NTISUB/E/104-008

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

LAS VEGAS AIRLINES
PIPER PA-31-350, N44LV

LAS VEGAS, NEVADA
AUGUST 30, 1978

NTSB-AAR-79-8

UNITED STATES GOVERNMENT

TECHNICAL REPORT DOCUMENTATION PAGE

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16. Abstract

About 0747 P.d.t., on August 30 1978, Las Vegas Airlines Flight 44, a Piper PA-31-350 (N44LV), crashed in VFR conditions shortly after takeoff from runway 25 at the North Las Vegas Airport, Las Vegas, Nevada. Flight 44 was a charter flight from Las Vegas, Nevada, to Santa Ana, California, with nine passengers and a pilot on board. After liftoff following a longer-than-normal ground roll, the aircraft pitched nose up, climbed steeply to about 400 ft above the ground, stalled, reversed course, and crashed 1,150 ft beyond and 650 ft to the right of the runway. There was no fire. All persons on board the aircraft were killed.

The National Transportation Safety Board determines that the probable cause of the accident was the backed out elevator down-stop bolt that limited down elevator travel and made it impossible for the pilot to prevent a pitchup and stall after takeoff. The Board was not able to determine conclusively how the down-stop bolt jam nut locking device came loose and allowed the stop bolt to back out.

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AIRCRAFT ACCIDENT REPORT

Adopted: June 7, 1979

LAS VEGAS AIRLINES
PIPER PA-31-350, N44LV
LAS VEGAS, NEVADA
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SYNOPSIS

About 0747 P.d.t., on August 30, 1978, Las Vegas Airlines Flight 44, a Piper PA-31-350 (N44LV), crashed in VFR conditions shortly after takeoff from runway 25 at the North Las Vegas Airport, Las Vegas, Nevada. Flight 44 was a charter flight from Las Vegas, Nevada, to Santa Ana, California, with nine passengers and a pilot on board. After liftoff following a longer-than-normal ground roll, the aircraft pitched nose up, climbed steeply to about 400 ft above the ground, stalled, reversed course, and crashed 1,150 ft beyond and 650 ft to the right of the runway. There was no fire. All persons on board the aircraft were killed.

The National Transportation Safety Board determines that the probable cause of the accident was the backed out elevator down-stop bolt that limited down elevator travel and made it impossible for the pilot to prevent a pitchup and stall after takeoff. The Board was not able to determine conclusively how the down stop bolt jam nut locking device came loose and allowed the stop bolt to back out.

1. FACTUAL INFORMATION

1.1 History of the Flight

On August 30, 1978, Las Vegas Airlines Flight 44, a Piper PA-31-350 Navajo Chieftain (N44LV), operated as a charter passenger flight from Las Vegas, Nevada, to Santa Ana, California. The aircraft had been chartered to transport nine Australian tourists from Santa Ana to Las Vegas for a tour of the Grand Canyon and return to Santa Ana.

About 0718, 1/ the pilot filed a visual flight rules (VFR) flight plan to Santa Ana, California, with the Las Vegas Flight Service Station (FSS). At that time, the pilot advised the FSS that he had the current weather for his destination. At 0738, Flight 44 was cleared to

1/ All times herein are Pacific daylight time based on the 24-hour clock.

taxi to runway 25. The flight taxied behind Las Vegas Airlines Flight 22, a charter flight bound for the same destination. At 0744:40, Flight 22 was cleared for takeoff, and at 0746:08 Flight 44 was cleared for takeoff.

Witnesses, who were located in the airport tower and in the airport parking area, stated that the pilot began the takeoff at the beginning of the runway and that the aircraft became airborne at the intersection of runways 25 and 30. Witnesses agreed that the takeoff appeared normal until the aircraft cleared the end of the runway at an altitude of about 100 ft above ground level. At that point, the aircraft pitched up and reached a maximum pitch attitude of 50° to 75°. The aircraft crossed the highway while climbing to an altitude of about 400 ft, 2,000 ft from the departure end of the runway. It then began what witnesses described as a "wingover" or "sudden violent nosedown turn" to the right, recrossed the highway and crashed in an almost level pitch attitude while in a slight right bank and a slight left yaw. Witnesses to the accident were attracted to the aircraft by the high pitch attitude after takeoff. During the posttakeoff maneuver, the engines were reported to be running at a high power setting.

The aircraft crashed about 1 minute after the takeoff roll began; it came to rest in an open field about 1,150 ft past the departure end of the runway and about 650 ft to the right of the runway. The impact heading was 025° magnetic.

The accident occurred during daylight hours at latitude 36°13'N and longitude 115°11'W. The elevation of the wreckage side was 2,207 ft m.s.l.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	1	9	0
Serious	0	0	0
Minor/None	0	0	0

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

None

1.5 Personnel Information

The pilot was properly certificated for the flight. (See Appendix B.)

1.6 Aircraft Information

The aircraft was certificated, equipped, and maintained in accordance with Federal Aviation Administration (FAA) requirements. (See Appendix C.) However, the inspection checklist did not conform to 14 CFR 43. The checklist had been provided by Piper Aircraft Corporation. Las Vegas Airlines purchased the aircraft new from Piper in May 1978.

The maximum allowable takeoff gross weight for the aircraft was 7,000 lbs. The forward center of gravity limit was 126 ins. aft of datum, and the rear limit was 135 ins. aft of datum.

The Safety Board computed the aircraft's weight and balance by using actual occupant and baggage weights and locations, aircraft documents and Piper procedures, the aircraft's proper operating weight and index number, and the actual fuel loading. The resultant takeoff weight was 7,236 lbs and the center of gravity was 134.1 ins. aft of the datum, or 0.9 in. forward of the aft limit.

No evidence was found that the pilot completed a passenger manifest or a weight and balance computation.

1.7 Meteorological Information

The surface weather observations for the McCarran International Airport, Las Vegas, Nevada, were as follows:

0650 - Sky condition--clear; visibility--50 mi; temperature--73°F; dewpoint--29°F; wind--240° at 05 kns; altimeter--29.87 ins.

0750 - Sky condition--clear; visibility--50 mi; temperature--81°F; dewpoint--31°F; wind--260° at 04 kns; altimeter--29.89 ins.

The computed density altitude was 4,100 ft.

1.8 Aids to Navigation

Aids to navigation were not involved in this accident.

1.9 Communications

No communications problems were reported.

1.10 Aerodrome Information

The North Las Vegas Airport is located 4 mi northwest of Las Vegas, Nevada, at an elevation of 2,207 ft m.s.l. The airport has three hard surfaced runways, 7-25, 12-30, and 04-22. Runway 25 was the active runway on the day of the accident. The runway is 5,005 ft long and 100 ft wide. A highway and a powerline cross the end of runway 25 about 900 ft past the departure end.

1.11 Flight Recorders

The aircraft was not equipped nor was it required to be equipped with a cockpit voice recorder or a flight data recorder.

1.12 Wreckage and Impact Information

The aircraft crashed on a heading of about 025° magnetic. The initial impact was about 165 ft from the highway that crosses the end of the runway. After the initial impact, the aircraft bounced and came to rest about 90 ft from that point. (See Appendix F.) Some portions of the aircraft interior were moved by rescue personnel before wreckage documentation was made.

The fuselage was broken at the forward frame of the main cabin door and there was extensive buckling in that area. The fuselage was driven down onto the wing and was buckled around the wing attachment point. The nose of the aircraft was compressed and torn open. The nose baggage door was separated from the aircraft; the door frame was deformed and the hinges were broken. The door locking mechanism was intact and in the locked position. The three cabin doors were intact and attached to their respective hinges. (See figure 1.) The lower fuselage structure and the cabin floor from the rear baggage compartment area forward to the rudder pedals were compressed and buckled.

All control surfaces were accounted for. The rudder trim was found 1/4 in. to the right; the elevator trim tab was 1/2 in. noseup; and the aileron trim was set at zero. All controls moved freely and the cables were still attached. The amount of control surface movement was not determined at the accident site. The landing gear was retracted, and the flaps were extended 15°.

Both wings remained attached to the fuselage. The right wing was buckled. The left wing main spar was broken, and the upper wing skin was torn at a point about 6 ft from the wingtip. The leading edges of both wings, between the engine nacelles and the fuselage, were separated from the wing spar.

