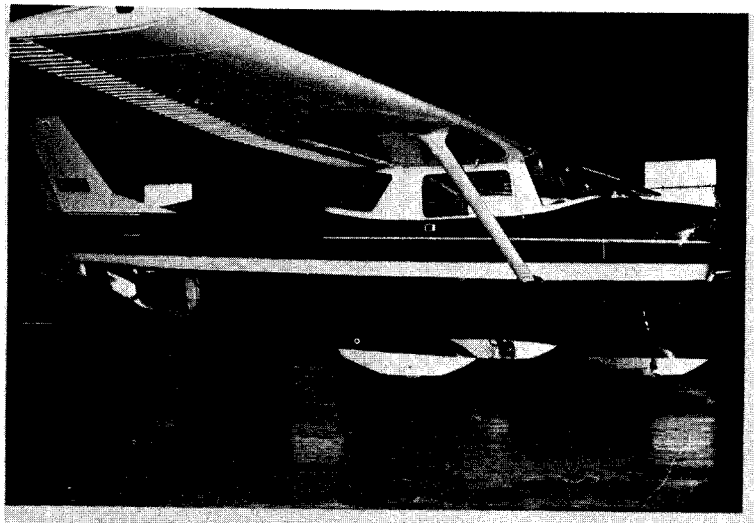
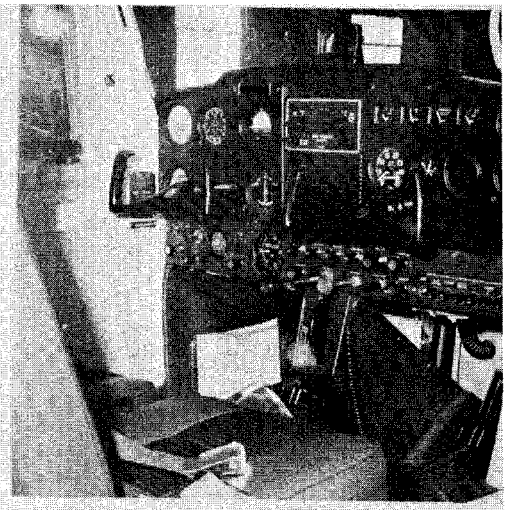




1968 CESSNA 150

CESSNA 150 H, a 1968 model aircraft with pilot and one passenger (R. F.), became inverted at night, clipped some small trees and crashed inverted. Aircraft motor plowed under a large flat rock (the only one in the field). Top metal structure of the cabin was ground away. Since pilot and passenger were hanging upside down in their seat belts, their heads dragged the ground. No shoulder harnesses were in the aircraft. Major deceleration forces were straight forward.

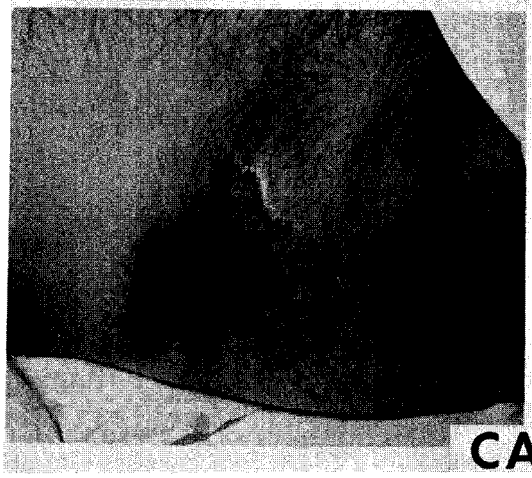
ACCIDENT INVESTIGATED BY:
GALE BRADEN AND DON ROWLAN
CAMI

CASE 20-1

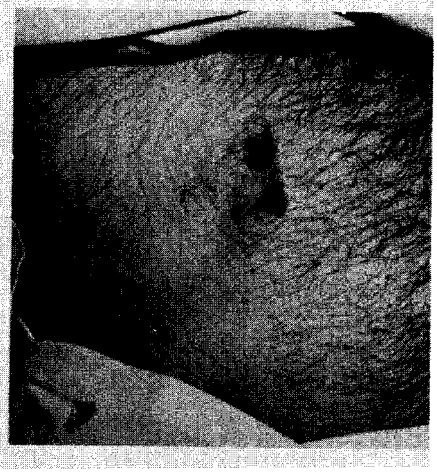
A. Tree tops clipped by inverted aircraft just before it crashed.

B. Forward motion of the aircraft was stopped when motor plowed under a large flat rock.

	INJURIES	STRUCTURES IMPACTED
Pilot: (S)	Head - Severe Lac. (Y-shaped) forehead & scalp. Moderate concussion. Lac. lower lip (R). Lac. (R) face. Numerous facial abrasions.	Torn metal - cabin roof & ground.
	Trunk - Pelvic abrasions.	Seat belt.
	Extremities - Lac. (R) forearm. Lac. (L) knee. Fx. (L) hand.	Lower instrument panel.
R. F.: (S)	Head - Lac's. anterior scalp & behind (R) ear. Abrasions. Moderately severe concussion.	Cabin roof & ground.
	Trunk - Pelvic abrasions.	Seat belt.
	Extremities - Lac. (R) elbow & (L) hand.	Instrument panel.



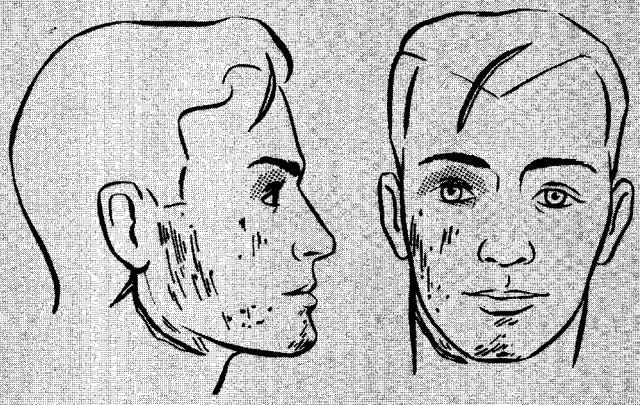
C & D Abrasion marks on the iliac crests offer positive proof of seat belt use.



CASE 20-2

F. Head outlines of head positions in inverted aircraft.

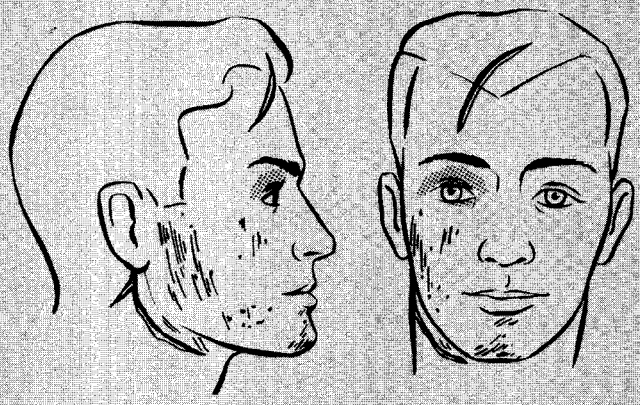
E & G Artist sketches of lacerations & abrasions of 2 occupants heads from dragging along the ground & contact with torn metal from top of cabin.



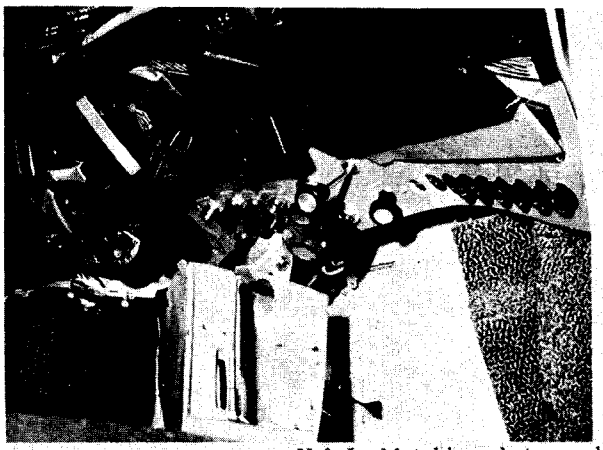
CASE 20-3

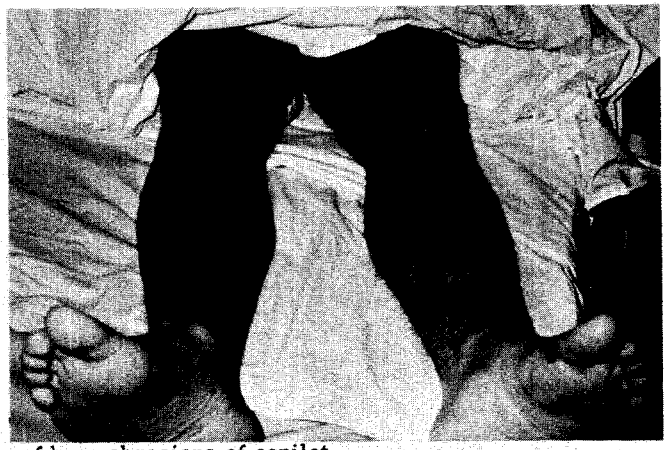
F. Head outlines of head positions in inverted aircraft.

E & G Artist sketches of lacerations & abrasions of 2 occupants heads from dragging along the ground & contact with torn metal from top of cabin.



CASE 20-3



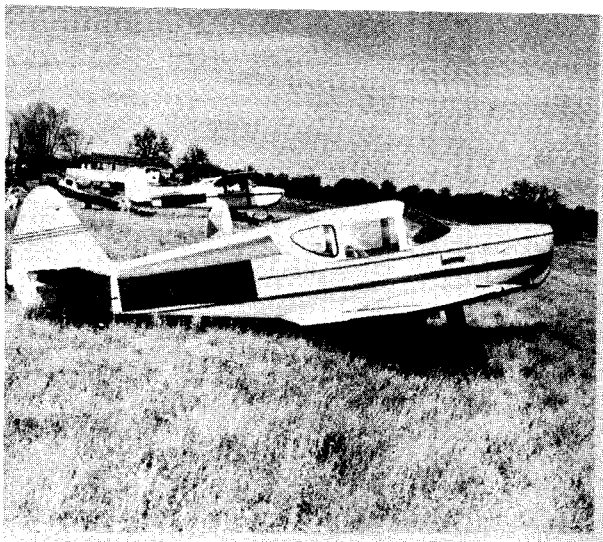


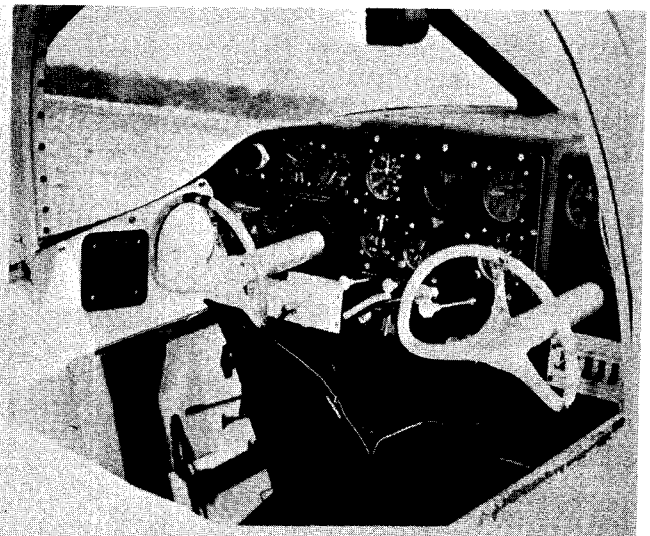
H & I Matching photographs of knee abrasions of copilot & lower instrument panel push buttons.

