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CRASH SURVIVAL STUDY:

**NATIONAL AIRLINES DC-6 ACCIDENT
AT ELIZABETH, N. J. ON FEBRUARY 11, 1952**

A. HOWARD HASBROOK

**CRASH INJURY RESEARCH
Cornell University Medical College
1300 York Avenue, New York 21, N. Y.**

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ABSTRACT

Crash survival details of a 140 mph crash involving a Douglas DC-6 transport aircraft, in which 32 of the 59 passengers survived, are presented and analyzed. Information is given on impact speed and attitude, directions of principal impact force, kinematic behavior of the fuselage, damage to cabin and seats, and injuries sustained in relation to passenger location; photographs and diagrams are shown. Findings are discussed and recommendations are made relative to crash survival design in future transport aircraft.

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PREFACE

Major efforts to increase safety in flying have always been justifiably aimed at preventing accidents. The beneficial results of such work by military and civil aviation safety groups are well known and are reflected in the decreasing fatality rate per hundred million passenger miles of transport flying.

Experience in all safety fields has shown, however, that because of variables in human behavior, accidents will occur despite all preventive efforts.

Some "non-preventable" air transport accidents result in complete demolition of aircraft structure; by the very nature of such accidents and because of the resulting damage to structure, it is known that no amount of realistic structural redesign could alter the injuries sustained by the passengers. However, a percentage of these accidents are in a class which may be termed survivable, or at least partly survivable. Such accidents usually involve impact speeds, deceleration distances, structural damage and impact forces which can be tolerated by human beings without fatal or dangerous injury.

The National Airlines DC-6 accident at Elizabeth, N. J. provides an example of the type of crash which is partly survivable and partly non-survivable. The accident was of a complex nature - as are most such survivable accidents - involving highly diverse conditions of structural damage, injuries, and magnitude and directions of crash force. This accident is covered in full detail in the following report in order to provide, perhaps for the first time, a complete picture of conditions which can occur in an extremely severe but survivable transport crash.

In addition, the report shows the type of information which should be obtained from survivable transport accidents in order to permit effective analysis and subsequent presentation of crash survival data which may be of use to engineering and safety groups.

Hugh De Haven
Director
Crash Injury Research

FOREWORD

The National Airlines DC-6 Elizabeth crash survival study is a portion of a Crash Injury Research reporting program intended to be of service to military and civilian design engineers, airlines, airframe manufacturers and safety groups.

The report is published by Crash Injury Research; the Project is in the Department of Public Health and Preventive Medicine at Cornell University Medical College, and is under the direction of Hugh De Haven. Crash Injury Research operates under an Office of Naval Research contract, jointly supported by the U.S. Departments of the Army, Navy and Air Force, and the Civil Aeronautics Administration.

The report was prepared by A. Howard Hasbrook, Administrator of CIR's Aviation Program, who took part in the official Civil Aeronautics Board "on-the-scene" investigation, photographed the wreckage and analyzed crash-injury details of the accident.

Salvatore Macri, Analyst, and E. Wellin, Staff Assistant, assisted in the compilation and analysis of medical data; M. Higgins, G. Draper and A. Rosenthal aided in the production of the report.

The cooperation of the Civil Aeronautics Board, through its Air Safety Investigators of the Bureau of Safety Investigation, is gratefully acknowledged. Crash Injury Research is also indebted to personnel of National Airlines, United Airlines, Hamilton-Standard Propeller Company, and the Douglas Aircraft Company who contributed technical information.

In addition, the Project is particularly grateful to the passengers aboard the aircraft - and their families - and to the Staffs of the St. Elizabeth Hospital, The Elizabeth General Hospital and the Alexian Brothers Hospital for invaluable medical data.

INTRODUCTION

If judgment of accident severity is based solely on the overall destruction of an airplane, the National Airlines DC-6 accident at Elizabeth, New Jersey would probably be classified as catastrophic and non-survivable.

Complete disintegration of major portions of the passenger cabin - followed by fire - a six hundred foot wreckage pattern and a 140 mph impact speed would seem to justify placing this accident in a non-survivable category with survival of any of the passengers attributable to luck. Furthermore, it would be likely to conclude that little or no crash survival information of value could be obtained from this accident - or from crashes of similar severity.

On the other hand, if judgment of an accident - in which some portion of the cabin remains reasonably intact - is also based on additional factors, information of value for the use of design engineers can be obtained from such accidents. These factors include the known "crashworthiness" of human structure, and the details of the incident, i.e., impact speed, flight path angle, nose-down angle, deceleration distance and other equally important data.

It was found in the National DC-6 accident, for example, that the rear half of the passenger cabin sustained crash force of low magnitude while forward portions of the airplane were being disintegrated. This, along with other detailed information, undoubtedly will be of more than academic interest to groups concerned with decisions relating to the design and use of aft facing and forward facing seats.

In addition, data concerning failures of seats and their attachments - some under conditions of *mean* longitudinal crash force of less than 6G in this accident - as well as on patterns of destruction of the cabin, directions of principal and secondary crash forces, effectiveness of 3,000 lb. safety belts, injuries, and many other pertinent details may be of value to safety groups and design engineers in the consideration of crash survival design requirements for future piston-driven and jet transport aircraft.

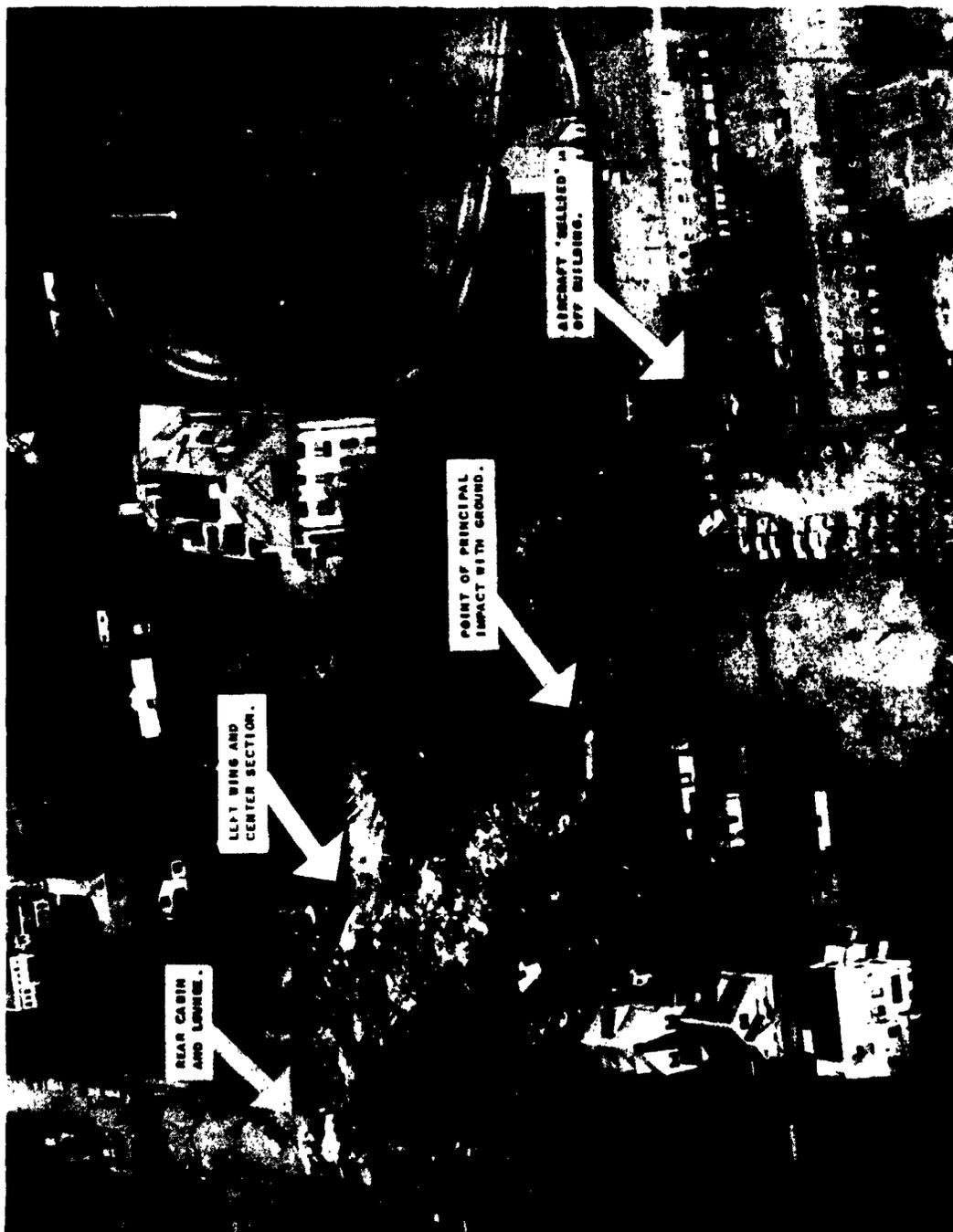


FIG. 1. UNITED PRESS AERIAL PHOTO SHOWING ACCIDENT SCENE.

THE ACCIDENT

A National Airlines Douglas DC-6, equipped with fifty forward facing passenger seats, four facing sideward, and four facing backward, took off from Newark, N. J. Airport just after midnight on February 11, 1952; fifty-nine passengers and a crew of four were on board. The weather was clear; the take-off was uneventful. In less than two minutes time after the aircraft cleared the end of the runway, mechanical difficulty occurred; Number 4 propeller was feathered, and Number 3 propeller reversed its pitch.

Unable to climb or even maintain altitude, the pilot attempted to return to the airport but failed; the aircraft struck the roof of a three and one-half story apartment house, while in a partially controlled descent (Fig. 1). Skidding from the roof, the airplane rolled to the right and struck the ground of a school yard at approximately 140 mph, in a nose-down attitude of approximately 10 to 15 degrees.

Disintegration of the forward half of the fuselage occurred as the airplane struck, bounced and cartwheeled. The rear half of the cabin - substantially intact - tore free from the wing center section and hurtled through the air, coming to a sudden stop after crashing against a large tree trunk 280 ft. from the point of initial impact with the ground.

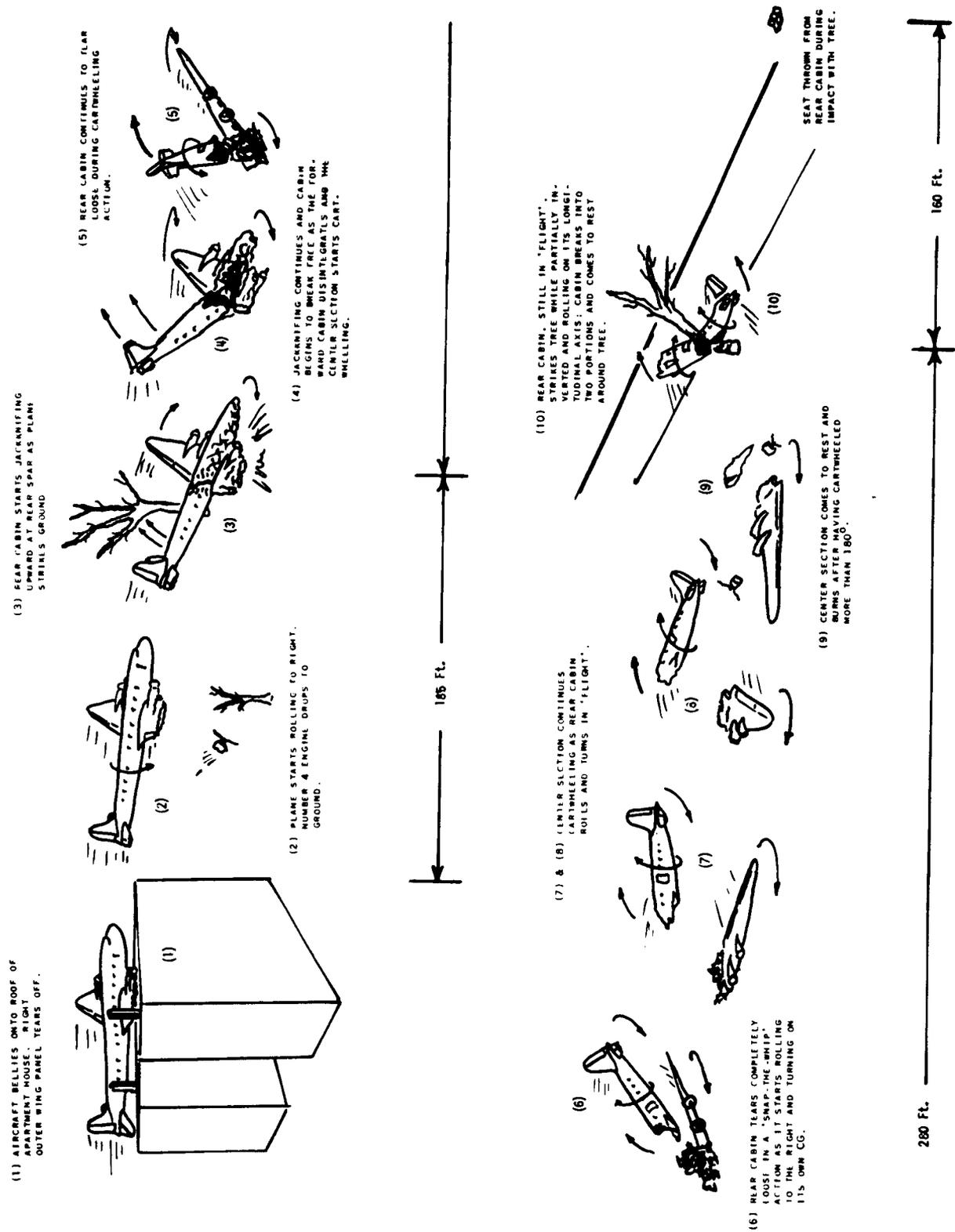
All occupants of the aircraft were wearing their safety belts at the time of the crash with the possible exception of one adult, and a four-months old infant held on his mother's lap.

Twenty-seven passengers - four of whom were sitting in aft-facing seats - and the three crew members in the cockpit were fatally injured. The stewardess and thirty-two passengers survived.

* * * * *

FIG. 2.

NATIONAL AIRLINES DC-6 FEBRUARY 11, 1952 ELIZABETH, N. J. CRASH.
ANALYSIS OF PROGRESSIVE DISINTEGRATION AND KINEMATICS OF AIRCRAFT.



THE CRASH

According to data available to Cornell's Crash Injury Research, the kinematic behavior of major components of the airplane during the crash was substantially as follows:

The aircraft was in a slightly nose-high attitude with the right wing down about 15° when it "bellied" onto the roof of the building (Fig. 2). Skidding across the roof, the plane struck and levelled the low rear parapet of the building to the roof line. Simultaneously, the right outer wing panel was torn off against the front parapet; gasoline from the ruptured tanks cascaded onto the roof and ignited.

Because initial contact with the flat roof was at a low angle, with very little if any rebound, no force of any consequence was transmitted to the seats or passengers.

Skidding off the building, the airplane rolled steeply to the right, with the nose down slightly, and a moment later struck hard ground at about 140 mph.

The stub of the right wing - outboard of #3 Engine - and the cockpit struck first; the forward cabin and center section hit in quick succession. At the same moment, tremendous crash loads - possibly in the order of 50G - were imposed on the center section structure. As the wing stub dug in - and the plane bounced and cartwheeled - the right side and bottom of the forward cabin, and the cockpit, began to heave and disintegrate.

The sixteen passengers and one infant who were seated ahead of the front wing spar were involved in the destruction of the forward cabin area; thirteen died.

At the same moment, a portion of the cabin roof and the right fuselage wall near the sixth and seventh rows of seats collapsed inward as the rear half of the cabin jackknifed upward; two of the four people in these seats survived.

The center section, left wing, the disintegrated forward cabin structure and the intact rear cabin cartwheeled toward a line of trees bordering a nearby street. During this cartwheeling action, the rear cabin structure tore free from the center section and hurtled through the air - rolling clockwise on its longitudinal axis and changing direction approximately 180°. This "free flight" of the intact cabin and lounge ended abruptly when it struck a thick tree trunk.

