TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-AM-73-1		

4. Title and Subtitle	5. Report Date
APPLICATION OF COMMERCIAL AIRCRAFT ACCIDENT INVESTIGATION TECHNIQUES TO A RAILROAD DERAILMENT.	January 1973
	6. Performing Organization Code
7. Author(s) Gale Braden, William Reed, and John J. Swearingen, D. Av. T.	8. Performing Organization Report No.
9. Performing Organization Name and Address FAA Civil Aeromedical Institute P. O. Box 25082 Oklahoma City, Oklahoma 73125	10. Work Unit No.
	11. Contract or Grant No.
	13. Type of Report and Period Covered OAM
12. Sponsoring Agency Name and Address Office of Aviation Medicine Federal Aviation Administration 800 Independence Avenue, S. W. Washington, D. C. 20591	14. Sponsoring Agency Code

15. Supplementary Notes

Research leading to preparation of this report was performed under Project AM-A-72-PRS-37.

16. Abstract

Crash investigation techniques utilized by human factors teams in investigating commercial airline crashes have been applied in the analysis of a railroad train derailment - crash.

Passengers in cars that remained upright experienced very low deceleration forces and practically no injuries in stopping from a speed of 90 miles per hour over distances in excess of 1,000 feet.

Four passenger cars and the diner were turned over on their sides and continued to slide after jackknifing. During the turnover and slide these cars were penetrated by railroad rails, cross ties, and a heavy compressor. Several passengers were ejected through windows and crushed beneath the cars. The 11 deaths and all severe and serious injuries occurred in these five overturned cars.

An analysis of escape routes from an overturned railroad passenger car is presented and shows that it is difficult for an injured passenger to escape.

17. Key Words	18. Distribution Statement
Crash injury, railroad accidents, vehicle design, emergency escape, crash safety.	Availability is unlimited. Document may be released to the National Technical Information Service, Springfield, Virginia 22151, for sale to the public.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	33	$3.00

Form DOT F 1700.7 (8-69)

ACKNOWLEDGMENTS

Photographs shown as Figure 2 *a*, *b*, and *c*; 10 *a* and *b*; 18 *a*, and 22 *a*, *b*, *c*, and *d*, are presented with the compliments of the *Salem Times Commoner*, Salem, Illinois.

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APPLICATION OF COMMERCIAL AIRCRAFT ACCIDENT INVESTIGATION TECHNIQUES TO A RAILROAD DERAILMENT

I. Introduction.

In the investigation of a commercial aircraft crash, the human factors team is concerned with the following tasks:

1. Try to reconstruct the crash sequence and estimate the magnitudes and directions of the deceleration forces in relation to the occupants.

2. Using still photography, record in detail the post crash environment, including external and internal structural damage, displacement of loose objects, intrusion of foreign objects, and the effects of fire.

3. From survivor interviews, medical records, and autopsy reports, determine the relationship of injuries to ejections, seat tie-down, restraint of occupants, body impact with surrounding structures, presence of loose flying objects, and intrusion of foreign objects.

4. Determine the effectiveness of escape and rescue efforts in terms of fire, exits available, escape routes, and functioning of escape equipment.

5. Note and record the locations of the fatally injured.

This report is unique in that it is believed to be the first attempt to apply these crash investigation procedures to a railroad passenger train derailment. It is stated in the *DOT Fifth Annual Report (FY 71)*[1] that there was a total of 5,602 railroad derailment accidents in 1970. This figure includes freight as well as passenger trains.

II. Report of Accident.

A. *Crash Sequence.* The train, which consisted of four locomotives, one baggage car, two passenger cars, a diner, six passenger cars, a club car, and three passenger cars, in that order, suddenly derailed while traveling in a southwesterly direction at a speed of approximately 90 miles per hour.

Figure 1 shows diagrammatically in five steps the sequence of events following derailment as reconstructed by the investigators. Step (*a*) shows a portion of the train before derailment on the center track with a main line track on its left and a spur line to the right. A distance of 50 feet separated the two outermost rails of the triple track system. The arrow indicates that the train was traveling from right to left on the page and the R's and L's designate the right and left sides of the coaches.

In (*b*) of Figure 1, the cars have begun to jackknife after the engineer has applied emergency brakes ("shot the bill"), locking all the wheels on the train. At this point the lead cars have jackknifed to about a 45° angle from the line of travel and, since each car is over 80 feet long, a path approximately 60 feet wide was swept by the sliding cars. In other words, all six rails, cross ties of three tracks, and the rail beds were destroyed at this point. Note further that the right sides of cars are approaching right sides of other cars and left sides are approaching left sides.

In (*c*) of Figure 1 the lead cars are approaching an angle of 90° to the original line of travel and are sweeping a path about 85 feet wide. At about this point the friction caused by the cars, trucks, and wheels sliding sideways and their gouging into earth, rails, and cross ties increased, causing the cars to overturn onto their sides (see step *d*).

It will be noted in (*d*) a pattern of overturn has been established. The baggage car (first car shown on the left of Figure 1*d*) is on its right side with front end up; the first passenger car is on its left side with front end down, and so on right-left-right-left. The cause for this arrangement becomes obvious from parts (*b*) and (*c*) of Figure 1, which show right sides approaching right sides and left sides left.

After overturn, the cars still had considerable velocity and continued to slide. Passenger Car Number One is known to have slid 180 feet after turnover (with one passenger ejected through a window) and was stopped only after the top of the car impacted the leading trucks of the baggage car (see *d* of Figure 1). Other overturned passenger cars continued to slide and the second passenger car and the Diner had impacts with the wheels of the cars ahead of them, leaving depressions in their roofs similar to Car Number One. In all, two locomotives, the baggage car, five passenger cars, and the Diner overturned. The rest of the train remained upright. Occupants of Passenger Cars 6, 7, 8, and 9, none of which overturned, stated they were able to stay in their seats by holding onto the seat in front; these passengers escaped with minor or no injuries. Unfortunately, the last three cars (Numbers 10, 11 and 12), possibly the safest cars to be in during this accident, were unoccupied.

All deaths and serious injuries occurred in the five overturned cars which followed the baggage car. The sixth car also overturned but was unoccupied since the air conditioning unit was inoperative.

CAMI investigators arrived at the scene of the accident the day following the derailment, but because of the urgency to clear the area and re-lay the tracks for other train traffic, all overturned cars had been righted and grading was already underway in preparation for laying new tracks. Figure 2 presents an aerial view of the train crash and two close-up scenes of overturned cars taken shortly after the derailment.

B. *External and Internal Damage To Train Components.* All four locomotives remained in line and did not jackknife. The lead and second locomotives were turned over onto their right sides while the last two locomotives remained upright. Following the locomotives, the baggage car was also turned over onto its right side. However, discussion of these cars is omitted from this report since, of this group, only the lead locomotive was occupied (by one engineer and a fireman who escaped through the left door with minor injuries). Fire occurred only in the second locomotive, and it was quickly extinguished by the fire department. As previously stated, Passenger Cars Number 5, 10, 11, and 12 were unoccupied and, for the sake of brevity, are omitted from the report. Passenger Cars 6, 7, 8, and 9 remained upright and sustained relatively minor damage. Car Number 6 is presented to represent this group of four cars. The captions accompanying the photographs of external and internal damage as well as penetration by foreign objects of the Diner and Passenger Cars 1, 2, 3, and 4, as presented in Figures 3 through 21, are in sufficient detail to afford the reader a clear understanding of the situation and will not be discussed further in the text.

C. *Passenger Distribution.* While this particular passenger train had a capability of carrying 450 passengers and the crew, the actual number aboard at the time of the derailment was 211 passengers, five crew members, and 10 employees (bartenders, waiters, porters, etc.). Because of the inherent difficulty of locating people after they have left the scene of the accident, only about fifty per cent of the passengers were interviewed. However, from statements of those interviewed, it was possible to compile a close approximation of the number in each car. Table 1 gives the capacity of each car, statements of occupants, and, based on the latter, our estimates of passenger distribution. It may be seen that our estimates for each car total 225 passengers, a difference of only 14 from the actual passenger load of 211.

D. *Discussion of Injuries.* According to medical reports, 97 of the 211 passengers were taken to hospitals for examination and treatment. CAMI investigators were able to obtain medical reports on 91 of the 97 passengers treated and succeeded in establishing the railroad car in which 78 were riding. Eleven passengers received fatal injuries (to be discussed later).

Since railroad seats are not equipped with safety belts, passengers on the top side of the car were thrown across the 10-foot-wide cars when they overturned, while passengers on the lower side were thrown against various structures next to them. Pinpointing the exact structure that caused a particular injury under the circumstances is impossible. However, some general observations may be made. For example, at least 23 survivors were treated for lacerations, the majority of which resulted from contacting and breaking the large observation windows. In general, those seated next to the lower side received lacerations of the head, upper trunk, and

TABLE 1

Passenger Car No.	*Car Capacity*	*Passenger Statements*	*Our Estimate*
1	56	Some room in front. 24 or 25. 20 or 21.	20
2	50	Pretty full. Almost full.	40
Diner	42	All bar seats taken (10). People at all tables but not full. Bar pretty full. About 20 people.	20
3	56	80% full. 30 people. Completely filled or almost. Pretty full. Almost full.	40
4	60	Car pretty full. Practically full (Porter).	40
5	56	Empty.	0
6	56	About 30 people.	30
7	56	20 people.	20
8	56	12 people. About 12 people. 10 people.	12
9	46	3 people.	3
		Total:	225

arms while those thrown across the aisle had lacerations of the lower extremities indicating that they were thrown up into the luggage rack with their feet and legs penetrating the windows. If the left side of the car went down, those seated on the left side received fractures of the upper left portions of the body. Conversely, if the right side of the car went down, those passengers seated next to the windows received more injuries to the upper right side of the body. Ten people were known to have received lacerations of the head and neck, seven of the arms and upper trunk, one of the lower trunk, and five of the feet and legs.

For the convenience of comparing the number and severity of injuries inflicted in the various cars of the train, injury severity has been divided into the following categories:

Class A. Severe—cranial fracture, spinal fractures with paralysis, internal injuries.

Class B. Fractures of arms, legs, ribs, and spine without paralysis.

Class C. Bruises, contusions, slight concussion, lacerations.

To summarize the injuries, 11 passengers were fatally injured, five received Class A injuries, 21 Class B injuries, and 52 Class C injuries. Table 2 presents the distribution of these injuries in Passenger Cars 1 through 10.

TABLE 2. Distribution of Injuries

Passenger Car No.	*Fatal*	*A*	*B*	*C*	*Total*
1 (overturned)	1	2	4	3	10
2 (overturned)	2	0	1	8	11
Diner (overturned)	2	0	5	9	16
3 (overturned)	2	3	4	12	21
4 (overturned)	4	0	5	11	20
5 (overturned—Empty)	0	0	0	0	0
6 (upright)	0	0	1	5	6
7 (upright)	0	0	0	0	0
8 (upright)	0	0	1	1	2
9 (upright)	0	0	0	3	3
Totals:	11	5	21	52	89

The injuries of an additional 13 passengers are known but it was not determined in which cars they were riding. Of this group, three had Class A injuries, four Class B, and six Class C.

From Table 2 it becomes obvious at a glance that all the fatalities and serious injuries, as well as 91% of the severe injuries and 82% of

the minor injuries, occurred in the first five cars that were overturned onto their sides.

In addition, as a point of interest, it should be noted that each of the overturned cars had some form of penetration by foreign objects as they continued to slide on their sides. Cars 1, 2, and 4 each had double rail penetrations. A heavy compressor was driven through the roof of the Diner and broke off a bar stool; Car Number 3 was penetrated by a full-length cross tie. The potential lethality of these objects is obvious but, in this accident, only the cross tie struck a passenger and resulted in a fatal head injury.

E. *Escape.* There are no emergency escape hatches or doors leading directly to the outside of a passenger car. As long as the car remains upright on its wheels, able-bodied passengers can wind their way through the narrow doors and passageway (slightly over 2 feet wide) around the restroom at either end of the car and go out the end of the car. It was impossible for rescue workers to move a seriously injured passenger on a 6-foot stretcher through the narrow, crooked passageway. Those that had broken arms or legs, or fractures of the vertebrae, could not escape on their own and had to wait to be lifted up through windows or carried up and down ladders. While five passengers were ejected through windows and fatally injured, at least three others were ejected through windows and survived with minor to serious injuries, and one was thrown from the end of the car (she was going from one car to another at the time of the derailment) into a field and survived with severe injuries. Figure 22 shows rescue workers helping passengers to escape from the overturned passenger cars.