J & K Matching photographs of pilot's knees & lower left instrument panel.

L. Head impact with upper instrument panel was prevented since both occupants heads dragged along the ground.

CASE 20-4



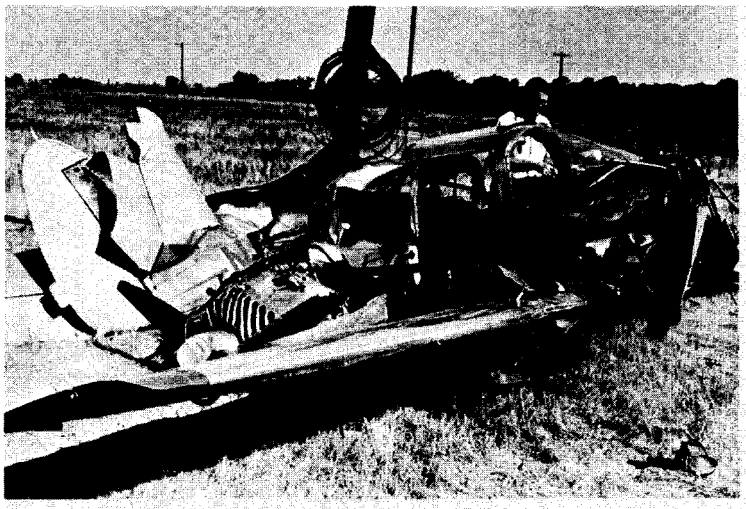


1946 TEMCO SWIFT

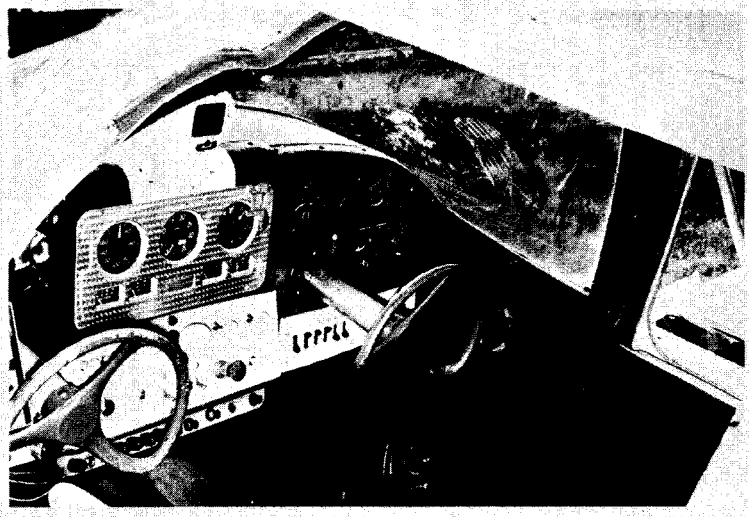
TEMCO SWIFT GC-1B, a 1949 model aircraft with pilot and one passenger (R. F.), struck some telephone wires between two poles, breaking one of the poles and sliding down the wires to impact the second pole with its (L) wing. As the second pole broke, the aircraft rotated through the air and impacted a third pole with the (R) side of the fuselage, wrapping around it and sliding down to the ground. Both occupants were wearing seat belts and they held. No shoulder harnesses were in the aircraft. The principal impact force threw the occupants to the side. They did not impact the instrument panel.

ACCIDENT INVESTIGATED BY:
DON ROWLAN AND EDDIE LANGSTON
CAMI

CASE 21-1



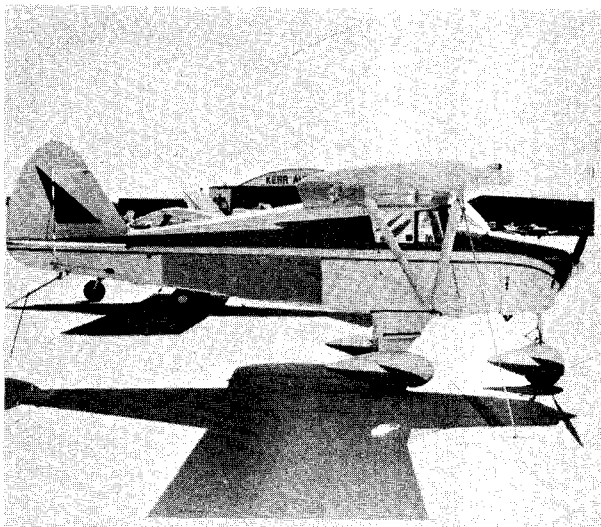
A. Telephone pole is completely buried in fuselage after side impact by aircraft.

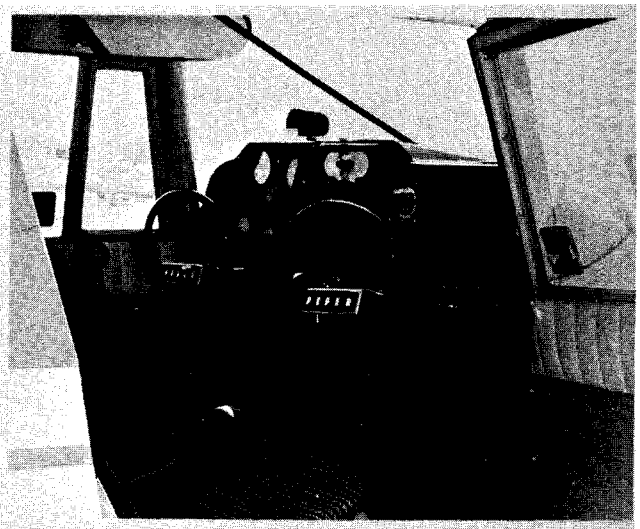


B. Since both occupants were thrown to the side, the instrument panel is unmarked.

	INJURIES	STRUCTURES IMPACTED
Pilot: (S)	Head - Small lac's. (L) forehead & scalp.	Side of cockpit (?).
	Trunk - None.	
	Extremities - Contusion (L) shoulder.	Side of cockpit (?).
R. F.: (S)	Head - Lac. (minor) (L) ear & (L) forehead.	Side of cockpit (?).
	Trunk - None.	
	Extremities - None.	

CASE 21-2





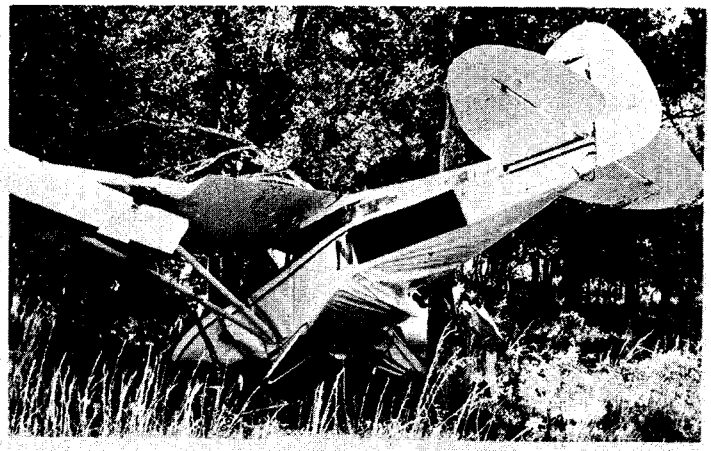
1961 PIPER COLT

PIPER COLT PA-22-108, a 1961 model aircraft with pilot and one passenger (R. F.), was flying at an altitude of 5, 000 feet when the pilot cut the engine to practice some power-off maneuvers. At about 2, 500 feet, he tried to restart the motor but could not and crashed while trying to return to his private air field. At impact the right wing of the aircraft struck a 10-inch diameter tree which tore it from the aircraft and opened the right side of the cockpit next to the passenger. Pilot and passenger were thrown to the right toward the opening. Seat belts (fuselage attached) were in use and held, but the seats came loose from their fittings. No shoulder harnesses were in the aircraft.

ACCIDENT INVESTIGATED BY:
TERRY WALLACE
CAMI

CASE 22-1

A. Distant view of crash site. Tracks in wheat field were made by rescue personnel as aircraft did not touch the ground before striking the tree.



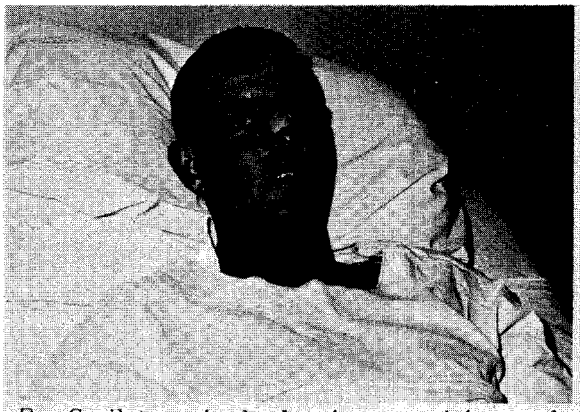
B. Rear view of aircraft after tree impact & 90° change of direction.

C. Right side of aircraft. Note bark missing from tree & snagged control cable about 5 feet above the ground.

D. Front of aircraft showing complete separation of motor & instrument panel.

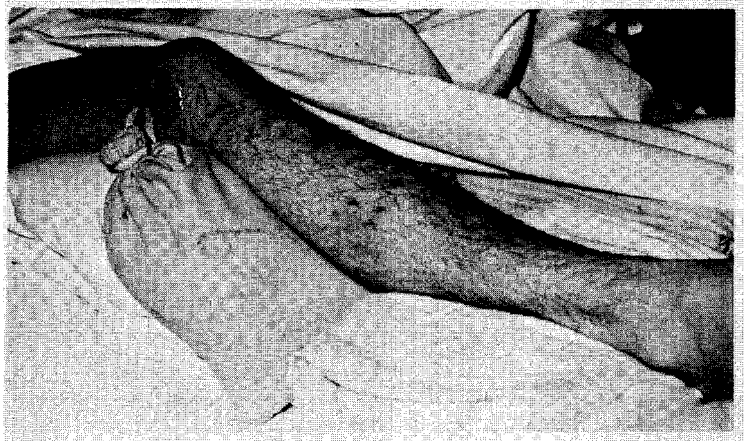
	INJURIES	STRUCTURES IMPACTED
Pilot: (S)	Head - Slight lac. on bridge of nose.	Unknown.
	Occipital hematoma & moderate concussion.	Unknown.
	Trunk - None.	
	Extremities - None.	
R. F.: (S)	Head - Slight lac. (R) center forehead.	Unknown.
	Trunk - Severe contusion of (R) abdomen & (R) iliac crest.	Seat belt.
	Fx. (R) iliac crest.	Seat belt.
	Extremities - Slight lac's. (R) forearm.	Torn metal (R) side of cabin.
	Fx. (R) tibia & fibula.	Lower (R) door frame.