Both engines were canted downward about 10° and attached in position. Both propellers were separated from their respective engines. Two of the six propeller mounting studs on the engine crankshaft hub were sheared on each engine. The propeller mounting flanges on both propellers were broken away from the other four studs. The on-site examination of the right engine and propeller disclosed the following: Two of the three propeller blades were in the "feathered" position; the

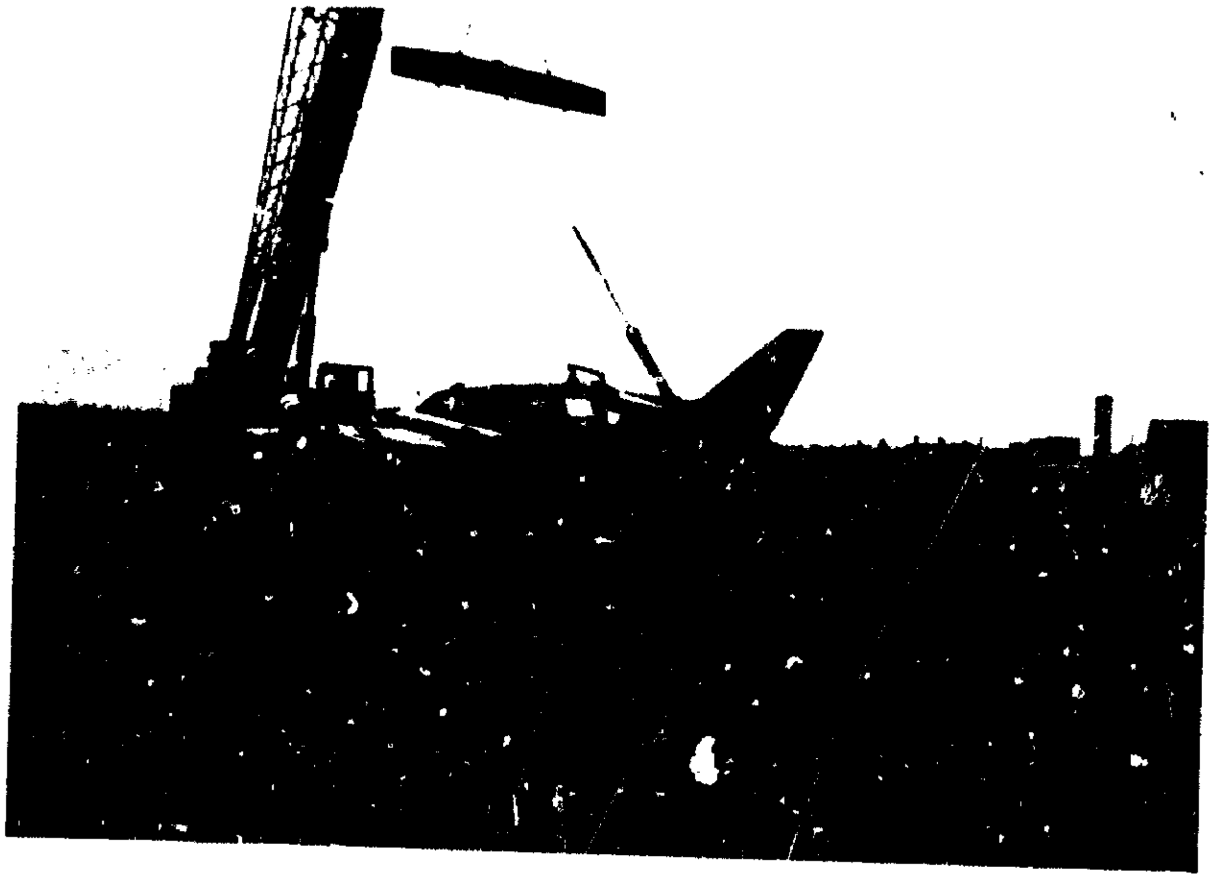

Figure 1. The aircraft when it was lifted initially. Note that the elevator was streamlined.

position of the propeller pitch change rod corresponded to a blade angle at or near feather; the propeller blades had no definitive impact rotational markings; the control lever on the propeller governor was in the "feather" position, and the firewall fuel shutoff valve control was in the "off" position. There was no evidence to indicate that the left engine had been shut down before the accident. Both engines and propellers were removed for further examination.

1.13 Medical and Pathological Information

An autopsy of the pilot revealed no evidence of preimpact incapacitation. All persons had sustained multiple fatal injuries. Common injuries to the passengers were: Crushed chests, lower extremity fractures, and upper extremity fractures. The medical examiner's report on the pilot stated:

> "The right coronary artery and the left anterior descending artery show severe eccentric arterio-sclerotic plaque formation. Both show 80% to 90% occlusion at various points. There is focal calcification in the left anterior descending artery. The left circumflex artery shows very minor sclerotic change. The myocardium shows no evidence of fibrosis or recent infarct."

An examination of the pilot's medical records disclosed that on March 29, 1978, he received a second-class medical certificate from the Nellis Air Force Base Clinic. It contained the following limitation: "Holder shall possess corrective glasses for near vision while exercising the privileges of his airman certificate." His near vision was reported to be 20/100. On April 3, 1978, the pilot received a first-class medical certificate from a civilian medical examiner. This medical certificate contained no limitations. His near vision was reported to be 20/20. No explanation could be found for the two visual acuity findings. The Airman Records Section of the Federal Aviation Administration did not discover the discrepancy before the accident.

1.14 Fire

There was no fire.

1.15 Survival Aspects

Although the occupiable area of the aircraft remained relatively intact, with a static reduction in cabin height of about 7 ins., and the intact cabin kept all occupants from being thrown from the aircraft, the accident was not survivable. Impact forces were excessive and exceeded human tolerances to vertical deceleration.

Positive restraint was maintained throughout the crash for 8 of the 10 occupants. The two rear seats broke free from the floor structure, allowing one of the occupants to be thrown forward. The other occupant of a failed seat remained restrained to the seat.

The wreckage location permitted rescue personnel to arrive at the accident site within minutes; however, all of the occupants of the aircraft were dead when assistance arrived.

1.16 Tests and Research

1.16.1 National Aeronautics and Space Administration Crash-Injury Study

Since all persons were killed even though the aircraft essentially stayed intact and there was no fire, the Safety Board requested that NASA conduct a crash-injury study of the accident aircraft. Data from Piper Navajo controlled crash tests were compared with the actual accident data to determine crash survivability.

Witness observations disclosed that the aircraft reached an altitude of about 400 ft before it pitched downward and descended at a steep angle. At impact, the aircraft's attitude was slightly nose up, with a slight roll to the right, and a slight left yaw. The aircraft bounced at impact and traveled about 80 ft in the air before coming to rest about 90 ft from the original impact point. The second impact was slightly nose down.

The interior measurements of the cabin, taken at the main spar, showed a 5-in. lateral expansion and a 7-in. reduction in the ceiling height. NASA test data showed that the actual change of ceiling height at impact was probably much greater than 7 ins., but the flexibility of the structure was such that little permanent compression remained.

The cabin floor structure was extensively damaged. The floor was most severely crushed under the front legs of all seats. In none of the NASA tests was floor damage as extensive as in the accident aircraft.

The pilot seats remained attached to the aircraft structure; however, both seats were bent forward about 30°. The first three rows of passenger seats also remained attached to the aircraft structure. These seats were found bent forward, to the right, and downward. The front legs on four of the seats had collapsed. The two rear seats broke free from the floor during the crash. Both of these seats were extensively damaged.

Data from a NASA crash test with impact parameters similar to the accident aircraft impact showed that an test dummy located in the third row of seats experienced 62 vertical g's, 40 longitudinal g's, and 15 transverse g's with a pulse duration of about .06 sec. From these data, NASA calculated that the peak pelvic accelerations experienced by the passengers in the third row of seats were greater than those measured on the test dummy. The maximum human tolerance limit without injury for downward acceleration is about 15 g's for a duration of 0.1 sec. 2/ Thus, the impact vertical g was at least four times greater than human tolerance without injury and would not be survivable.

1.16.2 Powerplants and Propellers

The Safety Board examined the engines at Hagelin Aircraft Motors, Long Beach, California. There was no evidence to indicate that the engines had malfunctioned or had experienced overspeed before the impact.

The propellers were examined at Hughes Aircraft, Las Vegas, Nevada. Propeller blade positions were determined to be unreliable because of broken pitch change knobs. Additionally, there were no blade hub markings to provide any reliable indications of blade angles at impact.

Marks on a right engine baffle plate, installed behind the propeller governor control lever, showed that the control lever had moved from its normal governing position to the feather position at impact.

2/ Dynamic Science Engineering Operations, "Crash Survival Design Guide," U.S. Army Air Mobility Research and Development Laboratory Technical Report, 1971, U.S. Army, Page 19.

The firewall fuel shutoff valve was found three-quarters open, and damage to its operating lever indicated that it had been fully open before impact.

1.16.3 Control Cable Routing

Because of a recent occurrence of control cable binding in a PA-31-350 Chieftain, the Safety Board conducted an extensive examination of the elevator control cables and turnbuckles between aircraft fuselage stations 76.0 and 86.50. A 4-ft section of the floor between the two stations was removed from the aircraft for the examination. A microscopic examination of the control cables, the turnbuckles, and the bulkhead lightening holes through which the cables travel did not reveal any evidence of cable rubbing or binding.

1.16.4 PA-31-350 Takeoff Performance

A performance study of N44LV's takeoff was conducted to identify the differences between expected takeoff performance and the aircraft's reported takeoff performance.

The study showed that under the accident conditions the aircraft should have had a takeoff ground run of 2,000 ft, 1,200 to 1,400 ft shorter than the accident aircraft's 3,200 ft to 3,400 ft takeoff run. The two-engine rate of climb for the density altitude of 4,100 ft should have been 1,275 fpm. This results in a climb gradient of 120 ft of altitude for each 1,000 ft of ground distance. The two-engine climb angle was calculated to be 6° at an airspeed of 113 kns with a normal pitch attitude of 13°. The aircraft would not have had any positive single-engine climb capability with 15° flaps at a density altitude of 4,100 ft.

N44LV's actual takeoff performance differed from its expected performance. According to witness statements, the aircraft pitch attitude at liftoff was normal; however, shortly after liftoff the aircraft started a pitchup which resulted in a maximum pitch attitude at the top of the climb of about 50°. At the top of the pitchup maneuver, the aircraft reached an altitude of about 400 ft at a distance of about 3,200 ft from its liftoff point. At the top of the pitchup, the aircraft rolled rapidly to the right and entered a steep dive. (See Appendix D.) The accelerate-stop distance was determined to be 2,625 ft, based on maximum braking beginning at 78 kns.