The only car on the train having a direct escape route to the outside was the Diner (see Figure 23). Figure 23 *a* shows the forward end of the diner as it appeared to the passengers after the derailment. All that was necessary to escape was to climb up on the booth seats, hold up the heavy metal door, climb through, and drop 3 feet to the ground. The rear end of the Diner (Figure 23*b*) presented a sheer wall and a narrow tunnel giving access to a small window on top of the car. Only one passenger was known to have climbed up on the counter into the tunnel and out the small window. All the rest used the door at the front of the Diner.

F. *Description and Location of Fatally Injured.* The diagrammatic sketch presented as Figure 24 identifies the locations of the bodies of the 11 people killed in this derailment in reference to the overturned cars.

Body Number 1 was ejected through a window of Car Number 2 and pinned beneath the car. Injuries included scalp laceration with possible skull fractures and fractures of the right shoulder, right upper arm, left forearm, and both knees.

Body Number 2 was found inside the second passenger car with fractured skull, severe lacerations of scalp and forehead, lacerations under both arms and across the chest, and severe lacerations of the right hip around to the groin. This passenger was probably ejected partly through a window and then fell back, or was pulled back, into the car.

Body Number 3 was found under the Diner. Injuries include massive skull fracture with drag marks on the side of the face and head and lacerations of the left knee and chest. This passenger was ejected through one of the windows of the Diner and dragged under the car as it slid on its side.

Body Number 4 was ejected from Car Number 1 as the car rolled onto its side; the body then became pinned under a rail between the Diner and Car Number 3. This person suffered head injuries, fractured pelvis, and lacerations of the shoulder, hip, and both lower legs. In addition, there was evidence of peritoneal bleeding.

Body Number 5, found between the Diner and Car Number 3, was crushed and torn beyond recognition. The body was ejected from one of the cars and was crushed as one or more cars slid over it.

Body Number 6 was found inside Passenger Car Number 3. Injuries included severe scalp lacerations and possible skull fracture, and lacerations of both arms and the left side of the neck. Lacerations indicate that the head and upper trunk were partially ejected through a window.

The seventh body was also found in Car Number 3. Injuries included skull fracture and lacerations of the back of the head. The color of hair matched that found on the end of a cross tie found in the car and it can be assumed this

person was killed by the intrusion of the cross tie into the passenger area.

Bodies 9 and 10 were found just inside the forward end (the boarding area) of Passenger Car Number 4. Both bodies received crushing injuries, but those of Number 9 were more severe than Number 10's. Number 9 had been decapitated and mangled. Injuries of Number 10 included head injuries and fractures of the left leg, right arm, and right knee. Since Bodies 8, 9, and 10 were all found in or just outside the boarding area of Passenger Car Number 4 and were the remains of a woman and two children, all with the same last names, it is possible that these three were caught in the boarding area on their way to or from the Diner and died from crushing injuries as the front end of the car was crushed in (see left side of Figure 18*b*).

The injuries of Fatality Number 11, who was found inside and near the rear of the fourth passenger car, are not known to the authors. She was rescued from the train and died enroute to the hospital.

III. Discussion.

This train had a capacity for carrying 450 passengers in addition to the crew as compared to a Boeing 747 aircraft which can carry 451 passengers and crew. Although the passenger-carrying capacity of these two modes of transportation is almost identical, the weights of the two vehicles is considerably different, with the train outweighing the 747 by a factor of almost five to one. If one compares the kinetic energy of this 1,500-ton train traveling 90 miles per hour (132 ft./sec.) with a 350-ton Boeing 747 landing at a velocity of 165 miles per hour (242 ft./sec.), it is interesting to note that the 800,000,000-foot pounds for the train is less than 25 per cent higher than the 650,000,000 foot pounds for the 747.

Translating these estimates of energy inertia forces imposed on the passengers, one can calculate an average deceleration of .15G for a normal 747 landing at a velocity of 242 ft./sec. Each portion of the train stopped in a different distance after the emergency braking procedure. The lead engine had a stopping distance of 990 feet while the last passenger car stopped in 1,450 feet. Deceleration distances of other units of the train were between the two values. With a given initial velocity of 90 miles per hour, one can calculate an average linear deceleration of .27G for the lead locomotive and .18G for the last passenger car. In other words, the average linear deceleration in this train derailment only slightly exceeded the deceleration forces experienced by the passengers of a 747 aircraft during a normal landing.

It is difficult to calculate forces imposed on car occupants when the passengers were thrown across the 10-foot-wide car into the luggage rack and/or windows on the opposite side as the car overturned. However, since it is known that the lead passenger car slid nearly 200 feet after overturning, or about one-fifth of its total stopping distance, one can estimate that the passengers still had a forward velocity of 37 miles per hour as their cars overturned. Impact with the opposite sides of the cars at this body velocity could result in substantially high deceleration forces.

Escaping from a railroad car is radically different than escape from a commercial aircraft. If the car is turned over onto its side, the passengers have three primary means of escape (see Figure 25). (1) They can climb over the ends of the seats through the aisle; through a 2-foot, 2-inch door; drop 3 feet, 8 inches to the floor; scale a 7½-foot-high wall; crawl through a 2-foot, 4-inch-high tunnel, being careful not to fall through the restroom door; drop down 3 feet, 4 inches, and out the end door; and drop 3 feet to the ground. (2) On the other end of the car, the escape is similar with the exception that they eliminate climbing a 7½-foot-high wall and, instead, crawl through a tunnel under the restroom up over a 3-foot, 8-inch-high wall and out the door. The door is heavy metal and is hinged on the top side, requiring that someone hold it up while others escape. After getting through the door and dropping down 3 feet, 8 inches, they can climb up another 3-foot wall and go out the end door and drop 3 feet to the ground. While this is the more desirable of the two escape routes discussed thus far, it should be noted that this route will always be on the down side of the car and may be blocked by the wall being pushed in (see Car Number 5, Figure 19*a*). Also, according to the *Human Engineering Guide to Equipment Design*,[2] a crawl space must be 30.5 inches high to accommodate the

95th percentile adult male, and some of the large adults will be forced to scoot through the tunnel under or over the restrooms on their bellies. (3) The third and last means of escaping an overturned railroad car is to climb up on the seats using the seat arms as steps and break out one of the double-pane windows on top of the car (Note none of the top windows of the overturned cars in this crash were broken out during the crash). Only those passengers with minor or no injuries were able to utilize one of these three difficult routes of escape on their own initiative.

It would appear that an escape hatch in the top of all passenger railroad cars would greatly enhance the escape procedures from an overturned car.

Other areas which merit discussion include carry-on luggage, crashworthiness design, and the need for a passenger list.

A. *Carry-On Luggage.* Flat, open-ended shelving for storing luggage is located at eye-level in one end of the passenger compartment of most of these cars. There were no luggage restraints and most of the shelves in the overturned cars were broken during the derailment, allowing the baggage to become flying missiles. After the derailment this luggage was scattered in the seats and aisle, impeding evacuation and rescue.

B. *Crashworthiness Design.* The electrical equipment and table storage cabinet doors were the type that could be lifted up and off the hinge pins. When the cars overturned, the doors moved free of the hinge pins and the doors and cabinet contents fell into the aisle, blocking escape routes and possibly causing injury. Another example of similar design was found on the bar stool seats in the Diner. Attached to the under side of the seat pan was a shaft 1½ inches in diameter and 6 inches long. This shaft rested inside the pedestal column and was free to rotate. It was also free to slide out of the pedestal column when the Diner car overturned as shown in Figure 14*c*.

None of the chairs in the Diner or in the restrooms were secured to the floor or wall . A large number of heavy base ashtrays were also not secured. These items became missiles during the derailment.

Sharp edges and protruding objects are two factors which could cause injury. Most serious are sharp edges of the structures associated with the window and window shade framework in the passenger compartments. The passenger overhead light switch, a long-handle metal toggle-type switch pointing almost straight down toward the passenger's head, should also be redesigned or relocated.

C. *Passenger List.* In this derailment, fire or water submersion was not a factor, yet of the 11 fatalities, one still had not been identified at the time of the investigation. The possibility of a railroad accident involving extensive fire or derailment into a body of water must be considered. Under those circumstances a complete loss of bodies or destruction of remains beyond recognition is likely to occur. Identification of fatalities under these conditions would be extremely difficult without a passenger list which is kept separate from the train.

IV. Conclusions.

In this particular derailment of a passenger train traveling at a speed of approximately 90 miles per hour, the individual units of the train experienced linear deceleration of slightly more than the passengers of a Boeing 747 during a normal landing; the passengers in those cars that remained upright received no significant injuries. Four passenger cars and the Diner were turned over onto their sides and slid a considerable distance after jackknifing. All 11 fatalities and all severe to serious injuries occurred in the five cars that overturned. As these cars overturned, passengers were thrown across the cars; some were ejected through the large observation type windows, and many were severely injured by secondary impact with broken glass, baggage racks, and other structures on the lower side of the cars. Lap belts would have prevented a large portion of the injuries due to secondary impact and ejections.

If this jackknifing phenomenon could be eliminated, the number of deaths and serious injuries could have been reduced. In addition, prevention of cars from overturning would have significantly reduced the financial loss. The estimated cost of repairing the two overturned locomotives ($325,000) was more than five times that for repairing the two that remained upright ($60,000). Damage to the seven overturned cars

($297,400) was nearly six times that for the seven cars that remained upright ($52,000).

As the five occupied cars continued to slide on their sides they were penetrated by a total of six railroad rails, a heavy compressor, and at least one cross tie. To the knowledge of the authors, only the cross tie struck and injured a passenger.

Since the train was traveling in a southwesterly direction at the time of derailment and it was only a few minutes after 12:00 Noon, a number of passengers on the left side of the train had their window shades partly drawn to keep the sun out of their eyes. In some instances these sunshades helped prevent occupant ejection from those cars that went down on their left sides. Installation of permanent retention devices to prevent ejection through these large 5-foot observation windows is indicated.

The most serious problem associated with an overturned railroad passenger car is that it is impossible for an injured person to escape on his own and, regardless of the seriousness of the injuries, it is necessary for rescue workers to pull the injured passengers up through the windows on the top side of the car by means of ropes or to carry them up and down ladders. The necessity for rough handling during such rescue efforts may have contributed to the seriousness of some injuries. An emergency escape hatch in the top of each railroad passenger car would seem advisable. Such an emergency door would allow an uninjured passenger to open it and step to the ground and would permit rescue workers to remove the passengers with severe injuries on stretchers.

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2. Morgan, C. T., J. S. Cook, A. Chapanis, and M. D. Lund: *Human Engineering Guide to Equipment Design*, McGraw-Hill Book Co., Copyright 1963.