CASE 22-2



E. Copilot received only minor nose injury as he was thrown sideways away from the instrument panel.

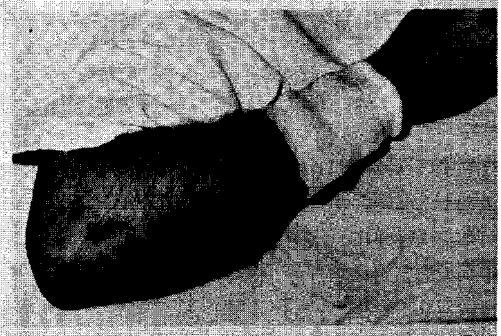
F. Seat belt abrasion on copilot.



G. Copilot fractured tibia & fibula of right leg.

H. Pilot with minor laceration of forehead.

I. Right leg of pilot with minor injuries.



J. Minor lacerations of pilot's right elbow.

CASE 22-3

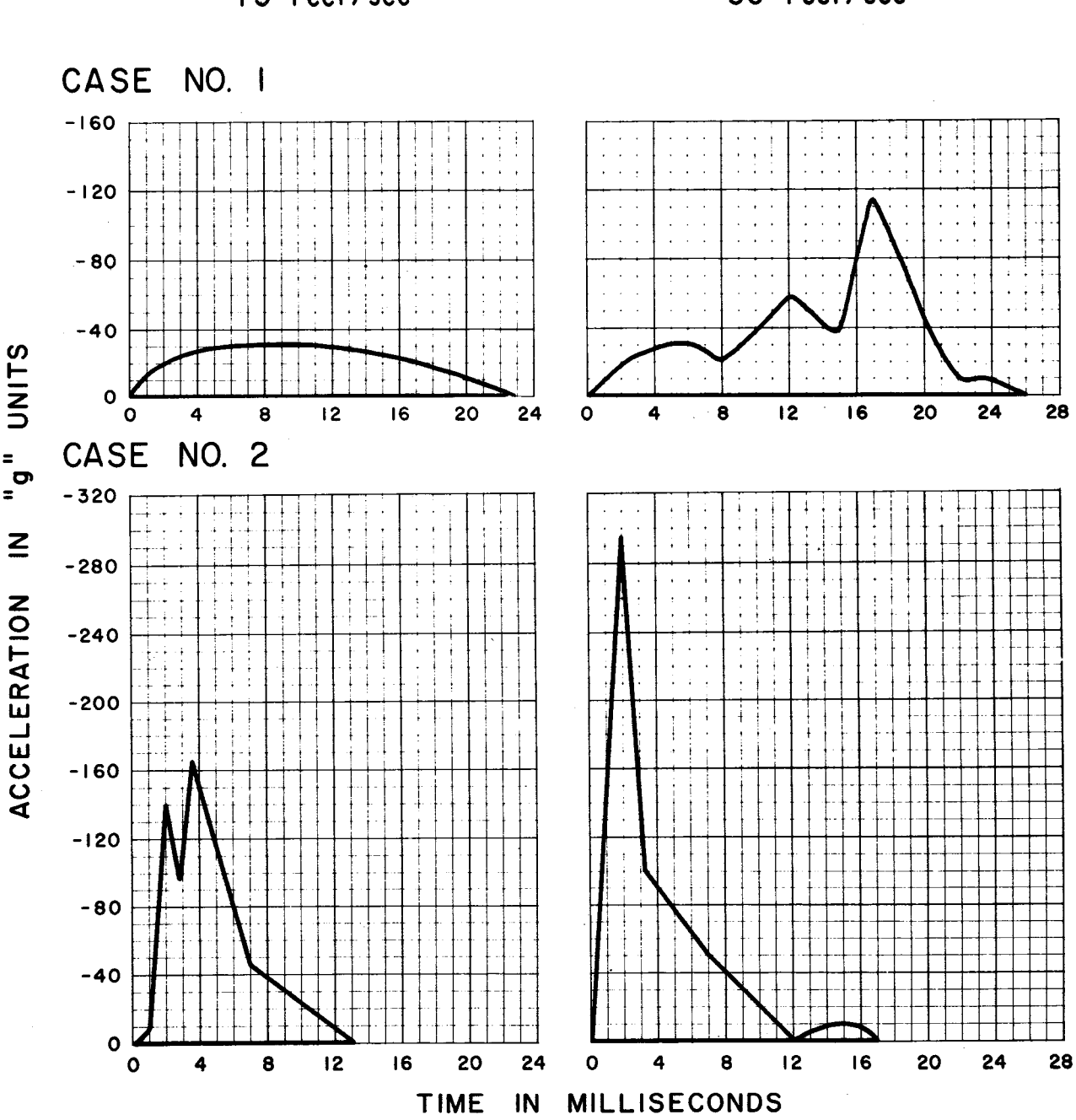


FIGURE 36. Comparison of test results of head impact tests against the Piper Pawnee aluminum ½ cylinder (Case 1), and one of the common rigid instrument panels in general aviation aircraft (Case 2).

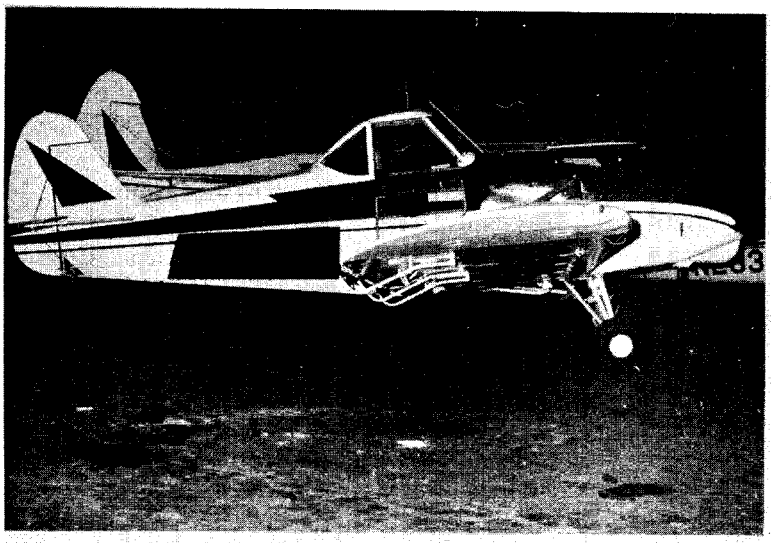
similar data for impacts against a rigid instrument panel in common use in general aviation aircraft, are presented in Figure 36. Note that not only does the aluminum roll reduce the peak "g" force at 15 ft./sec. from 160 to 30 "g", but also extends the time for deceleration from 12 milliseconds to nearly 24, while at 30 ft./sec. impact velocity it reduces the force of head impact from 300 "g" to 110 "g" with a doubling of the deceleration time. Decreased impact forces and extended duration times are most important for preventing head injuries, but of even more significance was the distribution of the load over a greater surface area. As the light aluminum

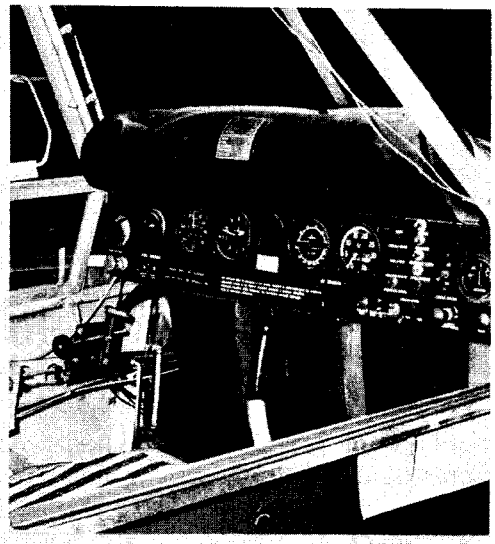
roll was impacted by the face, it deformed to roughly fit the contours of the head (Case 23 F and Case 24 E and F) and in the laboratory tests increased the head contact area from less than one square inch for the common rigid instrument panel to better than 16 square inches on the deformed aluminum roll. The importance of these three factors for head protection cannot be overemphasized and is further illustrated by these two pilots escaping with only minor lacerations (Case 23 G and Case 24 H). Even better protection could be afforded by covering the aluminum roll with a one-inch layer of slow-return padding to prevent facial lacerations from torn metal and to obtain a more even distribution of pressure loads.

This report would not be complete without pointing out still another area where general aviation aircraft design engineers could improve crash survivability with a minimum of effort. It has been noted throughout this study that protection of aircraft occupants from vertical impact has been virtually ignored. Three cases (25, 26 and 27) will serve to illustrate the need for improvements in this area. Human tolerances to vertical impact in the seated position have been established by the author,[72] by vertical ejection seat research,[73] and by Snyder studies of fall cases.[74 75] Also, numerous energy attenuating methods and devices have been developed [76 77 78 79] to reduce vertical loads on the spine during crash deceleration.

In Case 25 (a 1940 Piper Cub J-3C-65) numerous serious vertebral fractures resulted from vertical impact forces on a seat constructed of a cushion placed on top of a sheet of canvas laced to the sides of the seat structure. This flimsy structure gave way readily, allowing the buttocks of the front seat occupant to impact the heavy tubular structure under the center of the seat (Case 25 D). The forces involved in the crash of the 1964 Beech Musketeer A-23 presented as Case 26 were not all vertical as indicated by the pilot's receiving a brain concussion when his head hit the unpadded "A" post (Case 26 E) and the copilot's receiving a similar head injury from impact with the compass (Case 26 F) mounted on top of the instrument panel. However, the vertical component was significant as attested by the engine breaking straight down (Case 26 B and C) and the buckling of the legs of the front seats (Case 26 H and I). The fact that the legs did buckle to a degree probably prevented more serious back injuries of these two occupants. Fractures of L1 for both front seat occupants would have been avoided in this case if only one or two additional inches of vertical attenuation had been provided. It is interesting that the single occupant of the rear seat escaped without vertebral injury or even a back sprain. The rear seat cushion (3-inch-thick foam) is not mounted on a rigid seat pan and rigid legs as is the case with the front seats, but instead lies on top of lightweight aluminum stringers perforated with 5½-inch diameter holes. The attenuation offered by this type of construction, offering up to 9 inches of crush distance, was sufficient in this case to prevent vertebral fractures.

