SA-NONE FILE NO. 3-0125

AIRCRAFT ACCIDENT REPORT

EXECUTIVE JET AVIATION, INC.

LEAR JET L23A, N434EJ

NEAR THE EMMET COUNTY AIRPORT

PELLSTON, MICHIGAN

MAY 9, 1970

Adopted : DECEMBER 22, 1970

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D. C. 20591

REPORT NUMBER: NTSB-AAR -71-3

For sale by National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, Va. 22151. Annual subscription price $20.00 Domestic; $25.00 Foreign; Single copy $3.00; Microfiche $0.95.

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TARLE OF CONTENTS

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SYNOPSIS

On May 9, 1970, Lear Jet N434EJ, operated by Executive Jet Aviation, Inc., was on a nonscheduled air taxi flight from Detroit, Michigan to Pellston, Michigan. The aircraft crashed at approximately 2128 during an instrument approach to the Emmet County Airport at Pellston. Both crewmembers and the four passengers aboard received fatal injuries.

The aircraft made initial contact with trees on a hill located approximately 2½ miles southwest of the approach end of Runway 5. A swath approximately 45 feet wide and 254 ieet long, on a true heading of 107°, had been cut through the trees by the aircraft. The highest mean sea level (m.s.l.) elevation of the trees at the break points was 886 feet.

The aircraft remained airborne for approximately one-half mile, following initial tree impact, before striking trees again, after which the aircraft crashed to the ground and burned. The swath through the trees at the crash site was approximately 269 feet long on a true heading of 86°. The m.s.l. elevation at the highest point of tree contact in the crash area was 809 feet. The main wreckage was contained in a space approximately SO feet wide and 130 feet long. The ground elevation at the crash site is 730 feet. The latitude is 45°33'43" N. and the longitude is 84°50'17" W.

The area over which the aircraft flew while circling for landing, is sparsely populated, and none df the runways is equipped with approach lights. Consequently, few visual references are available for a night approach.

The 2133 weather at Pellston was 400 feet scattered clouds, neasured ceiling 800 feet overcast, visibility 7 miles, wind from 090° 10 knots, altimeter setting 29.76 inches.

The Board determines the probable cause of this accident to be illusions produced by the lack of visual cues during a circling approach over unlighted terrain at night to a runway not equipped with approach liphts or other visual approach aids. These illusions, which made the pilot think that he was higher than his true position, were made more acceptable to him because of a strong possibility of an erroneously high indication on his altimeter.

1. INVESTIGATION

1.1 History of Fliaht

N434EJ was scheduled to depart the Detroit Wayne County Airport at 1930 1/ for Pellston. A late arriving passenger delayed the departure until 2038.

The flight was cleared on an instrument flight rules (IFR) flight plan to the Pellston VOR 2/ via airways Jet 31 and Victor 297 at flight level (FL) 310 3/. Control of the flight was transferred to the Air Route Traffic Control Center (ARTCC) at Minneapolis. At 2056, N434EJ reported at FL 310, 4 miles north of Saginaw, Michigan. To avoid the weather, the flight requested permission to deviate hard left. This was followed closely by a request to deviate right and "to stay on top at 310." The deviations were approved by ARTCC.

The flight requested descent clearance at 2101. Clearance to maintain 13,000 feet, at the pilot's discretion, was given. The Pellston altimeter setting was given as 29.74 inches, but the flight was informed that the barometric reading was an hour old. N434EJ reported leaving flight level 310 for 13,000 feet.

At 2109, the Elinneapolis center cleared N434EJ for an approach to the Pellston Airport, and gave the current altimeter setting as 29.76 inches. Radar service was terminated at 2114, and the flight was advised to contact Pellston Radio.

Upon contacting Pellston Radio, N434EJ advised that it was 20 miles out and requested the weather. The 2059 weather was reported as scattered clouds a: 400 feet, measured ceiling 800 feet overcast, visibility 7 miles, thunderstorms and light rain showers, temperature 45° F., dew point 43° F., and wind 100° at 10 knots. The flight was also advised that the wind direction was varying from 080° to 120° with the intensity varying from 5 to 15 knots. The Flight Service Station (FSS) specialist requested whether the flight would land straight in on Runway 23 or circle for Runway 5. N434EJ advised that the decision would be made later.