At the moment of impact with the tree - a few feet above the ground - the cabin was rolling and partially inverted; the roof and the upper right-hand cabin wall failed inwardly. The occupants of Seats 27 and 27A were crushed as the tree trunk was forced part way through the cabin.

Almost simultaneously, the tree trunk broke at its base, and the left side of the cabin and floor structure failed under "explosive" tension loads; the fuselage then jackknifed around the tree with the two pieces of the cabin coming to rest at an angle to each other (Fig. 3). This wreckage did not burn. Of the thirty-five occupants originally in this portion of the airplane, 8 died, eighteen had varying degrees of injury, and nine sustained minor or no injuries.

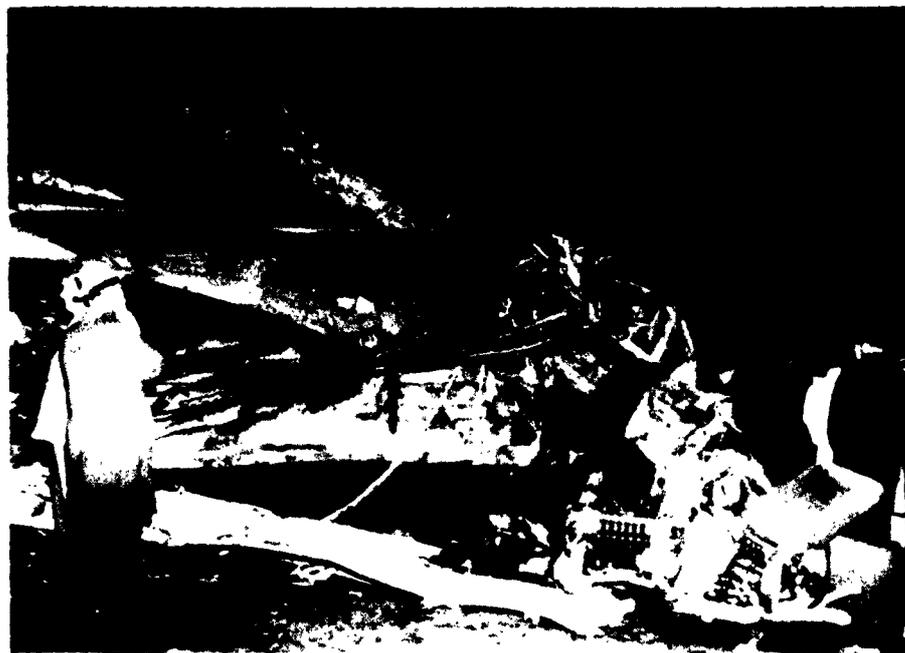


FIG. 3. UNITED PRESS PHOTO SHOWING REAR HALF OF CABIN WHERE IT CAME TO REST - INVERTED AND BROKEN IN TWO AROUND TREE.

While the rear cabin was crashing into the tree, the center section and left wing continued to cartwheel, coming to rest - and burning - after rotating around its vertical axis more than 200° from the direction of original ground impact. Wreckage and burning debris, the engines, and some of the passengers, still in their seats, were scattered along a 280 foot "wreckage path".

CRASH FORCE, STRUCTURAL DAMAGE AND GENERAL INJURY DATA

The glancing impact with the roof of the apartment building damaged the right outer wing panel, the nacelles, the belly of the airplane and the horizontal tail surfaces. However, the basic cockpit and cabin structure of the DC-6 sustained no appreciable damage, and the passengers did not feel any deceleration until the airplane struck the ground.

As shown in Fig. 2, the airplane was rolling clockwise and skidding - with the nose to the right - when it struck the ground; the initial crash force was from 11 o'clock, and slightly below the horizon. As the forward fuselage belly, the stub of the right wing, and the center section "dug in", the principal crash force came from the right (1 o'clock) and from below the airplane's longitudinal axis. Disintegration of the belly and righthand portions of the forward fuselage* - as well as the cockpit and the stub of the right wing - occurred almost simultaneously.

The mean deceleration of the crash was between 2G and 4G.

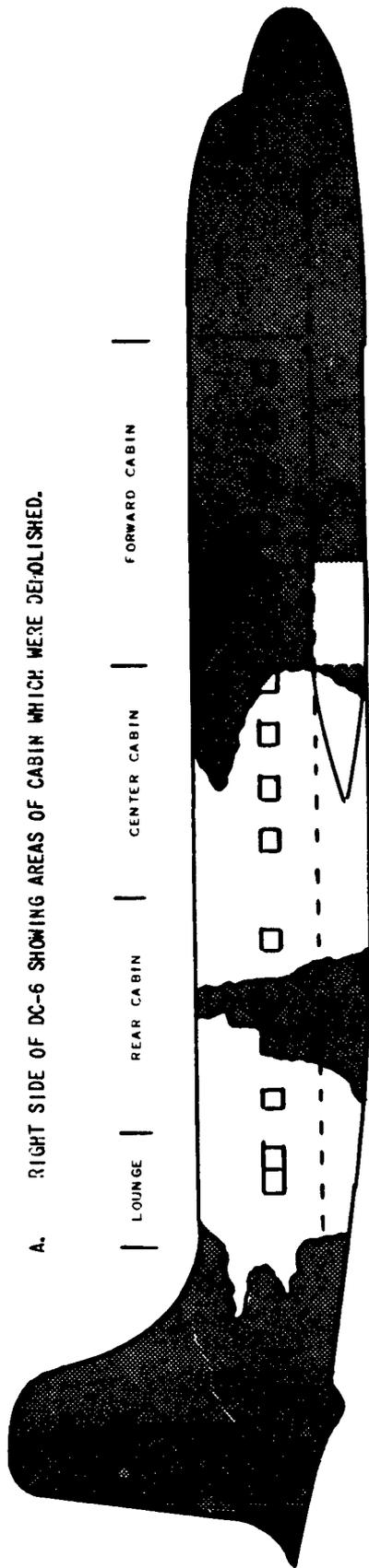
THE COCKPIT

Magnitude of the peak crash force imposed on the cockpit and forward fuselage structure is, of course, unknown. It was certainly more than 6G in the crew compartment since the pilot's 6G seat-rail attachments failed under forward tension loads as the captain was thrown forward at impact. On the other hand, the crew's 17½G safety belt webbings showed evidence of strain but remained intact. However, the buckle cam of the co-pilot's safety belt was missing; apparently, some portion of the damaged cockpit structure sheared off the bolt holding the cam.

As shown in Fig. 12, there was a wide difference in the type of damage sustained in different parts of the cockpit. The right side was completely disintegrated; this is indicated by the fragmented wreckage of the co-pilot's seat, as shown at B, Fig. 12. The engineer's seat, at C, shows less crushing of structure, and the condition of the captain's seat (at A) implies collapse of surrounding structure, rather than disintegration.

* Nose of airplane back to the forward wing spar.

A. RIGHT SIDE OF DC-6 SHOWING AREAS OF CABIN WHICH WERE DEMOLISHED.



B. LEFT SIDE OF DC-6 SHOWING AREAS OF CABIN WHICH WERE DEMOLISHED.

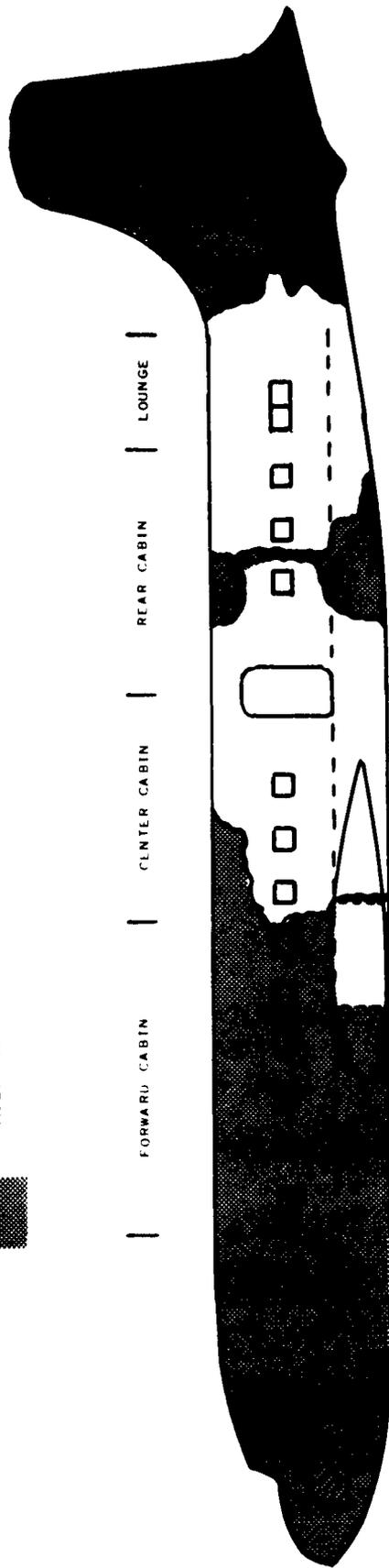


FIG. 4

Although the captain may not have sustained fatal injuries at initial impact, subsequent crushing of the cockpit structure as the fuselage collapsed and the center section dug into the ground and cartwheeled caused all three crew members to sustain multiple, fatal crushing injuries. Because of this, the use of shoulder harness and/or higher load factored crew seats probably would have made little difference in the exposure to injury experienced by the cockpit crew, in this accident.

FORWARD PASSENGER CABIN AREA

The belly, floor, sidewalls and roof of the passenger cabin - ahead of the wing - progressively disintegrated as they were "ground under" after initial ground contact. The first four rows of seats in this area, as shown in Figs. 14 and 18, were torn free and demolished. The direction of principal force imposed on these first four rows of seats was the same as that imposed on the forward fuselage structure - initially from the left and below the longitudinal axis of the airplane, and then from the right as the center section dug in. Loads imposed on the seats, seat attachments and the safety belts by the occupants are unknown. However, there was no evidence of failure of safety belt webbings on these seats. This would indicate that any force of reasonably "long" duration exerted on the safety belts was less than a force equal to a static "loop" load of 3,000 lbs. on each belt (17½G).

Of the sixteen adults (and one baby in arms) occupying these seats, thirteen sustained multiple, fatal crushing injuries. Of the four survivors in this area, those in Seats 3A and 8 sustained dangerous injuries; on the other hand, the passengers in Seats 1 and 6, although exposed to great danger from collapsing and disintegrating structure, had non-dangerous injuries. Although they were sitting next to persons who were fatally injured, these two passengers survived because they were not crushed by heavy structure nor did they strike objects or structures with sufficient impact to cause fatal concentrations of force on vital areas of the body.

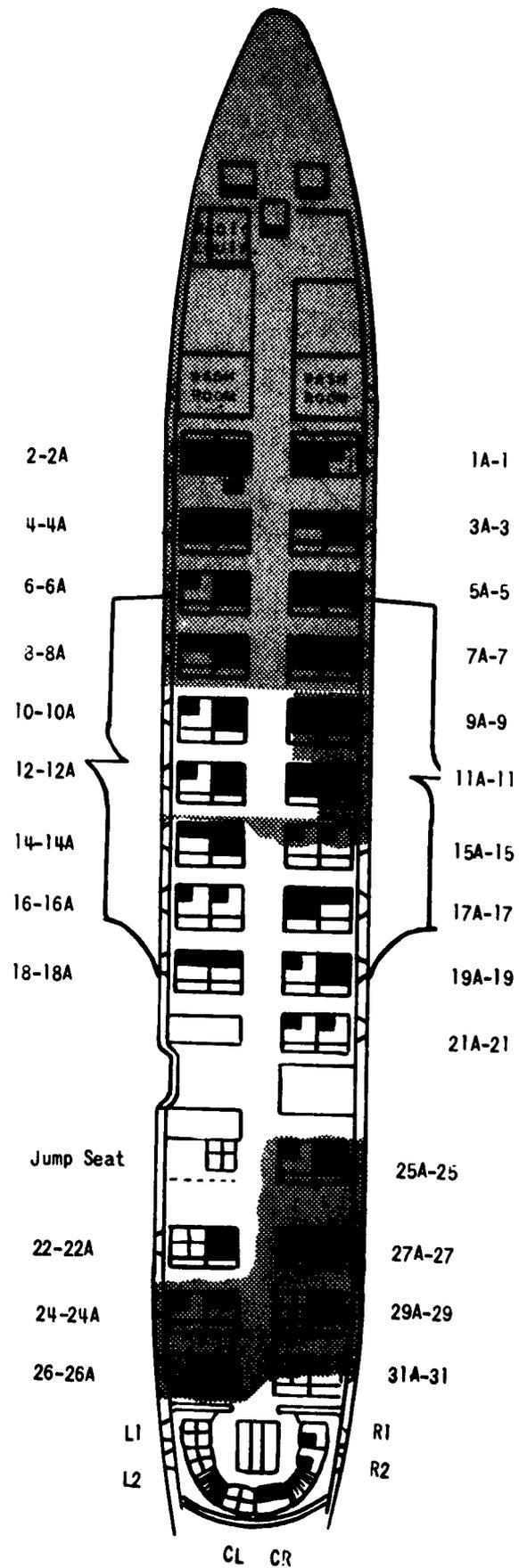
Since the entire floor structure under these eight seats (1-1A through 8-8A) disintegrated completely, additional seat anchorage strength could not have provided any appreciable increase in crash safety in this area. However, the height and ruggedness of the seat-backs may have been an important factor in providing some measure of protection for the heads and torsos of the four survivors.

FIG. 5. DIAGRAM SHOWING AREAS OF FLOOR STRUCTURE WHICH WERE DEMOLISHED, IN RELATION TO "DEGREE" OF INJURY.

INJURY:

-  FATAL
-  DANGEROUS
-  NON-DANGEROUS
-  MINOR-NONE

 DEMOLISHED



Of the four people, and one infant in arms, who were sitting in the *four aft facing seats* (1-1A, 2-2A), only one survived; the three other survivors in this area of complete demolition were sitting in *forward facing seats*.

THE CENTER SECTION AREA

When the wing stub and center section struck the ground, heavy crash forces were transmitted to the four double seats* whose aisle attachments were fastened directly to the center section structure. As the wing structure broke up, the cabin walls and ceiling adjacent to the center section collapsed and disintegrated; at about the same moment, the four double seats were torn loose and hurled - with their occupants - under the collapsing wreckage of forward cabin structure.

All the safety belts on these seats remained intact and the webbings showed no evidence of strain. This indicates that the occupants imposed "long period" tension loads of less than 3,000 pounds on the belts and seats. However, three of the quarter-inch aircraft bolts used to attach the aisle sections of the *left-hand seats* to the center section failed, indicating that very high jolt or shear loads may have been transmitted to the seat anchorages while lesser loads were being applied to the belts.

The damage to the two double seats** on the right side of the cabin indicates that the seats were crushed by inward collapse of sidewall structure; as might be expected, all four of the occupants were fatally injured.

On the other hand, the two double seats on the left-hand side of the cabin sustained less damage. The occupants of Seats 10 and 12 - next to the wall - sustained non-dangerous injuries, consisting mainly of multiple body abrasions and contusions and second degree burns; these burns apparently were caused by involvement with short duration flash fires since the seats showed no evidence of fire damage.

However, the two passengers sitting in the aisle seats were fatally injured; one, the occupant of 12A, sustained a fatal head injury - there is a possibility that he did not have his safety belt fastened at the moment of impact.

* 9A-9 through 12-12A

** See Photos 13, 46

THE REAR AREA OF THE FORWARD CABIN

Jackknifing of the fuselage at the rear wing spar caused the cabin ceiling to fold inward and collapse in the general area of Seats 14-14A and 17-17A; of the four people in these seats, two survived, with a multiplicity of severe injuries.

Break-up and collapse of the floor structure under Seat 15A-15 seems to have permitted it and its occupants to "fall away" from inward collapsing structure and to be thrown out into the open as the cabin tore free. Both occupants survived, with multiple bruises and lacerations over most of their bodies and second degree burns from the flash fires that broke out in scattered areas of the wreckage.

