pelvis*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Fatal

58 *Cause of injury to spine and pelvis*
(As for column 52)

59 *Injuries to upper limb*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Fatal

60 *Cause of injury to upper limb*
(As for column 52)

61 *Injuries to lower limb*
1 None
2 Minor
3 Moderate
4 Severe
5 Very severe
6 Fatal

62 *Cause of injuries to lower limb*
(As for column 52)

63 *Region of most significant injury*
1 Head and neck
2 Thorax
3 Abdomen
4 Upper limb
5 Lower limb
6 Spine

64 *Disposal*
1 No treatment
2 First aid at scene only — not taken to hospital
3 Treated in casualty and discharged

4 Admitted to hospital and later discharged
5 Died in hospital
6 Dead on arrival at hospital
7 Killed at scene

65 *Length of hospital stay*
1 0- 1 day
2 1- 2
3 3- 5
4 6-10
5 11-15
6 16-20
7 21-25
8 26-30
9 More than 30

66 *Occupant of a vehicle which struck a pedestrian*
1 No
2 Yes

67 *Seat belts fitted*
1 No
2 Yes
For motor-cyclist — safety helmet worn
1 No
2 Yes

68 *Seat belts in use*
1 No
2 Yes

69 *Type of seat belts*
1 Lap belts
2 3 point
3 Shoulder harness
4 Diagonal

70 *Alcohol present*
1 No
2 Yes

71 *Blood alcohol values*
1 0
2 0.01-0.05
3 0.06-0.10
4 0.11-0.15
5 0.16-0.20
6 0.21-0.25
7 0.26-0.30
8 0.31-0.35
9 More than 0.35

72 *Height (to nearest inch)*
1 5′ 3″
2 5′ 3″-5′ 5″
3 5′ 6″-5′ 8″
4 5′ 9″-5′ 11″
5 6′ 0″-6′ 2″
6 6′ 3″+ inches
9 Not recorded

73 *Weight (to nearest stone)*
1 6 stone
2 6- 7 stone
3 8- 9 stone
4 10-11 stone
5 12-13 stone
6 14+ stone
9 Not recorded

74 *Spare column*

75 *Spare column*

76 *Region (of Adelaide)*

77 *Driving experience — for drivers and riders only*
1 No licence
2 0- 6 months
3 7-12 months
4 13 months-5 years
5 6-10 years
6 11-20 years
7 21-40 years
8 40+ years
9 Not recorded

78 *Previous accidents — for drivers and riders only*
0 0
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8+
9 Not recorded

79 *Distance from origin* — 11 punch if home — for drivers, riders and pedestrians
1 0-½ mile
2 ½-1 mile
3 1½-2 miles
4 2½-5 miles
5 5½-10 miles
6 10½-15 miles
7 15+ miles
9 Not recorded

80 *Distance from destination* — 11 punch if home — for drivers, riders and pedestrians
1 0-½ mile
2 ½-1 mile
3 1½-2 miles
4 2½-5 miles
5 5½-10 miles
6 10½-15 miles
7 15+ miles
9 Not recorded

CODE NO. 2 — ACCIDENT CIRCUMSTANCES AND VEHICLE DATA CARD

1–4 *Accident No.*

0	0	0	0
1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

5 *Type of card*
2 Accident circumstances and vehicle data

6 *No. of this unit*

1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	Not elsewhere classified

7 *Natural lighting*
1 Day
2 Night
3
4
5
6
7
8
9 Not recorded

8 *Type of artificial lighting on this unit* (approaching scene)
1 Incandescent
2 Mercury vapour
3 Sodium vapour
4 Fluorescent
5 Primarily extraneous (shop windows, signs, etc.)
6 None
7 Not elsewhere classified
8 Not applicable
9 Not recorded

9 *Colour of this unit, if vehicle*
1 Grey, light green, light blue
2 White, cream
3 Orange, bright red
4 Dark red, purple, brown
5 Black, dark blue
6 Dark grey, dark green
7 Not elsewhere classified
8 Not applicable
9 Not recorded

10 *Contrast of vehicle colour with background*
1 Good
2 Fair
3 Poor
4 Not able to assess
5
6
7
8 Not applicable
9 Not recorded

11 *Location of accident; traffic control for this vehicle*
1 Not at an intersection
2 At an intersection, no traffic control for this vehicle
3 At an intersection, stop sign for this vehicle
4 At an intersection, traffic lights for this vehicle
5 At an intersection, police control for this vehicle
6 At an intersection, not elsewhere classified
7 Not at an intersection, traffic control for this vehicle (traffic lights, police, etc.)
8 Not applicable
9 Not recorded