Because the accident aircraft had an excessively long takeoff roll and entered a steep climb after takeoff which resulted in apparent loss of control, the Safety Board requested that the FAA and Piper Aircraft Corp. conduct a limited flight test. The October 6, 1978, flight test included an investigation of: (1) The long takeoff roll, (2) the relationship between altitude gained and distance traveled for several different rotation angles, (3) pitch angle vs speed to find the altitude gained before a stall, and (4) the effect of full noseup trim on takeoff performance. The tests were performed at the accident aircraft gross weight and at a center of gravity 2 ins. forward of the accident aircraft's. (See Table 1.)

TABLE 1.--FLIGHT TEST RESULTS

Run Number	1 2 takeoffs Results averaged	2	3	4 2 takeoffs Results averaged
Rotation angle	10°	7°	4°	0° @ 3,300 ft
Speed at 3,100 ft (kns)	89	93	98	100
Speed at 5,000 ft (kns)	96	103	115	--
Altitude at 3,100 ft	100	70	40	0
Altitude at 5,000 ft	270	220	100	--
Rotation speed - (kns)	80	80	88	--
Liftoff speed - (kns)	81	83	90	102 @ 3,300 ft
Gear-up initiation - (kns)	85	87	95	--
Gear-up completion - (kns)	90	92	102	--
Time @ 3,100 ft - (sec)	26	27.3	27.4	23
Time @ 5,000 ft - (sec)	43	43	40.2	--
Pitch angle at abort point	--	--	--	30°
Speed at abort point (kns)	--	--	--	85
Altitude at abort point (ft)	--	--	--	320
Time at abort point	--	--	--	--
Distance at abort point (ft)	--	--	--	5,000
Weight (lbs)/c.g. (ins.)	7,260/132	7,190/132.1	7,160/132.2	7,060/132.2

Four flight tests were flown. Run No. 4 closely approximated the accident aircraft flight profile. The airspeed corresponding to the reported accident takeoff distance of 3,200 to 3,400 ft was found to be 102 kns. During this run, the test aircraft rotated with no pilot input and lifted off with the control wheel and the elevator trim fixed at neutral. The time required to accelerate to rotation and liftoff was 23 sec. Control wheel position and elevator trim were maintained at the fixed neutral position after takeoff. After the aircraft lifted off, it pitched up unexpectedly at an acceleration rate of 2° per second and reached a pitch attitude of 30° at an altitude 320 ft above the end of the runway at a distance 5,000 ft from the beginning of the takeoff roll. During this maneuver, the landing gear was extended, the flaps were in the takeoff position, and engines were developing maximum continuous power. The FAA test pilot noted that the sudden pitchup maneuver demanded his attention to the point where retracting the landing gear was not accomplished. He also stated that at the peak altitude, the noseup pitch rate, the rate of climb, and the airspeed were decreasing. Recovery was initiated at 85 kns, and 320 ft above the ground, because no altitude would be lost during a recovery at that speed. An estimated 25 lbs of push force was required to recover from the pitchup maneuver. The test pilot recommended that if further tests were required, the installation of a spin recovery parachute would be necessary.

The acceleration runs with full noseup trim showed that the elevator floated to a neutral position by 50 kns and to a 1/2-in. noseup position by 60 kns. The test pilot believed that a pilot would recognize a mistrim condition at 50 to 60 kns when the nose began to pitchup. He said that if immediate corrective action was not taken, the aircraft would self-rotate by 65 to 70 kns and would lift off at 70 to 75 kns. The aircraft's minimum control speed is 78 kns.

1.16.5 Elevator Down Stop Examination

After the aircraft was removed from the accident site, the elevator down stop was found backed-out from its normal position. On February 12, 1979, a metallurgical examination of the torque arm and the elevator hinge assembly was conducted at Denver Research Institute, Denver, Colorado, to determine whether the bolt had backed out before or after the aircraft crashed. The examination disclosed:

1. Total movement of the hinge assembly from full up to full down was 17.5°. (See Figure 2.) Total movement recorded at the time of manufacture was 36° (16° up and 20° down).

2. The down-stop bolt measured 0.863 in. from the top of the bolt head to the base of the hinge assembly block. (See figures 3 and 4.)

3. The threads on the down-stop bolt, which had been within the hinge assembly block, contained smeared metal. The metal was smeared in a direction consistent with an impact to the head of the down-stop bolt. (See figure 4.)

4 The head of the down-stop bolt was bent as if it had been struck by a slightly off-center blow to the longitudinal axis. (See figure 4.)

5. The area on the torque tube arm where the down-stop bolt had been striking had seven separate impact marks. The design of the assembly is such that the bolt strikes the torque arm at a different position depending on the length of the bolt extension. The farthest outboard impact was also the deepest and aligned with the length of the bolt as it was found. (See figure 5.)

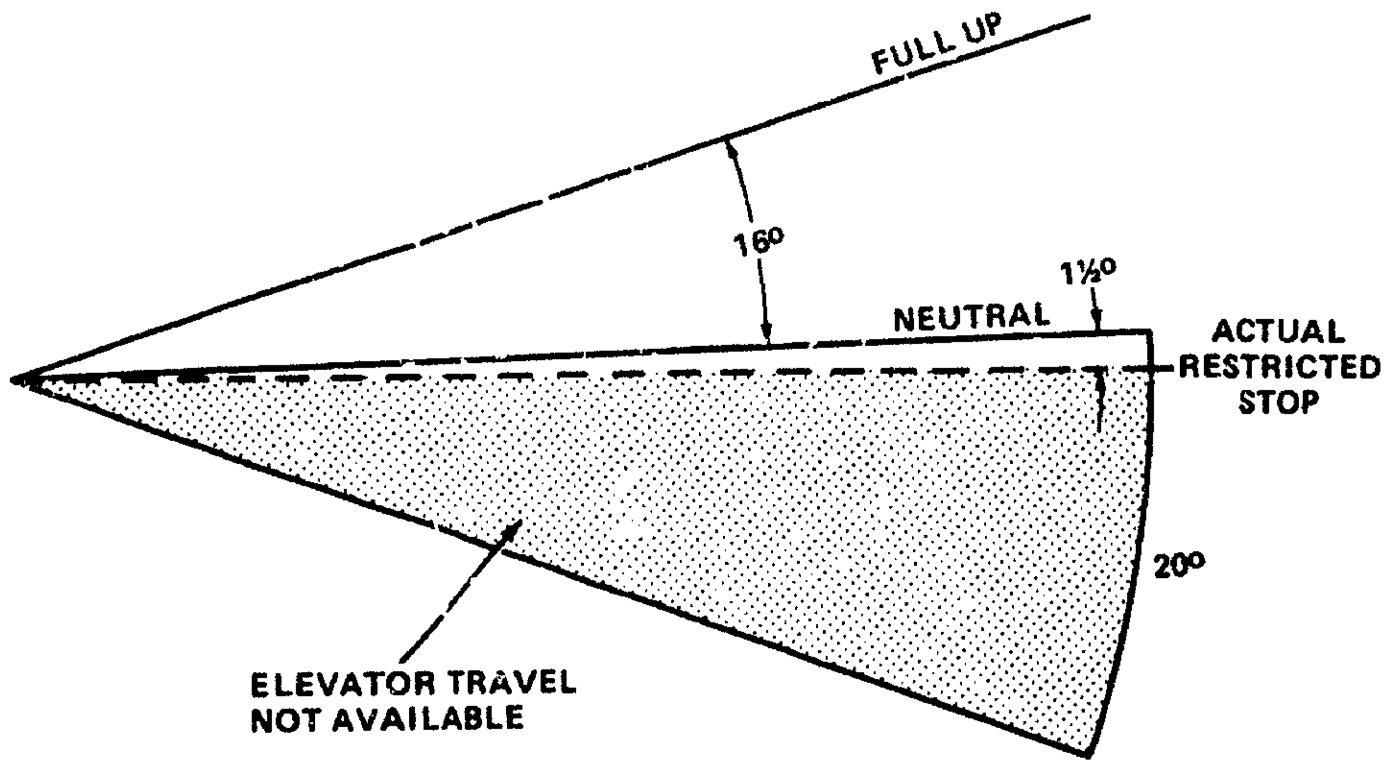

Figure 2. Elevator down travel restriction resulting from backed out down stop.

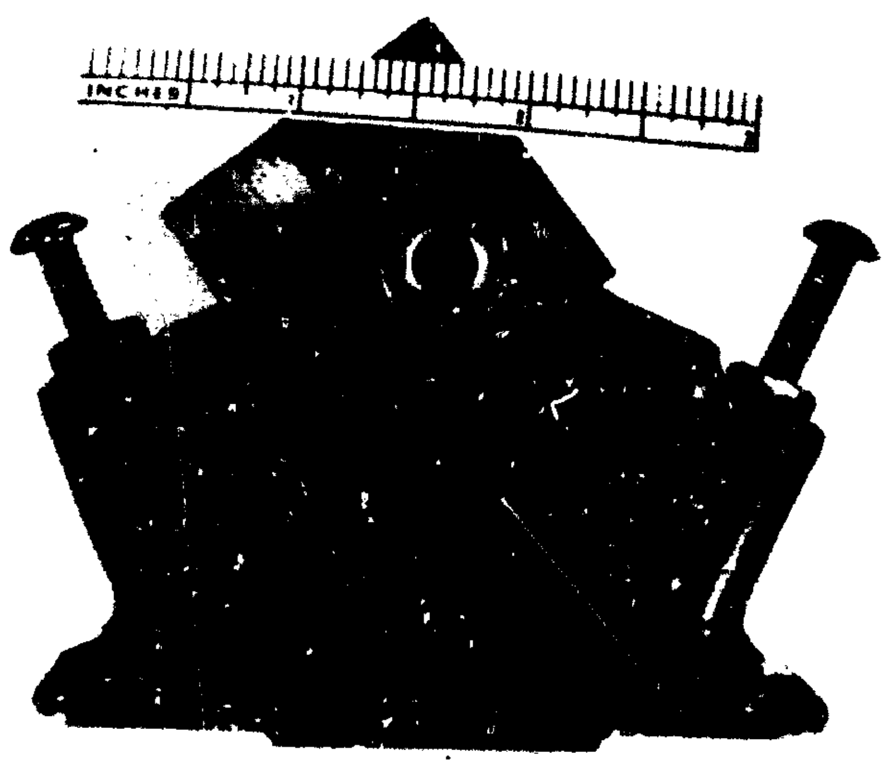

Figure 3. Elevator hinge assembly as found after the accident.