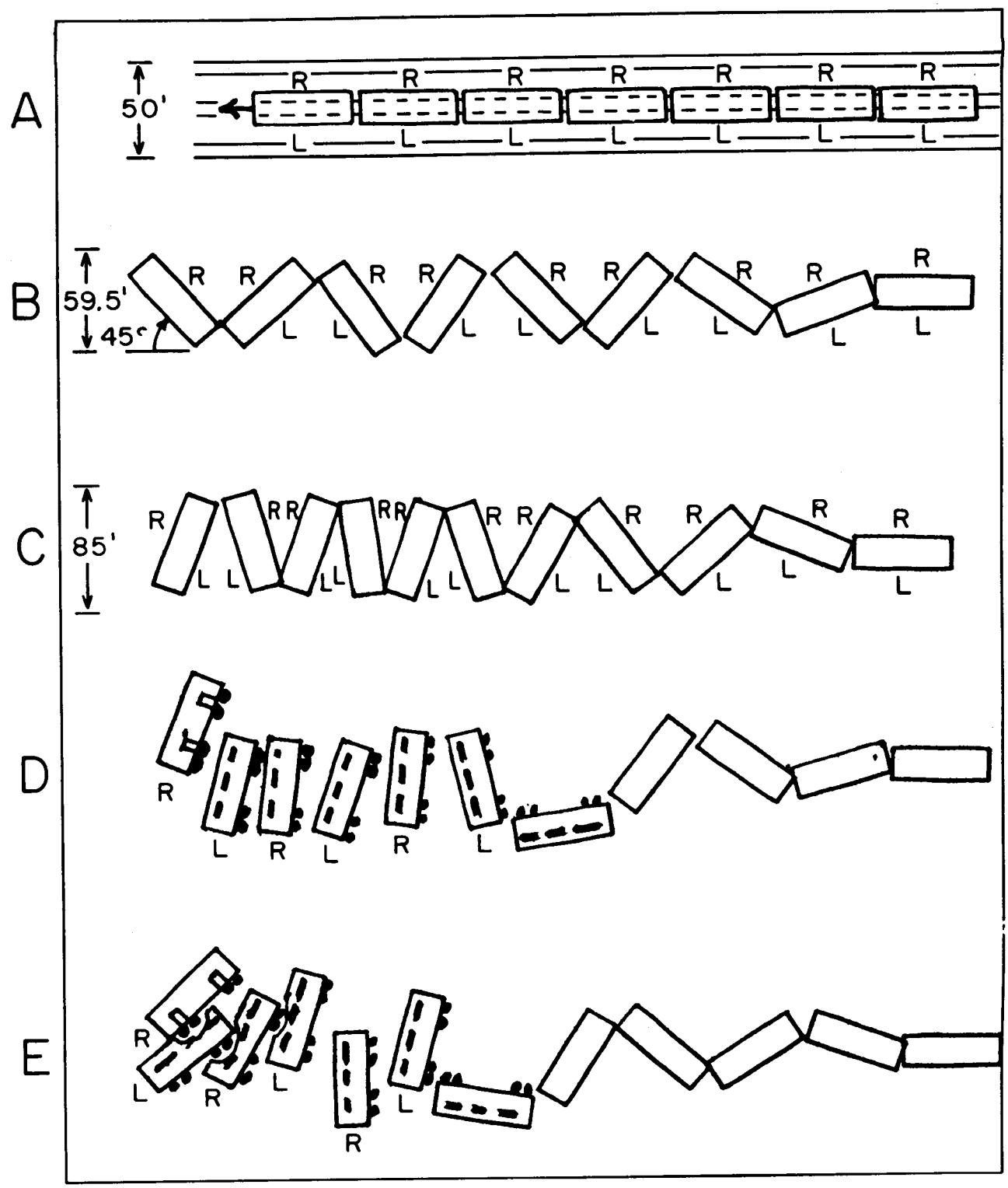
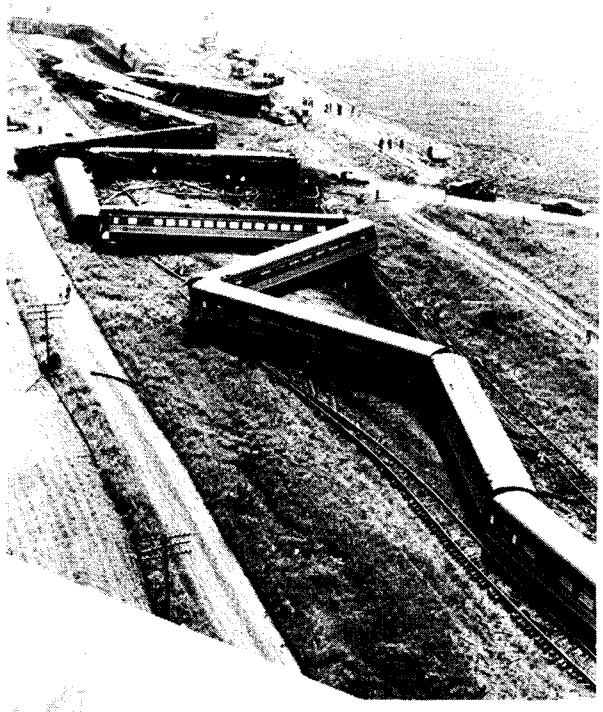


FIGURE 1. Sequence of events following derailment presented diagrammatically.

a. Aerial view of train derailment site. Of the four locomotives and 14 cars involved, it may be observed that the two lead locomotives, the baggage car, and the first six passenger cars are overturned and lying on their sides. The accident occurred at a location where three sets of tracks ran parallel to one another. Note that all rails, cross ties and road beds have been swept clean by the forward two-thirds of the train.

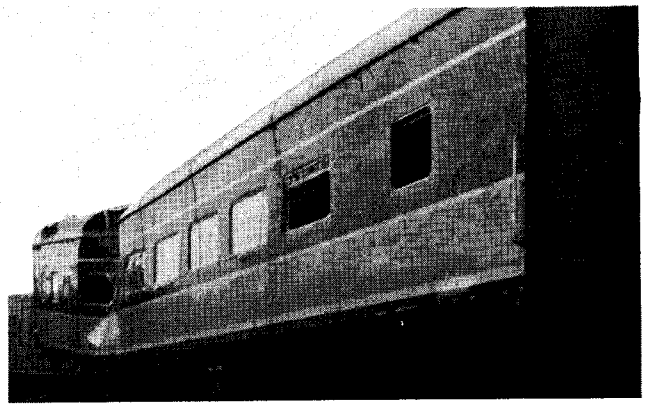


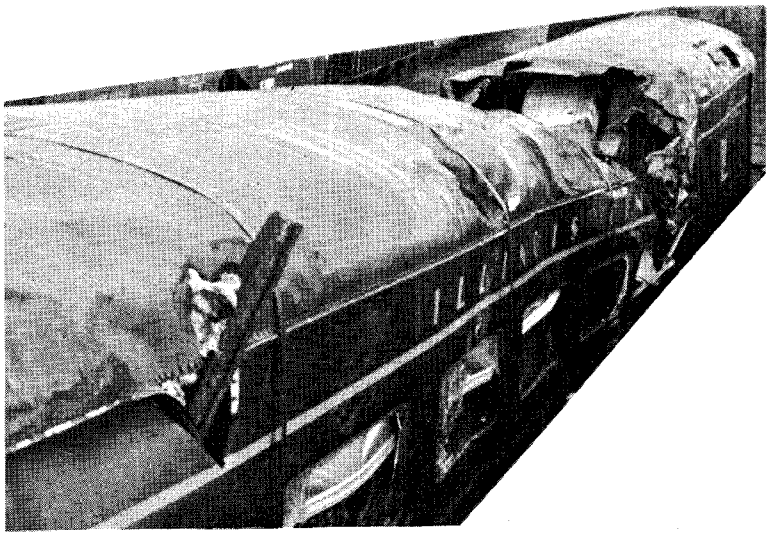
b. Close-up view of the ends of four of the overturned cars.

c. Twisted rails and splintered cross-ties attest to the severity of the forces involved. Note large loose gas bottles (used for air conditioning).

FIGURE 2. Photographs of the crash scene taken soon after the accident (before the start of the clean-up operation).

a. Passenger car number one directly behind the baggage car ended up on its left side with the top of the car against the leading trucks (wheels) of the baggage car. This view shows the right side (up side) of the car. The two missing windows were knocked out by rescue personnel in order to lift the injured up and out of the car.





b. Damage to the left side of car number one as viewed from front to back. Note the area of the roof crushed in by contact with the wheels of the baggage car, two rail penetrations, and broken windows with window shades bent outward.

c. Left side of car number one as viewed from the rear. This car slid over 180 feet after turning over onto its side.

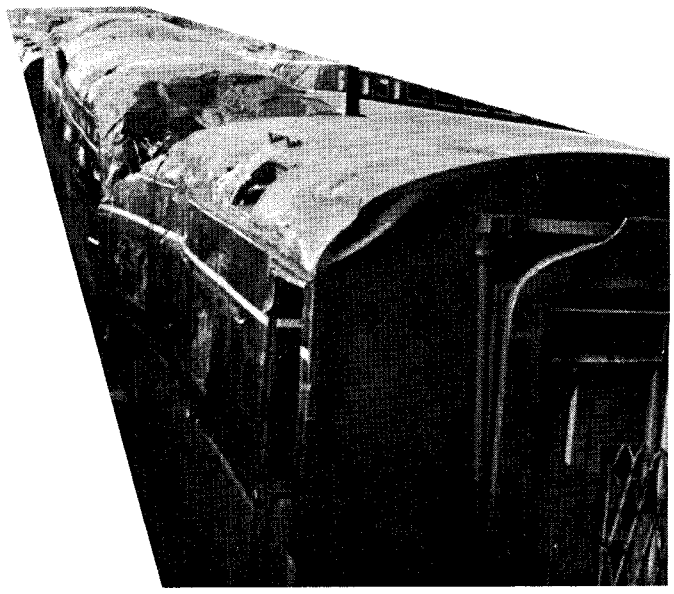
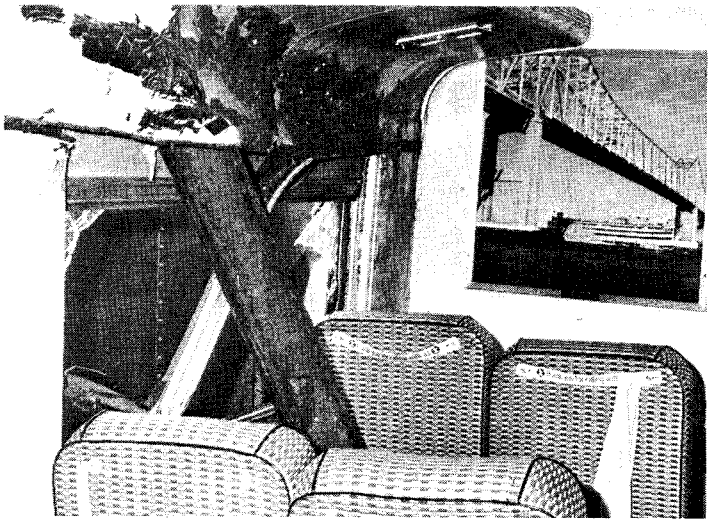


FIGURE 3. Three views of the exterior of Passenger Car No. 1 after having been righted by construction crews.

a. Rail penetration of left forward roof of car number one. The angle of penetration indicates that the car was sliding rear-end forward when it picked up the rail.



b. Rail went between first and second seats. Fortunately this area was not occupied at the time of rail penetration.

c. Rail stopped when the end of it rammed against the floor.