12 *Road alignment* (for this vehicle)
1 Straight
2 Curved
3
4
5
6
7
8 Not applicable
9 Not recorded

13 *Road surface conditions for this unit*
1 Dry
2 Wet
3
4
5
6
7
8
9 Not recorded

14 *Road surface conditions for this unit*
1 Smooth
2 Rough (holes, deep ruts)
3 Major irregularity (spoon drain, etc.)
4
5
6
7
8 Not applicable
9 Not recorded

15 *Road surface conditions for this unit*
1 Clean
2 Loose material
3
4
5
6
7
8 Not applicable
9 Not recorded

16 *Type of road surface for this unit*
1 Bitumen
2 Concrete
3 Gravel
4 Earth
5
6
7 Not elsewhere classified
8 Not applicable
9 Not recorded

17 *Type of accident for this unit*
1 Single impact; non-rollover
2 Multiple impact; non-rollover
3 Rollover secondary to single or multiple impact
4 Rollover principal
5 No impact
6
7
8 Not elsewhere classified
9 Not recorded

18 *Type of collision for this unit*
1 With moving vehicle } excluding cycles, motor-cycles
2 With stationary vehicle } excluding cycles, motor-cycles
3 With pedestrian
4 With cycle, motor-cycle
5 With movable object
6 With immovable object
7 Combinations of the above
8 Not elsewhere classified
9 Not applicable

19 *Type of this unit*
1 Car and car-type station sedans, vans, utilities
2
3 Motor-cycle, motor-scooter
4 Pedal cycle
5 Light truck, jeep-type vehicle small bus
5 Light truck, jeep-type vehicle weight), bus, semi-trailer
7 Car with trailer
8 3-wheel car, motor-cycle with sidecar
9 Other

20 *No. of occupants in this unit*
0 0
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 More than 7
9 Not recorded

21 *Type of this unit if car*
1 Four-door (neglect rear openings unless used by passengers)
2 Two-door
3
4
5
6
7
8 Not elsewhere classified
9 Not recorded

22 *Type of this unit if car*
1 Hard top
2 Soft top (erected)
3 Soft top (folded)
4
5
6
7
8 Not elsewhere classified
9 Not recorded

23 *Type of this unit if car*
1 Engine at front
2 Engine at rear
3
4
5
6
7
8 Not elsewhere classified
9 Not recorded

24–26 *Make of this unit if car*

001 Holden, FE, FC, FB, EK
002 Holden, FJ, FX
003 Holden EJ, EH
004
005 Ford Zephyr
006 Ford Prefect, Anglia
007 Ford Customline, Mainline
008 Ford Consul
009 Ford Falcon
010 Volkswagen 1200
011 Vauxhall Wyvern
012 Vauxhall Velox, Cresta
013 Vauxhall Victor
014 Standard Vanguard
015 Morris Minor, Minor 1000
016 Morris 850
017 Morris Oxford
018 Morris 8/40
019 Morris '6'
020 Chrysler Valiant
021 Simca Aronde
022 Austin A50, A55
023 Austin A95 Westminster; A90 Atlantic
024 Austin A30
025 Austin A40
026 Austin '8'
027 Jaguar
028 Humber Hawk
029 Humber Super Snipe
030 Riley 1½ litre
031 Riley 2½ litre
032 Plymouth, Dodge, De Soto
033 Wolseley
034 Mercedes 180, 190
035 Hillman
036 Chevrolet
037 Ford 'V8', pre-1949
038 Singer 'Gazelle'
039 Buick
040 Chrysler Royal
041 Simca 'Vedette'
042 Renault '760'
043 Austin-Healey
044 Fiat
045 Singer 1500
046 Studebaker
047 Skoda
048 Hudson
049 Mercedes 220S, 220SE
050 D.K.W.
051 Morris Elite, Morris Major, Austin Lancer
052 Triumph Herald
053 Ford Cortina
054 Rover
055 Standard 10, 8
056 Austin A70
057 Peugeot 403
058 Bedford
059 Pontiac
060 Triumph Mayflower
061 Renault Dauphine
062 Morris 1100
063 Austin Freeway
064 Renault Floride
065 Sunbeam Talbot
066 Renault R4
067 MG Magnette

Code 'not recorded' as '999'

24–26 *Make of this unit if motor-cycle or Scooter, motor-cycle with sidecar or three-wheeled car*