This need for attention to design for attenuation of vertical loads in aircraft with horizontal take-off as well as for those with vertical take-off and landing characteristics is dramatically shown in Case Number 27. Case 27, A through I, shows six young men sitting in an aircraft (a 1967 Cherokee 6 PA-32) with seat belts still fastened and with no visible injuries such that they appear to be sleeping. However, they all died from severe and massive internal injuries (see injury chart). After hooking its vertical stabilizer on some power lines and nosing up to some degree, this aircraft pancaked to the ground without any forward motion. The tall wheat all around the aircraft was completely undisturbed and one blade of the propeller was sticking vertically in the ground without any evidence of soil disturbance either fore or aft. The magnitude of the vertical deceleration force imposed on the bodies in this case is difficult to calculate, but assuming the aircraft started its vertical descent from a height of 100 feet along with a measured vertical crush distance of 4 inches for the seats and approximately 4 inches for the fuselage, one can calculate an average deceleration of 150 "g". However, since the tubing forming the seat legs was of small diameter, it is apparent that the seats crushed to the floor with much less force and the occupants experienced a vertical deceleration peak force much greater than 150 "g" for a brief period of time. Snyder [80] describes one case of man that was subjected to over 4,000 "g" in the seated position for a period of .0023 seconds and could have survived if his internal injuries could have been diagnosed





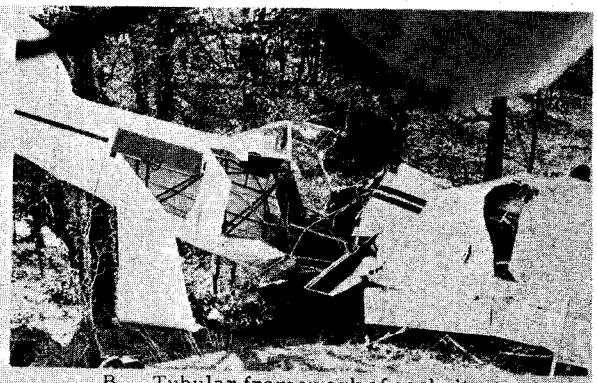
1961 PIPER PAWNEE

PIPER PAWNEE PA25, a 1960 model aircraft with pilot only, engaged in aerial application of insecticide, pulled up and stalled at about 140 feet in the air, nosed over, and impacted hard soil at approximately a 45° angle. The pilot was wearing helmet, shoulder harness, and a 3-inch seat belt. Helmet penetrated windshield and was torn off. Seat belt and shoulder harness broke in webbing. Pilot was thrown straight forward.

ACCIDENT INVESTIGATED BY:
JOHN SWEARINGEN AND JIM SIMPSON
CAMI

CASE 23-1

A. Small earthen depression from Pawnee impact.



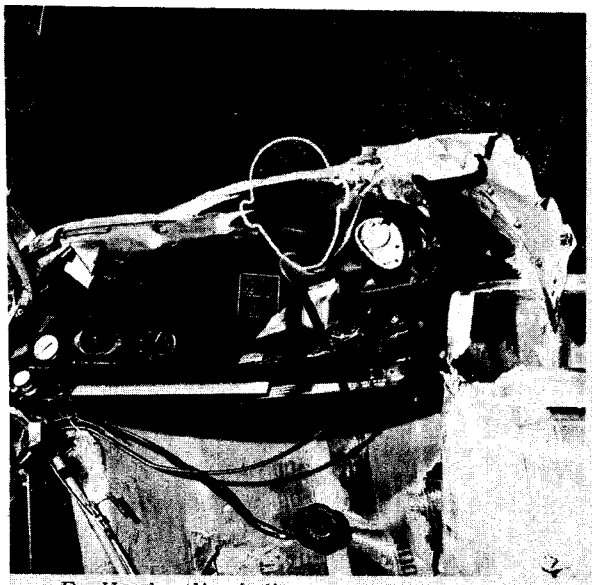
B. Tubular framework of cockpit maintained its integrity.

C. Crash design causes motor to fold under the aircraft.

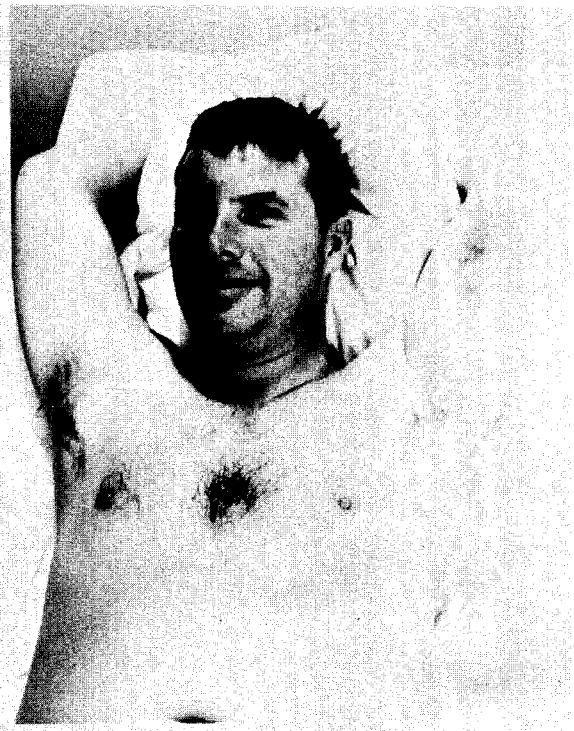
D. Seat attachments held since belts & harness were attached to fuselage.

E. Shoulder harness & 3" seat belt broke.

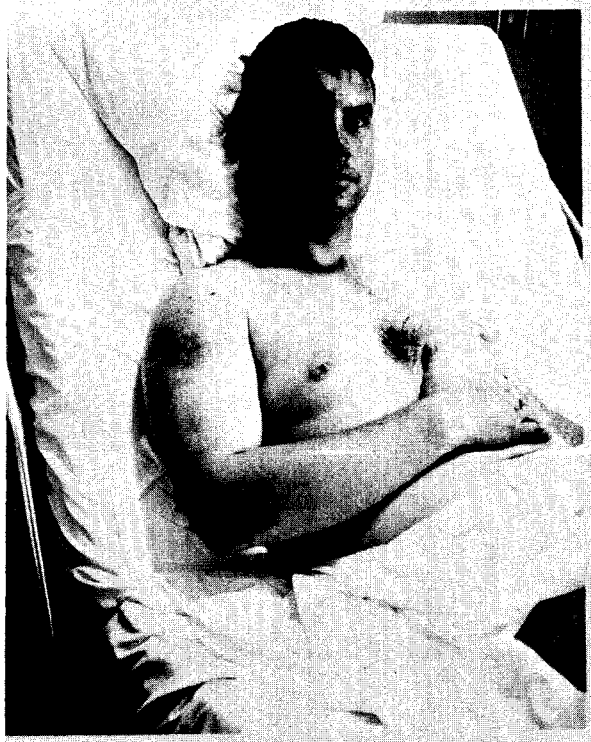
CASE 23-2



F. Head outline indicates area of head impact on light aluminum cylinder.

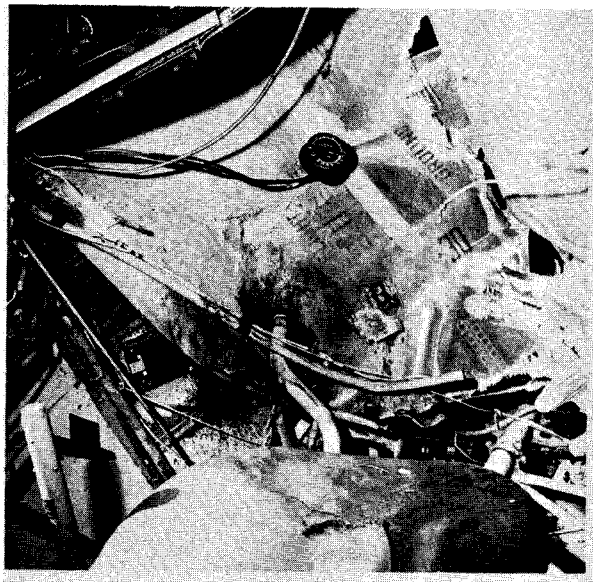


G. Pilot with minor bruises & facial lacerations 4 days after crash.



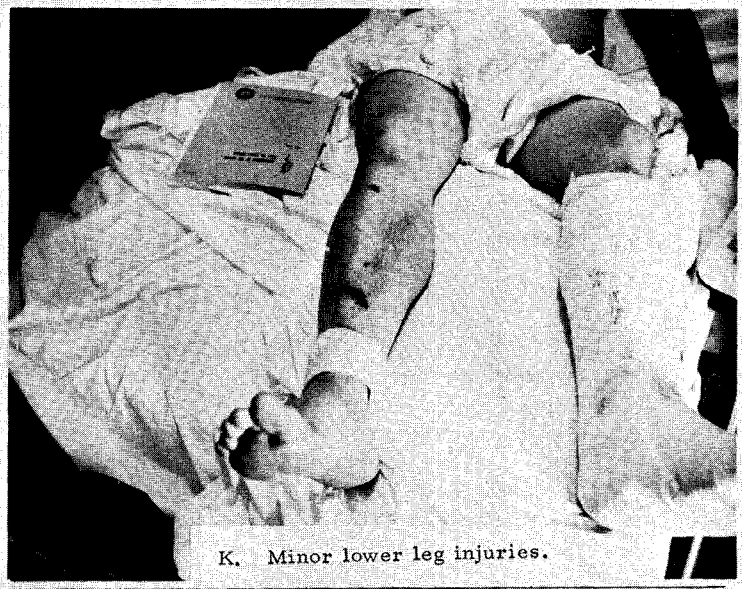
H. Bruise on right shoulder from contact with microphone.

CASE 23-3



I. Knees penetrated fiberglass hopper without serious injury. Left ankle was fractured in pedal area.

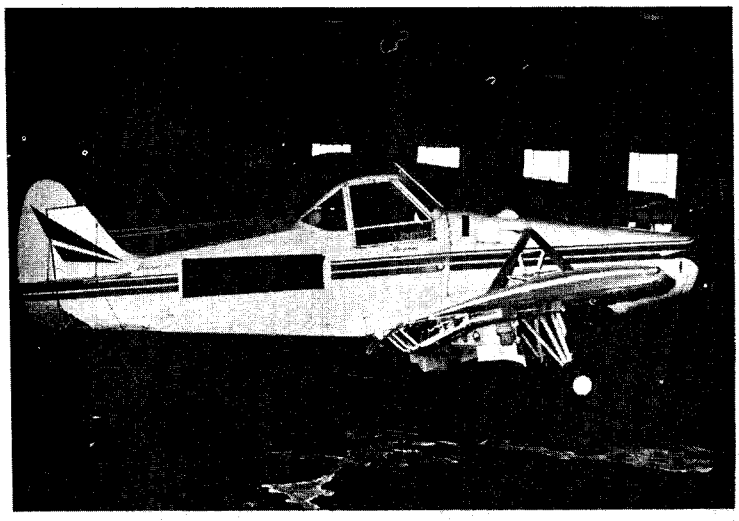
J. Perforated aluminum hopper liner served as good decelerator for knees.