At 2123, N434EJ reported procedure turn inbound and received fror FSS the same weather as previously received. At 2125, the flight reported the VOR inbound (inbound heading 243°), and was told that the wind was from 080° at 8 knots. At 2128, N434EJ reported runway in sight a.. that it was circling for a landing. (In order to establish a circling pattern, a right turn from the inbound heading to a westerly heading is made initially.) This was the last communication from N434EJ.

1/ All times herein are eastern standard based on the 24-hour clock.

2/ VOR: Very High Frequency (VHF) omnidirectional radio range.

3/ 31,000 feet *m.s.l.*, based on a barometric pressure of 29.92 on the altimeter.

The FSS specialist left his desk and went outside to watch for the flight and to look at the ceiling. He stated that he observed aircraft lights inbound to the airport on a normal approach, and then saw it making a right turn in order to circle the field to the left. He watched the aircraft fly in and out of low scud, and at times it was out of his view. The aircraft started to take an easterly heading, after which it appeared to make a slight descent, and then a slight ascent. A short time later, an orange flash appeared.

A witness living a mile north-northeast of the airport saw an aircraft on a westerly heading pass north of his home around 9 p.m. He stated that from the sound, the aircraft was in a normal pattern for a circling approach; a pattern which would pass slightly north of his home.

Another witness, whose home is approximately 2½ miles northeast of the airport, watched the aircraft as it turned toward the southeast on the downwind leg. All of the cabin lights appeared to be on. Because of the direction of the airplane from his house, and the engine power being developed, the witness believed that the aircraft was taking off. He said that there was no rain failing and that the moon was visible occasionally.

A third witness, sitting in her living room, heard the aircraft approaching and saw the plane's navigation lights pass her window. She stated that the aircraft was in level flight. She saw no fog but said that it was raining. Her home is one of several located about 1,000 feet north of the initial impact point with the trees.

1.2 Iniuries to Persons

Two crewmembers and four passengers were on board. All received fatal injuries.

1.3 Damage to Aircraft

The aircraft was almost completely destroyed by ground impact and ground fire.

The intact, or nearly intact, sections were the avionics compartment; the right wing flap; and the after portion of the fuselage with the vertical stabilizer, rudder, horizontal stabilizer, and elevators attached. The avionics compartment, after fuselage, and empennage, were found in the upright position.

1.4 Other Damage

The impact and fire destroyed several trees. There was no other ground damage.

1.5 Crew Information

Captain George O. Evans, aged 48, was employed by Executive Jet Aviation, Inc., on May 1, 1967, and was upgraded to captain on August 18, 1967. He held an airline transport pilot certificate with ratings in the Lear Jet models 23 and 24, and airplane multiengine land. He also had held a flight instructor's rating, which had expired on February 28, 1969.

His current first-class medical Certificate had the limitation that the holder shall wear correcting glasses for near vision while exercising the privileges of his airman certificate.

Captain Evans' total flight time was 7,760 hours, of which 6,945 were in jet aircraft. His total Lear Jet time was 2,142 hours of which i43.4 hours were flown during the previous 3 nwnths. During the 30 days preceding the accident, he flew 73.6 hours in the Lear Jet.

Captain Evans' flight proficiency record contains comments to the effect that all check requirements were completed in a highly qualified manner. A comment describes his command authority and crew coordination as complete and thorough.

Captain Evans had made six entries into the Pellston Airport, none of which was at nigh:. His most recent flight into Pellston was on November 30, 1969.

First Officer Joseph U. Karaffa, aged 40, was employed by Executive Jet Aviation, Inc., on April 6, 1970, and completed his initial training on April 9, 1970. He held a commercial pilot certificate with airplane single- and multiengine land, airplane single-engine sea, an3 instrument ratings.

His current first-class medical certificate contained no limitations.