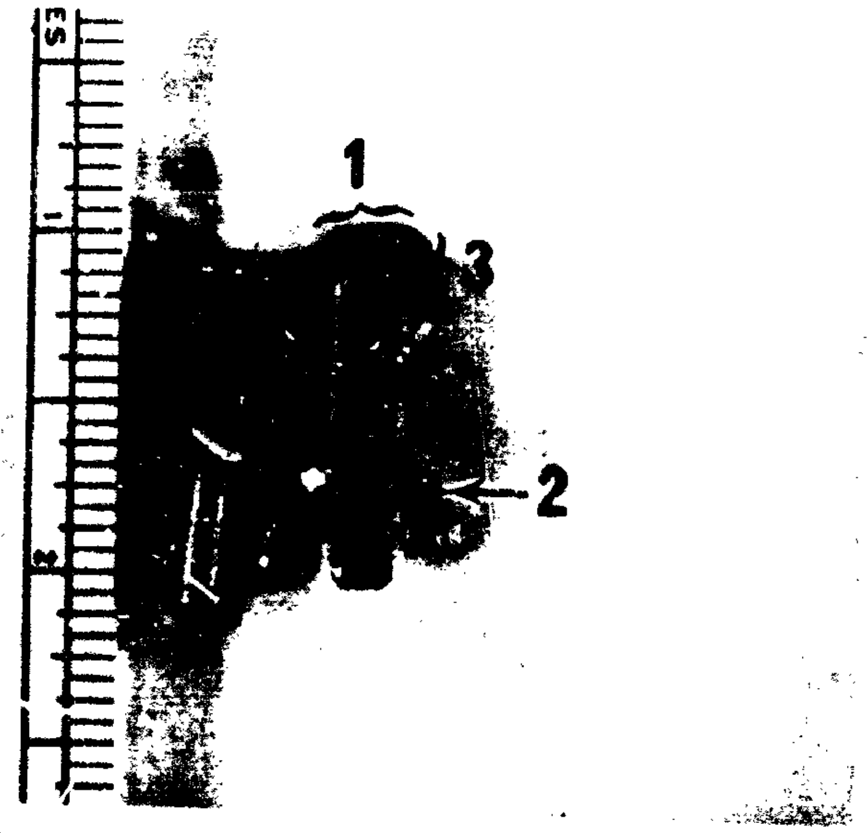

Figure 4. Up elevator stop and down elevator stop 1) Bent head of down-stop bolt, 2) Jam nut location as found, 3) Overspray from aircraft paint.

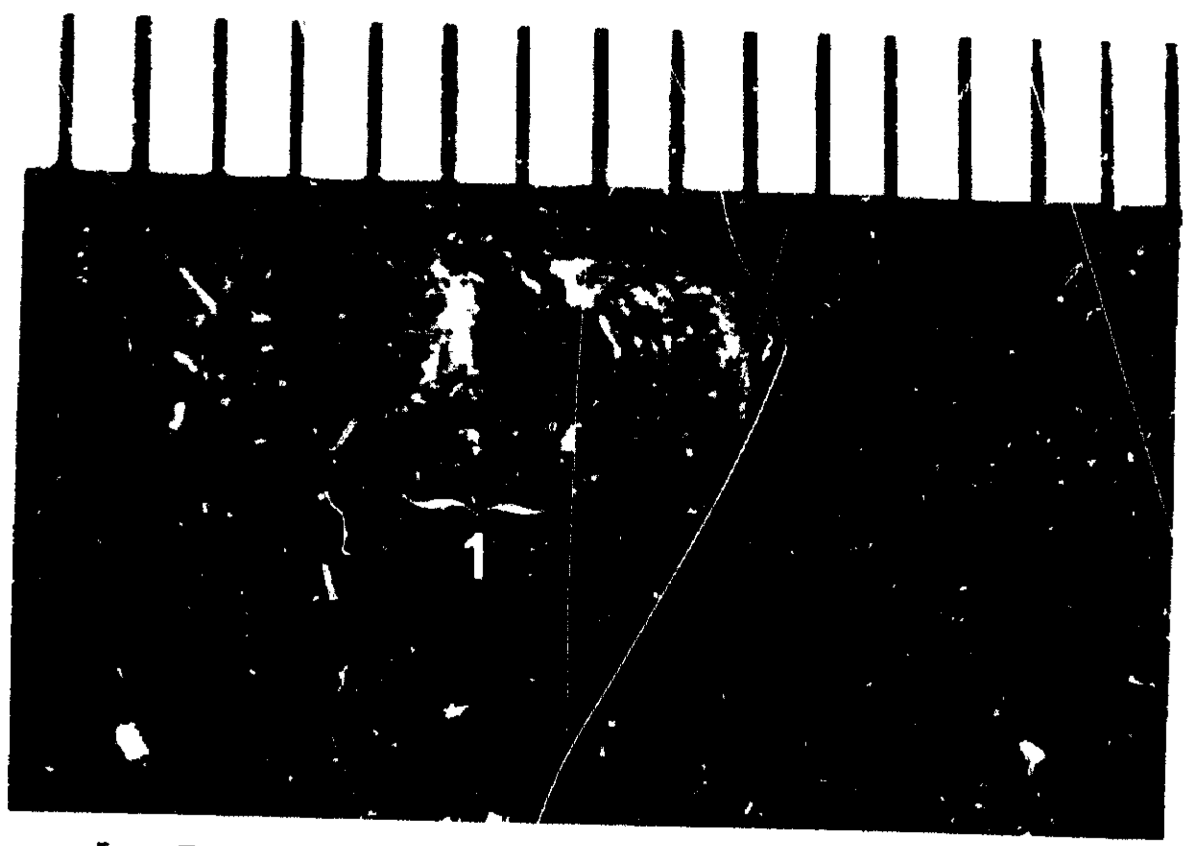

Figure 5. Torque arm multiple impact marks 1) Deepest mark aligned with bolt extension.

1.16.6 Special Investigation of Elevator Stop-Bolt Installation

A special investigation of the elevator down-stop bolt installation was conducted at the Piper Aircraft Corp. plant at Lakeland, Florida. The following items were explored:

1. The quality-control program at the Piper plant to insure that new aircraft leaving the factory are rigged properly.

2. The Piper Programmed Inspection Program to determine at which point during the inspection cycle a mechanic could be expected to check the elevator for proper installation and operation.

3. The elevator rigging of an in-service aircraft to determine if an elevator restriction of the magnitude found on the accident aircraft could be detected during a normal pre-flight inspection.

The investigation determined that:

1. The final quality control inspection of the elevator rigging is done during the manufacturing cycle when the elevator is fitted to the aircraft. Once the inspection has been completed, the control stop jam nut is tightened and a torque seal compound is placed on the nut to mark its position. Although the standard torque for the jam nut should be 12 to 15 in. lbs., a torque wrench is not used to tighten the nut. The final elevator rigging for the accident aircraft was completed on April 17, 1978. During production flight testing, the elevator rigging was not adjusted.

2. The Piper Programmed Inspection Manual does not have a specific inspection item that requires a mechanic to check the elevator controls for improper installation and improper operation as specified in Appendix D of 14 CFR 43. The company indicated, however, that several inspection items require a mechanic to perform maintenance in the area of the control stops and at that time he would be able to see if the stops were backing out.

3. The aircraft used for the FAA flight test was examined. When the aircraft was static, an elevator bungee spring kept the elevator resting against the down stop. In this condition, a properly rigged down elevator would be readily recognized when compared

with an elevator restricted to a 1 1/2° down deflection. However, when the elevator was restricted to provide only 1 1/2° of downward deflection, the curvature of the horizontal stabilizer gave the appearance that the elevator was deflected more than 1 1/2° when viewed from the rear of the aircraft. This could mean that during preflight a pilot could fail to detect a misrigged elevator.

An examination of control wheel position as an indicator of proper elevator rigging showed that when properly rigged, the control wheel was extended 4.65 ins. from the instrument panel. When the elevator travel was restricted to 1 1/2° of movement, the control wheel position was 8.1 ins. from the instrument panel. The difference in control wheel position did not inhibit access to the pilot seat, and since there was no elevator position indicator in the cockpit, the pilot could not determine the position of the elevator relative to control wheel position.

Markings on the elevator torque arm at the normal position and with the stop bolt backed out duplicated the impact markings found on the accident aircraft.

1.16.7 Effect of Elevator Down Stop on Aircraft Controllability

The Safety Board requested that Piper Aircraft determine the effect of the restricted elevator travel on the longitudinal controllability of the PA-31-350 Chieftain during takeoff, climb, and recovery from a stall. Electric pitch trim performance data were also requested. In order to determine the controllability, Piper conducted flight tests in February 1979 using the accident aircraft gross weight and c.g. conditions.