The three remaining seats on the right side of the cabin were forced into the aisle by inward flexion of the sidewall along with collapse of the ceiling structure; the aisle seat anchorages failed. The buffet just ahead of the entrance door - on the left side of the cabin - tore free and struck the seat ahead (18-18A), failure of the aisle anchorages permitted the righthand seats, with the exception of 21A-21, to pull free from the wall structure and hurtle onto the ground - with their occupants - as the cabin broke away from the center section. Two of the people in these seats on the right were fatally injured. One of the six survivors had dangerous head injuries. Five sustained non-dangerous injuries; the occupants of the rearmost seat had only a few lacerations, contusions and bruises.

Apparently none of the three double seats on the left side of the cabin - between the buffet and the center section - tore free during the initial phase of the principal ground impact. However, the attachments of Seat 14-14A probably were damaged when adjacent floor structure failed during jackknifing of the fuselage; this seat, with its occupants, was thrown into the main wreckage debris. One of the occupants was killed. The adjacent passenger had dangerous, but not fatal, head injuries.

The anchorages on Seat 18-18A seem to have been damaged when the seat was struck by the buffet; the seat subsequently tore loose when the rear cabin struck a tree broadside - after it had broken away from the center section. The people in this seat had dangerous injuries consisting of multiple fractures, lacerations and bruises - injuries which may have been sustained by prior involvement with downwardly collapsing ceiling and wall structures, as well as when the seat tore free.

Seat 16-16A, less than six feet from the center section break, was undamaged (Fig. 6); its anchorages were intact and the seat remained in place. Its occupants sustained only non-dangerous injuries. One person remembers finding himself hanging upside down, unlatching his belt, crawling out of the cabin and then helping other people out of the wreckage.

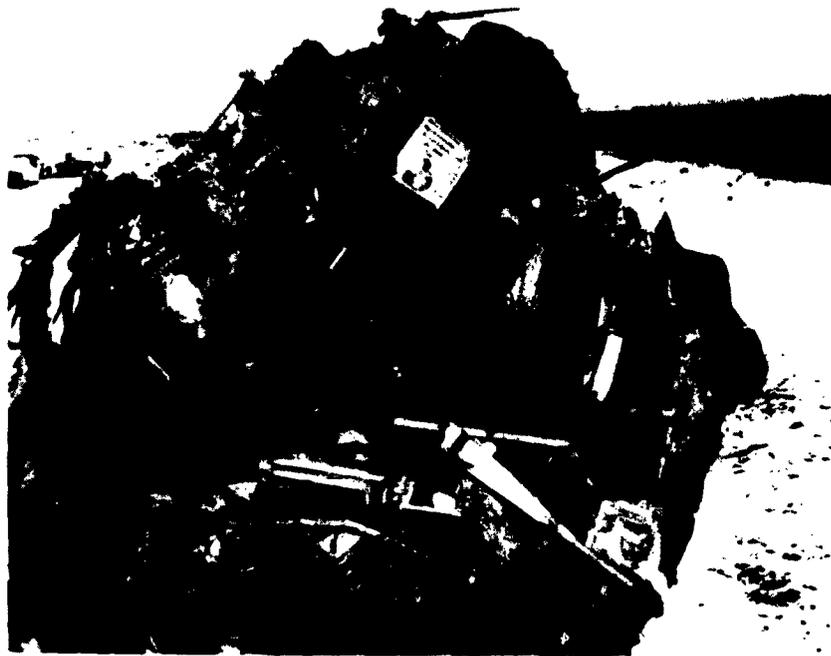


FIG. 6. SEAT 16A-16 WAS UNDAMAGED AND REMAINED IN PLACE.
THE TWO OCCUPANTS SUSTAINED NON-DANGEROUS INJURIES.

The extensive collapse of the right sidewall and ceiling in this area, as well as the acute flexion of the cabin, as denoted by the complete fragmentation of the coat closet structure behind Seat 21A-21, suggests that most of the survivors in this part of the cabin would have been more severely injured - and probably killed - if the buffet unit had not prevented complete collapse, or "flattening", of the cabin.

**AFT CABIN AREA
(Excluding Lounge)**

During the principal ground impact (in which the forward half of the airplane disintegrated, killing nineteen people) the seven forward-facing passenger seats in the rear cabin area remained in place and the fourteen occupants sustained no injury at this time.

However, after jackknifing and tearing free from the center section, the rear half of the fuselage spun on its own vertical CG and struck a large tree trunk broadside; simultaneously, heavy up and side forces - from the right - were imposed on the cabin structure, the seats, seat attachments and the occupants. A moment later, the cabin "wrapped" itself around the tree as the trunk forced its way partly through the fuselage, causing injury and death to nine of the fourteen passengers.

Seat 27A-27 - on the right side - was directly in the path of the tree trunk; the seat was crushed and the occupants killed.

As the cabin collapsed around the tree, the entire floor structure (with the exception of a small portion under Seat 22-22A) disintegrated under "explosive" tension loads. As a result, all of the seat attachments, with the exception of those on 22-22A, failed, throwing the seats and occupants into a pile inside the cabin shell.

Of the fourteen passengers in the rear cabin area, five died - primarily of crushing injuries of the head. These five were in seats whose location roughly approximated a triangle with its center line parallel and adjacent to the tree trunk. Undoubtedly, the crushing injuries sustained by these five passengers were caused by inward displacement and failure of the cabin wall and ceiling and, in some cases, actual - forceful - contact with the tree trunk itself.

Three of the nine surviving passengers had non-dangerous injuries. Five had minor or no injuries - although they were no more than two seats away from persons who were killed.

Only one of the surviving passengers had dangerous injuries - to the head - which were caused by downward displacement of overhead cabin and hatrack structure.

The stewardess was seated facing aft in a folding jump seat attached to the rear side of the buffet. She was uninjured except for a glancing blow on the head which she probably received from a hand fire extinguisher when it tore loose from its attachment clip and hurtled laterally across the cabin; she was reported to have been unconscious for only a few moments.

As can be seen from Fig. 7, clockwise rotation of the cabin (around its longitudinal axis) during impact with the tree trunk tended to pull the right hand seats "downward" and away from the tree - prior to failure of the floor structure. This may have had a marked effect in causing the seats - due to inertia - to initially "fall away" from the ceiling and tree as they came free from the disintegrating floor.

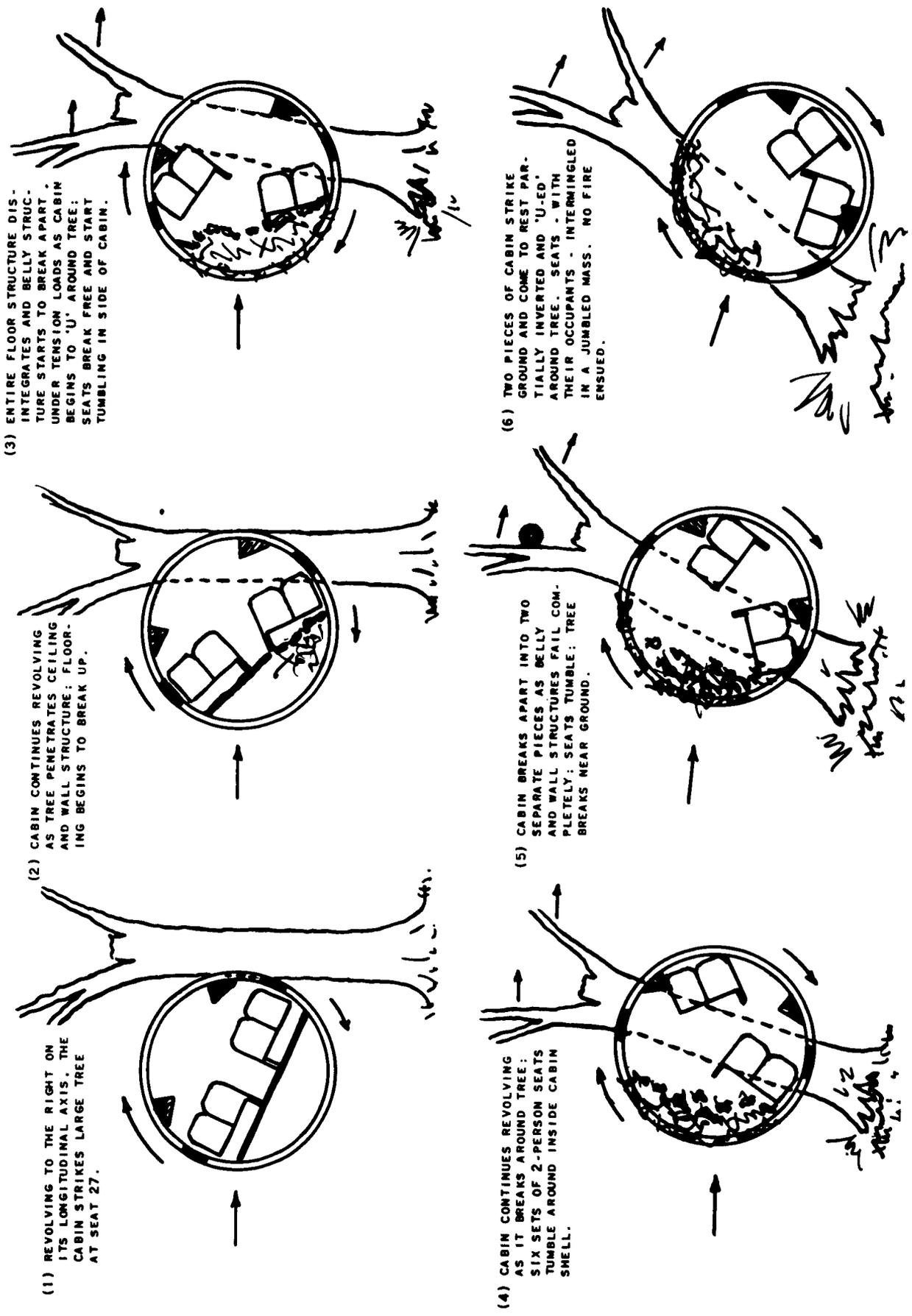


FIG. 7. VIEW (THROUGH SECTION A-A OF FIG. 8) LOOKING FORWARD THROUGH REAR CABIN AREA DURING IMPACT WITH TREE.

It is noteworthy - from the point of view of seat-back height design requirements - that the occupant of Seat 22 received only a minor laceration of the forehead although she was sitting only a few inches from a person who suffered fatal crushing injuries of the head; this survivor was a small child whose head was well below the top of the seat-back and thus was somewhat protected from downward crushing roof structure.

Had the rear cabin not been involved with such an "immovable object" as the large tree that it struck, there is every indication that all of the fourteen passengers in this area would have survived, with minor or, at the worst, non-dangerous injuries. Actually, the people in the rear cabin endured two accidents; the first - involving disintegration of the forward portion of the airplane and fatal injury to many persons in the front cabin - caused no serious injury to the occupants of the rear cabin. The "second accident", however - involving an abrupt deceleration against the tree with inward crushing of structure - caused the serious and fatal injuries which were sustained in the aft area of the cabin.

THE LOUNGE AREA

While nineteen people were being fatally injured in the forward part of the DC-6 as it struck the ground, the six passengers in the lounge felt no appreciable crash force - nor were they injured. However, when the rear half of the cabin struck a large tree broadside, the lounge occupants were thrown heavily against their safety belts, the seats and, in some cases, the center lounge table.

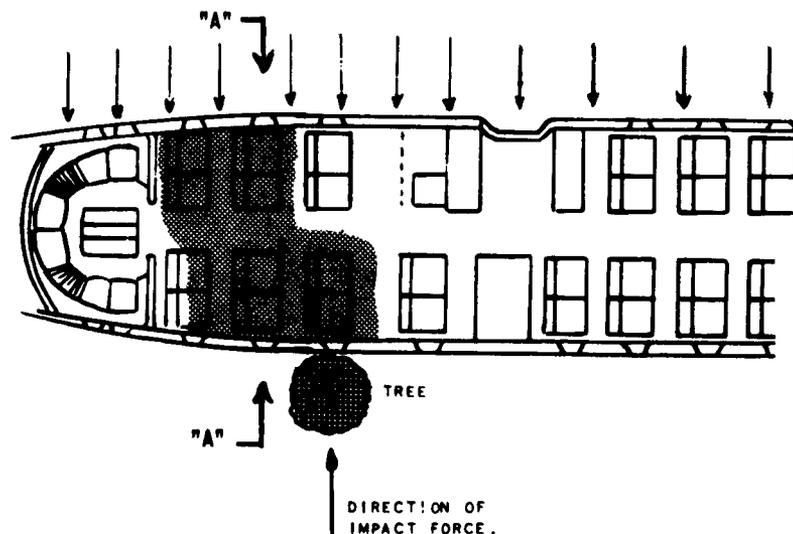


FIG. 8. VIEW SHOWING (1) POINT AND DIRECTION OF CONTACT OF REAR CABIN WITH TREE, AND (2) FLOOR AREA WHICH DISINTEGRATED AS CABIN BROKE IN TWO.

As shown in Fig. 8, the six lounge seats - with low seat-backs - were arranged in a semi-circle. Under the directional conditions of crash force which existed during impact with the tree, the passengers in the left-hand seats (L1, L2) were subjected to "forward facing" conditions and the upper attachments of their seats failed under tension loads, permitting the seats to pull partially away from the side-wall structure; however, the two passengers were uninjured. Those in the center seats (CL, CR) were subjected to "side-facing" loads; the passenger in CL had only minor injuries. The one in CR, however, was thrown heavily sideways against the unyielding armrest and sustained an injury of the lower spine.

The passengers in the right-hand seats (R1, R2) were, in effect, seated facing "aft". The person in R2, *who was short in stature*, suffered non-dangerous but painful lacerations of the face and head as well as a fractured facial bone and mild concussion. The lacerations of the head and face apparently were caused by flying fragments of nearby plastic partitions which shattered during the tree impact. The fractured facial bone may have resulted from the passenger "rebounding" and striking the table top. The occupant of R1 (a *tall man*) is reported to have suffered a non-dangerous back injury; this may have resulted from his "flexing" backward over the low seat-back with which the lounge seats were equipped.

From the point of view of injury potential in relation to seat design, and direction of crash force application, it is interesting to note that the two people who, in effect, were seated facing forward (L1 and L2) sustained no injuries whatsoever, while one of those facing "aft" in a low-backed seat (R2) did sustain a spinal injury although it was of a non-dangerous degree. On the other hand, the most serious injury (to the spine) was sustained under a "side-facing" condition (CR).



FIG. 8A. AREA WHERE REAR CABIN STRUCK TREE.
(NOTE SEAT 22, 22A).

INJURIES

The injuries sustained by the 59 passengers varied widely in seriousness - from multiple, crushing, fatal injuries to minor bruises and lacerations, or no injuries whatsoever.

Twenty-seven of the fifty-nine passengers were killed; eight suffered dangerous* injuries; fifteen sustained non-dangerous** injuries, and the remaining nine had minor or no injuries.

Sixty-four percent of the passengers received blows to the head of sufficient force to cause skull fracture and/or concussion, and/or death from brain lesions.

The injuries sustained by each person with respect to seat location are detailed in the Appendix.

FATAL INJURIES

Eighty-eight percent of the twenty-seven persons killed in the accident had fractures of the skull and/or of the ribs; eight of these had a combination of fractures of the skull *and* ribs *and* one or more of the extremities (arms or legs). Another five had fractures of the skull and ribs without fractures of the extremities. Nine of the twenty-seven dead had fractures only of the skull.

There was one case in which internal injuries were definitely reported; however, these internal injuries were associated with fractures of the ribs. Two other persons were reported as possibly having internal injuries - one of these passengers also had a fracture of the skull; the other had injuries of the chest. None of the three cases of reported and "possible" internal injuries was attributed to the safety belts.

Only one passenger sustained eviscerating injuries of the abdomen.

* *Dangerous: Injuries threatening life even under prompt medical care.*

** *Non-dangerous: Injuries which normally do not threaten life.*

In summary, of the 27 passengers killed in this accident:

48% sustained fractures of *both* the head and ribs.

33% sustained fractures of the head alone.

7.4% sustained fractures of the ribs alone.

3.7% were reported to have had internal injuries.

DANGEROUS INJURIES

Eight survivors sustained dangerous injuries. Two of these eight had a combination of dangerous fractures of the skull *and* ribs; a third had a skull fracture, and a fourth suffered fractures of the ribs.

Seven of the eight had concussion.