His total flight time was 6,533 hours, of which 3,036.7 were in jet aircraft. His total Lear Jet time was 36.7 hours.' The flight report on his proficiency and qualification check stated that he had completed all maneuvers io a very satisfactory manner, and that he was thorough and meticulous in following instructions and completing procedures.

Both crewmembers were free from flight duties for approximately 24 hours prior to this flight. (See Appendix B for details.)

1.6 Aircraft Information (Appendix C)

The aircraft was properly certificated. Examination of the maintenance records revealed that, with one exception, all requirrd entries had been recorded and signed off. The one exception was the altimeter

test conducted in September of 1969. This entry was not in the aircraft log. It was, however, recorded on Form M-11, which is a maintenance discrepancy record.

The weight and center of gravity were within the prescribed limits.

The aircraft was serviced with Texaco AVJET A-1 fuel at Columbus, Ohio, JP-1 at Canton. Ohio, and Shell 640A at Detroit, Elichigan.

1.7 Meteorological Information

The 2200 surface weather chart showed a low-pressure system centered over western Wisconsin, a quasi-stationary front extending southwestward from the low-pressure center, another quasi-stationary front extending eastward from the low-pressure center across northern Lower Michigan in the vicinity of Traverse City, and a squall line extending soutlrdestward from west-central Lake Elichigan.

The aviation terminal forecast issued by the Weather Bureau Forecast Office at Detroit at 1745, valid 1800-0600, was as follows for Pellston: 1,000 feet scattered, ceiling 2,000 Ceet overcast, visihility 5 miles, haze, wind 090° 15 knots and gusty, occasional ceiling 1,000 feet overcast, visibility 2 miles, light rain showers, fop, or thunderstorms, moderate rain showers.

1.8 Aids tn Navigation

Two types of instrument approaches are authorized for Pellston. These are VOR and Automatic Direction Finding (ADF). The ADF approach is made to a nondirectional, low-frequency radio beacon located on the airport. N434EJ made a VOR approach.

There were no reported difficulties with the navigational aids.

1.9 Communications

There were no reported difficulties in communications.

1.10 Aerodrome and Ground Facilities

E——t County Airport is situated adjacent to and northwest of the city of Pellston, Michigan, and consists of two crossing runways, 5-23, and 14-32. The airport elevation is 720 feet m.s.l. Runway 23, the principal instrument runway is 5,395 feet long, and 150 feet wide. The runway surfaces are bituminous overlay, macadam, with little gradient and good drainage. The runways are equipped with medium-intensity runway lights. During the approach of N434EJ, only Runway 5 was lighted.

Runways 23 and 32 are equipped with Runway End Identifier Lights (REIL). The FSS specialist stated that the switching mechanism for the REIL prevented their being turned off at the low-intensity runway light setting. He also stated that one of the REILs at the approach end of Runway 23 was not operating. A Notice to Airman (NOTAM) was not issued to that effect.

Subsequent to the accident, REIL and a Visual Approach Path Indicator (VAPI) were installed on Runway 5.

The terrain on which the airport is located is fairly level. Northeast of the airport toward the VOR, the terrain is relatively level for about 5 miles, where the ground rises to an elevation of 800 feet. Due west of the airport is a valley with the elevation rising only slightly above that of the airport for a distance of over 10 miles. High ground, with elevations exceeding 800 feet, commences one-half mile north of the airport and continues in a westward direction on the north side of the aforementioned valley. High ground may also be found southwest of the airport; rising to 800 feet approximately 2 miles from the threshold of Runway 5 and rising to over 1,000 feet approximately 2½ miles southwest of the threshold of Runway 5. These hills border the south side of the valley, which is approximately a mile wide. The ridge nearest the airport is oriented in a northwest-southeast direction. Thus, the approaches to Runways 23 and 32 are relatively clear of high terrain, while the approaches to Runways 5 and 14 have high terrain as much as 300 feet higher than the airport elevation, within 24 miles. The approach area to Runway 5 is without visual cues at night except for a few lights from widely scattered homes. The area is heavily wooded in the hilly regions. The runway has no approach lights.