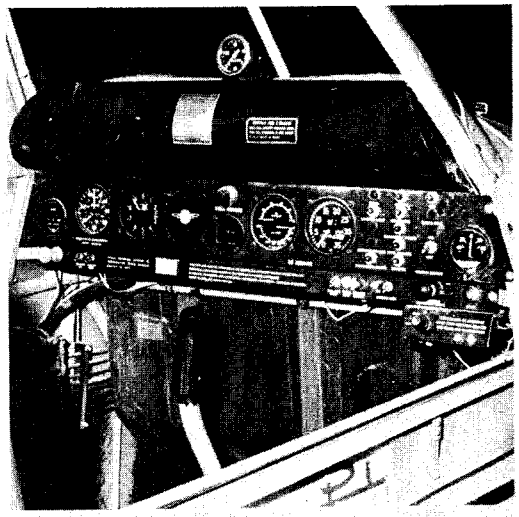


K. Minor lower leg injuries.

	INJURIES	STRUCTURES IMPACTED
Pilot: (S) Head	Depressed Fx. (R) frontal sinus, slight concussion.	Junction of windshield with instrument panel.
	Minor facial lac's.	Light semi-cylinder of aluminum at top of instrument panel.
Trunk	None.	
Extremities	Bruise on (R) shoulder & under (L) upper arm.	Light semi-cylinder of aluminum
	Small lac's. (L) hand.	Windshield.
	Small lac's. (R) anterior leg.	Knees penetrated fiberglass hopper
	Fx. (L) ankle.	Pedal.

CASE 23-4



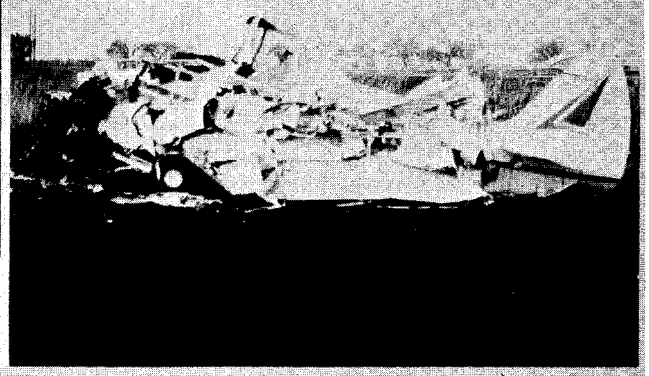


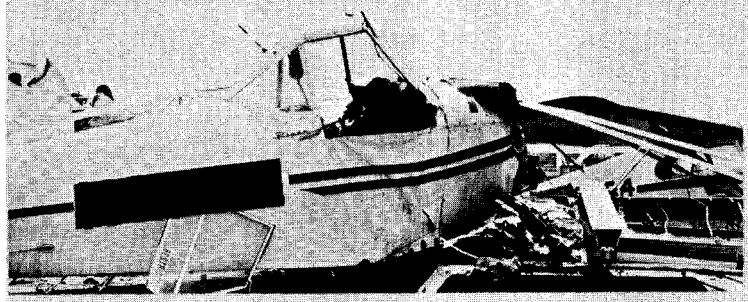
1966 PIPER PAWNEE

PIPER PAWNEE PA-25-235, a 1964 model aerial applicator with pilot only, had sprayed one-half of a field when the pilot made his pull-up on a west pass and caught some high wires with the left wing. The aircraft crashed 15 feet from the wires at about a 30° angle. The seat belt and shoulder harness were in use. The belt held but the harness failed. The pilot was thrown forward and to the left.

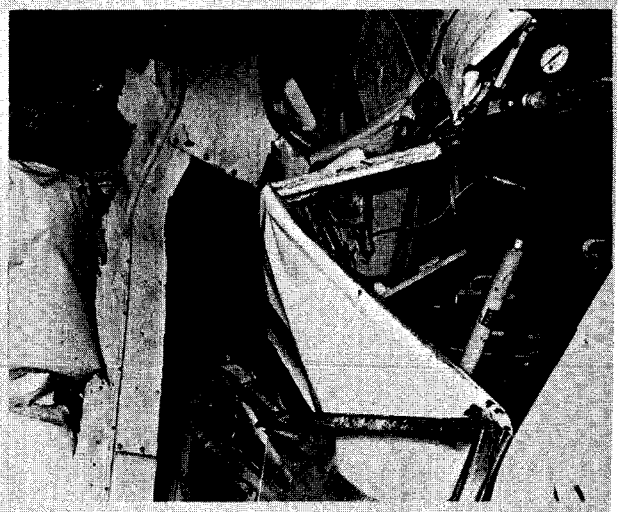
ACCIDENT INVESTIGATED BY:
GALE BRADEN AND EDDIE LANGSTON
CAMI

CASE 24-1



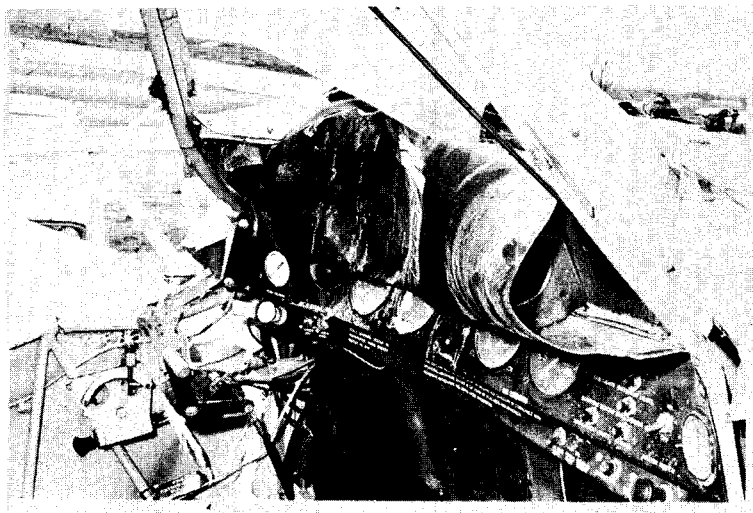


A, B & C Various views of aircraft showing how tubular construction around the cabin prevents its collapse on the pilot even in severe crash impacts.

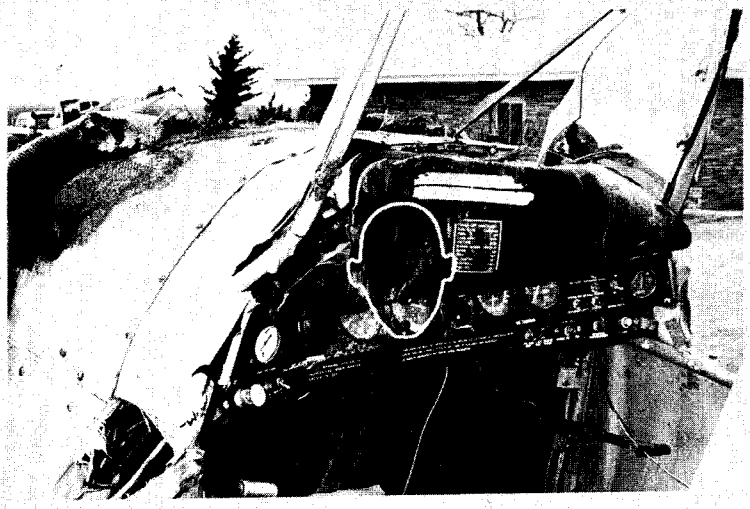


D. Sides of Pawnee cockpit are designed to buckle outward away from the pilot.

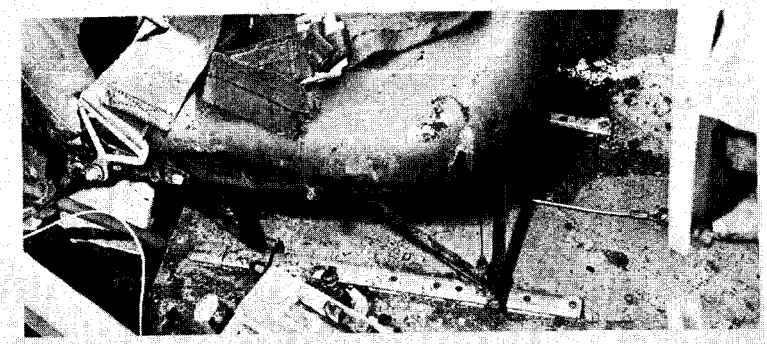
CASE 24-2



E. Side view of light aluminum cylinder at the top of the instrument panel designed to reduce head injuries.

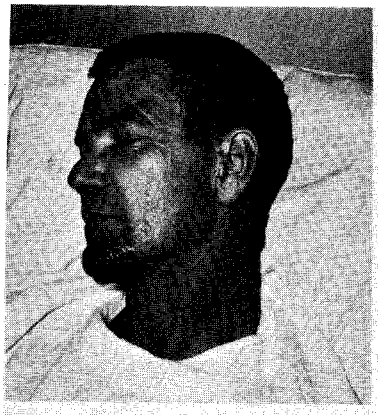


F. Outline showing area of pilot's head impact on aluminum cylinder. Note chin slipped down & contacted reset knob on altimeter.