Only one of the two persons who sustained a combination of fractures of the skull and ribs had internal injuries of the chest. Another, who sustained fractures of the ribs only, was reported to have had *possible* abdominal injuries; the "possible" and reported internal injuries were *not* attributable to the safety belts.

Three of the eight dangerously injured survivors sustained fractures of one or more of the extremities.

In summary, of the eight passengers who suffered dangerous injury:

25% had fractures of *both* the skull and ribs.

12½% had fractures of the skull alone.

12½% had fractures of the ribs alone, and

87½% had some "degree" of concussion.

NON-DANGEROUS INJURIES

Fifteen of the passengers sustained non-dangerous injuries; none had fractures of the skull. However, three sustained fractures of the ribs, and two received fractures of one or more of the extremities.

Two of these fifteen persons were reported to have had sprains of the back, and one a non-dangerous injury of the lower spine. One passenger had a fracture of the clavicle (collar bone), and one had a contusion of the chest wall.

None were reported to have had internal injuries.

Eight of the fifteen exhibited "degrees" of concussion which were not regarded as normally dangerous.

In summary, of the fifteen passengers who sustained non-dangerous injuries:

None had fractures of the skull, although

53.5% sustained concussion.

2% sustained fractures of the ribs, and

None had internal injuries.

MINOR OR NO INJURIES

The remaining nine passengers - and the stewardess - sustained minor or no injuries. The minor injuries consisted, in most cases, of nothing more than bruises, contusions and/or lacerations. Four of the nine reportedly sustained no injuries whatsoever; two of these are said to have taken a taxi to the airport immediately after the accident and boarded another airplane to their intended destination.

BURNS

Of the fifty-nine passengers involved in the accident, a total of thirteen received various degrees of burns as a result of being involved in the post-crash fire which developed on and around the left-wing and center section wreckage. The following is a breakdown of the number of persons who received burns with reference to their injury category:

	NUMBER BURNED
Fatals	4
Dangerously Injured	3
Non-Dangerously Injured	5
Minor or None	<u>1</u>
Total	13

FIG. 9-A

FORWARD
CABIN
AREA

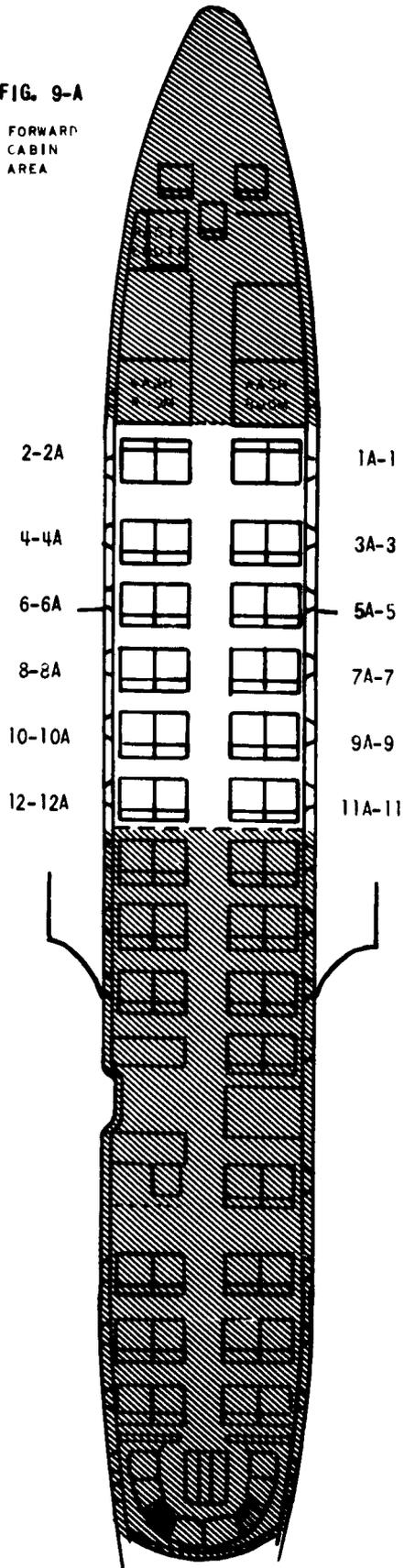
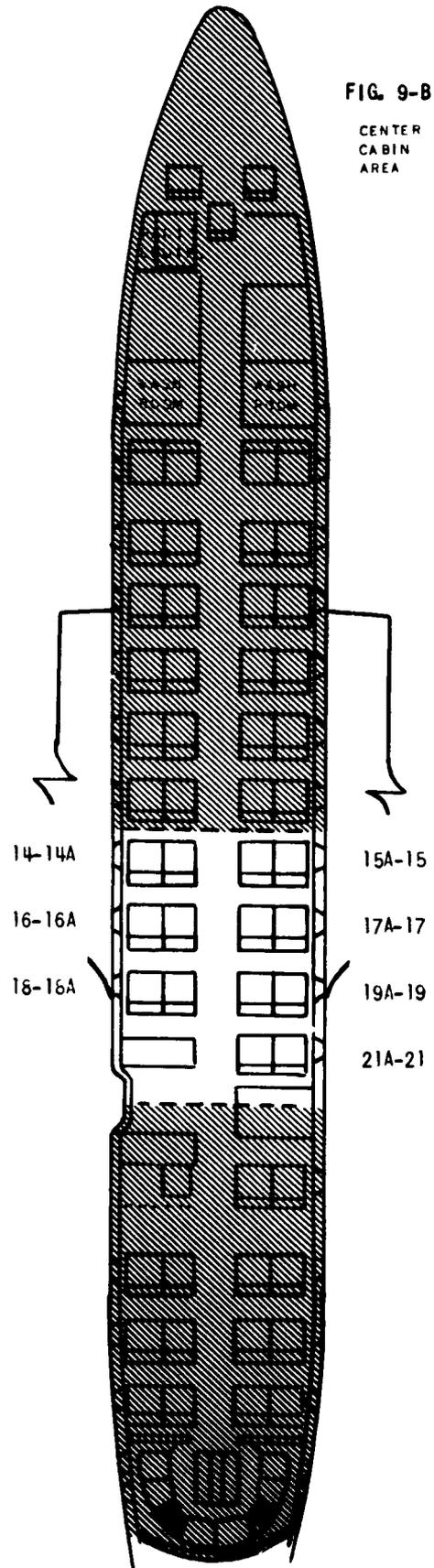


FIG. 9-B

CENTER
CABIN
AREA



FATAL INJURY IN RELATION TO CABIN DEMOLITION

FORWARD CABIN

As stated earlier in this report, the forward half of the fuselage - ahead of the rear wing spar - disintegrated during the principal ground impact. Nineteen of the twenty-seven fatally injured passengers were in this disintegrated area. These twenty-two dead represented 76% of the total number of passengers seated in the forward cabin.

Fatal injuries in this area resulted from the people being crushed, or by their striking, or being struck by wreckage. In most cases, they sustained multiple and fatal crushing injuries of both the head and chest, accompanied by fractures of the arms or legs.

There were, however, six persons in the front cabin who survived the crash. Four of the six were seated on the extreme lefthand side - furthest away from the "heavy impact" region. Two were on the right side; one was in the most forward row of seats and the other in the second row. The survival of these two can be attributed to nothing more than luck, in that they missed being crushed or hit by heavy structures as the cabin disintegrated around them.

CENTER CABIN

The center cabin - immediately aft but adjacent to the prime disintegration "zone" - was damaged to a severe degree and in danger of complete collapse; however, basic cabin structures held together sufficiently to protect many of the occupants, for eleven of the fourteen passengers survived. Sixty-three percent of these sustained *non-dangerous* injuries consisting, in some cases, of nothing more than bruises and lacerations.

Generally, the injuries sustained in the center cabin area were caused by (a) inward displacement of structure, and/or (b) the passengers being thrown - in their seats - against intact, but rigid cabin components and against wreckage of basic aircraft structure. Even when seats tore free, the semi-intact cabin shell apparently prevented many of the seats (and people) from being thrown against or under solid structures such as the engines and center section wreckage - and crushed.

FIG. 10-A

REAR
CABIN
AREA

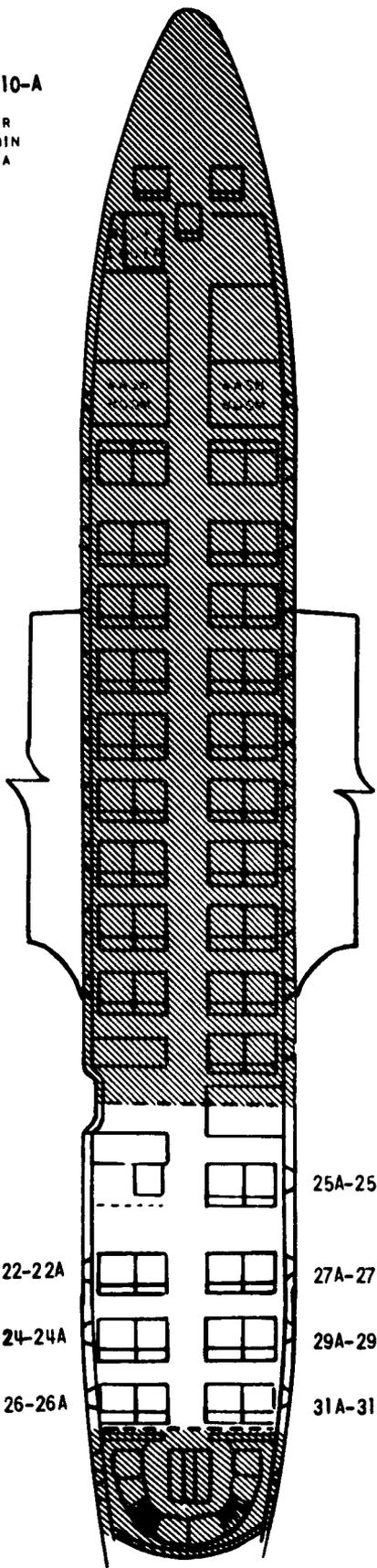
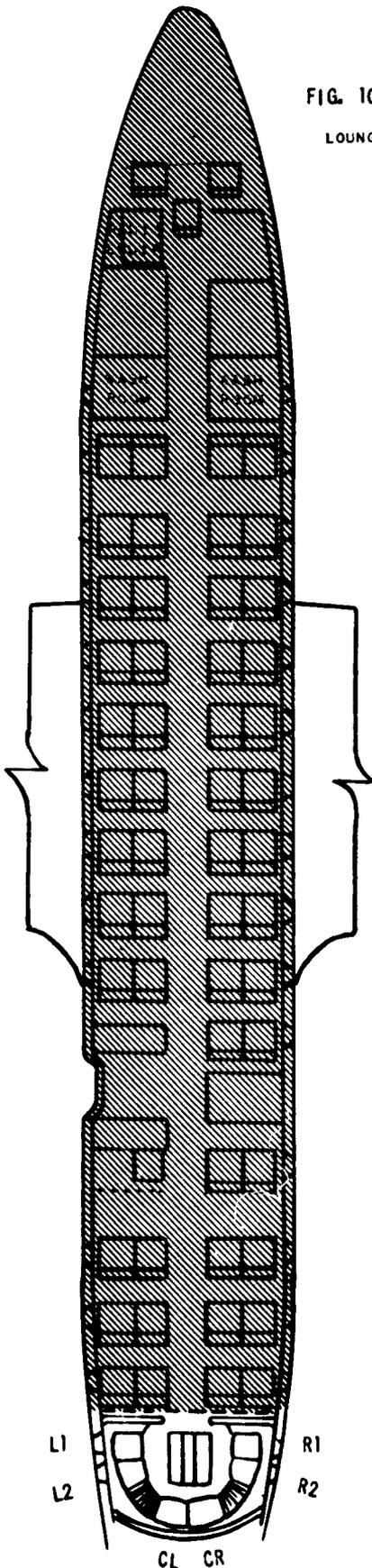


FIG. 10-B

LOUNGE



REAR CABIN

Causes of injury in the rear cabin, and causes of survival followed the same pattern as that in the forward cabin area. The passengers killed in the rear cabin mostly sustained crushing injuries of their heads and chests, and fractures of the extremities. This was due, again, to complete collapse and disintegration of part of the cabin structure (just ahead of the lounge) when the fuselage struck, and broke around, a large tree trunk.

Five of the passengers (or 36% of the fourteen passengers) in the rear cabin were killed - mostly as a result of being struck by inward crushing cabin structure and, in several cases, from being hit directly by the tree as it tore through the interior of the cabin.

An equal number of passengers (5) in this same general area sustained minor or no injuries, indicating that (a) the demolition area (with resulting fatal injuries) was sharply defined, and (b) that crash force, in itself, was not primarily a direct cause of injury.

As evidence of the above, two people, seated within a few inches of persons fatally injured, sustained nothing more than a few bruises and lacerations. In another instance, the occupant of a window seat sustained non-dangerous injuries, while his companion in the adjoining aisle seat received dangerous head injuries when the hatrack structure crushed downward - his head was above the top of the seat-back; the seat-back was relatively undamaged.

THE LOUNGE

The lounge structure (in the rear of the airplane) was substantially damaged and on the verge of collapse. However, there was little inward "flexion" or crushing of structure during the crash, and the damaged "shell" protected the occupants. All six occupants of the lounge were thrown heavily against their safety belts and seats but they were held in place; no fatalities occurred. Three of the passengers sustained injuries classed as minor or none; two had no injuries at all. Only one lounge passenger suffered a "dangerous" injury (to the lower spine) which probably resulted from sideward flexion against a rigid bookrack which served partly as an "armrest".

INJURY IN RELATION TO SEAT DAMAGE

In areas where cabin structure was *demolished*, fatal and dangerous injury generally coincided with severe damage to the seats. Twelve 2-person seats were located in the forward section of the cabin - which disintegrated during impact with the ground. Six were on the left side of the cabin, and six on the right. The first set on each side was aft-facing; the rest were forward-facing. Eleven of the twelve sets of seats were severely damaged and, in some cases, disintegrated. This damage resulted from disintegration and inward crushing of the cabin ceiling, walls and floor. Nineteen of the twenty-four people (and one baby) sitting in these seats, which were severely damaged, were killed. In most cases, they sustained multiple, fatal crushing injuries of the head and chest, accompanied by multiple fractures of one or more of the extremities.

Seven 2-person seats were in the rear cabin - a major portion of which was demolished on impact with the tree. Four of the seats sustained severe damage; five of the fourteen passengers were killed.

In other portions of the cabin which sustained severe damage but *were not demolished*, fatal and serious injury was *not necessarily* associated with severe seat damage. For example, although three of the seven sets of seats in the center cabin were severely damaged, only one person in the severely damaged seats was killed. The two others who were killed occupied seats which sustained little damage; their fatal injuries apparently were caused by small portions of rigid structure striking their chests and faces.

Eleven passengers survived in this center cabin area, five of whom were sitting in seats which sustained severe damage.

The lounge - relatively intact - contained three sets of seats, all of which were damaged to a minor degree; all six occupants survived.

GENERAL DETAILS OF SEAT DAMAGE IN RELATION TO INJURY

FRONT CABIN

The first five rows of seats on the left side of the forward cabin and the first six rows on the right side were severely damaged; some were practically disintegrated. Typical damage is shown in Figs. 13, 14, and 15. *Since these eleven sets of 2-person seats were located in the forward portion of the airplane that disintegrated during principal impact, the degree of demolition of the seats is not unusual.* The bottoms of the first four rows of lefthand seats were torn apart and practically disintegrated (see Fig. 18); the rear main cross tube of the first, second and fourth row seats were broken, destroying, to a great extent, the integrity of the seats and any protection which the seats might have provided the occupants.

As shown in Fig. 11, the seat-backs on all eleven sets of seats were damaged to a severe degree. The type of damage indicates that the seats were subjected, in most cases, to heavy crushing loads; these loads also were responsible for the crushing injuries sustained by the nineteen fatally injured persons.

The second and third rows of seats on the right side were also damaged by fire after impact. However, one occupant of these seats survived with critical injuries; evidently he was thrown clear of the seat when the safety belt end-attachments failed.