1.11 Flight and Cockpit Voice Recorders

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

1.12 Wreckage

At the initial impact site, the path of the tree damage was 254 feet long and 45 feet wide. Within this area were found the red and green navigation light lenses, landing light lens, vortex generators, and the left wingtip fuel tank nose cone. None of the recovered pieces from this area revealed any evidence of fire. None of the vegetation in the area was burned.

The wreckage at the main impact site was confined to an area measuring approximarely 130 feet by 50 feet. From cuts on the trees, the lateral attitude of the aircraft was determined to be approximately 37° left wing darn. Similarly, the descending angle of the aircraft through the trees

was found to be approximately 16°. The main wreckage site is located approximately 1-3/4 statute miles from the threshold of Runway 5. For details cf impact areas and wreckage distribution, *see* Attachment No. 1.

a. Systems

While all systems were irreparabl. damaged, information was, nevertheless. obtainable irom a few units.

The captain's altimeter showed · reading of 1,440 feet m.s.l., with an altimeter setting of 29.75 inche... The captain's flight director instrument showed a left hank of 36°.

A turn and bank indicator showed a left turn.

The landing flaps indicator revealed evidence of an extension equal to fully down landing flaps.

Two flipht spoiler actuators had a position equal to spoilers stowed.

A horizontal stabilizer actuator extension was compared to its counterpart on another Lear Jet aircraft. The trim indicator position thus determined was slightly aft of the green takeoff ban?.

b. Powerplants

The engines burned free of the aircraft structure and were found on the ground below their normally mounted position.

Both engines had ingested tree wood. The left engine compressor blades were curled at the leading edge tip. There were no gouges or tears on the blades. Charred wood pulp was noted in the turbine nozzles, cooling air pnssages, and between the stage 1 nozzle and the stage 1 shroud. The turbine blades and nozzle vanes exhibitel very fine dustlike metal fusion. some of which was loose and some firmly bonded. Fire damage precluded functional testing of the accessories. The inlet guide vanes (IGV) were undamaged and closed. The bleed valves were open.

On the right engine, hard object damage was found on 26 of the 31 compressor blades. All compressor blades were curled from forces opposing rotation. The IGV's were bent. circumferentially at the trailing edge and all were closed. The bleed valves were open. The combustion section contained large quantities of wood pulp. All turbine blades and nozzles exhibited a firmly bonded metal fusion, typical of aluminum. Fright metal was also noted on the nozzles, outer bands, and shrouds. Fire damage precluded functional testing of the accessories on the right engine.

No evidence of operational abnormalities, other than the ingested matcrial, was found in either engine.

1.13 Fire

At about 2129, the FSS specialist, who was watching N434EJ make a circling approach, saw an orange flash. At 2133, he advised Elinneapolis Air Route Traffic Control center of the aircraft accident, and then called the State Police, requesting that they inform the Emmet County Sheriff. He then activated the Pcliston fire siren. Shortly thereafter, he told someone at the fire Louse the approximate location of the crash, after which the fire equipment snd personnel proceeded to the scene.

1.14 Survival Aspects

This was a nonsurvivable accident.

The captain's body was found in the left seat of the cockpit, and the first officer's body was found in the right seat.

1.15 Tests and Research

a. The Captain's Altimeter

During the disassembly of the altimeter, it was observed that a brass screw had fallen out and was lying loose in the case. The screw was from a calibration arm assembly, and locks the movable aluminum calibration arm in place when the instrument is calibrated. The threads within the screw hole were torn and ragged. Deposits of aluminum particles were observed on the threads of the screw. An indentation was found adjacent to the screw hole and resembled that made by a staking tool, often used to stake a screw in place. Examination of the X-rays revealed that the locking screw was in place prior to disassembly. Considering that the screw may have loosened because of heat, a similar calibration arm mechanism was placed in an oven and heated for 2 hours at 1,100° F. This screw was found to be tight when examined. The test screw was removed and aluminum deposits were found on its threads. The hole from which it was removed displayed torn and broken threads similar to those of the accident calibration arm.