001 Honda 250 cc, 125 cc motor-cycle
002 Honda Cub motor-cycle
003 Vespa motor-scooter
004 Lambretta L 125, L 150 motor-scooter
005 Triumph 650 motor-cycle
006 ISO motor-scooter
007 Harley Davidson motor-cycle with sidecar
008 James motor-cycle
009 B.S.A. 250 cc motor-cycle
010 B.S.A. 650 cc motor-cycle
011 B.S.A. 125 cc, 150 cc motor-cycle
012 B.M.W. R60 motor-cycle
013 Triumph 500 cc motor-cycle
014 Harley Davidson motor-cycle
015 A.J.S. 350 cc motor-cycle, Matchless 350 cc motor-cycle
016 Heinkel motor-scooter
017 B.S.A. 350 cc motor-cycle
018 Jawa 250 cc, 350 cc motor-cycle
019 Messerschmitt 3-wheeled car
020 Puch 250 cc motor-cycle
021 Durkopp Diana motor-scooter

Code 'not recorded' as '999'

24–26 *Make of this unit if truck, jeep type vehicle, bus, semi-trailer*

001 Austin 10-ton truck
022 International truck
003 International — semi-trailer
004 Ford Thames van
005 Austin 3-ton truck, 5-ton truck
006 Chevrolet truck
007 Dodge utility, van
008 V.W. Kombi-Van, pick-up, etc.
009 Dodge truck
010 Bedford truck
011 Ford truck, utility
012 Bedford van
013 M.T.T. bus

014	Foden heavy truck
015	Commer van
016	International utility
017	Leyland bus
018	Ford semi-trailer
019	Diamond 'T' truck
020	Austin van
021	A.E.C. semi-trailer
022	Land Rover

27–28 *Year of manufacture of this unit* (code last two digits of year)

0 0
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9
Code 'not recorded' as '99'

29 *Weight of this unit, if car*

1 Less than 1,000 lb
2 1,000 to 1,499 lb
3 1,500 to 1,999 lb
4 2,000 to 2,499 lb
5 2,500 to 2,999 lb
6 3,000 to 3,499 lb
7 3,500 to 3,999 lb
8 Over 3,999 lb
9 Not recorded

Weight of this unit, if truck, jeep type, etc.

1 Less than 1 ton
2 1 ton but less than 2 tons
3 2 tons but less than 3 tons
4 3 tons but less than 4 tons
5 4 tons but less than 5 tons
6 5 tons but less than 6 tons
7 6 tons but less than 7 tons
8 7 tons or more
9 Not recorded
Note: include weight of load for trucks

30 *Speed of this vehicle prior to accident*

0 Stationary
1 1-10 m.p.h.
2 11-20 m.p.h.
3 21-30 m.p.h.
4 31-40 m.p.h.
5 41-50 m.p.h.
6 51-60 m.p.h.
7 61+ m.p.h.
8 Reversing
9 Not recorded

31 *Speed of this vehicle at impact or on rollover*

0 Stationary
1 1-10 m.p.h.
2 11-20 m.p.h.
3 21-30 m.p.h.
4 31-40 m.p.h.
5 41-50 m.p.h.
6 51-60 m.p.h.
7 61+
8 Reversing
9 Not recorded

32 *Skidding due to braking*

1 No
2 Yes
3
4
5
6
7
8 Not applicable
9 Not recorded

33 *Movement of this unit prior to accident*

1 Proceeding straight ahead, not overtaking vehicle on traffic lane
2 Proceeding straight ahead, overtaking vehicle on traffic lane
3 Turning right
4 Turning left
5 Stationary on traffic lane
6 Parked off traffic lane
7 Performing U-turn
8 Entering traffic lane
9 Not elsewhere classified
Note: Consider movement on smooth curves as for straight roads

34–35 *Alignment of principal other vehicle, or direction of principal impact if no other vehicle* (*see para. 9.12*)

0 0
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9
77 Not elsewhere classified
88 Not applicable
99 Not recorded
Code: Rollover only as 13
Top impact as 14
Bottom impact as 15

36–37 *Point of principal impact*
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9
Note: Code wheels as being in areas 2, 4, 8 and 10
Code area between wheels as 3, 6, 9, and 12
Code top as 13, 14, 15 and 16, for corners with the front right corner as 13 and then clockwise round the car; 18, 19 for front or rear.
77 Not elsewhere classified
88 Not applicable
99 Not recorded

38 *Permanent deformation at point of principal impact*
1 Nil
2 0-3 in.
3 3½ to 9 in.
4 9½ to 15 in.
5 15½ to 30 in.
6 More than 30 in.
7
8 Not applicable
9 Not recorded
Note: Deformation measured on a line from the point of impact to the centre of the vehicle