A number of the seats had deep vertical V-type dents in the tops of the seat-backs (see Fig. 12); it is indicated that this was caused by impingement of rigid hatrack structure on the tops of the seat-backs as the cabin roof and floor collapsed toward each other.

CENTER CABIN

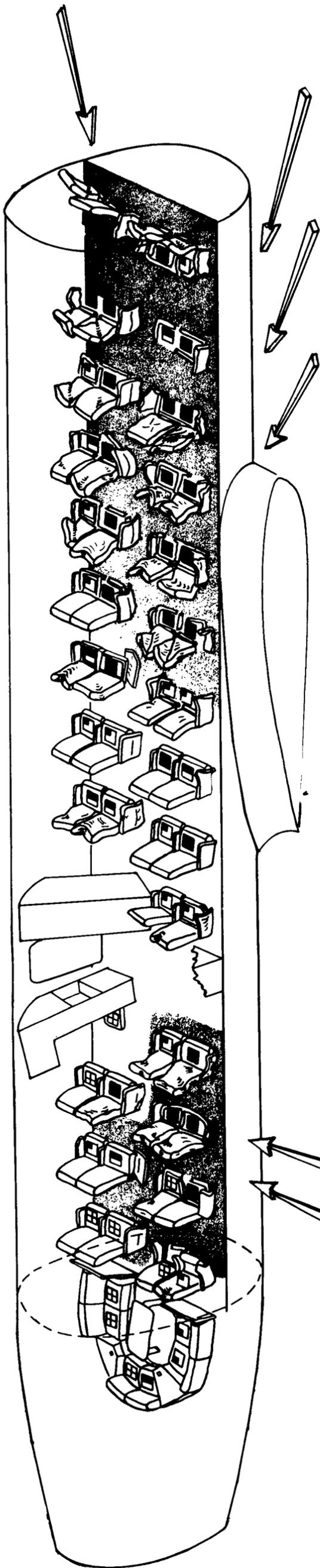
In the center cabin area, three of the seven 2-person seats were severely damaged; three occupants of the damaged seats sustained dangerous injuries; a fourth was killed.

FIG. 11.

NATIONAL AIRLINES DC-6 FEBRUARY 11, 1962 ELIZABETH, N. J. CRASH

RECONSTRUCTION DRAWING SHOWING AREAS OF FLOOR DEMOLITION AND "DEGREE" OF INJURIES SUSTAINED BY PASSENGERS IN RELATION TO DAMAGE AND LOCATION OF THEIR SEATS IN THE AIRCRAFT AT THE TIME OF THE CRASH.

INITIAL CONTACT OF COCKPIT IN "WIPING ACTION" PRODUCED LIGHT CRASH FORCE FROM SLIGHTLY BELOW AND LEFT OF PLANE'S LONGITUDINAL AXIS.



- INJURED FATALLY
- INJURED TO DANGEROUS "DEGREE"
- INJURED TO NON-DANGEROUS "DEGREE"
- SUSTAINED MINOR OR NO INJURIES

CONTACT OF PLANE'S BELLY AND RIGHT CENTER SECTION PRODUCED PRINCIPAL CRASH FORCE FROM BELOW AND RIGHT OF LONGITUDINAL AXIS.

BROADSIDE CONTACT OF REAR CABIN WITH LARGE TREE - AFTER SEPARATION FROM CENTER SECTION - PRODUCED HEAVY CRASH FORCE FROM ABOVE AND AT RIGHT ANGLE TO LONGITUDINAL AXIS.

Two of these three seats were apparently thrown out into the burning wreckage area when the cabin broke away from the center section. The people in Seat 15A-15 suffered non-dangerous injuries but received burns on their faces and extremities, as well as multiple bruises and lacerations.

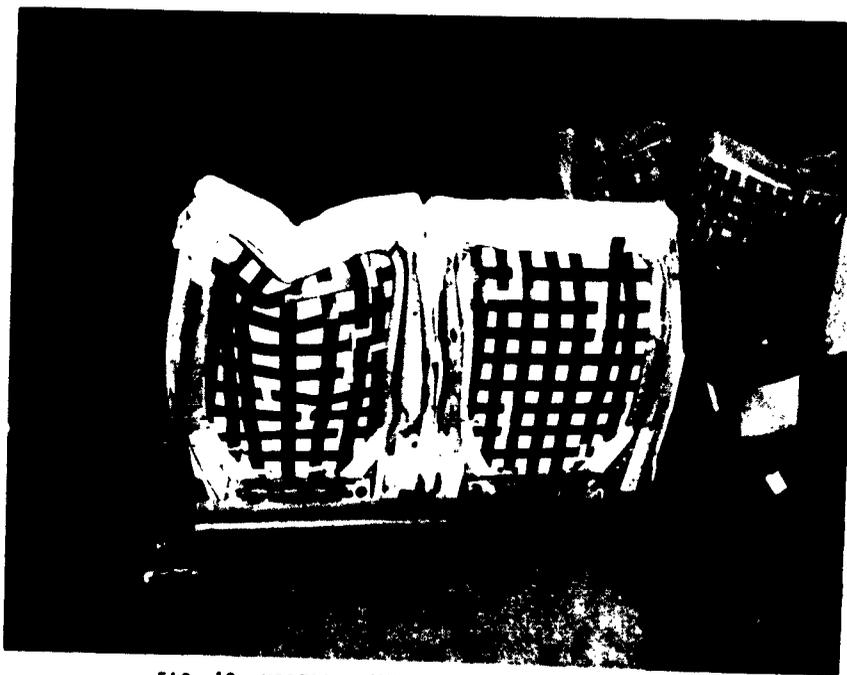


FIG. 12. VERTICAL 'V' DENT IN TOP OF SEAT-BACK CAUSED BY HATRACK STRUCTURE.

The four remaining sets of seats in the center cabin area were damaged to a minor degree. Five of the occupants had non-dangerous injuries, one had dangerous injuries, and two were killed. The dangerous and fatal injuries sustained in "intact" seats were probably caused by "small" pieces of wreckage striking the peoples' heads and chests as the seats broke free.

REAR CABIN

In the rear cabin, the four rows of seats on the right side were generally damaged to a severe degree due to (a) inward crushing of cabin wall and roof structure, and/or (b) forcible contact with the tree trunk as it broke into the interior of the cabin.

Four of the people in these severely damaged seats were killed; a fifth had dangerous injuries. The remaining three sustained minor injuries only.

The three sets of seats on the left side of the rear cabin were damaged slightly. Three of the occupants had minor or no injuries, a fourth suffered non-dangerous injuries, a fifth had dangerous injuries, and the remaining passenger was killed. Both the fatally and dangerously injured passengers in these seats apparently were struck by downward crushing roof and hat-rack structures.

THE LOUNGE

The three sets of 2-person seats in the lounge sustained only minor damage. Three of the occupants had minor or no injuries, two had non-dangerous injuries; the sixth occupant sustained a lower back injury, probably due to sideward flexion against the book rack structure forming the armrest at the side of the seat.

To summarize:

Eighty-eight percent of the fatally injured passengers and 62% of the dangerously injured persons occupied seats that sustained severe damage.

On the other hand, 60% of the non-dangerously injured passengers and 77% of the passengers with minor or no injuries occupied seats that were virtually intact.

As noted, before, all but three sets of seats - excluding those in the lounge and the stewardess's seat - were torn free sometime during the accident. Many of these seats and their occupants were crushed by heavy wreckage. However, other seats, although free to plummet against structure, provided some degree of protection for their occupants. It appears, therefore, that seats can be designed to give protection for passengers who are not directly involved with demolition of heavy aircraft structures.

TYPES OF SEAT DAMAGE

The primary frame structure of the twenty-six 2-person seats in this aircraft consisted of formed and riveted sheet metal - with the exception of a large-diameter metal cross tube at the rear of the seat-bottom. The seat-bottom frame, seat-back hinge brackets, safety belt anchorages and the aft end of the side seat structure - on the aisle - were attached to this tube.

Interlaced plastic straps formed the backs and bottoms of the seats. These served to transmit - via foam rubber cushions - the passengers' normal seated body loads to the primary seat frame.

Of the four major seat components (seat-back frames, rear cross tube, seat-bottom frames and the armrests), the seat-backs and cross tubes evidenced the most crashworthiness, even when the seats were involved with disintegrating cabin and floor structure.

On the other hand, the bottom frames did not exhibit similar resistance and many were demolished; some were torn completely free from the rear cross tubes. In addition, the inboard side seat units, including the aisle armrests, were bent at their point of attachment to the seat-bottom; in many cases, they were torn completely free from the seat frame (see Fig. 24). The non-ductility of the cast fitting used to attach the aft side seat structure to the cross tube, as well as the thinness of the sheet metal used at the forward attach points, apparently contributed to failure under the leverage loads imposed when the seats were forced toward the aisle.

In cases where the side units remained attached to the seats, the upper portions of the units (armrests) did not cause serious injury.

A number of seats had V-type dents in the tops of the seat-backs. Many of these - particularly in sections of the cabin which were not completely demolished - were "V-ed" in the *vertical* plane; this was caused by downward crushing of rigid portions of the hatrack structure. In addition, several seat-backs in destroyed portions of the forward cabin had deep V dents in the *horizontal* plane (see Fig. 13). These probably were due to rearward crushing of the seats against

the heads and faces of the passengers who were sitting in the seats immediately to the rear. However, since the occupants of these seats sustained multiple, fatal crushing injuries of the torso as well as the head, it is unlikely that blows from the seat-backs were primarily responsible for death.

Figures 14, 15, 16, 17, 18 and 19 show the seats arranged in the order in which they were installed in the aircraft - with the exception of the lounge seats and the three seats which were not torn free in the accident. The damage to the seats at the front (Figs. 14 and 18) indicates the relation between seat damage and demolition of the forward cabin.

As noted before, except for the seat-back in the rear center which came free, the three sets of 2-person seats in the lounge sustained little damage. The outboard armrests on the lounge seats, because of their being an integral part of the magazine rack structure, did not yield when struck, and therefore provided little resilience or "give" to the passengers' torsos.

INCIDENTAL SEAT NOTES

In a number of cases, the seat-back recline tube failed in tension.

In almost all cases - even when the seats were completely demolished - the anchorage fittings for the safety belts remained intact.

The stewardess's jump seat - attached to the rear side of the aft buffet, and facing aft - was undamaged.

The crew members' seats in the cockpit sustained major damage; the co-pilot's seat was disintegrated (see Fig. 20).

Note: Figures 13 to 20, inclusive, may be seen on the following two pages.



FIG. 13. SEATS 7-7A AND 9-9A.



FIG. 14. VIEW LOOKING AFT AT FIRST THREE ROWS OF RIGHT-HAND SEATS. FIRST ROW WAS AFT FACING.



FIG. 15. VIEW LOOKING FORWARD AT RIGHT-HAND SEATS FROM CENTER AND FORWARD CABIN.



FIG. 16. VIEW LOOKING AFT AT RIGHT-HAND SEATS FROM CENTER AND REAR CABIN.



FIG. 17. VIEW LOOKING AFT OF LEFT-HAND SEATS (FROM THE CENTER AND REAR CABIN) WHICH TORE FREE.



FIG. 18. FIRST TWO ROWS OF LEFT-HAND SEATS (FIRST ROW IS AFT FACING).



FIG. 19. VIEW LOOKING FORWARD OF LEFT-HAND SEATS (FROM FORWARD CABIN) WHICH TORE FREE.



FIG. 20. CO-PILOT'S, ENGINEER'S AND PILOT'S SEATS.

TYPES OF SEAT ANCHORAGE FAILURE

Each 2-person seat was attached to the fuselage structure at four points. The inboard ends of the seats were attached to floor structure; the outboard ends were attached to wall intercostals.

The inboard attachments consisted of two U-shaped channels - riveted to fore and aft sections of the side seat structure. Each channel, in turn, was bolted to the floor structure by means of a quarter-inch aircraft bolt.

The outboard end of the seat was attached to the wall intercostal by means of two rod-like pins which fitted through slots in the intercostal. However, only one of these pins - the rear one - was threaded and secured to the intercostal by means of a nut. The forward pin was merely inserted in the intercostal slot.

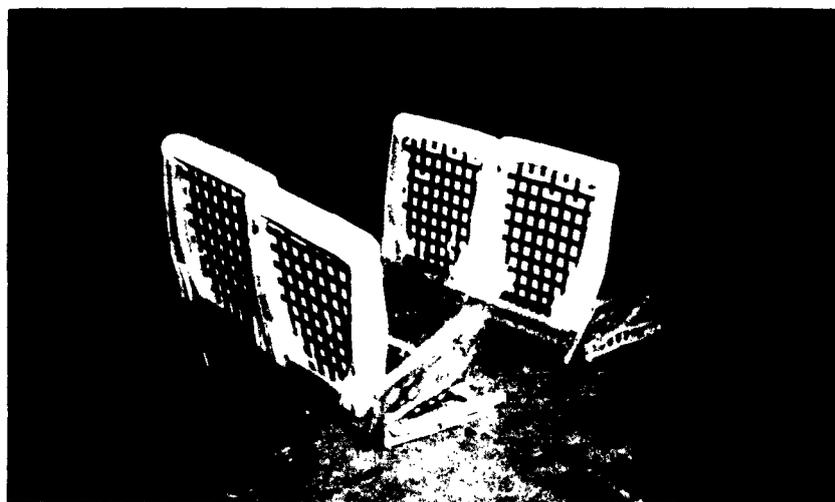


FIG. 21. SEATS 19-19A AND 17-17A WITH RELATIVELY INTACT INTERCOSTALS STILL ATTACHED BY REAR PINS. FATALITIES OCCURRED IN SEATS 19 AND 17A.

Thus, in effect, although the seats had four points of attachment, only three of them provided resistance to loads in all directions. Failure of aisle attachments in combination with an aft load on the seat would permit the front pin to pull out of the intercostal. The seat would then be free to rotate around the rear wall attachment (Fig. 21 shows intercostals still attached to seats by rear pins only).

Inward flexion of the cabin walls caused the inboard side structure of the seats to bend toward the aisle. This bending produced high leverage loads on the U-shaped channel fittings, the attachment bolts and the floor structure. In some cases, the seat channel fittings fractured and failed across the rivet holes where the channel was riveted to the side seat unit (see Fig 22). However, in a few cases, the channel fittings pulled free - as complete units - from the sheet metal structure.



FIG. 22. FAILURE OF SEAT ATTACHMENT CHANNEL UNIT. NOTE FRACTURE ACROSS RIVET HOLES.



FIG. 23. FLOOR BEAM CHANNEL FAILED AT REAR AISLE ATTACHMENT (SEAT 18-18A).

In other cases, the *floor beam channels* failed, as shown in Fig. 23. Usually, small pieces, approximately one inch in length, of the rigid floor channel remained attached to the seat channel units (Fig. 24); the pieces displayed fractures characteristic of brittle material.



FIG. 24. PIECE OF FLOOR CHANNEL ATTACHED TO SEAT SIDE STRUCTURE.

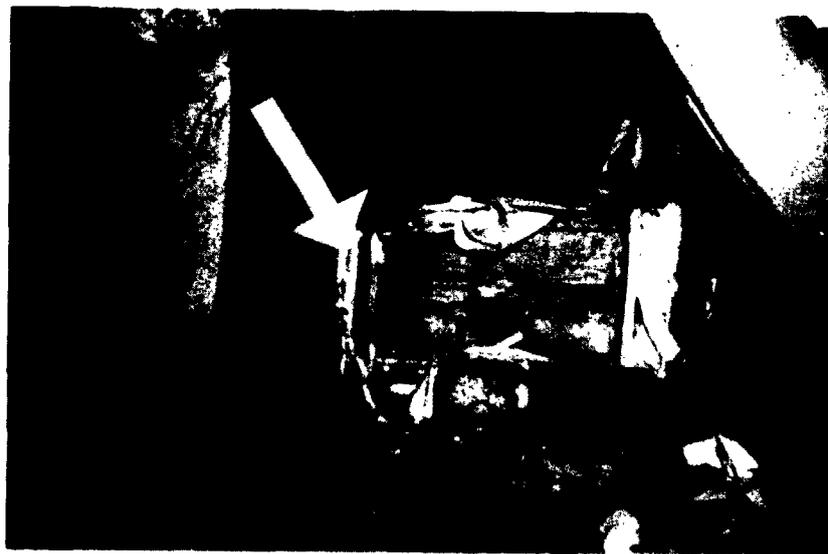


FIG. 25. INTERIOR OF LEFT SIDE OF CABIN. INTERCOSTAL ON SEAT 18-18A PULLED FREE. NOTE RIVET HOLES IN FORMER RING.