A staking indentation was then applied to the metal adjacent to the hole in the test specimen. The staking produced a spreading of the metal around the indentation; a condition not found in the examination of the accident altimeter. The test also revealed that the force necessary 'io peen an indentation to the depth found in the accident altimeter would have bent the mechanism to the extent that the instrument would have been unusable.

Further examination of the altimeter revealed that an incorrect pivot was instailed in one end of a rocking shaft. At the opposite end of the rocking shaft, an end stone was missing. A ring jewel within the mechanism was installed off center. A second rocking shaft rear support

pivot was incorrect. An incorrect link pin, which holds a spring clip in place at the pneumatic capsule, was installed. An end stone, which supports a shaft within the mechanism, was installed upside down.

The altimeters were originally manufactured by Kollsman, and had been purchased by Lear Jet Industries. They were remanufactured by Instrument and Flight Research, Wichita, Kansas. The captain's altimeter had been in operation in the copilot's instrument panel for 3,046.9 hours after remanufacture. It was then removed from the aircraft and overhauled by Coll-Aire, Inc., an FAA-approved repair station, and installed in the captain's panel of N434EJ. The reason for the overhaul was an "out of tolerance" condition which occurred September 28, 1969. At the time of the accident, the altimeter had accumulated 485.4 hours since overhaul.

Two other altimeters overhauled by Coll-Aire for Executive Jet, Inc., were sent to the Kollsman Instrument Company for examination. Some had never been on an aircraft since overhaul. These altimeters were found to he out of tolerances. Another overhauled altimeter was sent to the Aero-Sonic Company. It was found to be unrepairable.

b. Aircraft Performance

Flight tests were conducted at Executive Jet, Inc., to determine (1) the effect of pitch change of the aircraft if the spoilers were inadvertently activated, and (2) the amount of power required to maintain 120, 130, and 140 knots in various configurations.

The weight of the aircraft was programmed to be as close as possible to the weight of the accident aircraft when the crash occurred (10,999 pounds). The landing gear was down in both tests, and flap settings of 20° and 40° were used.

The results were as follows:

Test I: Effect of pitch change whan spoilers are activated.

Flaps 20° (two exercises)

Airspeed 145 knots in both exercises.
Loss of altitude: 200 and 150 feet, respectively.
Rate of descent: 700 and 550 feet per minute, respectively.

Flaps 40°

Airspeed 145 knots.
Loss of altitude: 100 feet.
Rate of descent: 550 feet per minute.

The spoiler extension, which was made on approach during a turn on base leg was barely noticeable, by altitude change, control column movement, or aerodynamic buffet. Attitude change was gentle, and entry into the altitude excursion was gradual. These characteristics were true in both the stick-fixed and stick-free configurations.

Test 11: Power to maintain various speeds in several configurations.

Configuration:	Flaps 20°, Gear Down			Flaps 40°, Gear Down		
Airspeed	140	130	120	140	130	120
Altitude	7.5	7.5	7.5	7.7	7.7	7.7
R.A.T. (Ram Air Temp.)	18.5	16.0	15.0	15.0	15.0	15.0
R.P.M.	86	85	83	89	88.5	88
E.P.R. (Pressure Ratio)	1.40	1.30	1.35	1.52	1.50	1.53
Fuel Flow	1,050	900	880	1,100	1,100	1,075
E.G.T. (Exhaust Gas Temp.)	420	440	430	450	460	450

Altimeter setting (Columbus, Ohio): 30.02

Lear Jet Industries, Inc., provided the following information as requested:

With both engines flamed out, the aircraft, weighing 11,000 pounds with the landing gear darn and 20° flaps, would have to have an initial airspeed of 135 ± 5 knots in order to trave? 3,000 feet horizontally with an altitude loss of 81 feet. With a 40° flap setting, the airspeed would have been 125 ? 5 knots.