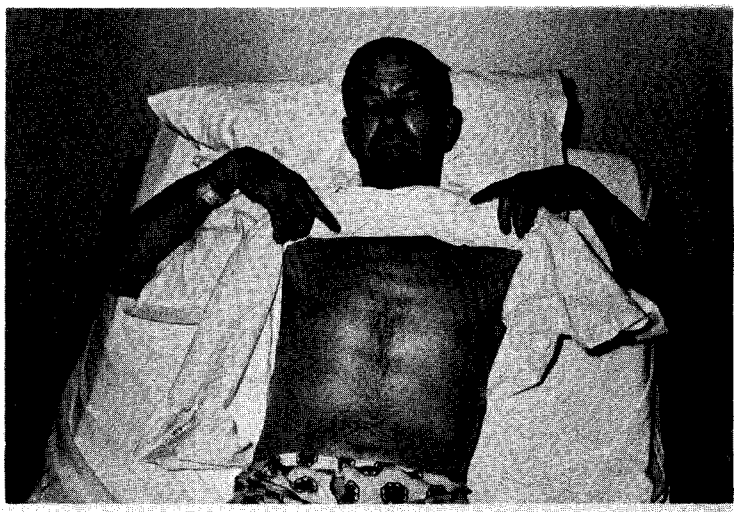


G. Shoulder harness failed in webbing but seat & seat belt held.

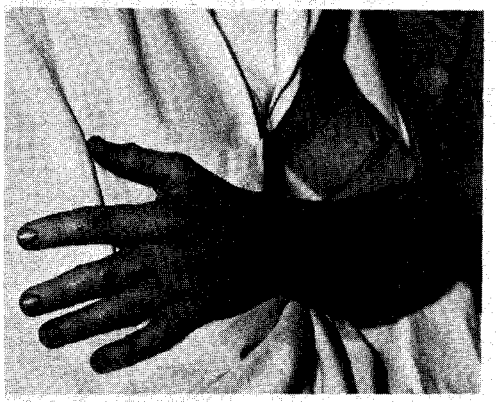
CASE 24-3



H. Slight chin laceration was only head injury.



I. No chest injuries.

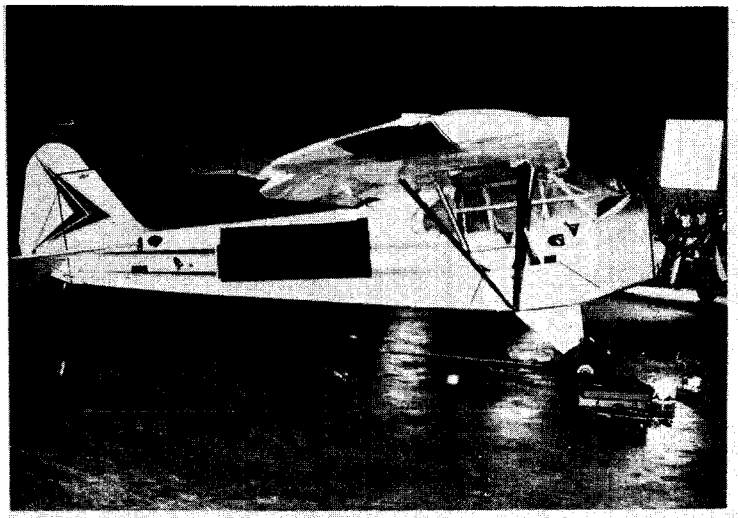


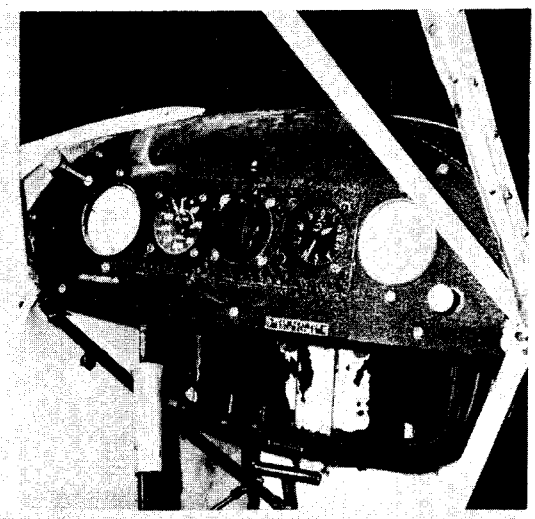
J. Minor laceration of left hand.

K. Practically no leg injuries.

	INJURIES	STRUCTURES IMPACTED
Pilot: (S)	Head - Slight abrasion above (L) eye.	Light cylinder of aluminum above instruments.
	Minor lac. chin.	Altimeter reset knob.
	Trunk - None.	
	Extremities - Lac. between index & 2nd finger.	Windshield.
NOTE:	Pilot was spraying with DiSyston & received extensive exposure & severe reaction to it when hopper ruptured & sprayed it over his body.	

CASE 24-4



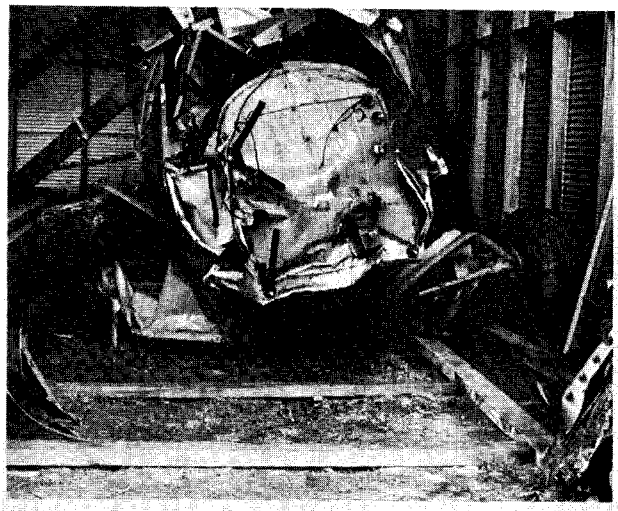


1940 PIPER CUB

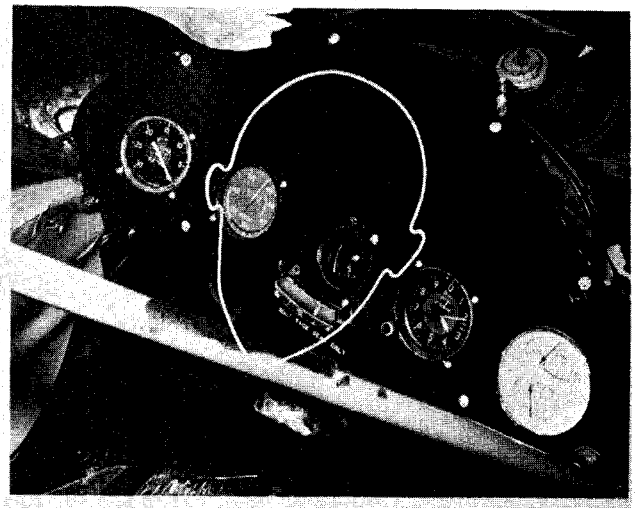
PIPER CUB J-3C-65, a 1940 model aircraft with pilot (rear) and one passenger (front), was flying over farm land looking at stock. Aircraft pulled up in a (R) turn and (R) wing struck the top wires of a high tension line. Aircraft fell into some lower wires where it hung a few seconds, arresting all forward motion and fell 80 feet to impact the ground in a flat attitude. Vertical impact velocity was approximately 70 feet/second. Both occupants were wearing seat belts and they held. No shoulder harnesses were in the aircraft. Occupants were thrown forward only slightly, the major force on the bodies being from head to seat.

ACCIDENT INVESTIGATED BY:
BILL REED AND DON ROWLAN
CAMI

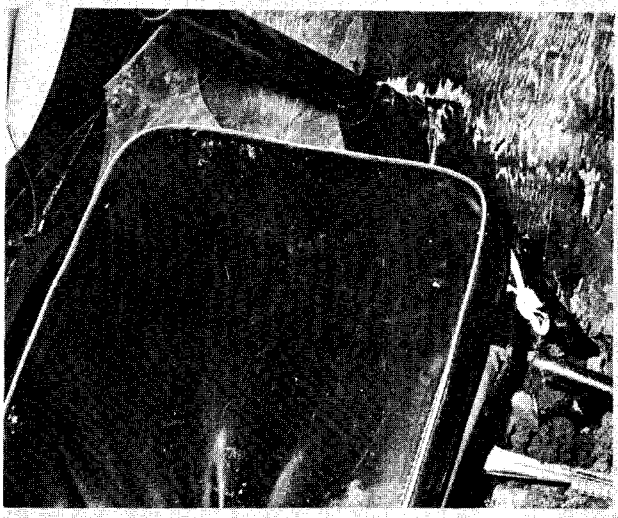
CASE 25-1



A. Upward bending of landing gear indicates heavy vertical crash forces.



B. Outline indicating area of head impact.

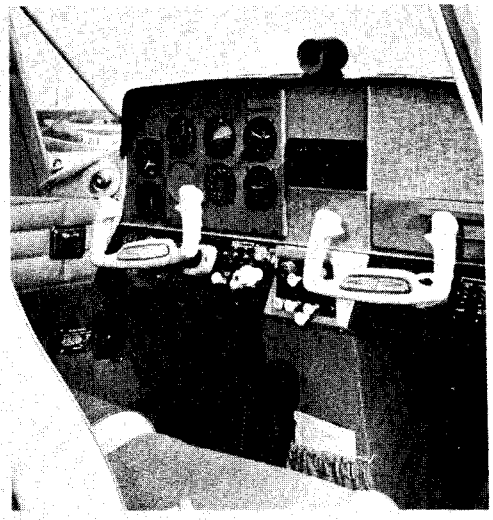


C. Upward buckling of floor structure further indicates vertical forces.

D. Front seat cushion & laced canvas removed to show tubular structure under seat that was responsible for vertebral fractures.

	INJURIES	STRUCTURES IMPACTED
Front: (S)	Head - Contusions & hematoma (R) parietal area.	Instrument panel.
	Trunk - Fx. ribs 1, 2, 5 (L). Fx's. T5, T12, L1 & L2.	Instrument panel. Tubular connection between control sticks under canvas seat bottom.
	Extremities - Fx. both ankles.	Diagonal tubular frame structure directly above ankles.
Pilot: (S)	Head - (R) eye black, small lac's. (R) zygoma area & (R) side of lip.	Back of front seat.
	Trunk - Fx. L1 & L2.	Heavy tubular structure under canvas seat bottom.
	Extremities - None.	

CASE 25-2

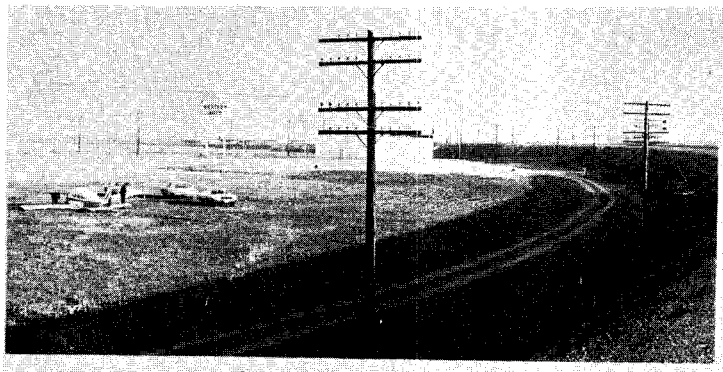


1966 BEECH MUSKETEER

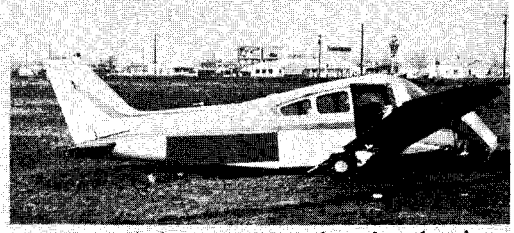
BEECH MUSKETEER A-23, a 1964 model aircraft with pilot and two passengers (R. F. and R. R.), was on a night approach to a runway when the (R) fuel tank ran out of fuel at about 300 feet altitude. An attempt was made to switch to the (L) tank, but the selector was turned past the (L) tank position to "off." The aircraft crashed with (L) wing down and very little forward motion. A heavy vertical impact was encountered. All seat belts were in use and held. No shoulder harnesses were in the aircraft. Occupants were thrown forward, to the left, and down.