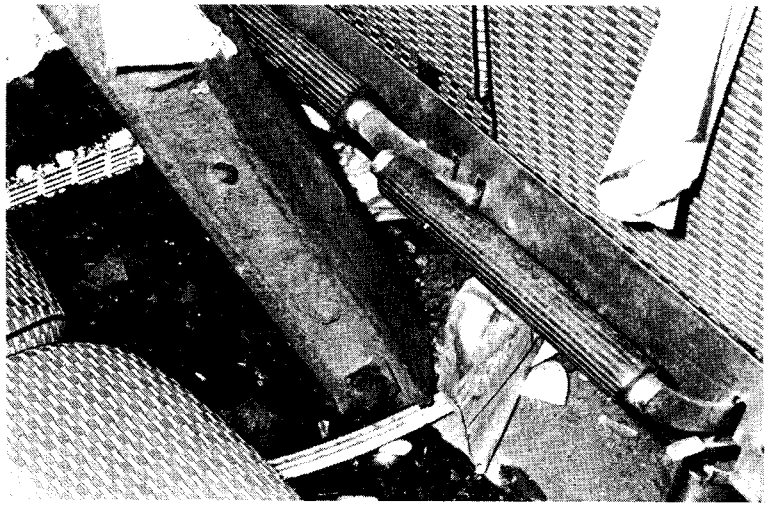
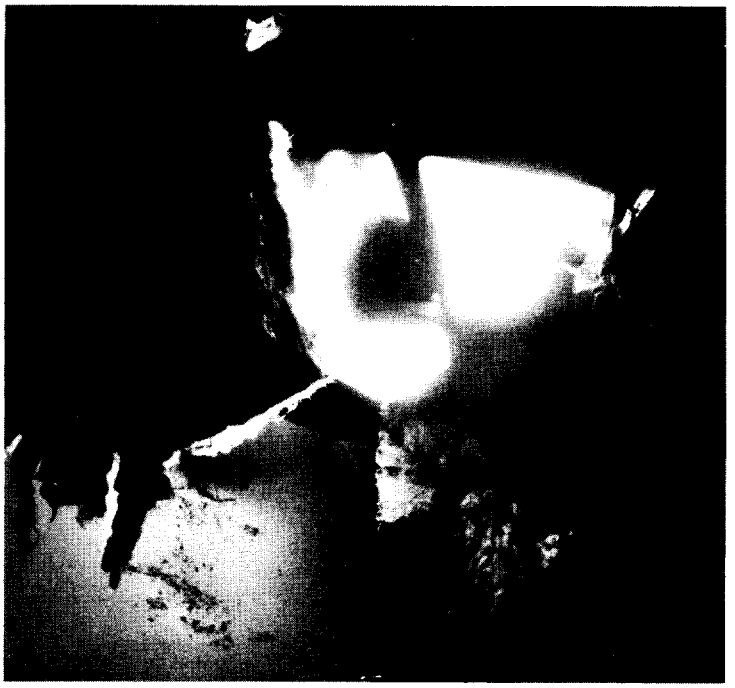


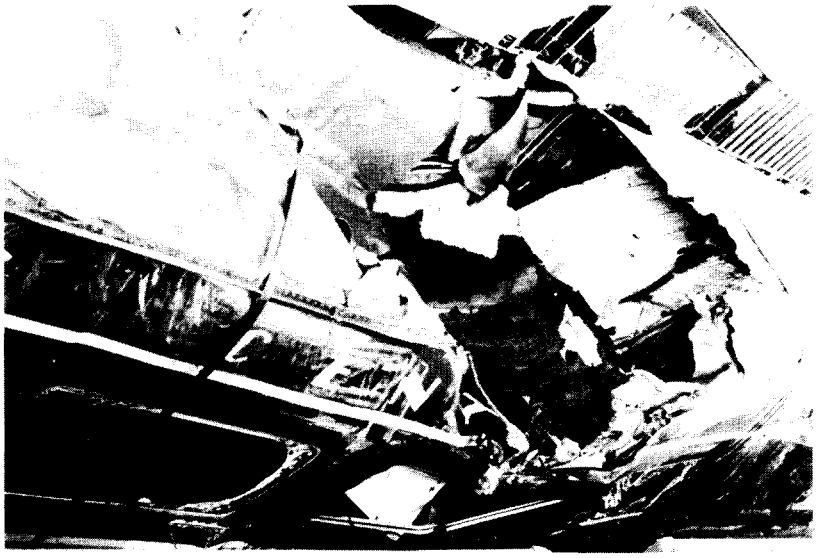
FIGURE 4. Close-up views of a rail penetration into Passenger Car No. 1.

a. Hole in roof made as a second rail penetrated the roof of car number one about 5 feet ahead of the one shown in the previous figure. This rail penetrated the car at about the same angle and probably about the same time as the one previously described.

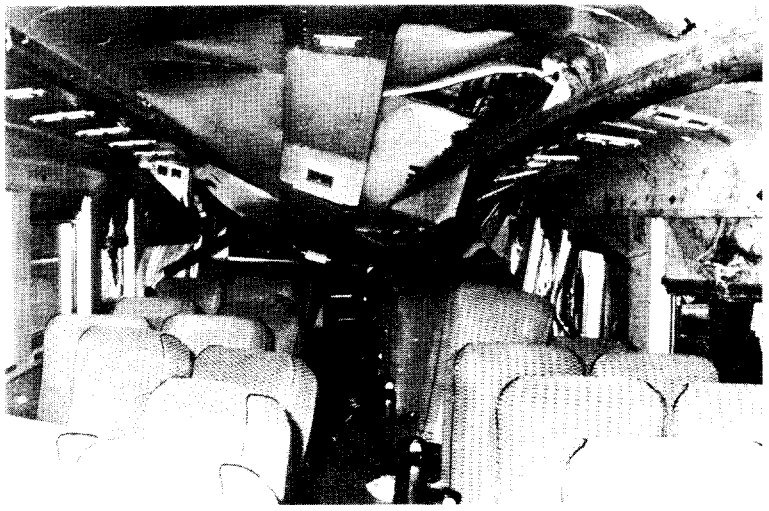


b. The leading end of this rail entered the ladies rest room and smashed the commode. Fortunately the room was unoccupied at the time.

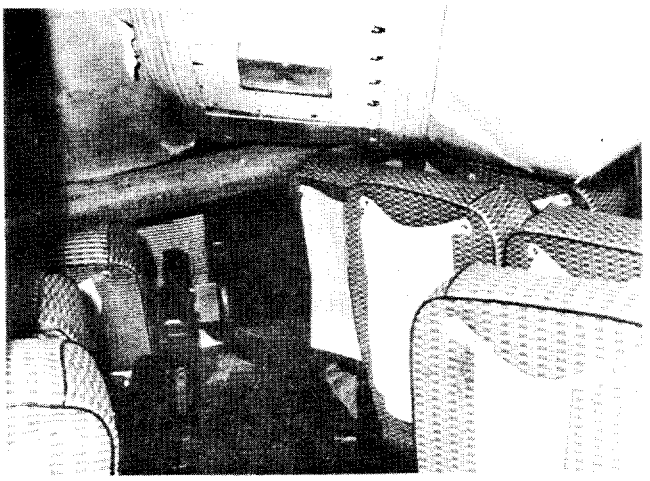
FIGURE 5. Damage to Passenger Car No. 1 made by a second rail penetration.



a. Close-up view of depression in the roof of car number one made during the impact with the wheels of the baggage car.



b. Inside view of car no. one looking toward the rear. Railroad seats are designed to be rotated after pulling them toward the aisle 3/4-inch to unhook a catch. Note that all the seats in the left of the picture (right side of car) are unhooked and rotated aisle-end forward.



c. Roof is depressed below the level of seat back tops. Passengers were trapped in their seats.

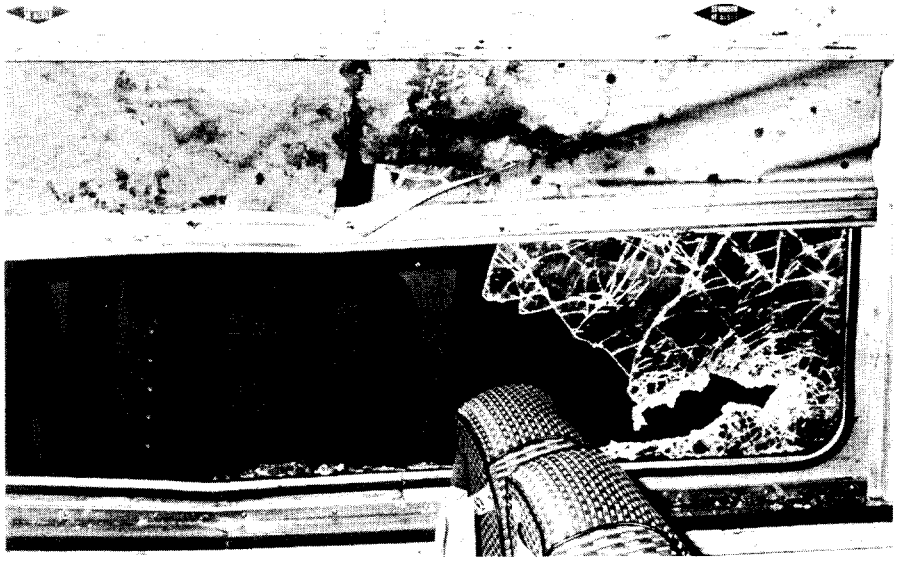
FIGURE 6. Close-up views of external damage caused when the top of Passenger Car No. 1 impacted the wheels of the baggage car.

a. Right forward section--very minor damage--seats rotated.

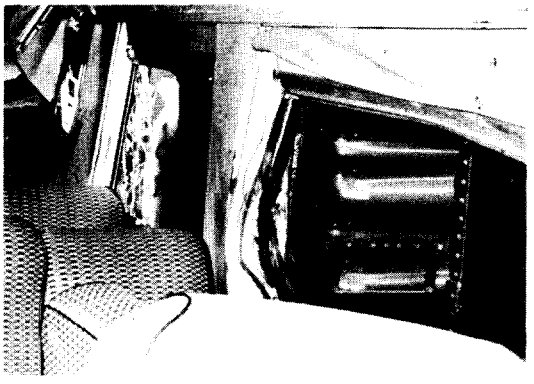
b. Large windows (5 ft. long, 2 ft. high) broken out by body impacts as car rolled over. Note seat in foreground rotated 90° to face window. Passengers ejected (at least two).

FIGURE 7. Seat distortion in Passenger Car No. 1.

a. Window shades bent out and windows broken by body impact.

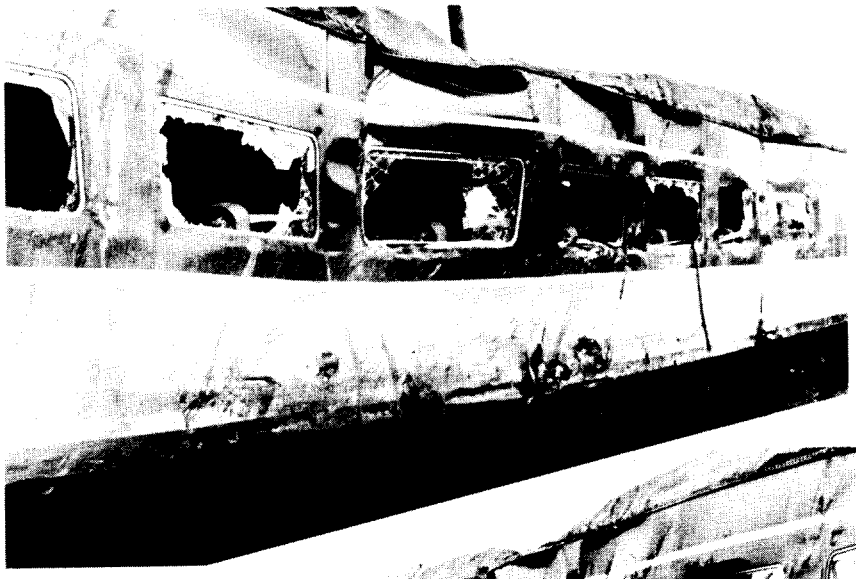


b. Close-up of dents in window shade rod and lower window sill. Since the sun was shining in the left side of the car, some shades were partly drawn and probably prevented ejection of some passengers.

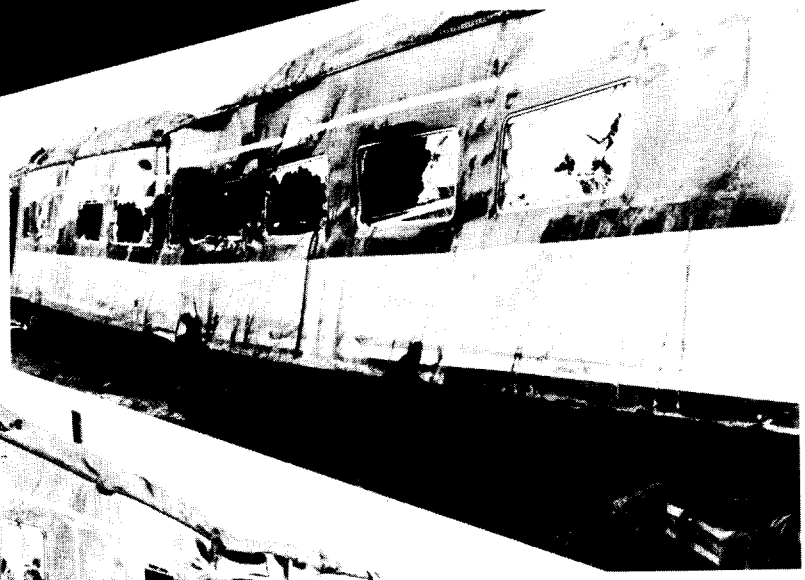


c. Window shade rod bent upward as passenger from right side of car was thrown across the car and ejected through this window.