With gear down and flaps set at 15°, at the accident gross weight and c.g. conditions, and using maximum thrust determined in the Piper flight tests of February 2, 1979, the elevator deflection required for takeoff was 2.8° trailing edge down. This value exceeded the maximum 1.5° deflection available to the accident aircraft. In these tests the longitudinal controllability was determined for stall speed. The Piper results showed that recovery from a stall back to trim speed required a 3 to 5 lb push force by the pilot to depress the nose 10° below the horizon. The altitude used to recover was 260 ft. This push force would require more than the 2.8° takeoff trim elevator travel in the amount equivalent to 3 to 5 lbs. This expectation was confirmed in one of the tests in which Piper determined that a 1.5-lb push force developed an elevator deflection of 3.2° trailing edge down. The required elevator deflection would be expected to be greater than

2.8° with gear up, the accident climb condition, because of the stabilizing influence of the gear caused by the drag force located below the vertical center of gravity. The elevator trim setting during the test represented 76 percent of the available trim measured from full noseup. The Piper tests were conducted both with gear down and flaps 0° to 15°, and with gear up and flaps up. Therefore, it was not possible to determine the effects of gear retraction on the amount of elevator required. The effect of flaps was negligible when the elevator tab was trimmed full aircraft noseup.

The electric trim rate tests showed that 32.5 sec were required to trim the aircraft from a full noseup to a full nosedown setting. This equates to an 8-sec interval between neutral trim (FAA tests) and three-quarter trim (Piper tests). Trimming the trim wheel manually would reduce the 8-sec interval to slightly less than 3 sec.

In addition, the time required to retrim from full noseup to the takeoff setting would be 24 sec, almost the length of time used in the accident aircraft's estimated takeoff roll of 3,200 ft.

1.17 Additional Information

1.17.1 Excerpts From CAR 3

3.340 Stops. All control systems shall be provided with stops which positively limit the range of motion of the control surfaces. Stops shall be so located in the system that wear, slackness, or take-up adjustments will not appreciably affect the range of the surface travel. Stops shall be capable of withstanding the loads corresponding to the design conditions for the control system.

1.17.2 Excerpts From 14 CFR 23.675 Stops

(a) Each control system must have stops that positively limit the range of motion of each movable aerodynamic surface controlled by the system.

(b) Each stop must be located so that wear, slackness, or takeup adjustments will not adversely affect the control characteristics of the airplane because of a change in the range of surface travel.

(c) Each stop must be able to withstand any loads corresponding to the design conditions for the control system.

1.17.3 Excerpts From 14 CFR 43.15 Additional performance rules for inspections.

(c) Annual and 100-hour inspections. (1) Each person performing an annual or 100-hour inspection shall use a checklist while performing the inspection. The checklist may be of the person's own design, one provided by the manufacturer of the equipment being inspected or one obtained from another source. This checklist must include the scope and detail of the items contained in Appendix D to this part and paragraph (b) of this section.

1.17.4 Excerpts From FAA Western Region Air Taxi System and Procedures Management Manual July 1976

PROCEDURE FOR COMPUTING AIRCRAFT LOAD CONDITION:

Unless the pilot in command knows without doubt that a particular loaded condition is well within the weight and balance operating limitations of the specific aircraft, due to the limited number of passengers and/or weight of cargo, he must compute the loaded condition before each flight.

1.17.5 Excerpts From Las Vegas Airlines Operations Manual

WEIGHT AND BALANCE PROCEDURES:

The PIC will fill out a loading manifest for all commercial flights, unless he knows, without doubt, that weight and balance conditions are within limits. Actual or declared weights will be used.

1.17.6 Excerpts From Piper Pilots' Operating Manual Pre-Flight Procedures

f. Empennage

4. Elevator Free and Condition

OPERATING TIPS

The following Operating Tips are of particular value in operation of the Navajo:

1. Learn to trim for takeoff so that only a very light back pressure on the wheel is required to lift the airplane off the ground.

2. The best speed for takeoff is about 90 MPH under normal conditions. Trying to pull the airplane off the ground at too low an airspeed decreases the controllability of the airplane in the event of engine failure.

TAKEOFF AND CLIMB

"At a minimum speed of 76 KIAS, rotate the airplane from the ground. Trying to lift off at too low an airspeed decreases controllability in the event of an engine failure. If the airplane has been properly trimmed, only a light back pressure on the control wheel will be necessary to lift the airplane from the ground. Before airspeed reaches 128 KIAS, retract the landing gear. Accelerate to barrier speed (100 KIAS); then retract the wing flaps."

"Upon reaching an altitude of 500 feet above ground level, apply climb power by setting the throttles to 38 inches Hg. manifold pressure and the propellers to 2400 RPM. Lean the mixture to a minimum fuel flow of 27 gallons per hour at a maximum exhaust gas temperature of 1500°F and maximum cylinder head temperature of 475°F. Adjust cowl flaps as necessary to maintain engine temperatures within limits."

RIGGING

"Although the fixed flight surfaces on the Navajo cannot be adjusted in position for rigging purposes, it may be necessary on occasion to check the position of these surfaces. The movable surfaces all have adjustable stops as well as adjustments on their cables or push-pull connections so that their range of movement can be altered. The positions and travels of the various surfaces are as follows:

1. Elevator: 16° up, 20° down, ±1° (relative to rudder)."

1.17.7 Las Vegas Airlines Takeoff Procedures

The following takeoff procedure is taught and used by Las Vegas Airlines. It is a modification of the procedure outlined in the Piper PA-31-350 Pilots Operating Handbook.

1. Apply maximum power.
2. Rotate the aircraft at or above 80 knots.
3. Take off at 90 knots and raise the gear as soon as possible.
4. Retract flaps from 15 degrees at 100 knots.
5. Accelerate to and climb at 140 knots.
6. At 400 feet above ground level reduce to climb power and continue normal climb.

1.17.8 Excerpts From Piper Aircraft Inspection Report (Checklist) 3/

"INSPECTION REPORT

THIS FORM MEETS REQUIREMENTS OF FAR PART 43

Make	Model	Serial No.	Registration No.
NAVAJO CHIEFTAIN	PA-31-350		

Circle Type of Inspection (See Notes 1,2,3)

50 100 500 1000 Annual

DESCRIPTION	L	R	50	100	500	1000
* * * *						
D. CABIN GROUP						
10. Check Control wheels column, pulleys, and cable for condition and operation				0	0	0
E. FUSELAGE AND EMPENNAGE						
1. Remove inspection plates and panels . .				0	0	0
* * * * *						
21. Check horizontal stabilizer and elevator surfaces for damage			0	0	0	0
22. Check elevator and tab hinges, horns and attachments for security, damage and operation (See Note 16)				0	0	0
23. Check horizontal stabilizer attachments						
24. Check elevator and tab hinge bolts and bearings for excess wear				0	0	0
25. Check elevator balance weight for security				0	0	0
26. Check elevator trim mechanism condition and operation				0	0	0
27. Check elevator balance spring tension. (Refer to Service Manual Section V). .			0	0	0	0
28. Check aileron, rudder, elevator cables, all trim cables for correct tension and condition, turnbuckles, guides, and pulleys for safeties, damage and operation				0	0	0
29. Clean and lubricate elevator and rudder trim drum screw					0	0

3/ The same checklist items are contained in the Piper Navajo Series PA-31-31P-31-350 Programmed Inspection Manual.

1.17.9 Elevator Down St[illegible] Service Difficulty Reports

PA-31's

A review of the FAA Service Difficulty Reports pertaining to the PA-31 disclosed three cases where elevator down stops were discovered backed out to a point where elevator deflection was affected. All of the cases were reported after the Las Vegas Airlines accident.

1. November 29, 1978; aircraft total time--444 hours: The pilot experienced control problems and made an unscheduled landing. A down elevator stop bolt was found backed out.

2. December 18, 1978; aircraft total time-- 13 hours: When the new aircraft arrived from the factory no elevator down movement was observed. Inspection found the down elevator stop bolt backed out with the factory installed inspection seal in place.

3. January 3, 1979; aircraft total time-- 1,429 hours: Elevator down stop bolt was found loose and backed out causing loss of down elevator authority.

Similar Installations

During the investigation the Safety Board discovered that the same type of control stop design used on the PA-31 is used widely by several general aviation manufacturers. A review of the FAA Service Difficulty Reports for all general aviation aircraft types disclosed the following cases where elevator control stops had backed out.

1. April 29, 1974; type of aircraft--PA-28-140: The elevator up stop was found loose and backed out.

2. May 2, 1976; a Cessna 337: The elevator controls jammed in neutral. An inspection found a stop bolt and nut separated from the aircraft.

3. January 5, 1976; a Beech 58: The elevator down travel was found to be 6° instead of 15°. The factory-installed slippage mark was intact. (Total time--36 hrs.)

4. January 22, 1979; a PA-32-300: The pilot encountered forward control problems with a 500-ft/min climb. He made an unscheduled landing and found elevator stop bolts loose and one backed out 1/4 in. (Total time--445 hrs.)

1.17.1 Certification Requirements for Aircraft Handling Qualities

Civil Air Regulation 3 specified the longitudinal static stability and control requirements that must be demonstrated during certification flight tests. The stick force versus velocity, or stick-free stability, requirements must be demonstrated at maximum gross weight and at the aft c.g. limit during climbs, using 75 percent maximum continuous power. Review of the Chieftain Type Inspection Report revealed that at these conditions, the aircraft met the stable stick force requirements. A pull force of about 4 lbs was required to decelerate to 90 kns from the trim speed of 105 kns. This equates to a gradient of about 1.6 lbs per 6 kns of speed change. The gradient for acceleration above trim speed was slightly higher at 1.8 lbs per 6 kns.