As a consequence of aisle attachment failures, severe tension loads were imposed on the aft ends of the intercostals when forward and side crash loads were applied to the seats. This resulted in the intercostals pulling completely free from the former rings in the fuselage (see Fig. 25).

The aisle seat attachments of four 2-person seats were anchored directly to the center section structure. Seats 10A and 11A displayed typical fracture failures of the seat channel units. However, on Seat 12-12A (and the rear aisle attachment of 10A), the aisle attachment bolts failed. This probably resulted from a combination of both shear and tension forces.

In summary, failures of the seat attachments (with the exception of those on seats located on flooring which disintegrated) appear to have been due to inward displacement of wall structure, with subsequent failures of the aisle attachments, followed finally by failures of the intercostals. This indicates that a force, more than equal to the $1\frac{1}{2}G$ minimum side load factor, for which the seat attachments were designed, was imposed on the seats by inward flexion of wall structure.

SAFETY BELTS

The safety belts in this airplane were manufactured by Air Associates, Inc. of Teterboro, New Jersey, and were of the new type with a minimum loop-holding capacity of 3,000 lbs. The webbing and buckles of all the passengers' safety belts - with the exception of two which burned - were found intact.

Four metal end-attachments on two of the passengers' safety belts failed (see Appendix). These failures were due to acute bending of the gooseneck section of the end-attachment units. Because these safety belt attachment units were attached to rigid anchorage studs, very little lateral movement of the units was possible; a "universal joint" type of anchorage attachment probably would have eliminated this cause of failure.

The safety belts on the crew members' seats were also of the same manufacture and strength; the belt installations on both the captain's and the flight engineer's seats were intact. The buckle cam on the co-pilot's seat had been torn free from the buckle; the webbing was intact.

BUFFETS

The bottom anchorages of the two buffets - fore and aft of the main passenger entrance - failed; both buffets moved forward and to the right (see Figs. 6, 41 and 52). As may be noted in the photographs, the buffet units were practically undistorted and undamaged. As a result, they served to keep the cabin roof - in the center portion of the fuselage - from collapsing to the floor during impact with the tree.

The compartment latches on the buffet were intact.

PLASTIC PARTITIONS

The transparent, sheet plastic partitions separating the lounge from the rear cabin shattered into sharp-edged fragments. A number of pieces were found embedded in the upholstery of the right-hand lounge wall; a passenger sitting in this area sustained numerous lacerations of the head, face and arms.

The plywood-honeycomb sheet partitions used for both coat closets in the cabin also disintegrated during the crash.

RADIO GEAR

The radio equipment - aft of the cockpit - and the radio shelf unit as a whole, broke free and moved forward into the cockpit.

HAND FIRE EXTINGUISHER

The hand fire extinguisher located in the upper section of the aft coat closet pulled free from its retaining clip. The stewardess was struck a glancing blow on the head and she was stunned momentarily; this was attributed to her being struck by the fire extinguisher.

SUMMARY

A Douglas DC-6 aircraft with 59 passengers and four crew members descended along a flight path angle of about 15 degrees and struck hard ground at a speed of approximately 140 mph; the nose was down 10 to 15 degrees below the horizon. The principal crash force, of unknown peak magnitude, came from a direction of about 1 o'clock and below the aircraft's longitudinal axis.

Twenty-three of the twenty-nine 2-person seats were broken completely free. None of the 3,000 lb. safety belts failed in the webbing. Failure occurred in two of the metal end-attachments.

During the principal impact with the ground, the fuselage ahead of the center section disintegrated; the seats in this area were damaged extensively. Thirteen of the seventeen passengers seated in front areas of the cabin (ahead of the front wing spar) were killed; typical injuries were multiple, crushing injuries of the head and chest.

While these people were being killed during the principal impact, the passengers in the rear cabin remembered feeling no appreciable force; none sustained serious or fatal injury.

After this initial ground impact, the center section and the rear half of the fuselage cartwheeled. During this cartwheeling action, the rear fuselage jackknifed upward and tore free.

The rear half of the fuselage then struck a large tree broadside and broke in two; five of the fifteen occupants in the rear cabin area were killed by inward crushing structure and contact with the tree. Nine of the fifteen occupants sustained non-dangerous or minor injuries.

The total distance of deceleration, from the point of first ground contact to the final stopping point of the rear cabin against the tree was approximately 280 feet; the mean deceleration of this portion of the aircraft was less than 4G.

Since there were no recording accelerometers in this aircraft, the magnitude and duration of *longitudinal peak forces are unknown*. Judging, however, from the evidence of strain in the pilot's safety belt, and the nature of failures in the pilot's seat attachments, dynamic forces in the cockpit appear

to have been equivalent to static loads of from 6G to 17½G.

The entire structure of the cabin shell and floor ahead of the center section was demolished; the magnitude of the crash loads in this area are unknown.

Peak forces acting on the center section - *because of its mass and rigidity* - may have ranged above 50G for short periods of time.

Aft of the center section, longitudinal crash forces appear to have been less than a dynamic force equivalent to a static load of 6G. Apparently, the fuselage structure was incapable of transmitting high-G longitudinal loads to seats in the center and rear cabin during the principal impact because of: (1) The energy absorbing characteristics of the fuselage shell and floor immediately adjacent to the relatively strong, rigid center section structure; and (2) Jackknifing of the rear cabin - due to the principal crash force being imposed from a point slightly to one side of the longitudinal axis of the aircraft.

Where floor structure remained reasonably intact, side forces resulting from flexion of the cabin walls appear to have been responsible for seat anchorage failure.

Since the anchorages failed on all but three of the standard 2-person seats located over intact flooring, the lateral crash force exceeded the 1½G design load factor - probably by a wide margin.

Factors contributing to failures of seat anchorages were: (1) Attachment of the outboard sections of the seats to wall structure which flexed in relation to the floor; (2) Attachment of the inboard ends of the seats to rigid floor structure which failed by cracking and breaking; (3) Distortion and failure of the inboard (aisle) seat structure which caused heavy *leverage* loads to be applied to the rigid floor attachments; and (4) Inability of the seats to deform without breaking free under the side forces caused by flexion of the wall structure.

The injuries sustained in this accident ranged in seriousness from multiple, crushing fatal injuries to no injuries whatsoever.

Twenty-seven of the fifty-nine passengers were killed. Eight of the 32 survivors suffered dangerous injuries; fifteen sustained non-dangerous injuries; and the remaining nine had minor or no injuries.

Eighty-eight percent (88%) of the 27 fatally injured persons sustained fractures of the skull and/or ribs. Sixty-four percent (64%) of all the passengers received blows to the head of sufficient force to cause skull fracture and/or brain lesion, and/or concussion.

Factors apparently contributing to head injury in areas of the cabin which were not demolished were: (1) Inability of the seat-back to provide sufficient protection for the top of the head from downward collapse of hatrack structure, because of the limited height of the seat-backs; (2) Rigidity of hatrack structure; and (3) Failure of seat anchorages which permitted the seats - and their occupants - to be thrown against structure.

None of the cases of skull fracture and/or severe concussion among the survivors were attributed to striking the seat backs. Evidently the ductility of the structure in the top of the seat-backs provided a non-lethal distribution of force on the forehead and face.

Cases of reported internal injury were few among both the survivors and persons fatally injured.

Among the passengers killed, one was definitely reported to have been injured internally; however, this was associated with accompanying fractures of the ribs.

One person sustained eviscerating injuries - attributed to heavy crushing force.

If any of the other fatally injured persons actually sustained internal injuries of the lower torso, it would not have affected the final result; death would have resulted, in any event, from the fatal head and/or chest injuries which were sustained.

Only one of the survivors was definitely reported to have sustained internal injury; it was associated with fractures of the ribs.

No cases of internal injury were attributed to the safety belt.

The majority of the fatally injured passengers occupied seats which were extensively damaged. Most of the survivors were in seats which sustained little or no damage. This indicates that fatal and serious injuries are not due directly to "the force of the crash" but generally result from:

(1) Crushing of the occupants by structure; and/or (2) Seat anchorage failure, permitting the occupants (in their seats) to be thrown against rigid structure.

The interlaced plastic webbing in the backs and bottoms of the seats - in combination with foam rubber cushions - provided resilience; no compression fractures of the spine were reported to have been sustained by survivors occupying the standard 2-person seats.

The buffets, because of their individual unit strength, resisted deformation and prevented the cabin ceiling structure from collapsing and thereby exposing the passengers, in the center and rear cabin areas, to fatal injury. Anchorages of the buffets failed, however, and permitted the units to move out of place; one seat was forced loose from its anchorages as a result of being struck by one of the buffets.

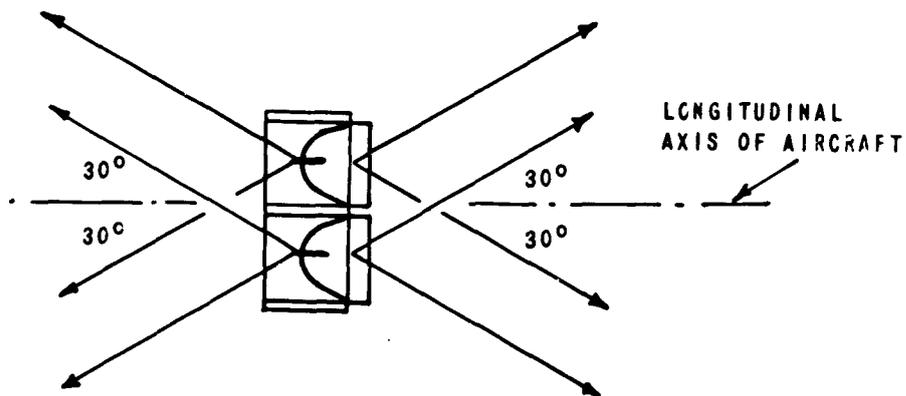
This accident points to the difficulty of classifying transport crashes in their entirety as being either "survivable" or "non-survivable". In this crash, the cabin area ahead of the center section was demolished to a non-survivable degree, while most of the center and rear cabin could be classed as survivable areas.

In order to properly classify accidents of this type, all facts concerning the details of both the *incident* and the *results of the accident* must be reported. These include: the aircraft's flight path angle, impact angle; attitude of the aircraft at impact, its impact speed; what the impact was against; distance of deceleration, direction of crash force loading, type of aircraft structure, types of seats, types of safety belts, the site and nature of injuries sustained by the passengers, the causes of injury, where the passengers were sitting, and damage to the various sections of the cabin, seats and safety belts.

While this accident may not necessarily be typical of severe but survivable transport crashes, it does provide insight into the crash force, impact speed, and impact attitude which large transport aircraft structures and seats can be subjected to, with large-scale survival.

RECOMMENDATIONS

- (1) The floor structure should preferably be the strongest part of the entire fuselage in order to provide a platform to which the seats will remain attached - up to the point of disintegration of major portions of the aircraft.
- (2) The floor structure should also be sufficiently ductile to provide failure by progressive buckling and collapse rather than by shattering or "explosive-types" of failure.
- (3) The passenger "tie-down" (safety belt, anchorage, portions of the seat which carry the safety belt loads, seat anchorages and the basic floor structure) should have a strength, fore and aft, (see item #5, below) equal to the load capacity of the safety belt. If the basic floor structure has a greater strength, the passenger seats and seat anchorages should not be designed to fall completely under loads less than those required to cause extensive failure of basic cabin structures.
- (4) Seat structure should be ductile, as well as strong, to permit deformation without complete failure of major portions of the seat, and resultant failure of passenger tie-down.
- (5) Seats should be designed to resist fore and aft longitudinal loads imposed from any point within 30° of the longitudinal axis of the aircraft (see diagram below - Fig. 26).



- (6) Seat-floor anchorage units should deform without complete failure, up to the point of disintegration of the floor structure.
- (7) If the seats are attached to both the wall and floor structure, the seats and their attachments should be designed so that *flexion* of the wall and floor will not break the seats loose.
- (8) Seats and seat anchorages should be tested dynamically - as well as statically - on typical portions of floor and/or wall structure. "Weaving" and deformation of the floor and wall structures should accompany the application of dynamic impact loads - particularly if the seats are of rigid design.
- (9) If practical, seat-backs should be high enough to provide some protection for the tops of the passengers' heads.
- (10) Buffet units should be attached to primary fuselage structure in such a way as to prevent large scale displacement up to the point of fuselage disintegration.
- (11) If practical, buffets should be used to partition off the cabin into a number of sections.
- (12) Overhead hatrack structure should be of de-lethalized design and construction.
- (13) Fire extinguishers and other "lethal" objects should be secured according to load factors not less than those used for the passenger tie-down.
- (14) Brittle plastic partitions should not be used in the passenger cabin.
- (15) The stewardess should be in the most aft section of the cabin.
- (16) The stewardess and other crew members should wear shoulder harness, as well as safety belts, during take-offs and landings - regardless of the direction they are seated, i.e., aft, forward, or side-facing.
- (17) End-attachment fittings of the safety belts should be mounted on swivelling anchorages to prevent fracture failures due to bending.

* * * * *

APPENDIX I

Scale* used by Crash Injury Research in Classifying "Degree" of Body Injury

A. Minor or None (Degrees 1 and 2)

1. *No Injury*

2. *Minor*

"Minor" contusions, lacerations, abrasions in any area(s) of the body. Sprains, fractures, dislocations of fingers, toes, or nose. Dazed or slightly stunned. Mild concussion evidenced by mild headache, with no loss of consciousness.

B. Non-Dangerous (Degrees 3 and 4)

3. *Moderate*

"Moderate" contusions, lacerations, abrasions in any area(s) of the body. Sprains of the shoulders or principal articulations of the extremities. Uncomplicated, simple or green-stick fractures of extremities, jaw or malar structures. Concussion as evidenced by loss of consciousness not exceeding 5 minutes, without evidence of other intra-cranial injury.

4. *Severe - but not dangerous (Survival normally assured)*

Extensive lacerations without dangerous hemorrhage. Compound or comminuted fractures, or simple fractures with displacement. Dislocations of the arms, legs, shoulders or pelvisacral processes. Fracture of transverse and/or spinous processes of the spine, without evidence of spinal cord damage. Simple fractures of vertebral bodies of the dorsal and/or lumbar spines, without evidence of spinal cord damage. Compression fractures of L-3-4-5. Skull fracture without evidence of concussion or other intra-cranial injury. Concussion as evidenced by loss of consciousness from 5 to 30 minutes, without evidence of other intra-cranial injury.

*Based on observations during first 48 hours after injury and previously normal life expectancy.

C. Dangerous-to-Life
(Degrees 5 and 6)

5. *Serious - Dangerous (but survival probable)*

Lacerations with dangerous hemorrhage. Simple fractures of vertebral bodies of the cervical spine, without evidence of spinal cord damage. Compression fractures of vertebral bodies of dorsal spine and/or of L-1 and L-2, without evidence of spinal cord damage. Crushing of extremities, or multiple fractures. Indication of moderate intra-thoracic or intra-abdominal injury. Skull fracture with concussion as evidenced by loss of consciousness from 5 to 30 minutes. Concussion as evidenced by loss of consciousness from 30 minutes to 2 hours, without evidence of other intra-cranial injury.

6. *Critical - Dangerous (survival uncertain or doubtful).*

(Includes fatal terminations beyond 24 hours.) Evidence of dangerous intra-thoracic or intra-abdominal injury. Fractures or dislocations of vertebral bodies of cervical spine with evidence of cord damage. Compression fractures of vertebral bodies of dorsal spine and/or L-1, L-2, with evidence of spinal cord damage. Skull fracture, with concussion as evidenced by loss of consciousness from 30 minutes to 2 hours. Concussion as evidenced by loss of consciousness beyond 2 hours. Evidence of critical intra-cranial injury.

D. Fatal Degrees of Injury
(Degrees 7 through 10).

7. *Fatal - within 24 hours of accident.*

Fatal lesions in single region of the body, with or without other injuries to the 4th degree.