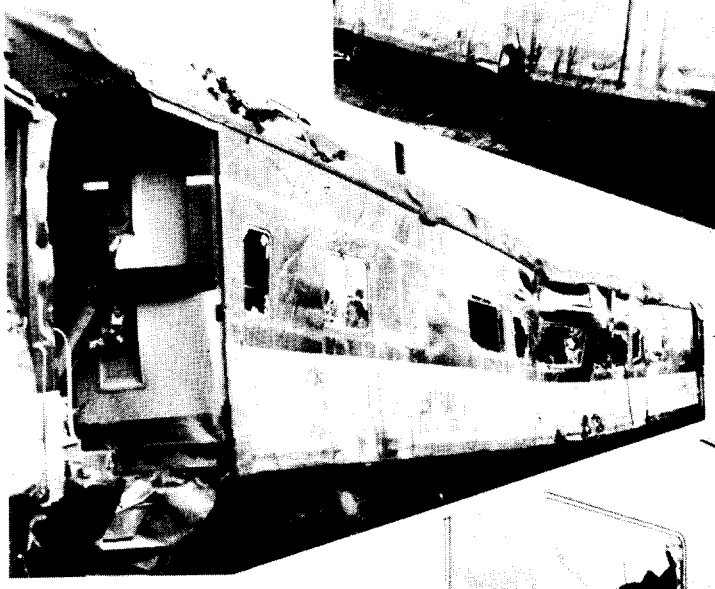
FIGURE 8. Inside views of window damage on the left side of Passenger Car No. 1.



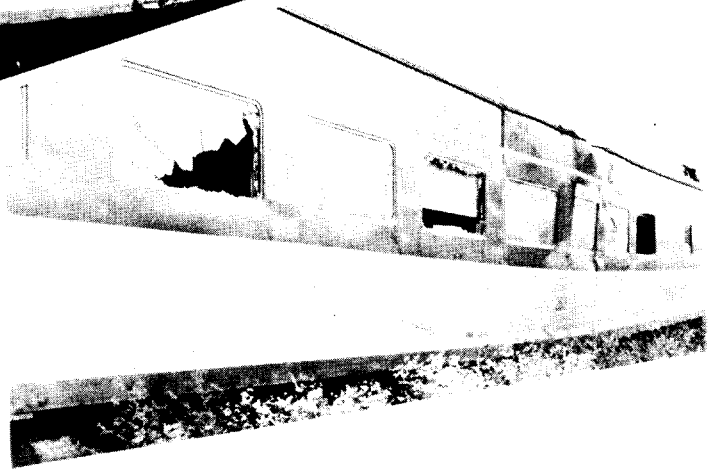
a. Right side (down side) of passenger car no. 2. Six of 7 large windows knocked out. Note window shades are up. Depression in roof is from contact with wheels of car no. one.



b. Angle of skid marks indicates car was sliding front end forward.



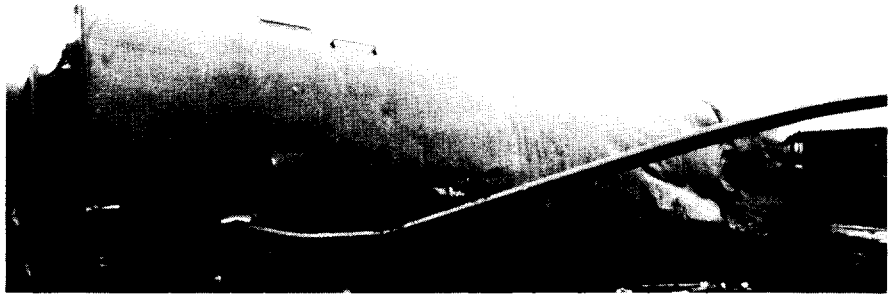
c. View of right side of car from rear end. Note rail penetration into boarding area.

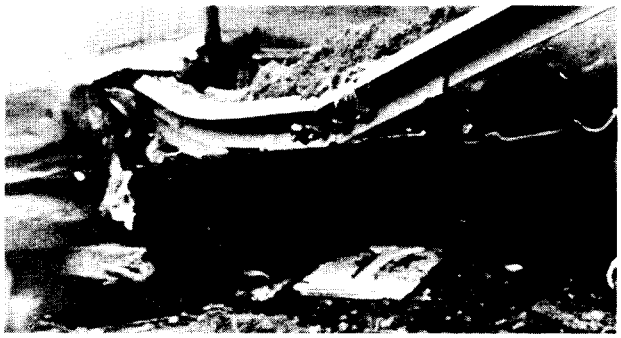


d. Slight damage to the left side (up side) of car no. 2. Missing windows were broken out by rescue personnel. Some shades are down.

FIGURE 9. Four views of the exterior of Passenger Car No. 2 after having been set back upright.

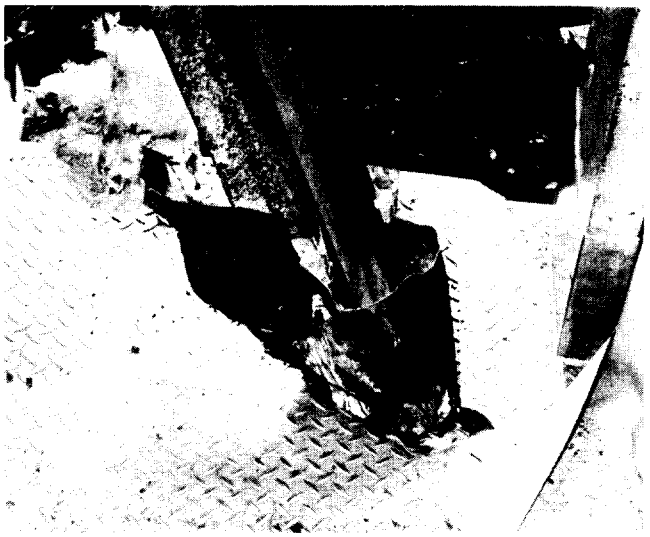
a. Two rails penetrated rear roof of car angled front to back. Note car no. one, at right, still near the roof depression in car no. 2.





b. Close-up of a rail penetration still in place. As shown in picture above, the second rail has been removed. A body of one of the fatally-injured is trapped under the car after having been ejected through a window. The car was later righted to rescue the body.

c. End of the rail shown in above picture terminated its travel against the steel floor of the right rear boarding station. Note roof metal and insulation still wrapped around the end.



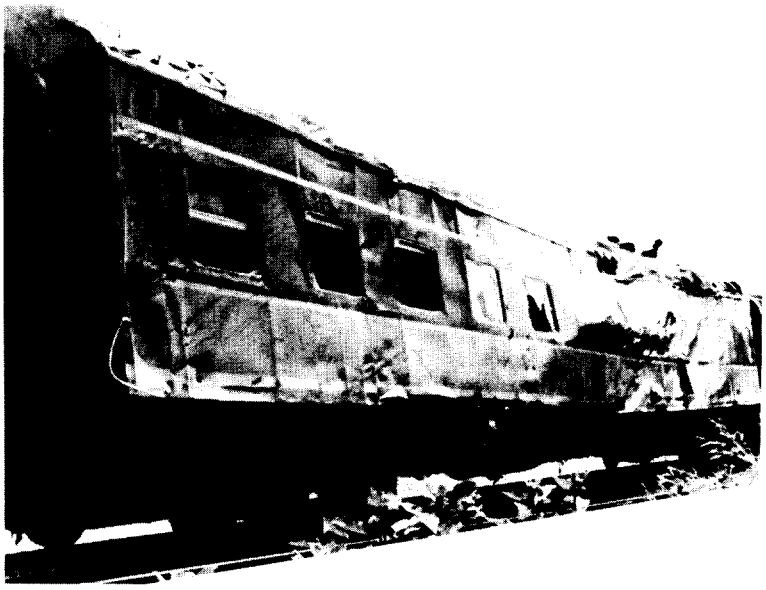
d. Mark on rest room wall at the rear end of the passenger area made as the end of the second rail slid down the wall

FIGURE 10. Two rails also penetrated Passenger Car No. 2.

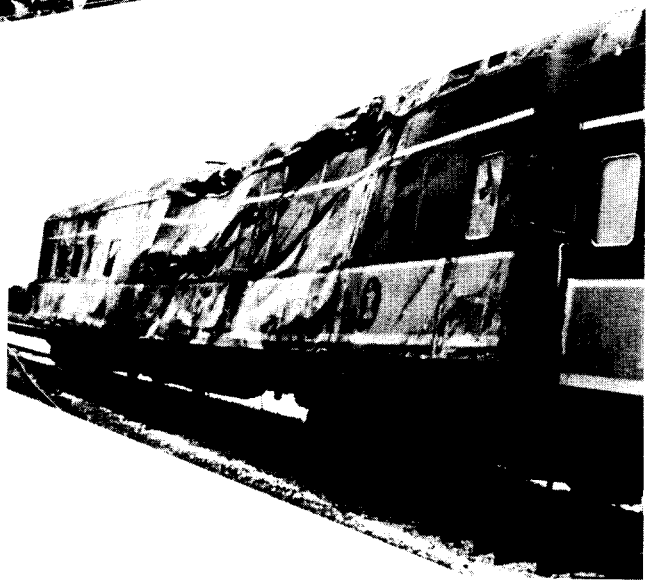
a. Interior view of the right side of car no. 2, looking from the rear. Note that the roof depression with sharp edges is not as severe as in car one, leaving about 5 feet of clearance above the floor. Seats are relatively straight, but damage to windows is severe.

b. All seats on the left side of the car are unhooked and rotated aisle side forward approximately 45°. This rotation may have protected some passengers to a degree as some were trapped in their seats and not thrown to the opposite side of the car.

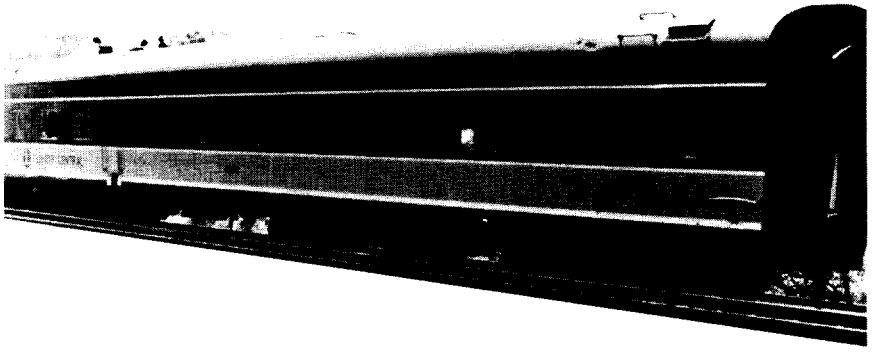
FIGURE 11. Photographs showing seat cocking and roof and window damage as viewed from the inside of Passenger Car No. 2.



a. Left side (down side) of diner as viewed from front end. Three of the five 42"x26" windows in the dining area have been knocked out. Note car frame structure showing through side metal covering at left of picture, indicating forward end of car went up into the air as it rolled over and then impacted the ground.

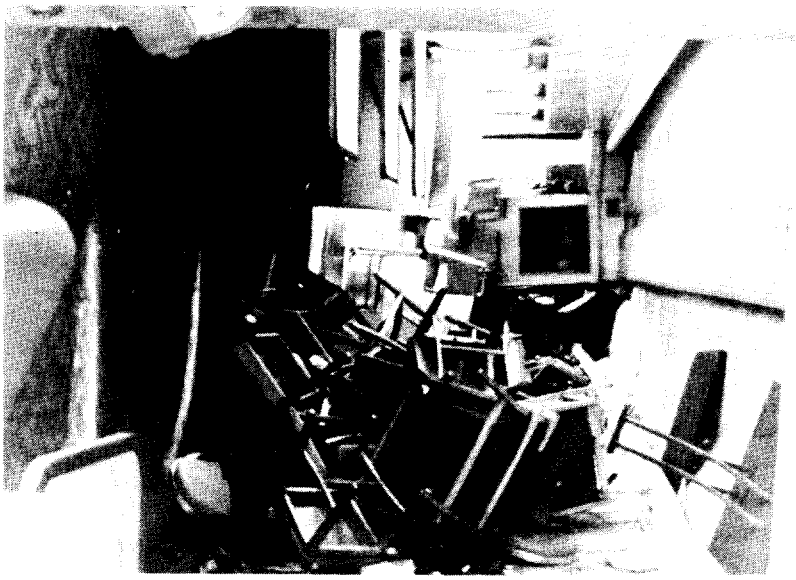


b. Skid marks on the rear end of the left side of the diner indicate that the car slid at about a 45° angle rear-end forward after it rolled over onto its side. The area of most severe damage (without windows) is the kitchen and counter serving area.



c. Right side (up side) of diner had very little damage. The small window at the extreme left of the picture was broken out by rescue personnel after a passenger had climbed into the narrow passageway alongside the kitchen.