The effect of 100 percent power, the power used during initial climb, on stick-free stability is known to be destabilizing. The certification process does not require that stability be demonstrated at this higher power. Therefore, it was not possible to evaluate the stability at the higher power.

The certification requirements for longitudinal control determines if satisfactory longitudinal control is available in a climb to pitch the nose downward from a stall back to trim speed. The tests were accomplished using maximum power, maximum gross weight and full aft c.g., and gear and flaps extended. The Type Inspection Report results indicated that the Chieftain met the "satisfactory" requirements and that 300 feet of altitude was required to recover from the stall. However, the data did not show the amount of elevator travel required to recover from the stall.

1.18 New Investigative Techniques

None.

2. ANALYSIS

The aircraft was certificated, equipped, and maintained according to applicable regulations. Meteorological conditions were excellent and did not adversely affect the flight.

The pilot was properly certificated and had received the training and off-duty time prescribed by applicable regulations. There was no evidence of a medical problem that might have affected his performance. Although the pilot had severe arteriosclerosis, no evidence was found to suggest that he had suffered a heart attack before the accident impact. This is the third recent incident where vision discrepancies were not detected by the FAA when screening physical report forms. Because of the Safety Board's concern regarding the continuing irregularities with airman medical certification, and because the Civil

Aeromedical Institute's review of the medical certification process has not detected such irregularities, the Safety Board wishes to reiterate its Safety Recommendation, A-79-40, which was issued to the Federal Aviation Administration on June 5:

> "Develop improved procedures to enhance the quality control function of the Civil Aeromedical Institute with respect to its capabilities for detecting physical disabilities in airmen and performance deficiencies of Aviation Medical Examiners. (Class II - Priority Action) (A-79-40)"

Based on available evidence, the Safety Board concludes that the airframe and powerplants were not factors in the accident. Soft terrain, low forward speed, high sink rate, sudden propeller stoppage, and possibly a last minute reduction in power made by the pilot contributed to the lack of rotational markings on the right propeller blades. Although blade angle at impact could not be determined, marks on a right engine baffle plate, installed behind the propeller governor control lever, showed that the control lever had moved from its normal governing position to the feather position at impact. Thus, the propeller pitch change rod would also have moved during impact. Additionally, a test flight conducted after the accident showed that if an engine had failed during the takeoff, the aircraft could not have performed the posttakeoff maneuver that was described by ground witnesses.

The Safety Board examined the aircraft systems to determine if they had any effect on the pilot's apparent loss of control. The autopilot system was found in the off position as required by operating procedures, and there was no evidence of any malfunction in either the autopilot trim system or the elevator trim system.

Except for the backed out elevator control stop bolt, all flight controls, flight control surfaces, and cables showed no evidence of preimpact failures or binding. The elevator down-stop bolt was found backed out from its correct position, which limited down elevator deflection to a maximum of 1 1/2°.

A photograph of the aircraft when it was lifted initially, shows that the elevator was essentially aligned with the horizontal stabilizer. (See figure 1.) Since the elevator bungee spring keeps the elevator against the down stop while the aircraft is in a static position, the photograph indicates that the elevator stop bolt was mispositioned before impact.

In addition, the metallurgical examination of the stop bolt showed the progressive marking of the elevator torque arm as the stop bolt backed out. The farthest inboard markings were the most pronounced and were aligned with the extended bolt position discovered after the accident. Since the stop bolt was bent the torque arm must have sustained a sharp blow at impact. From this evidence, the Safety Board concludes that before impact the down elevator stop bolt was backed out from its normally installed position and the backed-out position limited down elevator travel. Further, the indentations found on the elevator torque arm assembly showed that the bolt had been backing out for some time.

The additional FAA Service Difficulty Reports confirm that the backed-out stop bolt found on the accident aircraft was not an isolated event, but was the first of several. Although the Safety Board was not able to determine conclusively the reason for the backed-out bolts, the most plausible reason is that they were not tightened properly. The Safety Board does not believe that the jam nut locking device used on the elevator stops provides an adequate positive lock to prevent the stop from backing out and affecting the control characteristics of the aircraft.

At the time of the accident, Las Vegas Airlines had almost completed three inspection cycles in the Piper Programmed Inspection Program, which was part of the company's approved maintenance program. Since the last inspection was conducted on August 25, 1978, the Safety Board attempted to determine why the backed-out bolt was not discovered during the aircraft inspection cycle, but was unable to do so. A review of the Piper inspection program disclosed that inspection items concerning the empennage did not specify checking the elevator for proper travel or rigging. However, Appendix D of 14 CFR 43 specifies that flight controls must be checked during inspection for improper installation and improper operation. Because the Piper inspection checklist acts as a reminder to maintenance personnel of inspection items to be completed, items omitted from the checklist will not likely be inspected. When an inspection checklist is provided in the maintenance documents supplied with an aircraft, the airframe manufacturer must assure that the checklist covers all required inspection items that could affect the airworthiness of the aircraft. In addition, the FAA must assure that such items are covered when they approve the use of the checklist as a part of an approved maintenance program. Finally, the mechanic who signifies, by signing off a required inspection, that the aircraft is airworthy must assure that the inspection items contained in 14 CFR 43 have been complied with.

A pilot's preflight inspection cannot be expected to detect a backed-out stop bolt, because the control stops cannot be easily observed by the pilot. In addition, unless a pilot views the elevator from the side while moving it, he has no clear neutral position reference from which to judge the adequacy of control surface travel, and the curvature of the horizontal stabilizer can cause an elevator with restricted travel to appear farther deflected than it is. A pilot is equally unlikely to detect an elevator restriction during a pretakeoff check because: (1) The check is to insure that the controls are free to move, (2) the control wheel can still move about 4 1/2 ins. when the down stop is backed out, (3) no control binding will be present, and (4) the control wheel normally rests statically in a forward position, but not against the instrument panel; consequently, there is no neutral reference point which shows where the control wheel should normally be.

Since no weight and balance data or passenger manifest could be found for the accident flight, the Safety Board calculated the weight and balance for the aircraft. The Safety Board's weight and balance calculation showed that the aircraft was 236 lbs overweight and that the center of gravity was 0.9 in. inside the aft limit. Company procedures specified that "if a pilot could determine without a doubt that a particular loading condition was within limits, he did not have to figure a weight and balance." Additionally, guidance materials from FAA's Western Region contained the same provisions. Had the pilot calculated the weight and balance for this flight instead of estimating it, he would have found that the aircraft was overweight.

As a result of a recent change to 14 CFR 135 the regulation now requires that the weight and balance be computed for all flights involving multiengine aircraft. Therefore, underestimates of weight and balance should no longer be a safety problem.

Type certification data showed that at this center of gravity and 75 percent maximum continuous power, the level specified in CAR 3B, the aircraft met the FAA requirements for positive longitudinal static stability. However, the regulations do not address the more demanding condition of 100 percent maximum continuous power.

During the FAA flight test conducted after the accident, a takeoff was made which essentially duplicated the accident aircraft's flight profile. During the takeoff roll, neutral elevator and elevator trim tab were maintained to see if the aircraft could become airborne without an elevator input. The test aircraft became airborne within 100 ft of the accident aircraft's liftoff point and started a rapid pitchup. The test pilot recovered from the pitchup at 85 kns with the landing gear extended by reducing the pitch attitude. The test pilot indicated that the push force was about 25 lbs and was not considered to be excessive.

Flight test data also showed that the accident aircraft would have needed at least 3 1/2° of down elevator to maintain a trimmed condition after takeoff. Since only 1 1/2° of authority was available, the aircraft would have had a noseup pitching moment when it became airborne. Further, once a noseup pitching moment was created, the pilot would not have had the down elevator authority required to stop the pitching moment and get the nose of the aircraft back down. Once the aircraft had entered a stall condition, 3 to 5 lbs of push force, which generates more than twice the elevator travel available to the pilot, was required to get the nose 10° below the horizon and recover from the stall. Recovery required over 250 ft of altitude which indicates that the pilot of the accident aircraft may not have had enough altitude to recover from a stall even if he had full elevator authority. The test results indicate that the accident aircraft had a near neutral elevator condition after liftoff with an ensuing pitchup and the pilot was unable to recover from the pitchup condition. Therefore, the Safety Board concludes that once the aircraft became airborne, the crash was inevitable.

Although the accident aircraft takeoff profile was essentially duplicated during flight tests, the Safety Board was not able to determine conclusively why the takeoff roll was 1,200 to 1,400 ft longer than normal to compensate for high gross weight with higher indicated airspeed. Even with the restricted elevator travel, the pilot would have been able to rotate the aircraft and lift off at the normal takeoff point. However, the longer-than-normal takeoff roll had little effect on the cause of the accident. Although the higher speed achieved at liftoff from the longer ground roll would have required more down elevator authority to prevent a pitchup, the normal liftoff speed of 90 kns would have required at least twice the available elevator authority to prevent a pitchup. Therefore, the Safety Board concludes that even if the aircraft had been properly trimmed and had lifted off at its normal takeoff point and speed, the aircraft would have pitched up and crashed.

On March 29, 1979, Piper Aircraft issued a Service Bulletin which required that PA-31 operators inspect their aircraft within the next 25 hours for loose elevator stop bolts and that the stop bolts be torqued to 20 to 25 in./lbs. Additionally, the Piper final quality control inspection of elevator rigging has been changed. Piper now torques the stop bolts to the recommended torque valve when the elevator is rigged.