ACCIDENT INVESTIGATED BY:
BILL REED AND LEE LOWREY
CAMI

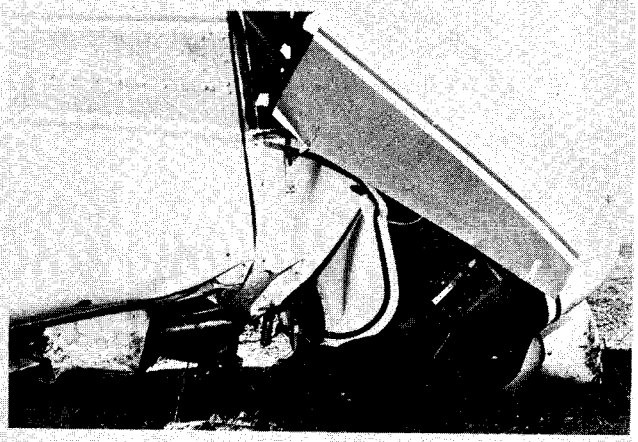
CASE 26-1



A. General view of crash site.

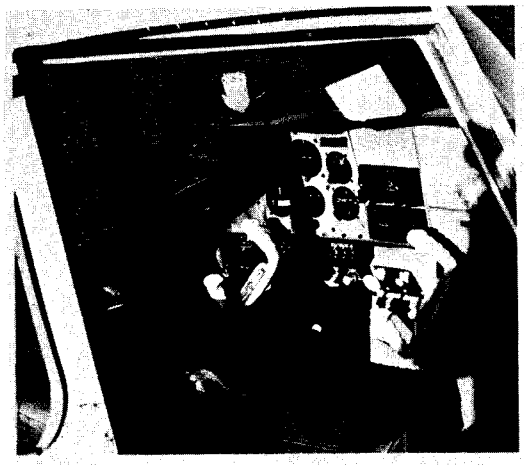


B & C Short 6-foot gouge mark under the aircraft, upward bending of the landing gear, & downward bending of motor all indicate that the aircraft crashed nearly flat with heavy vertical loads.

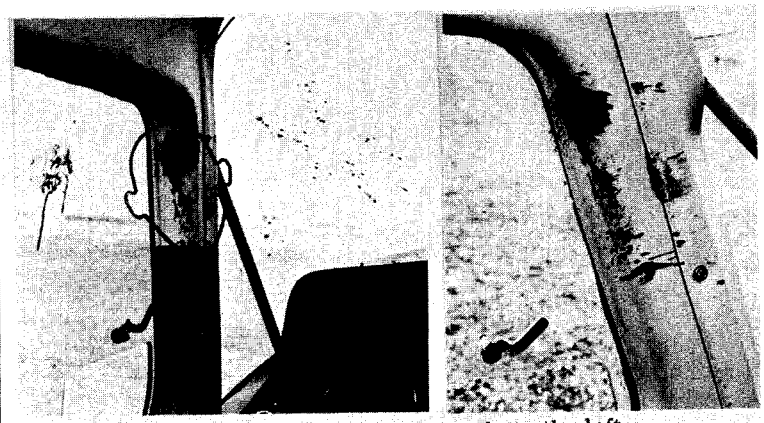


	INJURIES	STRUCTURES IMPACTED
Pilot: (S)	Head - Brain concussion. Lac. scalp.	(L) "A" post.
	Trunk - Fx. L1, bruises.	Rigid seat bottom--no attenuation.
	Extremities - None.	
R. F.: (S)	Head - Brain concussion. Lac. scalp.	Compass & top edge of instrument panel.
	Trunk - Fx. L1.	Rigid seat bottom--no attenuation.
	Extremities - None.	
R. R.: (S)	Head - None.	
	Trunk - None (no vertebral Fx's.	Seat pan of rear seat yielded - light aluminum.
	Extremities - Fx. humerus (R) & (L).	Broken between body & upper seat back.

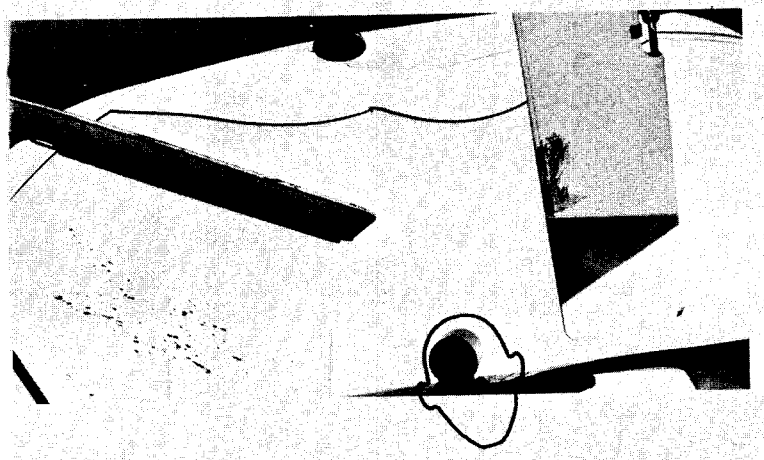
CASE 26-2



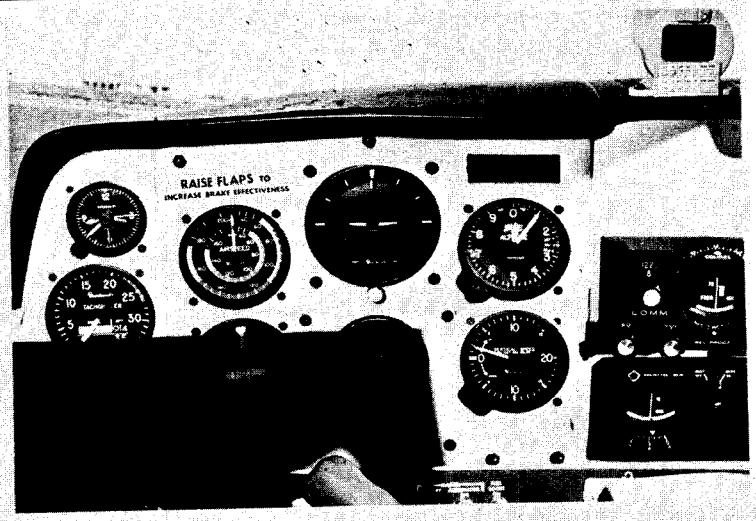
D. Cabin interior.



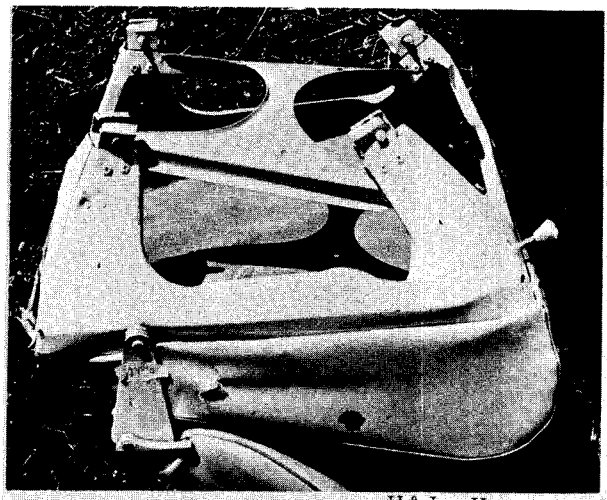
E. Pilot was thrown slightly to the left & his head hit the rigid "A" post.

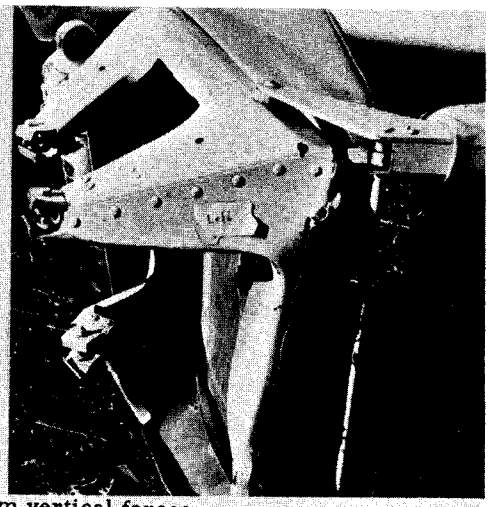


F & G Copilot's head struck compass & top center edge of instrument panel.



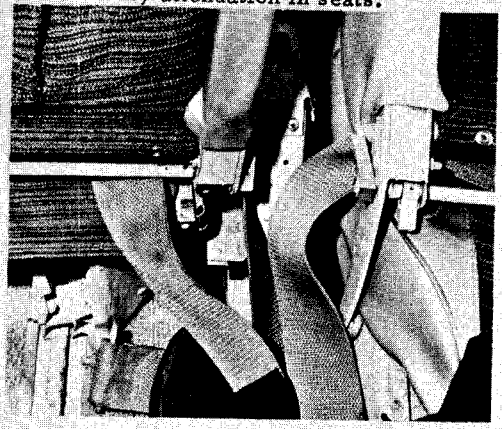
CASE 26-3



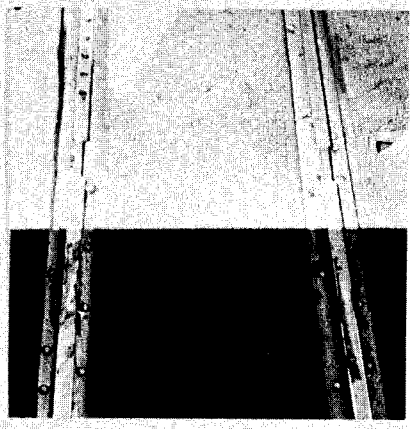


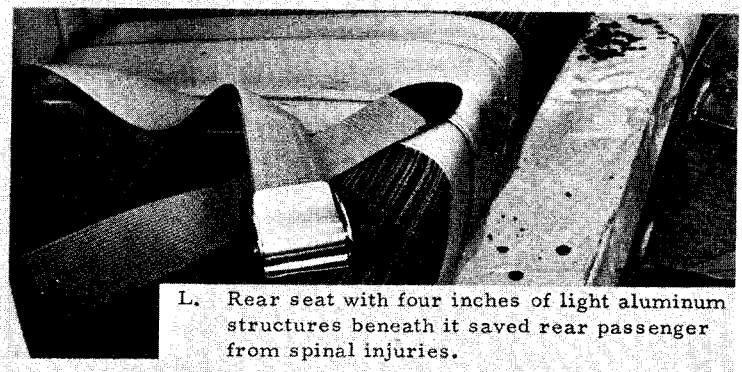
H & I Heavy seat legs buckled from vertical forces. Vertebral fractures could have been prevented by attenuation in seats.

J. Outboard belts fuselage-attached.



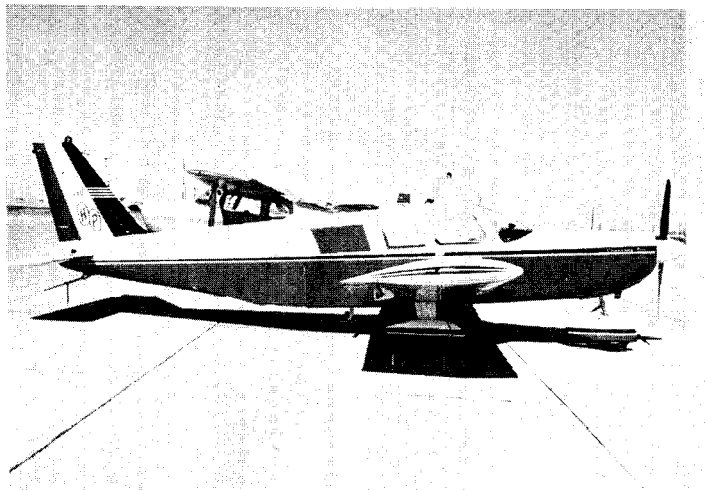
K. Inboard belts attached to floor.