FIGURE 12. Three views of external damage to the Diner taken after this car had been righted.

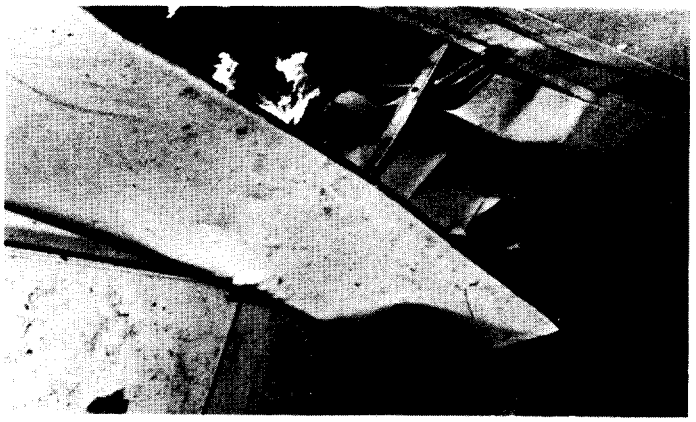


a. Inside view of diner looking toward the rear of the car while it was still on its left side. Passengers, loose chairs and broken tables were all thrown into a pile.

b. Same view as a above except that the car has been righted. At least two passengers were ejected through one of the windows in the right of the picture.

FIGURE 13. Loose chairs inside the Diner were thrown into a pile.

a. The diner was not penetrated by any railroad rails, but a heavy compressor entered through the upper left corner of the car above the counter serving area and hit one of the stools, breaking it off. Hole and compressor are visible in the picture.



b. Close-up of hole made by entrance of the compressor. Fortunately, no one was struck by this heavy missile since most of the passengers had been thrown to the front of the car before the car turned over and picked up the compressor.

c. Close-up view of compressor and broken stool.

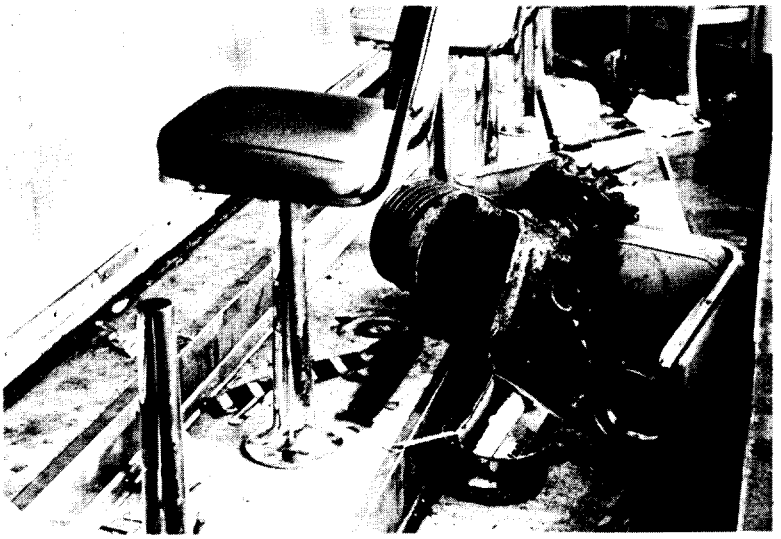
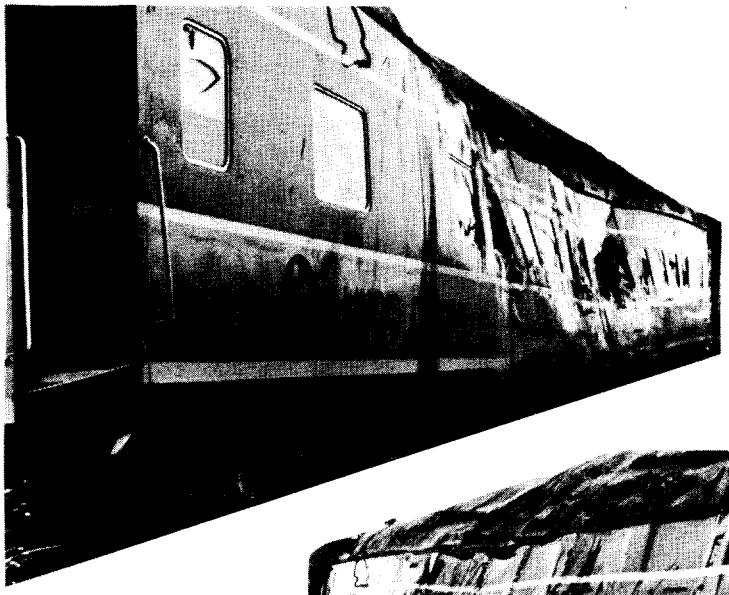
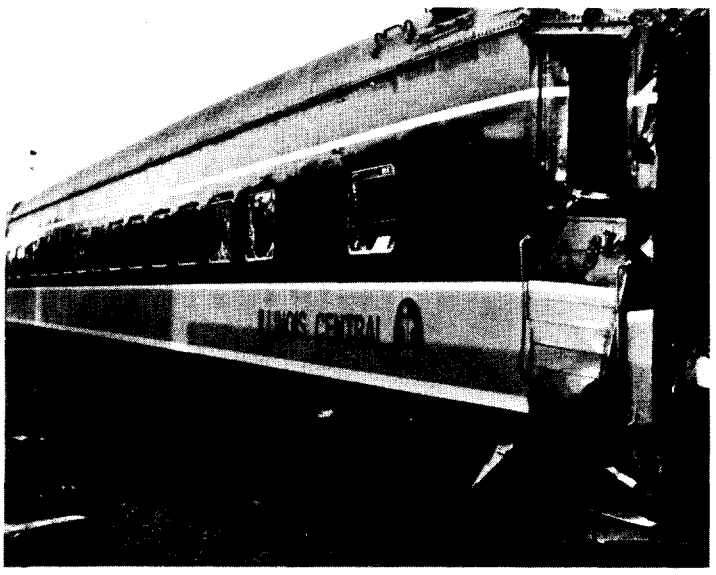


FIGURE 14. A heavy compressor penetrated the roof of the Diner just above the counter service area and broke off one of the stools at the counter.



a. Right side of passenger car no. 3, showing the most severe damage was to the central portion. This area near the roof was pushed in over 2 feet. Note windows in this car are smaller (34" long, 24" high) and less glass is broken out.

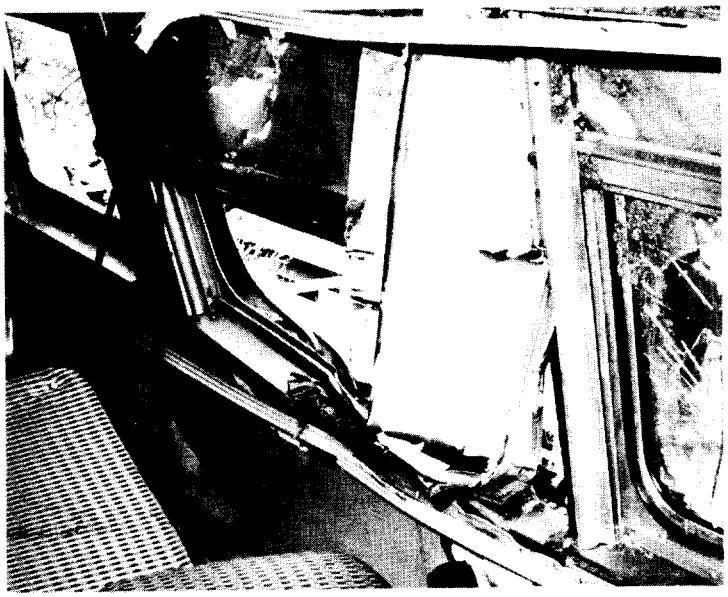
b. One passenger was killed when a crosstie came into the car through the hole near the center of the picture.



c. Left side (up side) of passenger car no. 3 shows little damage. Missing windows were knocked out by rescue workers.

FIGURE 15. Three views of Passenger Car No. 3 after it had been set back up on its wheels.

a. Interior view of the right side of car no. 3 showing heavy damage to seats where the wall was crushed in.



b. Close-up view of damage caused by intrusion of a cross-tie.

c. One seat was almost completely demolished.

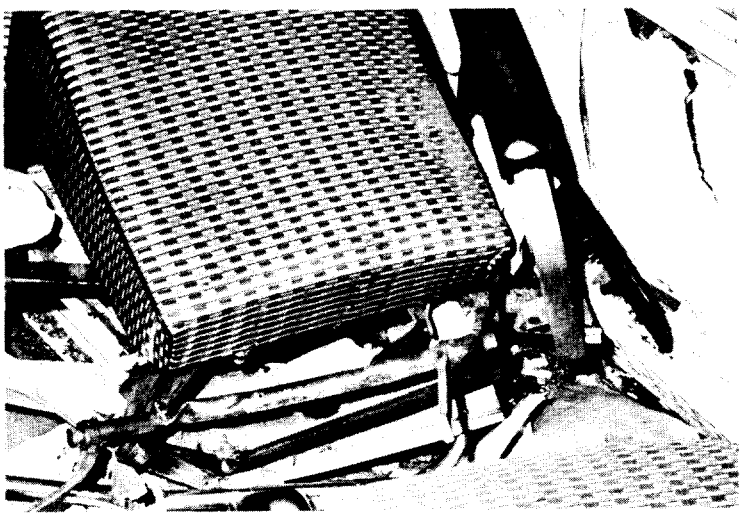
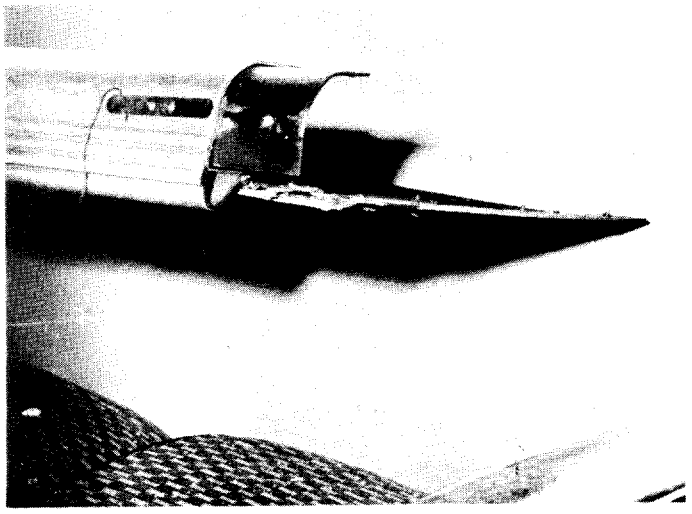


FIGURE 16. Seat and window damage inside Passenger Car No. 3.

a. Seats are unhooked and rotated aisle end forward as in previous cars. As upper right wall was pushed in, the baggage rack broke down and left numerous sharp edges. Passengers received severe injuries when thrown against these edges as car rolled over.



b. Close-up view of sharp end of baggage rack.

c. Sharp baggage rack support structures exposed when rack collapsed.