On April 2, 1979, the FAA issued an Airworthiness Alert which stated:

"During a recent accident involving an air taxi aircraft, an elevator stop bolt was found backed out so as to restrict elevator down travel (aircraft nose down control). The stop bolt was threaded into an aluminum casting, and was secured by a lock nut torqued against the face of the casting. This is a fairly common design, used on many different aircraft.

"Aircraft operators and maintenance personnel are advised to periodically check control surface travel to the aircraft specifications, and to check the condition of control surface stops. This should be done after any maintenance involving control surfaces or control rigging, and at least done at each annual or 100 hour inspection. Pilots should also visually check the range and freedom of control surface travel before every flight. These actions can help to prevent accidents and incidents involving aircraft control systems."

3. CONCLUSIONS

3.1 Findings

1. The aircraft was certificated and maintained according to approved procedures; however, the inspection checklist used during maintenance did not conform to 14 CFR 43.

2. The pilot was certificated and qualified for the flight.

3. The accident was not survivable because of the high impact forces.

4. The airframe and powerplants were not factors in the accident.

5. The pilot did not calculate the weight and balance of the aircraft before takeoff.

6. Company and FAA procedures specified that the pilot did not have to calculate weight and balance if he could determine without a doubt that the aircraft was within the limits.

7. The aircraft was about 236 lbs over the maximum allowable takeoff weight limit; however, the aircraft's center of gravity was 0.9 in. inside the aft limit.

8. The down elevator control stop was found backed out from its normal installed position. The position of the bolt limited the down elevator travel to only 1 1/2° of a normal 20° range.

9. The down elevator stop bolt had backed out over some period of time and had not been detected during preflight inspections or aircraft maintenance inspections.

10. An adequately conducted preflight inspection of the aircraft probably would have failed to identify the down elevator restriction.

11. The Piper Programmed Inspection Program was deficient in that it did not specify inspecting the elevator for proper installation or operation.

12. With the 1 1/2° restriction in down elevator authority and at a rearward center of gravity condition, the aircraft developed a noseup pitching tendency which could not be controlled.

13. The aircraft entered a pitchup maneuver after takeoff that resulted in loss of control and a stall.

14. Recovery from the stalled condition at low altitude was not possible because the elevator deflection required for recovery was more than twice that available.

15. Once airborne the crash was unavoidable.

16. The accident was not survivable.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the backed out elevator down-stop bolt that limited down elevator travel and made it impossible for the pilot to prevent a pitchup and stall after takeoff. The Board was not able to determine conclusively how the down stop bolt jam nut locking device came loose and allowed the stop bolt to back out.

4. RECOMMENDATIONS

As a result of this accident, the Safety Board forwarded two recommendations to the Federal Aviation Administration. On March 12, 1979, the Safety Board recommended that the Federal Aviation Administration:

"Issue an Airworthiness Directive to require the immediate inspection of all Piper aircraft equipped with control stop bolt installations where extension of the stop bolt can limit control surface travel to determine if stop bolt position or jam nut torque has changed. Require readjustment of the stop bolt and retorquing of the jam nut as necessary. Require that the stop bolt installation be modified to include safety wire or some other positive nonfriction means of preventing rotation of the stop bolt during the application of vibratory loads. (Class I, Urgent Action) (A-79-7)

"Issue a Maintenance Bulletin to alert general aviation inspectors of the possibility of loosened or misadjusted control stop bolts on general aviation aircraft. Stops on various models of aircraft should be spot checked to ensure that control stop bolts are positively secured and that there is no possibility that vibratory loads can result in a change in the range of travel of any control surface. (Class I, Urgent Action) (A-79-8)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

June 7, 1979

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The Safety Board was notified of the accident about 11:00 a.m., on August 30, 1978. The investigation team went immediately to the scene. Working groups were established for operations, witnesses, structures and systems, maintenance records, powerplants, human factors, and aircraft performance.

Participants in the on-scene investigation included representatives of the Federal Aviation Administration, Piper Aircraft Corporation, Las Vegas Airlines, Avco Lycoming, and Hartzell Propeller, Inc.

2. Public Hearing

No public hearing or depositions were conducted.

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APPENDIX B

PERSONNEL INFORMATION

Mr. Charles A. Herning, 48, was the pilot-in-command of the flight and occupied the left seat. He was employed by Las Vegas Airlines as a Navajo captain. He held commercial pilot certificate No. 1312275, with airplane single-engine land, multiengine land, and instrument ratings. He had a first-class medical certificate dated April 3, 1978, with no limitations. He also held a second-class medical certificate issued on March 29, 1978 with the limitation "the holder shall possess correcting glasses for near vision while exercising the privileges of his certificate." No reason could be found for the disparity between the two medical certificates.

The captain had accumulated about 6,325 flying hrs, 247 hrs of which were multiengine and 121 hours were in the PA-31-350. According to his logbook, he also had accumulated about 3,558 hours of multiengine time in centerline thrust aircraft, such as the T-37, T-38, T-39, A-37 and F-111.

Captain Herning had entered a flight training course at Terra Training, Las Vegas, to obtain his Air Transport Pilot Certificate. However, he terminated his training after flying about 8 hours in the Beech Baron (B-55) because, according to his flight instructor, the captain was too busy to complete the course.

Captain Herning completed PA-31-350 ground school on July 23, 1978. He received his initial check-out in the aircraft on July 24, 1978, after completing 14.5 hours of flight training. Since his initial training, he had logged about 106 hours in the aircraft.

APPENDIX C

AIRCRAFT INFORMATION

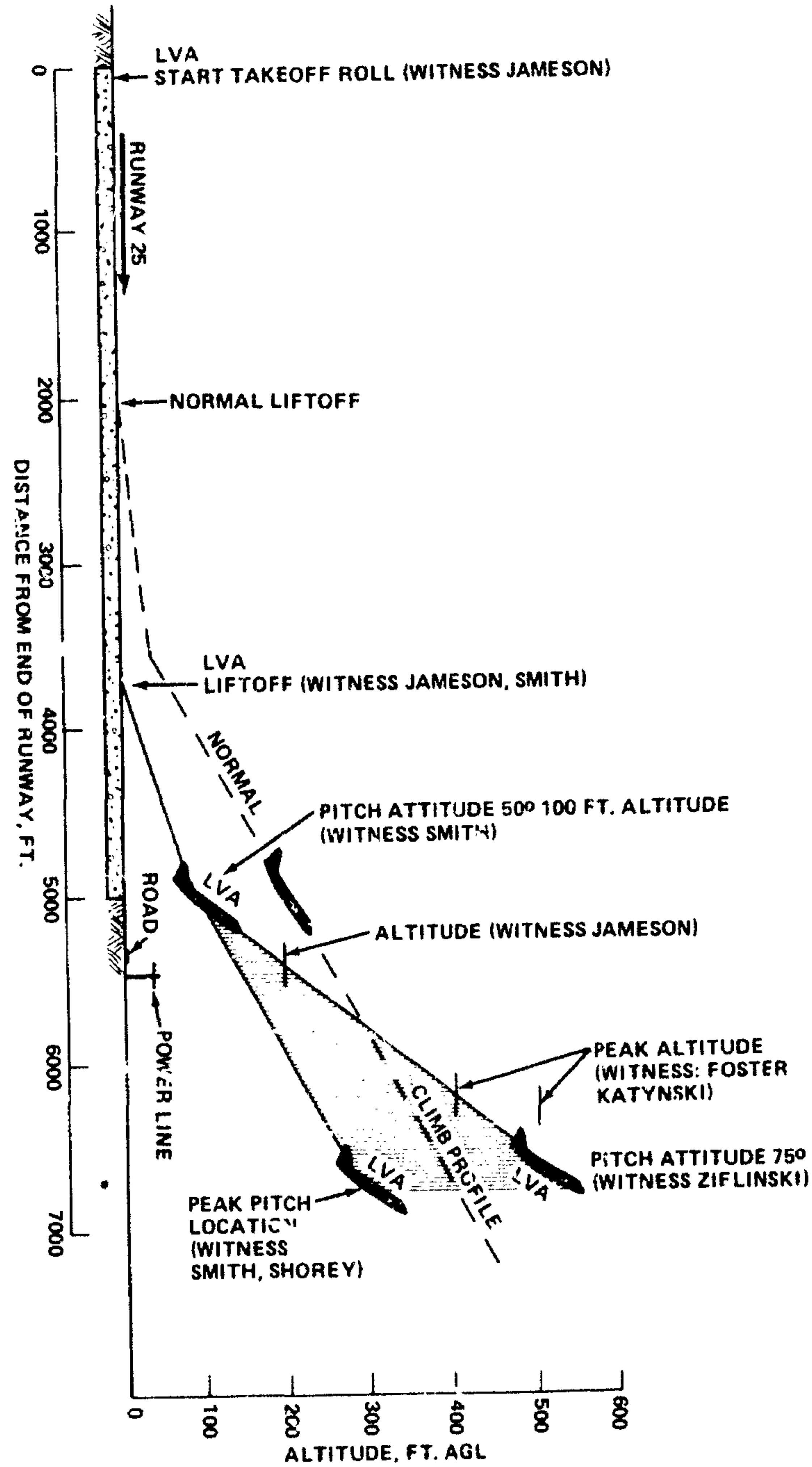
The aircraft, N44LV, was a Piper PA-31-350 Navajo Chieftain, serial No. 31-7852099. It was purchased new from the Piper Company in May 1978, by Las Vegas Airlines. The total airframe hours since new was 522.9. The last maintenance inspection was conducted on August 25, 1978.

The aircraft was powered by one Avco Lycoming TIO-540-J-2BD engines and one LTIO-540-J-2BD engine.