39 *Region of maximum deformation of passenger compartment*
1 No deformation
2 Left side
3 Right side
4 Top
5 Front
6 Rear
7 Other
8 Not applicable
9 Not recorded

40 *Movement of this unit during the accident*
1 Did not rollover
2 Did rollover
3
4
5
6
7
8 Not applicable
9 Not recorded

41 *Sequence of rollover, if applicable*
1 Before collision
2 After collision
3 Before and/or after collision
4 Rollover only, no collision
5
6
7 Not elsewhere classified
8 Not applicable
9 Not recorded

42 *Type of rollover*
1 Side over side to the right
2 Side over side to the left
3 Side over end
4 End over end
5 Roll in mid-air
6
7 Not elsewhere classified
8
9 Not recorded

43 *Degree of rollover*
1 ¼ roll
2 ½ roll
3 ¾ roll
4 1 roll
5 1¼ roll
6 1½ roll
7 1¾ roll
8 2 or more
9 Not recorded

44 *Rollover surface*
1 Hard, smooth
2 Hard, rough
3 Soft
4 Irregular surface, with some hard rough material
5 Irregular surface, with no hard rough material
6
7
8 Not applicable
9 Not recorded

45 *Spin*
1 Negligible spin
2 Clockwise, before accident
3 Anticlockwise, before accident
4 Clockwise, after collision and/or during rollover
5 Anti-clockwise, after collision and/or during rollover
6 'Jack-knifed'
7 Not elsewhere classified

8	Not applicable
9	Not recorded

46–47 *Condition of tyres fitted to this unit*

Front wheel/s

1	Both good
2	Both poor
3	R.H. good, L.H. poor
4	R.H. poor, L.H. good
7	Not elsewhere classified (collision damage, etc.)
8	Not applicable
9	Not recorded

Rear wheel/s

1	Both good
2	Both poor
3	R.H. good, L.H. poor
4	R.H. poor, L.H. good
7	Not elsewhere classified (collision damage, etc.)
8	Not applicable
9	Not recorded

48 *Overall vehicle damage* (other than car)

1	Nil
2	Minor
3	Moderate
4	Severe
5	Extremely severe
6	
7	
8	Not applicable
9	Not recorded

48 *Overall car damage (multiple areas of damage)*

col. 48 — front	col. 49 — compartment	col. 50 — rear	
1	1	1	Nil
2	2	2	Minor
3	3	3	Moderate
4	4	4	Severe
5	5	5	Extremely severe
6	6	6	
7	7	7	
8	8	8	Not applicable
9	9	9	Not recorded

51–54 *Vehicle doors* (after accident)

	Front right col. 51	Front left col. 52	Rear right col. 53	Rear left col. 54
Remained closed, operate normally	1	1	1	1
Open, cannot shut; no damage to door	2	2	2	2
Open, cannot shut; damage to door	3	3	3	3
Open, operate normally	4	4	4	4
Jammed shut; cannot open	5	5	5	5
Remained closed, do not operate normally	6	6	6	6
Not elsewhere classified	7	7	7	7
Not applicable	8	8	8	8
Not recorded	9	9	9	9

55 *Vehicle door locks*
1 Longitudinal restraint
2 No longitudinal restraint
3
4
5
6
7 Not elsewhere classiified, e.g., locks on rear doors differ from those on front
8 Not applicable
9 Not recorded

56 *Type of windscreen glass*
1 Tempered
2 Laminated
3 Plate
4 Tempered (tinted)
5 Laminated (tinted)
6 Plate (tinted)
7 Not elsewhere classified
8 Not applicable
9 Not recorded

57 *Form of windscreen glass*
1 Curved, one piece
2 Flat, one piece
3 Curved, two piece
4 Flat, two piece
5
6
7 Not elsewhere classified
8 Not applicable
9 Not recorded

58 *Damage to windscreen*
1 No damage
2 Tempered glass broken, probable occupant contact
3 Tempered glass cracked or broken, no occupant contact
4 Laminated glass cracked or broken, probable occupant contact
5 Laminated glass cracked or broken, no occupant contact
6 Not elsewhere classified; but occupant contact probable
7 Not elsewhere classified; no occupant contact
8 Not applicable
9 Not recorded

59 *Damage to window glass* (other than windscreen)
1 No damage
2 Damage, probable occupant contact
3 Damage, no occupant contact
4 No damage, probable occupant contact
5
6
7
8 Not applicable
9 Not recorded

60 *Steering wheel damage*
1 No damage
2 Minor damage, probable occupant contact
3 Moderate or severe damage, probable occupant contact
4 Damaged, not due to occupant contact
5 No damage, probable occupant contact
6
7 Not elsewhere classified
8 Not applicable
9 Not recorded