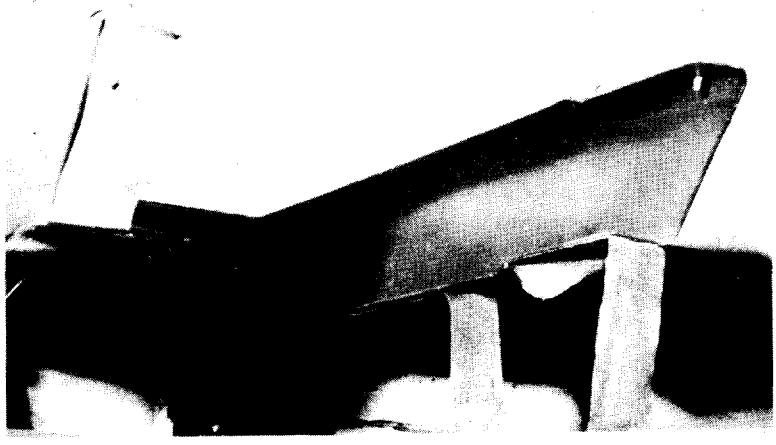
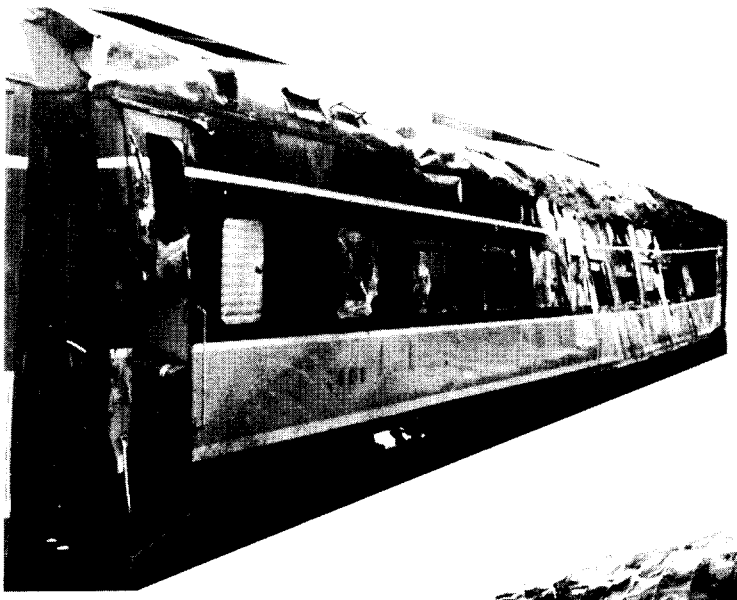
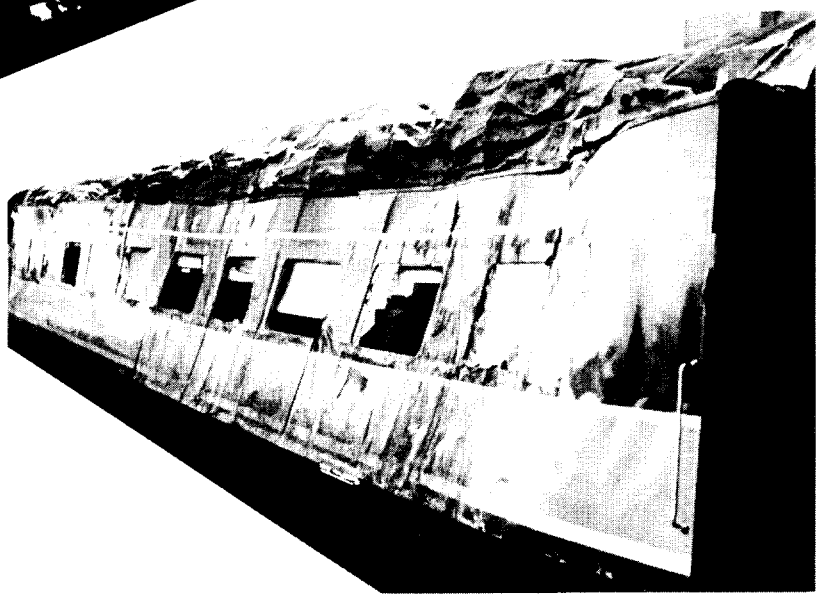


FIGURE 17. As the luggage rack failed on the right side of Passenger Car No. 3, sharp structures were exposed.

a. Passenger car no. 4 down on its left side with two rail penetrations. One passenger crawled through the hole made by the rail and walked down the rail to the ground.

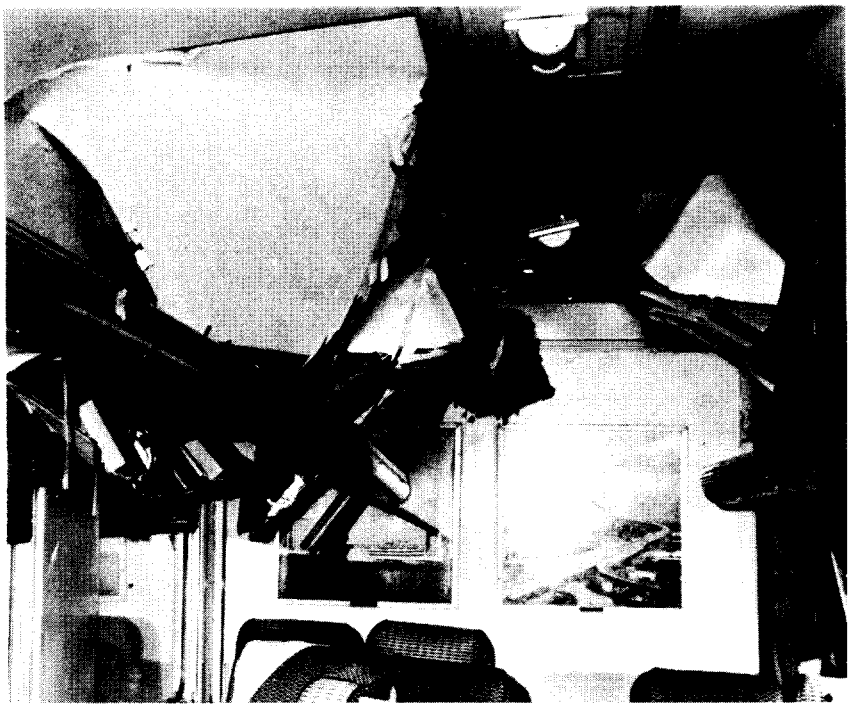


b. View of left side after it had been righted shows side caved in similar to car no. 3. The number of deaths and seriously injured in this car was greater than in any other single car.

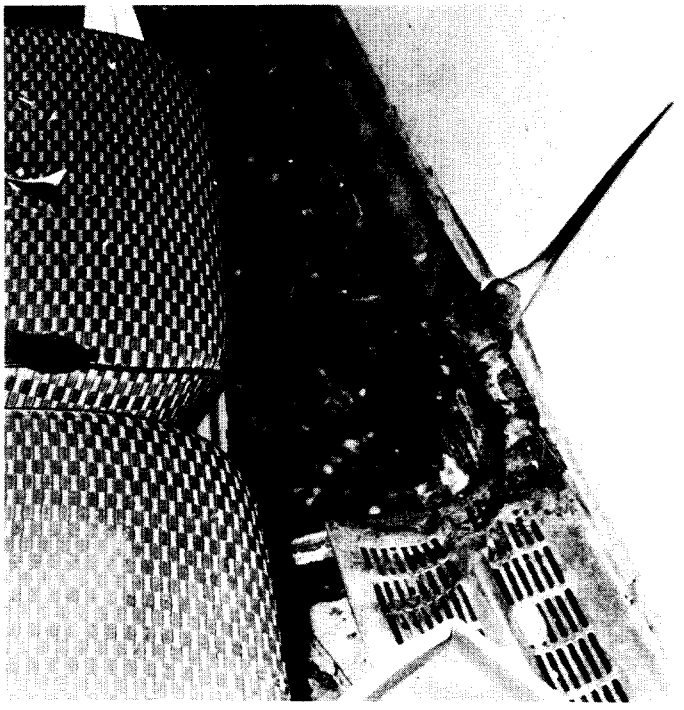


c. Close-up of severely damaged end shows scratch marks to indicate that the car was sliding perpendicular to the tracks after it turned over.

FIGURE 18. Views showing rail penetrations and external damage to Passenger Car No. 4.



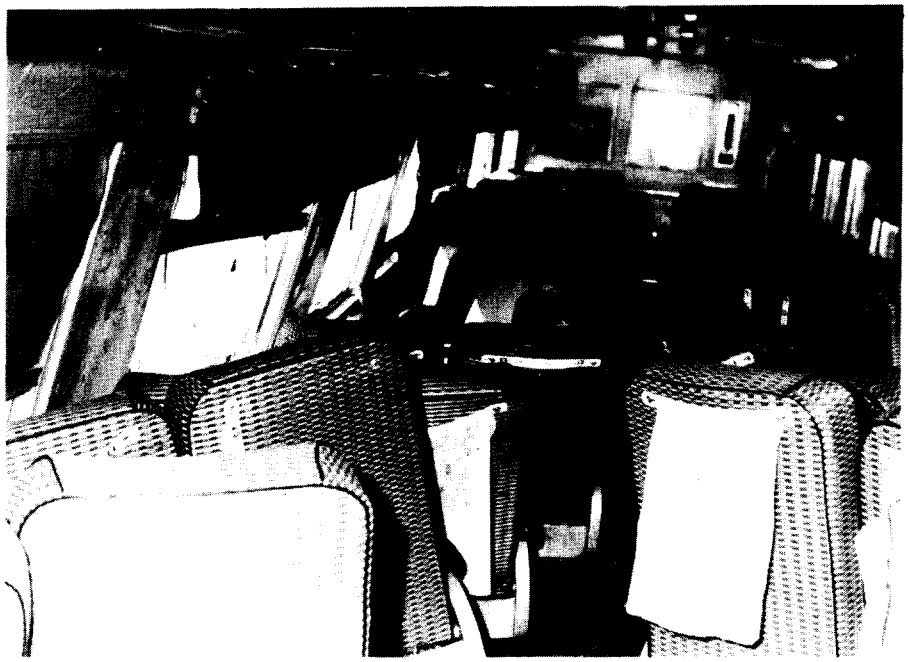
a. Hole made by the second rail penetration in passenger car no. 4. Note also outside wall collapse has almost completely obstructed aisleway under ladies rest room.



b. End of rail slid down the wall and pinned a woman's dress to the floor, but did not injure the woman.

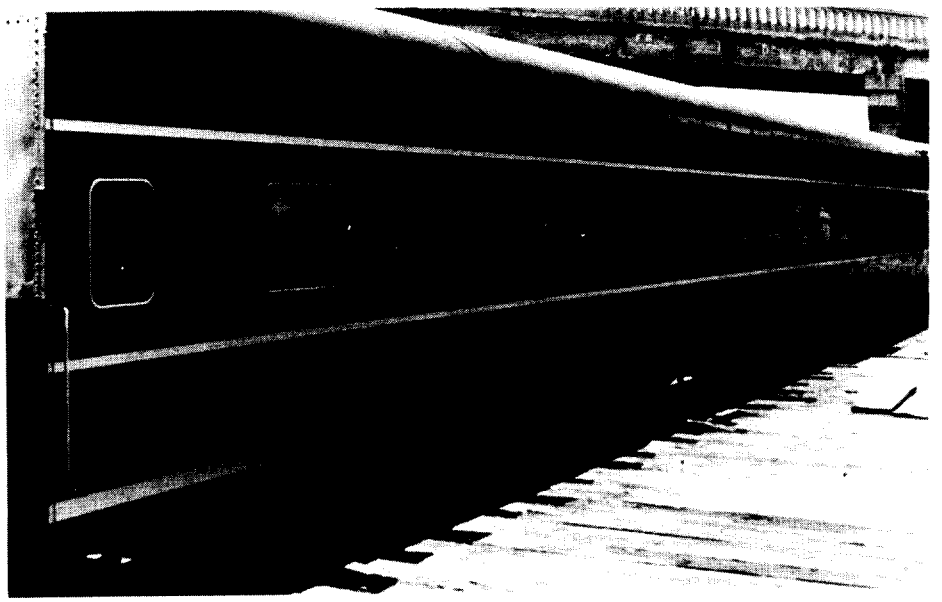
FIGURE 19. Internal damage from a second rail penetration into Passenger Car No. 4.

a. Interior view of passenger car no. 4, looking forward. Most of the seats are unhooked and rotated aisle end forward.



b. Seat damage in the area where the side wall was pushed in.