A study was made in 1969 by Drs. Kraft and Elworth of the Boeing Company, relative to night visual approaches. One of the areas considered was the visual angle that provides information to the pilot. This is the angle subtended at the eye by the nearest and farthest lights of a city as the pilot follows his flightpath. To a pilot flying on a level course at a constant altitude, this angle increases progressively as he approaches the city. To a pilot descending vertically at a constant distance (as in a helicopter), this angle progressively decreases. Between these extremes, there is a specific flightpath in which the visual angle subtended by the city remains coastant. The study states that if the airplane is maintained on this path, the pilot may be losing important closure information without

his awareness. Visual information is also available from the relative motion of the light pattern as seen from the cockpit. However, this motion must exceed one minute of angle per second before it is perceived.

Using the information from Attachment No. 2, calculations were made in order to determine the approximate rate of change In visual angle during the approach of N434EJ. The distance used was from the point on the turn to final approach, when the aircraft would have been heading due south, to the point of initial impact with the trees. For these calculations, the aircraft is assumed to have been at 600 feet (above the airport elevation) a: the former point and 166 feet at the latter. The elapsed flight time between these two points at 127 knots is 34.6 seconds. The differences between the visual angles is .279° using the runway lights for visual reference, and .350° if the town of Pellston is included with the runway. The rate of change of the visual angle under these conditions is .484 minutes per second and .607 minutes per second, respectively. Both values are less than the threshold of 1 minute per second rate of change.

lhe background for these studies is based on a straight in type of approach. The pilot of N434EJ was making a circling approach. Therefore, he may have had some sort of a cue from the apparent rotation of the scene as he executed the turn. At present, there are no data which tells whether a pilot may effectively use such apparent rotation of the scene in estimating height and distance at night.

1.16 Other Pertinent Information

1.161 Executive Jet, Inc., Procedures.

a. Circling Approaches

The training manual used by Executive Jet, Inc., states that at circling minimums, all obstructions within 1.7 miles of the airport boundary, will be cleared by 300 feet. (This follows the TERPs 4/ criterion. See Attachment No. 2 for illustration of the circling area.) The instrument final approach fix is departed with the aircraft in a LANDING configuration with GEAR DOWN and FLAPS 20°. A speed of V_{Ref} + 20 knots 5/ and a 30° bank (maximum) is maintained during the maneuver to assure terrain clearance throughout the approach. When on final approach with the runway visible, flaps are placed in the full down position, final landing checklist is completed, and a speed of V_{Ref} + 5 knots + gust correction is maintained. After determining the direction of the circle prior to approach, the pilot-in-command will determine which pilot is to maintain contact with the runway, and which pilot will monitor the aircraft altitude, airspeed, and angle of bank. The aircraft will not descend below the published circling

4/ TERPs: United States Standard for TERminal Instrument Procedures.

5/ A reference speed which in this case is 1.3 times the stall speed (V_{so}) for the landing weight at which N434EJ was operating. V_{Ref} was 122.5 knots.

minimum altitude for the approach until the turn to final is initiated, the runway is in sight, and the aircraft is in a position to make final descent for landing. If during the circling maneuver, VFR (Visual Flight Rules) cannot be maintained at published minimum altitude or visual contact with the airport is lost, a missed approach must be initiated.

b. First Officer Flying Duties

On nonrevenue flights, and on revenue flights transporting cargo only, the first officer may perform the duties of the pilot-in-command under the direct supervision of the captain.

The pilot not flying the aircraft during IFR circling approaches calls out any altitude, airspeed, or descent deviations from normal, or as specified by the captain. These deviations are defined as:

Altitude - Whenever actual indicated altitude varies from minus 50 feet to plus 100 feet from required altitude for that portion of the approach being made.

Airspeed - Whenever airspeed is ± 10 knots from programmed speed.
Minus speed must never be less than 1.3 V_{so} (V_{Ref}).

Sink Rate - Whenever descent rate exceeds 1,000 feet per minute on final.