61 *Dash panel damage*
1 No damage
2 Minor damage, probable occupant contact
3 Moderate or severe damage, probable occupant contact
4 Damaged, not due to occupant contact
5 No damage, probable occupant contact
6
7 Not elsewhere classified
8 Not applicable
9 Not recorded

62 *Rear vision mirror damage*
1 Nil
2 Damaged, probable occupant contact
3 Damaged, no occupant contact
4 No interior mirror
5 No damage, probable occupant contact
6
7
8 Not applicable
9 Not recorded

63 *Seat belts fitted (car, truck, etc.); safety helmet worn (motor-cycle)*
1 No
2 Yes
3
4
5

6
7
8 Not applicable
9 Not recorded

64 *Front seat damage*
1 No damage
2 Damaged, due to inertia of seat and/or occupants
3 Damaged, resulting from damage to vehicle body
4 No damage, probable occupant contact
5
6
7
8 Not applicable
9 Not recorded

65 *Engine mounting damage*
1 Undamaged
2 Damaged; one mount or more partly torn free
3 Damaged; one mount or more completely torn free
4
5
6
7 Not elsewhere classified
8 Not applicable
9 Not recorded

66 *Number of principal other unit*
0 No other unit involved
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 Not elsewhere classified

67 *Type of principal other unit*
1 Car, and car-type station sedans, vans, utilities
2 Pedestrian
3 Motor-cycle, motor-scooter
4 Pedal cycle, motor-assisted cycle
5 Light truc, jeep-type vehicle, small bus
6 Heavy truck (over 2 tons tare weight), bus, semi-trailer
7 Car with trailer
8 3-wheeled car, motor-cycle with sidecar
9 Other

68, 69, 70 *Make of principal other unit if car*
001 Holden, FE, FC, FB, EK
002 Holden FJ, FX
003 Holden EJ, EH
004
005 Ford Zephyr
006 Ford Prefect, Anglia
007 Ford Customline, Mainline
008 Ford Consul
009 Ford Falcon
010 Volkswagen, 1200
011 Vauxhall Wyvern
012 Vauxhall Velox, Cresta
013 Vauxhall Victor
014 Standard Vanguard
015 Morris Minor, Minor 1000
016 Morris 850
017 Morris Oxford
018 Morris 8/40
019 Morris '6'
020 Chrysler Valiant
021 Simca
022 Austin A50, A55
023 Austin A95 Westminster; A90 Atlantic
024 Austin A30
025 Austin A40
026 Austin '8'
027 Jaguar
028 Humber Hawk
029 Humber Super Snipe
030 Riley 1½ litre
031 Riley 2½ litre
032 Plymouth, Dodge
033 Wolseley
034 Mercedes 180
035 Hillman
036 Chevrolet
037 Ford 'V8', pre-1949
038 Singer 'Gazelle'
039 Buick
040 Chrysler Royal
041 Simca 'Vedette'
042 Renault '760'
043 Austin-Healey
044 Fiat
045 Singer 1500
046 Studebaker
047 Skoda
048 Hudson
049 Mercedes 220S, 220SE
050 D.K.W.
051 Morris Elite, Morris Major, Austin Lancer
052 Triumph Herald
053 Ford Cortina
054 Rover

055	Standard 10, 8
056	Austin A70
057	Peugeot 403
058	Bedford
059	Pontiac
060	Triumph Mayflower
061	Rennault Dauphine
062	Morris 1100
063	Austin Freeway
064	Renault Floride
065	Sunbeam Talbot
066	Renault R4
067	M.G. Magnette

71 *Type of principal other unit (if car)*

1 Front
2 Rear engine
3
4
5
6
7
8 Not elsewhere classified
9 Not recorded

76 *Overall vehicle damage — car*

1 Front
2 Minor
3 Moderate
4 Severe
5 Extremely severe
6
7
8 Not applicable
9 Not recorded

77 *Weight of principal other unit, if car*

1 Less than 1,000 lb
2 1,000 to 1,499 lb
3 1,500 to 1,999 lb
4 2,000 to 2,499 lb
5 2,500 to 2,999 lb
6 3,000 to 3,499 lb
7 3,500 to 3,999 lb
8 Over 3,999 lb
9 Not recorded

78 *Speed on impact of principal other unit (m.p.h.)*

0 Stationary
1 1-10
2 11-20
3 21-30
4 31-40
5 41-50
6 51-60
7 61 and over
8 Reversing
9 Not recorded

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