Pertinent engine data follows:

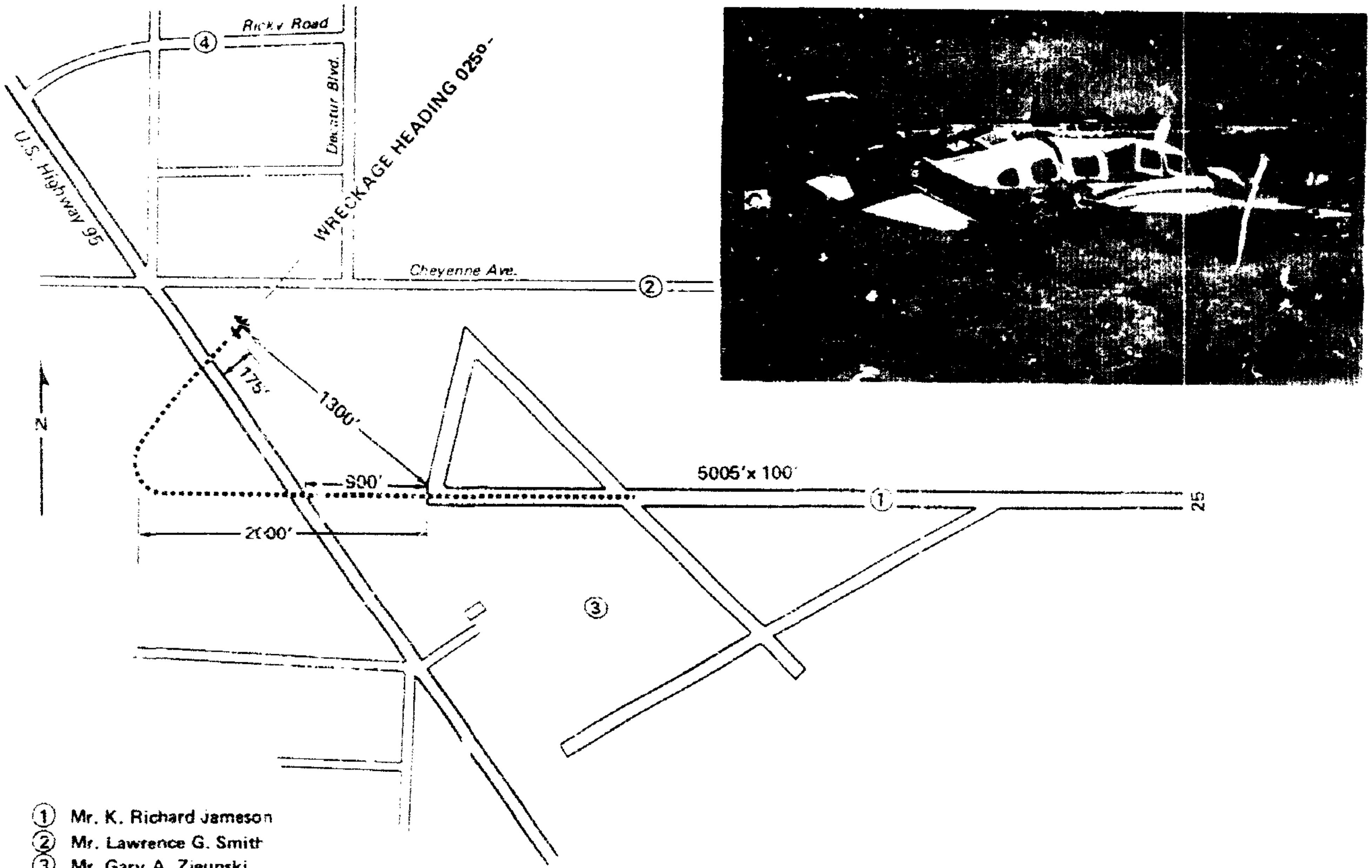
Position	Serial No.	Total Time (Hrs.)
1	L-5337-61A	522.9
2	L-1392-68A	522.9

APPENDIX D



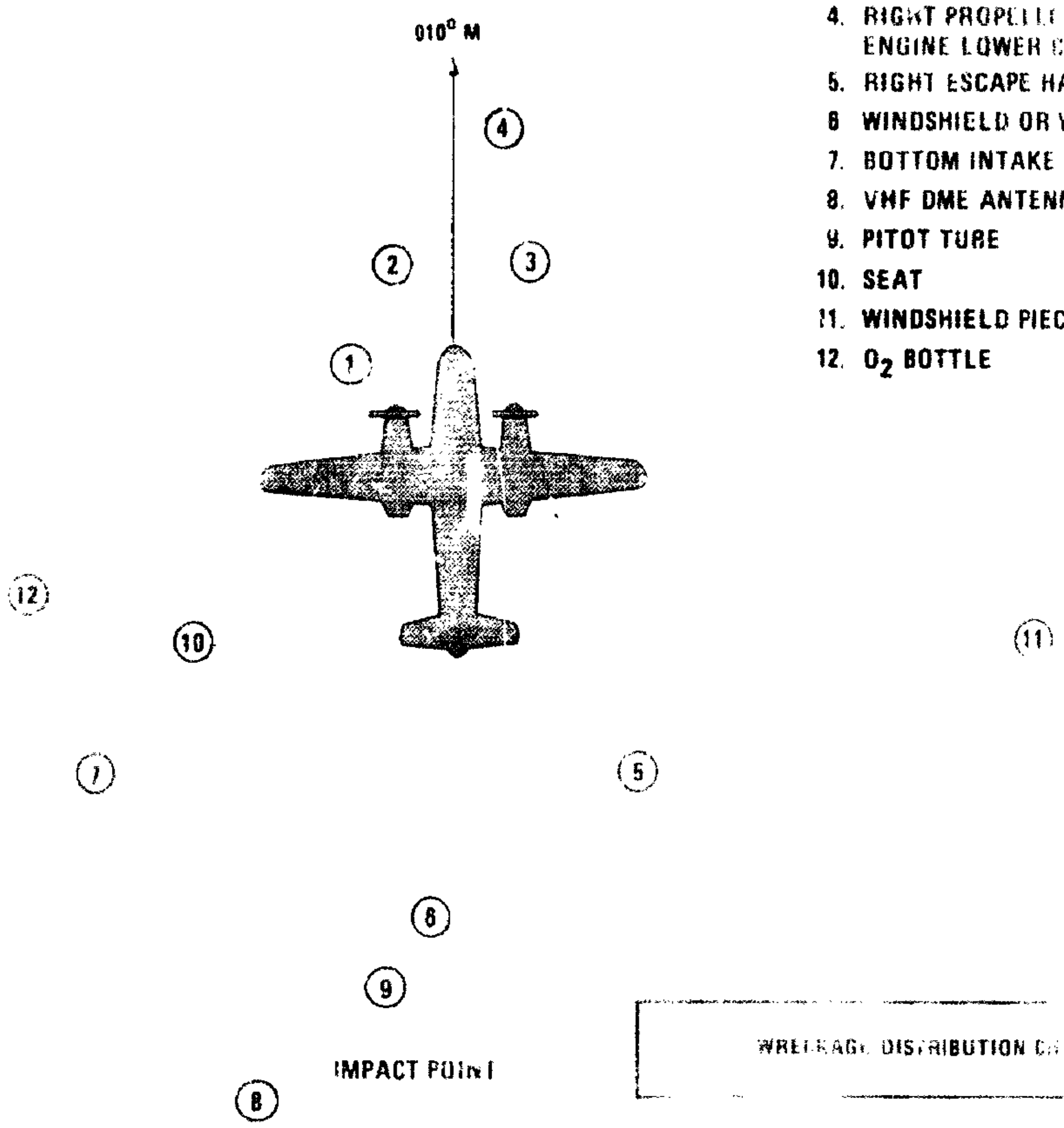
LVA
START TAKEOFF ROLL (WITNESS JAMESON)
RUNWAY 25
NORMAL LIFTOFF
LVA
LIFTOFF (WITNESS JAMESON, SMITH)
NORMAL
PITCH ATTITUDE 50° 100 FT. ALTITUDE
(WITNESS SMITH)
LVA
ALTITUDE (WITNESS JAMESON)
ROAD
POWER LINE
PEAK ALTITUDE
(WITNESS: FOSTER
KATYNSKI)
CLIMB PROFILE
LVA
LVA
PITCH ATTITUDE 75°
(WITNESS ZIFLINSKI)
PEAK PITCH
LOCATION
(WITNESS
SMITH, SHOREY)
0
1000
2000
3000
4000
5000
6000
7000
DISTANCE FROM END OF RUNWAY, FT.
0
100
200
300
400
500
600
ALTITUDE, FT. AGL

APPENDIX E



① Mr. K. Richard Jameson
② Mr. Lawrence G. Smith
③ Mr. Gary A. Zieunski
④ Mr. Frank L. Katynski

APPENDIX F



KEY:

1. LEFT PROPELLER
2. TOP COWLING R. ENGINE
3. FRONT BAGGAGE DOOR
4. RIGHT PROPELLER AND RIGHT ENGINE LOWER COWLING
5. RIGHT ESCAPE HATCH
6. WINDSHIELD OR WINDOW
7. BOTTOM INTAKE MANIFOLD
8. VHF DME ANTENNA
9. PITOT TUBE
10. SEAT
11. WINDSHIELD PIECES
12. O_2 BOTTLE

WRECKAGE DISTRIBUTION CHART

NOTE:

CIRCLES PHYSICALLY REPRESENT LOCATION OF PARTS IMMEDIATELY AFTER IMPACT