8. *Fatal - within 24 hours of accident.*

Fatal lesions in single region of the body, with other injuries to 5th or 6th degree.

9. *Fatal*

Two fatal lesions in two regions of the body, with or without other injuries elsewhere.

10. *Fatal*

Three or more fatal injuries - up to demolition of body.

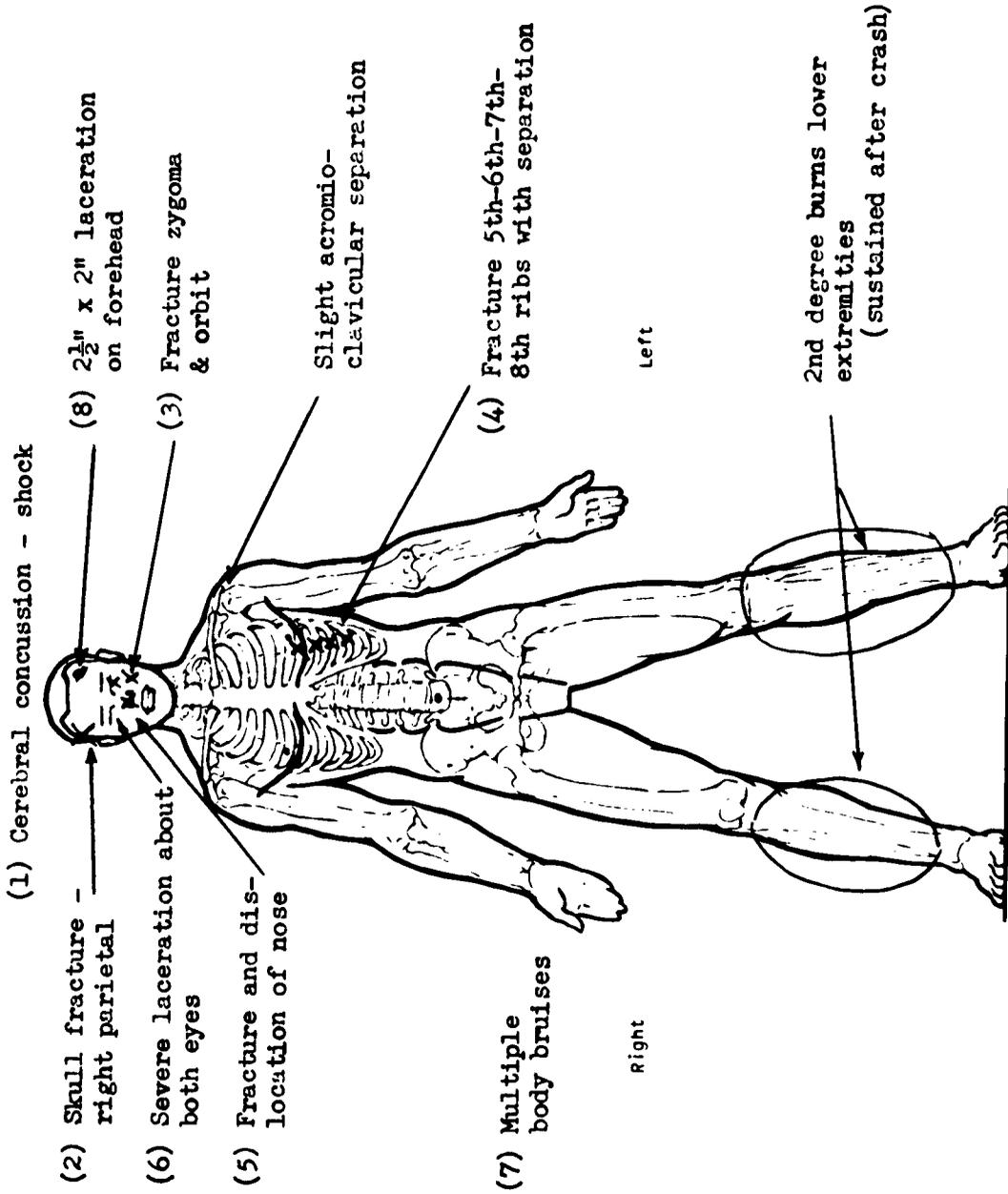
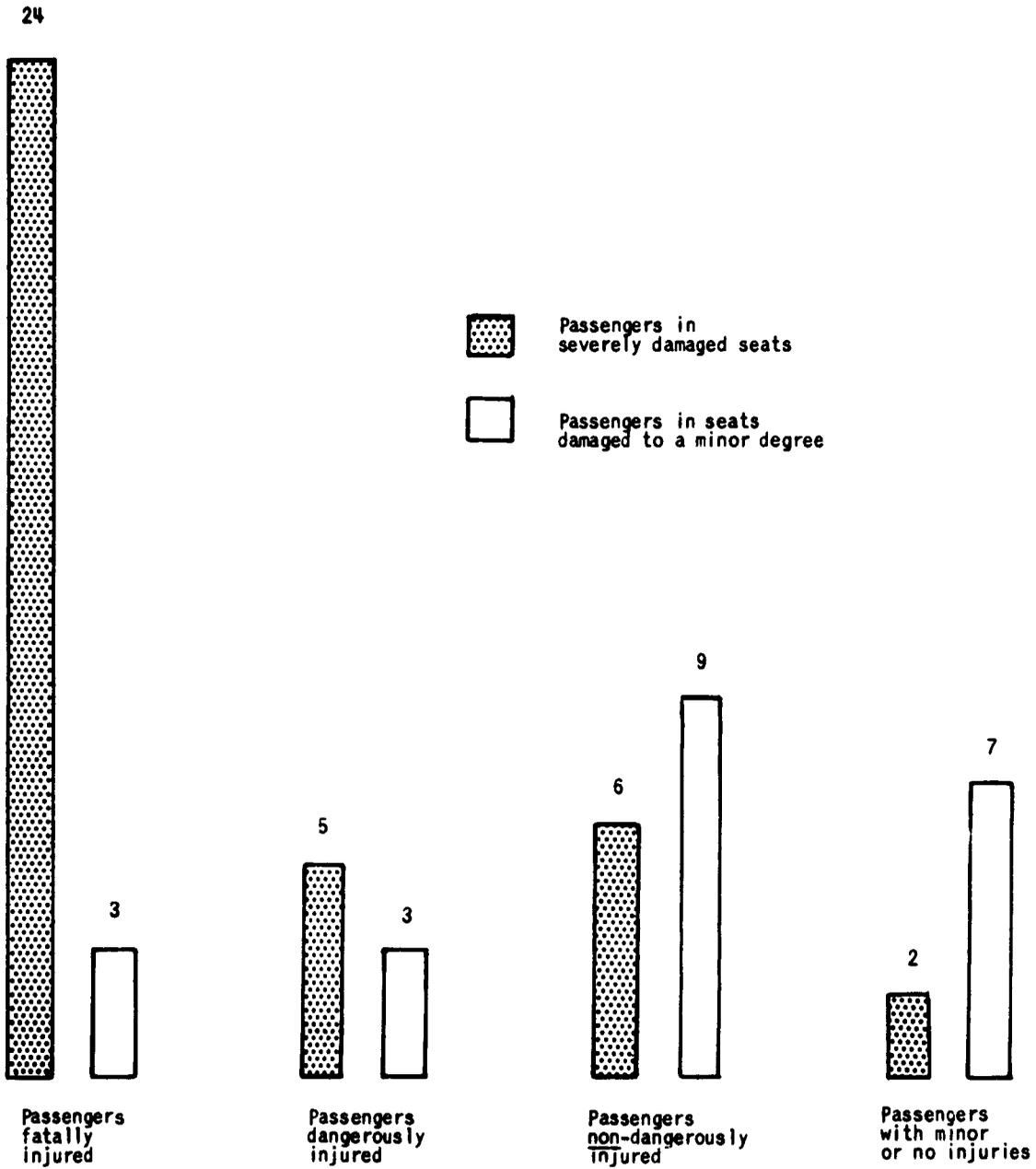


FIG. 27. DIAGRAM SHOWING INJURIES SUSTAINED BY A SURVIVOR IN THE TRANSPORT ACCIDENT COVERED IN THIS REPORT. INJURY CLASSIFICATION: DANGEROUS.

APPENDIX 3

FIG. 28. NUMBER OF PASSENGERS AND THEIR "DEGREE" OF INJURY IN RELATION TO "DEGREE" OF DAMAGE TO THEIR SEATS.

(National Airlines DC-6 Elizabeth, N. J. Accident)



APPENDIX 4

The gender, age and injuries sustained by each of the surviving passengers (as well as some of the fatals) in relation to their seated location, are shown on the following eight pages.

A list of gross fatal lesions sustained by other fatally injured passengers whose seated location was not ascertained follows the above mentioned pages.

SEAT #2	(AFT FACING)	SEAT #2A
<p>Male Child: Age 4½ FATAL</p> <p>Injuries: <i>Fatal</i>. Fractured skull; fracture of ribs and legs.</p>	<p>Female Adult: Age 26 FATAL</p> <p>Injuries: <i>Fatal</i>. Fractured skull; shock; crushing injury of chest; fractured ribs. Lived 1 hour.</p> <p>Female Baby: Age 15 mos. (on lap) FATAL</p> <p>Injuries: <i>Fatal</i>. Compound fractures of skull and spine.</p>	

First
Row

SEAT #1A	(AFT FACING)	SEAT #1
<p>Male Adult: Age 52 FATAL</p> <p>Injuries: <i>Fatal</i>. Fractured skull; crushing fracture of chest; fracture of leg.</p>	<p>Female Adult: Age 32 SURVIVOR</p> <p>Injuries: <i>Non-Dangerous</i>. Minor concussion; mild shock; fracture of left tibia; multiple lacerations of leg; 2nd and 3rd degree burns of lower half of left leg and dorsum of foot; 3rd degree burns of right leg.</p>	

Second
Row

SEAT #4	(FORWARD FACING)	SEAT #4A
<p>Gender and Age Unknown FATAL</p> <p>(Injuries not identified in detail for this seat.)</p>	<p>Gender and Age Unknown FATAL</p> <p>(Injuries not identified in detail for this seat.)</p>	

SEAT #SA	(FORWARD FACING)	SEAT #3
<p>Male Adult: Age UNK. SURVIVOR</p> <p>Injuries: <i>Dangerous</i>. Fractured skull; severe brain contusion; fractures of 2nd and 5th ribs; hemothorax of right side with complete collapse of lung; multiple laceration and abrasion; laceration of forehead.</p>	<p>Gender and Age Unknown FATAL</p> <p>(Injuries not identified in detail for this seat.)</p>	

<p>Male Adult: Age 32 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i> Moderate concussion; fracture of 1st, 2nd and 3rd ribs; fracture of right fibula; pleuritis of upper right chest; multiple contusions and abrasions.</p>	<p>Gender and Age Unknown <u>FATAL</u> (Injuries not identi- fied in detail for this seat.)</p>	<p>SEAT #6 (FORWARD FACING) SEAT #6A</p>
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Third
Row

<p>Gender and Age Unknown <u>FATAL</u> (Injuries not identi- fied in detail for this seat.)</p>	<p>Gender and Age Unknown <u>FATAL</u> (Injuries not identi- fied in detail for this seat.)</p>	<p>SEAT #5A (FORWARD FACING) SEAT #5</p>
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<p>Female Adult: Age UNK. <u>SURVIVOR</u> Injuries: <i>Dangerous.</i> Severe concussion; frac- ture of transverse pro- cess second lumbar (spine); acromio clav- icular separation, right side; second degree burns on left leg; laceration of left leg.</p>	<p>Gender and Age Unknown <u>FATAL</u> (Injuries not identi- fied in detail for this seat.)</p>	<p>SEAT #8 (FORWARD FACING) SEAT #8A</p>
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Fourth
Row

<p>Gender and Age Unknown <u>FATAL</u> (Injuries not identi- fied in detail for this seat.)</p>	<p>Gender and Age Unknown <u>FATAL</u> (Injuries not identi- fied in detail for this seat.)</p>	<p>SEAT #7A (FORWARD FACING) SEAT #7</p>
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<p>Female Adult: Age 39 <u>SURVIVOR</u></p> <p>Injuries: <i>Non Dangerous</i> Sprain of back; contusions to right forehead; multiple body abrasions; contusion of right shoulder; 2nd degree burns of both feet, legs and right hand.</p>	<p>Female Adult: Age UNK. <u>FATAL</u></p> <p>(Injuries not identified in detail for this seat.)</p>	SEAT #10 (FORWARD FACING) SEAT #10A
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Fifth Row

<p>Gender and Age Unknown <u>FATAL</u></p> <p>(Injuries not identified in detail for this seat.)</p>	<p>Male Adult: Age 50 <u>FATAL</u></p> <p>Injuries: <i>Fatal</i>. Shock; mild concussion; internal injury of chest; tenderness in lower abdomen (vomiting); fracture of proximal 1/2 of ulna and dislocated radius of right upper extremity; laceration of forehead and edema of right eyelid; abrasions of nose and face. (Died after 17 days)</p>	SEAT #9A (FORWARD FACING) SEAT #9
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Sixth Row

<p>Female Adult: Age 25 <u>SURVIVOR</u></p> <p>Injuries: <i>Minor</i>. Multiple contusions and abrasions; both legs sore and stiff; 2nd degree burns on both legs; sore hips from seat belt.</p>	<p>Male Adult: Age 26 <u>FATAL</u></p> <p>Injuries: <i>Fatal</i>. Skull fracture with intra-cranial hemorrhage. (Died after 20 hours.)</p>	SEAT #12 (FORWARD FACING) SEAT #12A
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<p>Gender and Age Unknown <u>FATAL</u></p> <p>(Injuries not identified in detail for this seat.)</p>	<p>Gender and Age Unknown <u>FATAL</u></p> <p>(Injuries not identified in detail for this seat.)</p>	SEAT #11A (FORWARD FACING) SEAT #11
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<p>Male Adult: Age 26 <u>SURVIVOR</u> Injuries: <i>Dangerous</i>. Severe concussion; laceration of left leg; contusion of shoulder; 2nd degree burns on face; 2nd and 3rd degree burns on back of hands and left ankle.</p>	<p>Gender and Age Unknown <u>FATAL</u> (Injuries not identified in detail for this seat.)</p>	<p>SEAT #14 (FORWARD FACING) SEAT #14A</p>
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Seventh Row

<p>Male Adult: Age 22 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Moderate shock; back sprain, pain in cervix and upper portion of back; contusions and abrasions of left leg; 2nd degree burns of face; 1st degree burns on both hands and forearms.</p>	<p>Female Adult: Age 21 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Moderate shock; mild concussion; deep laceration of posterior surface of left leg, with muscle protruding through wound; multiple bruises of face; 2nd degree burns of face; 2nd and 3rd degree burns of hands, arms and feet.</p>	<p>SEAT #15A (FORWARD FACING) SEAT #15</p>
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Eighth Row

<p>Male Adult: Age 34 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Fractures of 9th, 10th, 11th ribs, right side; multiple body bruises; 2nd degree burns of face; 2nd and 3rd degree burns of hands and wrists.</p>	<p>Female Adult: Age UNK. <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Moderate concussion; shock; fracture of 7th left rib; fissure fracture of maxilla; sprained cervical muscles; partial severance of right Achilles tendon; dislocation of left sternal clavicular joint; fracture and sprain of ankle; multiple abrasions and contusions.</p>	<p>SEAT #16 (FORWARD FACING) SEAT #16A</p>
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<p>Gender and Age Unknown <u>FATAL</u> (Injuries not identified in detail for this seat.)</p>	<p>Female Adult: Age 40 <u>SURVIVOR</u> Injuries: <i>Dangerous</i>. Severe concussion; possible abdominal injury; fractures of left 6-7-8-9-10-11th ribs; fractured pubis; fracture of right femur, upper third; colles fracture of left wrist; fractured right tibia, left fibula.</p>	<p>SEAT #17A (FORWARD FACING) SEAT #17</p>
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<p>Male Adult: Age 26 <u>SURVIVOR</u> Injuries: <i>Dangerous</i>. Severe concussion; skull fractured; moderate shock; comminuted fracture through head of tibia and proximal 1/4 of fibula with slight displacement; transverse laceration on left frontal region; edema of both eyelids.</p>	<p>Female Adult: Age 44 <u>SURVIVOR</u> Injuries: <i>Dangerous</i>. Cerebral concussion; skull fractured; shock; fracture of zygoma and orbit; fractures of 5, 6, 7, 8, 10th left ribs; separation fracture and dislocation of nose; severe lacerations about both eyes; 2 1/2" x 2" laceration of forehead; multiple body bruises; 2nd degree burns on lower extremities.</p>
SEAT #18	SEAT #18A
(FORWARD FACING)	