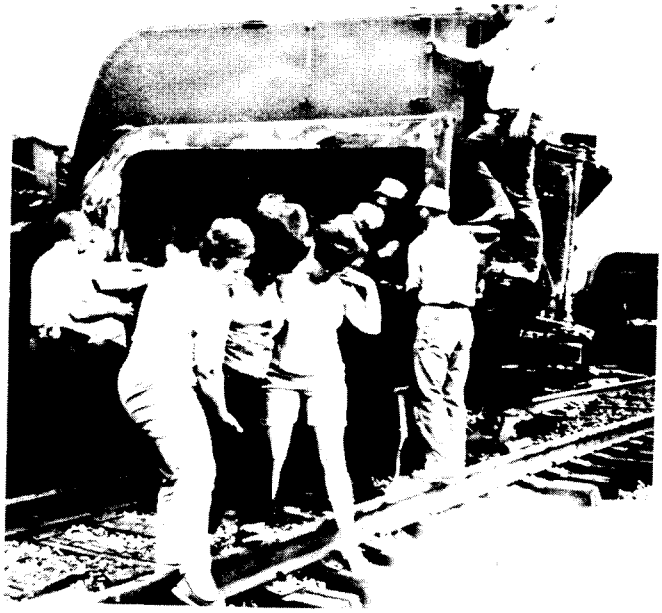
FIGURE 20. Seat and window damage in Passenger Car No. 4.



a. Passenger car no. 5 overturned but was unoccupied and is not shown. This is passenger car no. 6. It remained upright as did cars 7, 8 and 9 with passengers and cars 10, 11, 12 (empty). Damage is slight and injuries to the passengers were minor or none.

b. Even though the car remained upright, some seats became unhooked and rotated. The passengers in these cars stated they were able to remain in their seats by holding on.

FIGURE 21. Passenger Cars 6, 7, 8, and 9 did not overturn and Passenger Car No. 6 is shown here to depict relatively minor damage to these cars.



a. Injured passengers being helped out the end of the car and down to the ground after having climbed over partitions and through the 2-foot high tunnels over or under the rest rooms as shown in Figure 25.

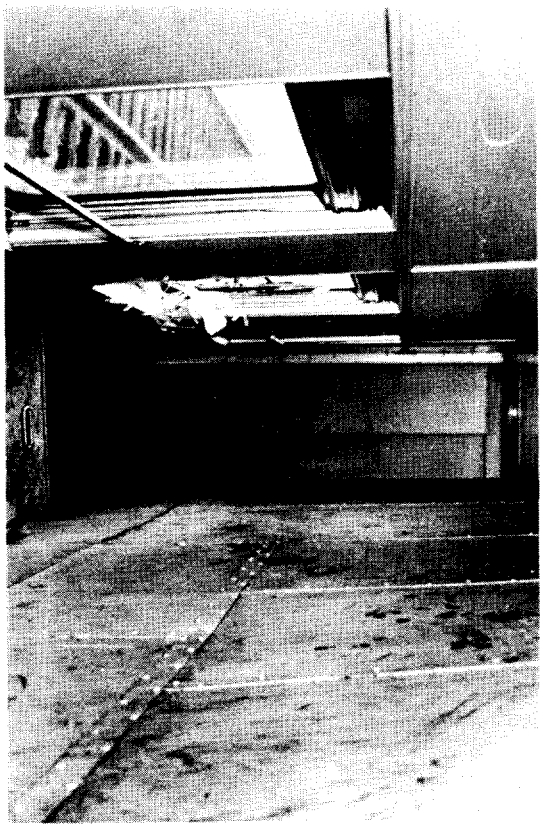
b. Some were rescued by being lifted up through windows by means of ropes.

c. Other rescue workers brought ladders to assist passengers to the ground after they climbed up the seats and out the windows.

d. View of rescue workers lowering a ladder through a window they have knocked out to rescue passengers.

FIGURE 22. Photographs of passenger escape taken soon after the crash.

a. Front end of diner as it appeared with car on its side. Passengers escaped by climbing up on the booth and out the end door.



b. Rear end of diner on its side offered a more difficult escape route. One passenger climbed up into the 2-ft. high tunnel shown here and was rescued through the small broken window.

c. As the diner overturned two passengers were ejected through this window into a depression under the car but could not crawl out from under the car. They climbed back through the window and went out the end door shown in a.

FIGURE 23. Photographs showing escape routes from the Diner.

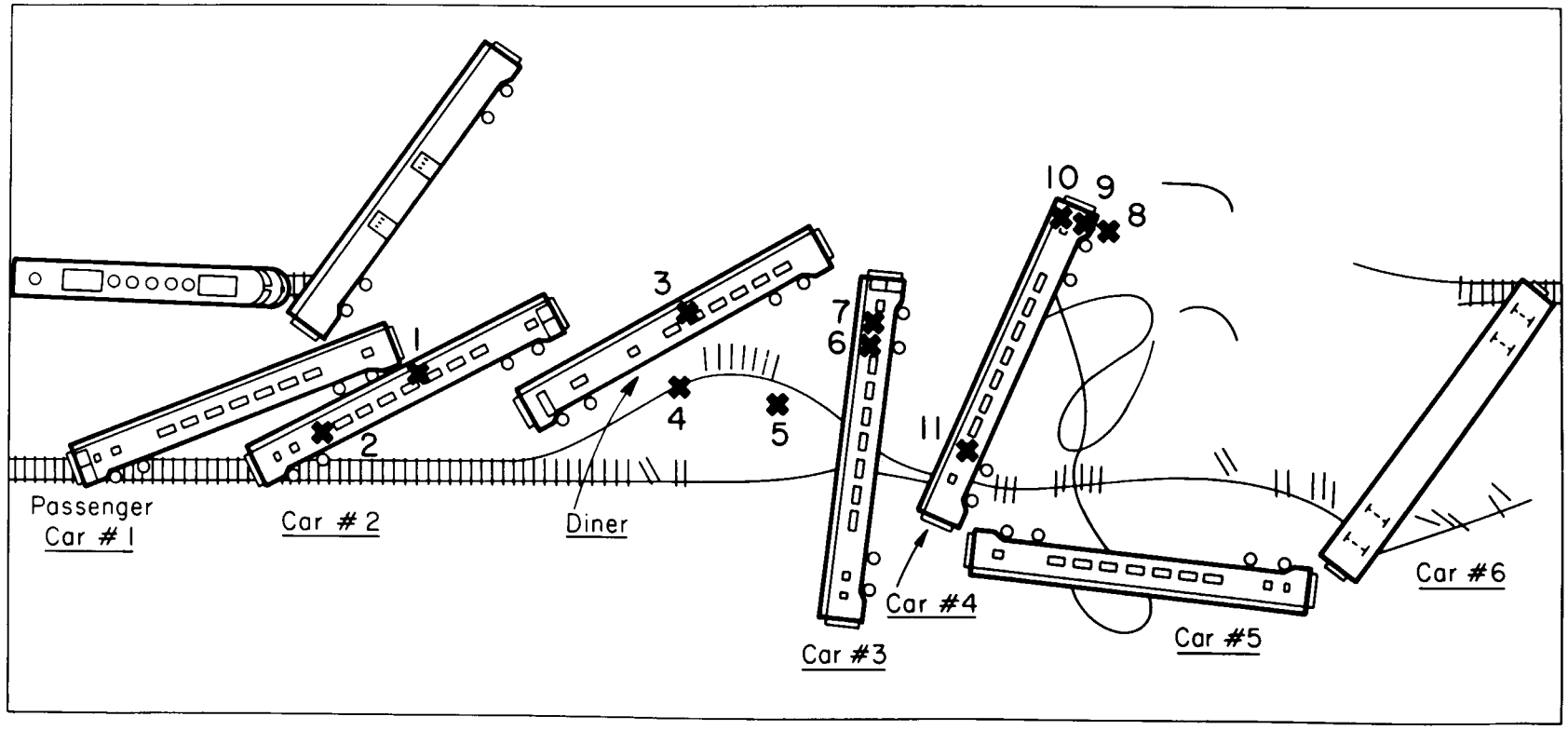


FIGURE 24. Diagram of crash site showing location of the bodies of the ones who were fatally injured.

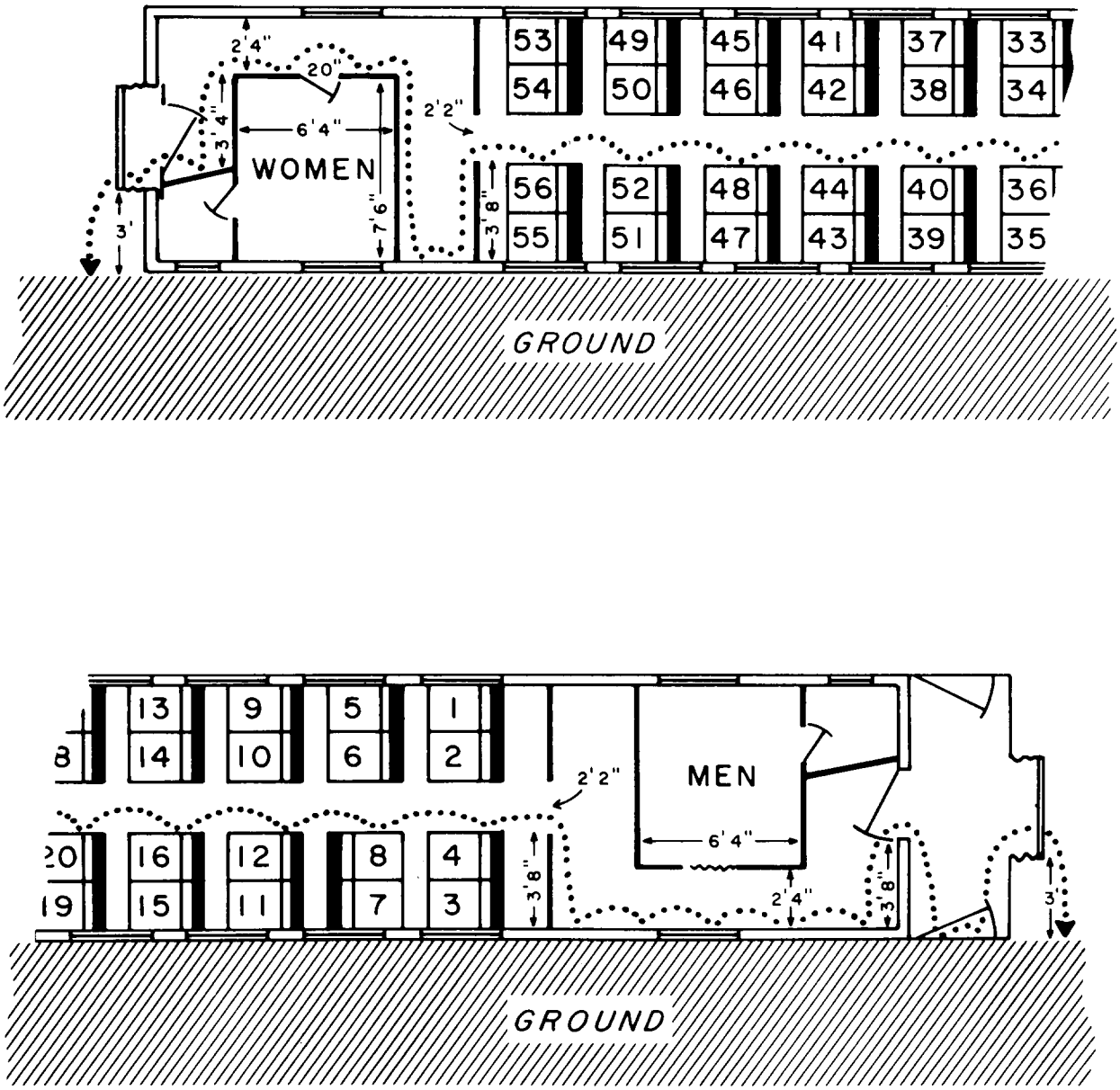


FIGURE 25. Diagrams showing two possible escape routes from a railroad passenger car that has rolled over onto its side.