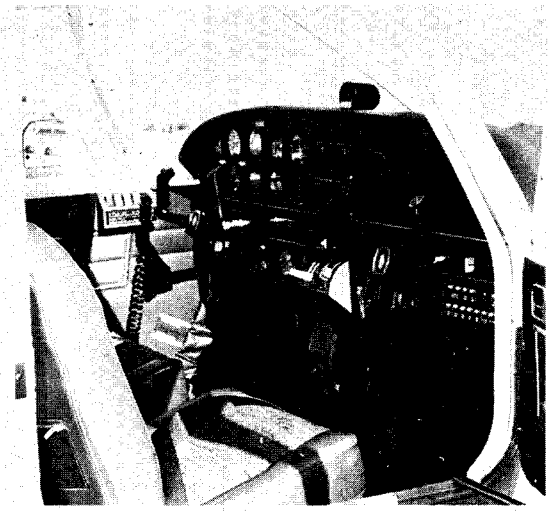




L. Rear seat with four inches of light aluminum structures beneath it saved rear passenger from spinal injuries.

CASE 26-4



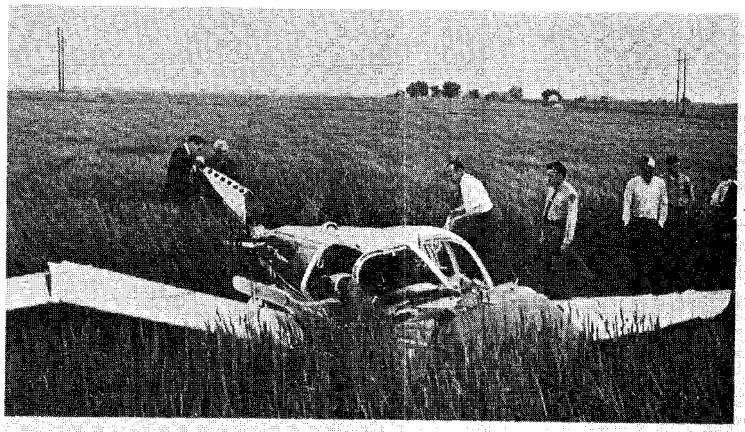


1968 PIPER CHEROKEE "6"

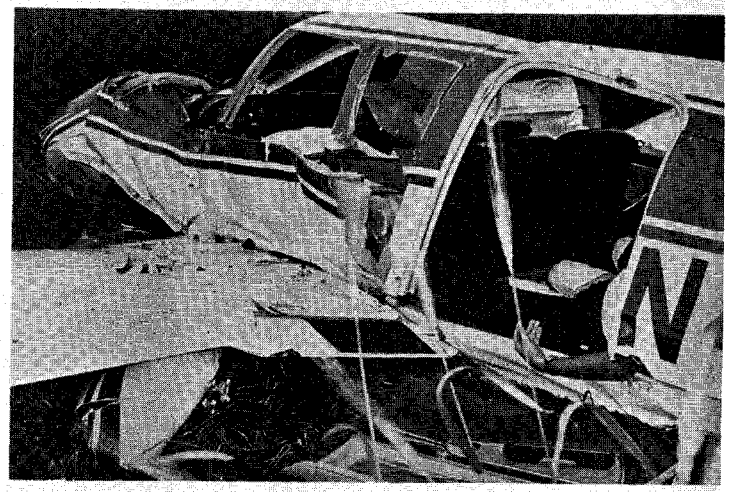
PIPER CHEROKEE 6 PA-32-300, with pilot and five adult passengers (R. F., C. L., C. R., R. L., R. R.) ran out of fuel at night and attempted an emergency landing. Unfortunately, the pilot could not see a power line on which he hooked the vertical stabilizer, causing loss of landing lights and making the aircraft nose up into the air. The aircraft then pancaked to the ground without any forward motion. Seat belts were in use and held. No shoulder harnesses were in the aircraft.

ACCIDENT INVESTIGATED BY:
LEE LOWREY
CAMI

CASE 27-1



A. Aircraft crashed flat in a tall wheat field. Note wheat all around aircraft is undisturbed.



B. Motor is bent downward, landing gear pushed up into wings, instrument panel completely undamaged & rear passenger appears to be sitting flat on the ground.

INJURIES	STRUCTURES IMPACTED
Pilot: (F) Head - Extensive Fx. skull (calvarium & base) with severe brain hemorrhages. Compression Fx's. of cervical vertebrae.	All injuries from vertical impact force against seats, floor & underlying structures. Instrument panel & control wheel were undamaged.
Trunk - Fx's. both clavicles; (R) anterior ribs 1, 2, 3, 4 & 5; (R) post ribs 1, 2, 3, 4, 5, 6, 7 & 8; (L) anterior ribs 1, 2, 3 & 4. Fx. sternum & pelvis (symphysis). Rupture & hemorrhages pulmonary arteries, lungs, kidneys, bladder, vena cava.	Same as above.
Extremities - Fx. (R) femur, (R) & (L) tibia & fibula.	Same as above.
R. F.: (F) Head & Neck: Cerebral congestion without Fx.	Same as above.
Trunk - Rupture & hemorrhages lower lungs, adrenals, kidneys; Fx. both ilium (posterior) with anterior displacement.	Same as above.
Extremities - Fx. (R) upper femur with anterior displacement.	Same as above.
Center & Rear Passengers: (F) No autopsy performed. However, with the total absence of external injuries, it must be assumed that death resulted from similar internal injuries (cerebral hemorrhage, lung rupture, hemorrhage, etc.	

CASE 27-2

C & D Front seat occupants appear to be uninjured & asleep.

CASE 27-3

E & F Views of right front & center seat occupants.

CASE 27-4

G, H & I All occupants have seat belts fastened, appear to be sitting on the ground, & died from severe internal injuries produced by vertical forces.

CASE 27-5

and repaired in time. The author[72] has experienced vertical decelerations of up to 95 "g" for .0075 seconds with internal injuries corrected by surgery. In the same study, all subjects tolerated 220 "g" for .0065 seconds without injury or pain when the test seat was equipped with 4 inches of crushable foam under the seat pan. Judging from the massive internal injuries of the occupants in the crash case being presented here as compared to those for the fall case presented by Snyder, the peak vertical force generated when the seats bottomed out must have been in the range of 5,000 to 6,000 "g". The significant point to be made here is that the seats must not be of a frail design that allows them to crush, using up valuable deceleration distance while dissipating very little of the impact force and then bottom out against rigid structure and producing very high, intolerable "g" forces. Numerous simple methods for gradual vertical deceleration have been devised and are in use on Army helicopters. Use of energy attenuators in the design of the seats of this aircraft would have allowed the six occupants of this aircraft to survive without injury.

IV. Conclusions.

An evaluation of the crashworthiness of current general aviation aircraft has been presented in terms of simple packaging and shipping principles. It is concluded that in most instances these well-known principles have been so grossly ignored that serious and fatal injuries have occurred in anything more severe than a hard landing. Many pilots have remarked that "light aircraft are made for flying and not for crashing" and the selected accidents presented in detail in this report prove their statement to be sadly true. In fact, of all vehicles designed for human transportation, the so-called general aviation aircraft offer the least protection from, and chances of survival in, crash decelerations. Beech Aircraft Corporation has made a sincere effort to build a cabin structure that approaches a sensible shipping container. Other companies have manufactured special purpose aircraft (Piper Pawnee, Cessna Ag Wagon, Grumman Ag Cat and the Helio-Courier) with cabin structures that can withstand 40 "g" impacts without collapsing. Most of the small general aviation aircraft built for passenger transportation are so fragile that they will open up and spill their contents or collapse inwardly in crash decelerations exceeding about 10 "g".

Thirteen of the aircraft described in this report (Cases 4–15 inclusive and 17) sustained crash forces of 10 "g" or less (calculated). These aircraft all crashed in a forward direction and the cabins remained intact to the extent that the author is of the opinion that all occupants would have survived without injury had they been properly restrained with shoulder harnesses and seat belts. Of the 31 occupants, 10 received fatal injuries, and of those that survived, 8 received severe injuries, 8 moderate injuries, and 5 minor or no injuries. Lack of protective design in the instrument panel in these 13 accidents was the direct cause of 5 severe and 2 moderate brain injuries, 30 facial fractures, 11 severe and 10 moderate facial lacerations, 33 fractured bones in arms and legs, and 9 joint dislocations. Poor control wheel design resulted in 7 severe trunk injuries. Further evidence of the lethal construction of the instrument panel is presented in Cases 20, 21 and 22. In Case 20, the aircraft crashed inverted and in Cases 21 and 22 they crashed sideways in such a manner that the occupants did not impact the instrument panel and survived with minor injuries even though the crash forces were considerably greater than those in similar fatal accidents in which occupants were thrown into the instrument panel.

Minor or no injuries occurred in "crashes" of one and two "g" decelerations. Severe but nonfatal injuries were common in 3 to 5 "g" accidents. Fatalities and very severe injuries occurred in crash decelerations of 6 to 10 "g". At 10 "g" and above, most present general aviation aircraft disintegrate to the extent that the value of restraint equipment for crash survival is doubtful. Inasmuch as the Bonanza appears to have about a 25 "g" cockpit and the Piper Pawnee one that can withstand impact forces up to 40 "g", the manufacturers of general aviation aircraft should be encouraged to strengthen cockpit design in all future aircraft models.

Almost 100% of the occupants of the 70 light aircraft accidents investigated to date were wearing seat belts, indicating that people are aware of the need for restraint equipment and are willing to wear it in this type of transportation. However, in most cases, the seat belts and seats themselves are inadequately attached to the

cabin structure and fail or are ineffective even in moderate decelerations.

Even if all seat belts were ideally installed, they would restrain only the pelvis and still would allow the head, trunk, and appendages to continue to flail forward into structures that are so lethal that even minor velocity body impacts are sufficient to rip, tear, and crush body structures. Plexiglass windshields, unpadded "A" posts, rigidly-mounted compasses above the instrument panel, weak control columns that break off to form spears, lethal control wheels, instrument panels loaded with heavy instruments, sharp edges, and protruding knobs, heavy exposed pedal structures, and the lack of slow-return padding, all combine to make the area forward of the front seat occupants extremely unsafe for body impact. The statistics presented at the beginning of this report prove that this environment is so lethal to body impact that your chances of being killed are twice that of receiving serious injury.

The use of properly-designed and installed shoulder harnesses would help prevent impact of the head and upper torso with these structures, but experience has shown that shoulder harnesses have not received the acceptance of the general public. The automatically inflatable air bag looks very promising for use in body restraint and may offer a solution in future general aviation aircraft.

Nothing new in the way of principles or statistics has been presented in this report, but the author hopes that by presenting actual cases revealing structures responsible for specific injuries and showing the extreme severity of these injuries even in minor decelerations, that some action may be stimulated to reduce this needless loss of human life and suffering.

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