Ninth
Row

<p>Female Adult: Age 26 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Mild concussion; multiple body bruises; hematomas on skull; lacerations of right foot and right toe; lacerations of left thigh and left leg.</p>	<p>Gender and Age Unknown <u>FATAL</u> (Injuries not identified in detail for this seat.)</p>
SEAT #19A	SEAT #19
(FORWARD FACING)	

FORWARD BUFFET	
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Tenth
Row

<p>Female Adult: Age 17 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Concussion; moderate shock; semi-conscious first few hours; tenderness of lower right ribs; laceration of knees.</p>	<p>Female Adult: Age 54 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i> Mild concussion; 4" laceration of scalp over right temple; multiple body bruises.</p>
SEAT #21A	SEAT #21
(FORWARD FACING)	

AFT BUFFET	
Coat Closet	AFT FACING
<p>Stewardess's Jump Seat</p> <p>Female Adult: Age 22 SURVIVOR Injuries: <i>Minor</i>. Mild shock; contusion of forehead and back of head; abrasions of both hands and knees.</p>	

Eleventh
Row

<p>Male Adult: Age 44 SURVIVOR Injuries: <i>Non-Dangerous</i>. Moderate concussion and shock; contusion of skull left side; laceration of scalp; comminuted fracture of scapula; multiple body bruises.</p>	<p>Gender and Age Unknown FATAL</p> <p>(Injuries not identified in detail for this seat.)</p>
SEAT #25A	(FORWARD FACING) SEAT #25

<p>Female Child: Age 5 SURVIVOR Injuries: <i>Minor</i>. Shock; contusions of occipital region; abrasions of forehead.</p>	<p>Female Adult: Age 40 FATAL Injuries: <i>Fatal</i>. Compound fracture of skull; crushing injury of chest.</p>
SEAT #22	(FORWARD FACING) SEAT #22A

Twelfth
Row

<p>Gender and Age Unknown FATAL</p> <p>(Injuries not identified in detail for this seat.)</p>	<p>Male Adult: Age 26 FATAL Injuries: <i>Fatal</i>. Cerebral hemorrhage; basilar skull fracture; dislocation of left shoulder; compound dislocation of right ankle; multiple contusions and abrasions. (Never regained consciousness - died after 9 days.)</p>
SEAT #27A	(FORWARD FACING) SEAT #27

<p>Male Adult: Age 38 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Shock; fractured left clavicle, outer third; contusions of face and neck; abrasions of hands and face.</p>	<p>Male Adult: Age 55 <u>SURVIVOR</u> Injuries: <i>Dangerous</i>. Extreme concussion; colles fracture, right wrist; fractured left humerus.</p>
SEAT #24	(FORWARD FACING) SEAT #24A

Thirteenth Row

<p>Male Adult: Age UNK. <u>SURVIVOR</u> Injuries: <i>Minor</i>. Emergency treatment only; laceration on forehead and lower leg; pain and swelling of right hand.</p>	<p>Male Adult: Age 50 <u>FATAL</u> (Injuries not identified in detail for this seat.)</p>
SEAT #29A	(FORWARD FACING) SEAT #29

<p>Female Adult: Age UNK. <u>SURVIVOR</u> Injuries: <i>Minor</i>. (First Aid only)</p>	<p>Male Adult: Age UNK. <u>SURVIVOR</u> Injuries: <i>Minor</i>. Bruises and contusions.</p>
SEAT #26	(FORWARD FACING) SEAT #26A

Fourteenth Row

<p>Male Adult: Age 52 <u>SURVIVOR</u> Injuries: <i>Minor</i>. Laceration over left eye. First aid.</p>	<p>Male Adult: Age 29 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Severe shock; severe contusion and sprain of right knee; ecchymosis of both lower extremities with many deep abrasions; contusion of chest walls (bilateral); ecchymosis of left upper arm; slight abrasion on forehead.</p>
SEAT #31A	(FORWARD FACING) SEAT #31

<p>Female Adult: Age 17 <u>SURVIVOR</u> Injuries: <i>None</i>. Some shock - no treatment.</p>	<p>Male Adult: Age 47 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Mild shock; suspected fracture of 7th dorsal; abrasions of entire body.</p>	<p>LOUNGE SEAT R-1</p>
<p>Male Adult: Age UNK. <u>SURVIVOR</u> Injuries: <i>None</i> Mild shock - no treatment.</p>	<p>Female Adult: Age 42 <u>SURVIVOR</u> Injuries: <i>Non-Dangerous</i>. Cerebral concussion; fracture right zygoma and malar bone; marked ecchymosis of both eyelids; tenderness over right maxilla; multiple contusions and abrasions; laceration of scalp; left ankle painful.</p>	<p>LOUNGE SEAT R-2</p>
<p>TABLE</p>		
<p>Male Adult: Age 42 <u>SURVIVOR</u> Injuries: <i>Minor</i>. Shock; chip fracture of base of distal phalanx of great toe; multiple abrasions of both legs.</p>	<p>Male Adult: Age 44 <u>SURVIVOR</u> Injuries: <i>Dangerous</i>. Shock; fracture of the body of the 9th dorsal vertebra with compression; multiple body bruises; small abrasions on face and forehead.</p>	<p>LOUNGE SEAT CENTER R</p>
		<p>LOUNGE SEAT CENTER L</p>

LIST OF GROSS FATAL LESIONS AND OTHER
INJURIES SUSTAINED BY PASSENGERS WHOSE
SEATED LOCATION WAS NOT ASCERTAINED

Male Adult, Age 41	Fractured skull.
Female Adult, Age 40	Fractured skull, crushing injury of chest, compound fracture of leg.
Male Adult, Age 61	Evisceration, second and third degree burns of body.
Male Adult, Age 42	Compound fracture of skull, fracture of legs, crushing injury of chest.
Female Adult, Age 32	Crushing injury of chest, fracture of legs.
Female Adult, Age 56	Fractured skull, legs and arms.
Male Adult, Age 45	Fractured skull; 1st, 2nd and 3rd degree burns of face and hands.
Male Adult, Age 60	Compound crushing fracture of skull, fracture of ribs and legs.
Male Adult, Age 48	Compound fracture of skull, fracture of legs and ribs, 2nd degree burns of face.
Male Adult, Age 41	Fractured skull, crushing injury of chest, fracture of legs.
Male Adult, Age 49	Fractured skull.
Male Adult, Age 56	Compound fracture of skull, crushing injury of chest, fracture of leg.
Male Adult, Age 56	Crushing injuries of chest, 2nd degree burns of face.
Male Adult, Age 30	Compound crushing fracture of skull.
Male Adult, Age 34	Compound fracture of skull, fractured rib.
Female Adult, Age 47	Fractured skull, crushing injuries of chest.
Male Adult, Age 42	Fractured skull, crushing injuries of chest.
Female Adult, Age 29	Compound fracture of skull.
Female Adult, Age 52	Pulmonary embolism, fractured ribs, rupture of diaphragm.



FIG. 30. SEATS THROWN - AHEAD OF CENTER SECTION FROM FORWARD CABIN.



FIG. 32. SEAT 12-12A (NOTE INTERCOSTAL AND PORTION OF CABIN FORMER RING).



FIG. 29. WRECKAGE OF FORWARD CABIN AND COCKPIT.

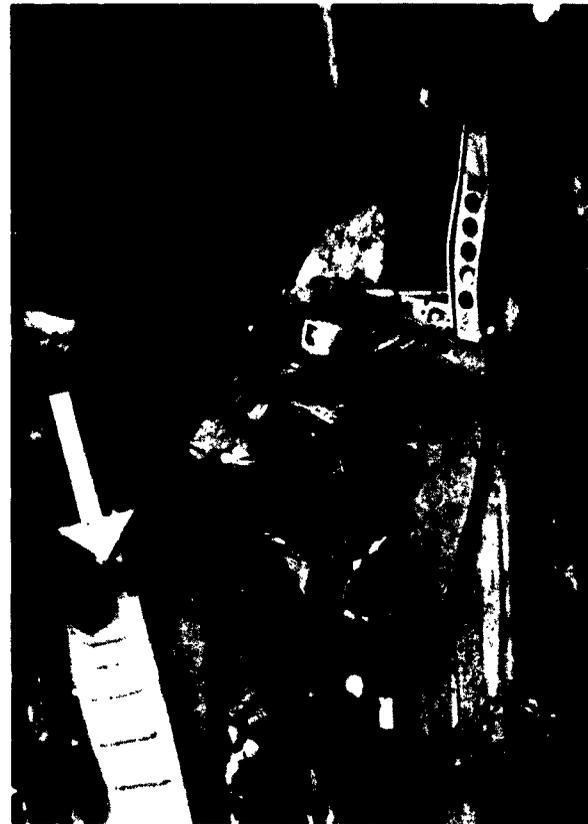


FIG. 31. SEAT 7-7-A (NOTE HATRACK STRUCTURE AT UPPER LEFT).



FIG. 34. PRESSURE BULKHEAD HELPED PREVENT COLLAPSE OF LOUNGE.



FIG. 33. UNDERSIDE OF LOUNGE SECTION



FIG. 36. TREE CRUSHED ROOF; WALL AND FLOOR FAILED AS CABIN BROKE AROUND TREE.



FIG. 35. ONLY REMAINING 'INTACT' PORTION OF CABIN.



FIG. 38. LOUNGE (NOTE FRACTURED PLASTIC PARTITION).



FIG. 40. STEWARDESS'S JUMP SEAT (NOTE FIRE EXTINGUISHER CLIP ABOVE SEAT).



FIG. 37. INVERTED LOUNGE AND REAR CABIN SECTION.



FIG. 39. SEAT 22-22A. AREA WHERE TREE BROKE INTO CABIN.



FIG. 42. CENTER CABIN STRUCTURE ADJACENT TO REAR SPAR (LOOKING AFT).



FIG. 44. LEFT HALF OF COCKPIT (NOTE SEAT RAILS).



FIG. 41. AFT SIDE OF FORWARD BUFFET. BOTTOM ANCHORAGES FAILED UNDER FORWARD, LATERAL AND UP LOADS.



FIG. 43. FLOOR STRUCTURE UNDER BUFFET AREA.



FIG. 46. SEATS 11-11A AND 15-15A (TWO PERSONS SURVIVED IN 15-15A).

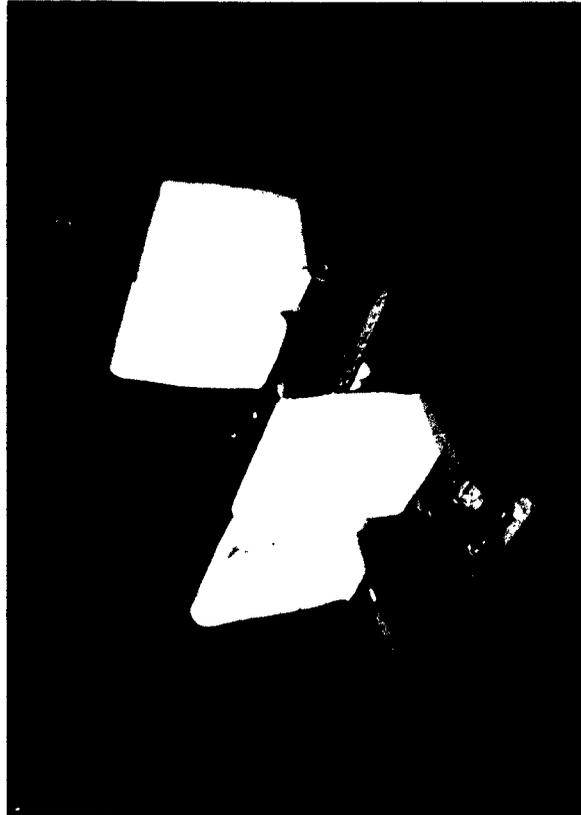


FIG. 48. SEATS 17-17A AND 19-19A (TWO OF THE FOUR PASSENGERS WERE KILLED).



FIG. 45. SEATS 9A-9 AND 7A-7 (ALL FOUR OCCUPANTS SUSTAINED FATAL INJURY).



FIG. 47. SEATS 18-18A AND 14-14A (OCCUPANT OF 14A FATALLY INJURED).



FIG. 49. SAFETY BELT END-ATTACHMENT FAILURE.



FIG. 50. HATRACK STRUCTURE FROM FORWARD CABIN.

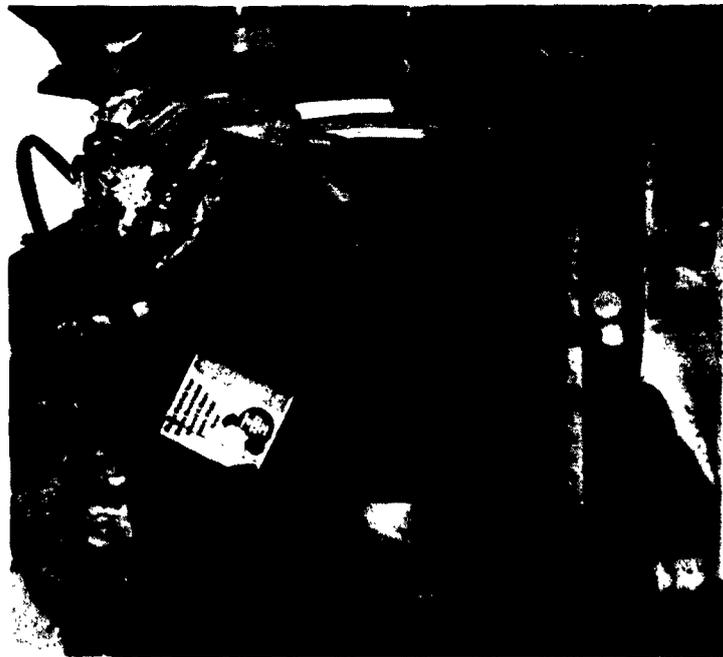


FIG. 51. SEAT 16A-16 WAS UNDAMAGED AND REMAINED IN PLACE. THE TWO OCCUPANTS SURVIVED WITH NON-DANGEROUS INJURIES.

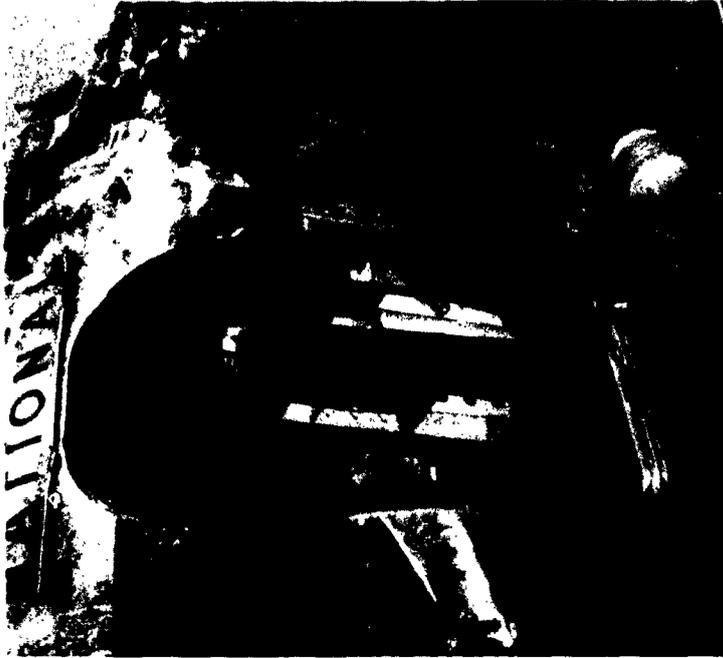


FIG. 52. AFT BUFFET REMAINED INTACT BUT WAS DISLODGED.