The pilot not flying should monitor engine instruments, cross-check flight instruments, reset radio frequencies, and communicate as necessary.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The examination of the aircraft structures, components, systems, and powerplants revealed no indication of preimpact failure or malfunction, except for the captain's altimeter. The causal area therefore primarily involves the operation of the aircraft during the execution of the circling approach.

a. The Captain's Altimeter

This instrument read 1,440 feet when it was found in the wreckage. The elevation of the terrain at the wreckage site is 730 feet. However, the instrument case had buckled inward from impact, causing a supporting post of the altimter frame to collapse. This caused the sector gear mechanism to unmesh from the gear train, which moves the pointers. When this occurs in an altimeter, the spring loaded hands are driven rapidly toward a high altitude reading. As impact forces continued to be applied to the captain's altimeter, the needles were finally locked into the positions in which they were found. Therefore, the rending of 1,440 feet is not considered to be valid.

Examination of the altimeter revealed that some incorrect parts had been installed, some parts were missing, one part was installed upside down, and a ring jewel was installed off center.' Such conditions undoubtedly caused excessive friction. A setscrew, which holds the calibration arm in place, may not have been tightly set. If the screw were loose, the altimeter would have read high by 225 to 250 feet.

The Board believes that while the evidence is not conclusive, the captain's altimter was probably reading inaccurately.

b. Operations

The flight from Detroit to the Pellston area was without incident. The instrument approach to the Emmet County Airport at Pellston was legal, and vithin the circling minimums required.

Under the procedures prescribed by Executive Jet, Inc., the Board believes that the captain was at the controls during the approach and at the time of the accident. Therefore, any deviations from programmed altitude, airspeed, or rate of descent should have been reported to the captain by the first officer. Since there was no cockpit voice recorder installed, there is no way to determine whether this was done. Similarly, there is no way to determine whether the altimeters were cross-checked, or when they might have been during the flight.

(1) The Circling Approach

Executive Jet, Inc. pilots are taught that at circling minimums, they will have an obstruction clearance of 300 feet within a 1.7 mile radius of the airport boundary. This philosophy follows the TERPs criteria in determining the circling approach area. Attachment No. 2 illustrates this area around the Emmet County Airport, and shows that 300 or more feet obstruction clearance is provided. N434EJ flew outside the area while proceeding west during the circling approach, anti was outside the area when initial contact with the trees was made.

The reascns for the flight's leaving the area are not known. It is quite possible, for example, that the scattered clouds may have caused the captain to extend his flightpath. The FSS specialist stated that at times the aircraft disappeared as the flight went in and out of scud. No doubt this was due to the scattered clouds at 400 feet. However, in view of the FSS specialist's location, the aircraft might have disappeared behind the clouds, and not have gone in and out of them. Another reason is the difficulty in determining the 1.7-mile limit. In most cases, this would be a difficult task in the daytime, much less at night. The lack of visual cues at night can cause a pilot to think that he is closer to the runway and higher than he really is. The hazards of night approaches over areas lacking visual cues are well known, and have been publicized. One

authority states, "Under conditions of haze, smoke. dust, glare, or darkness, expect to be higher than you are." 6/ He also states that shadows are a key factor in depth perception, and that their absence, when due to visibility restrictions, unknowingly confuses the pilot. Under such condilions, the pilot interprets his altitude as being higher than it actually Is. "This effect is also encountered during night (especially blackout) landings." Captain Prosper Cocquyt explains in his paper, "Sensory Illusions," that a pilot determines his relative height by estimation of the distance to landmarks and the angle between the direction of observation of the landmarks and his horizon. This angle is usually positive, as the landmarks are usually observed below his horizon. When the pilot's observation of nis horizon is not the true horizon, then the angle becomes the original angle plus the included angle between the true and imagined horizon. Cocquyt states that when imaginary heights are positive, the pilot has the sensation of flying higher than his true height. Imaginary ground is above the actual ground beyond the landmarks. Thus in the case of night flying, the pilot may see stars below his imaginary horizon and mistake them for ground lights. A serious hazard arises if an optical illusion, resulting in an imaginary height, persists during the course of the landing procedure.

The Board believes that the illusions caused by the darkness and lack of visual cues in the area of the circling approach were such that the pilot could not determine his altitude accurately enough by use of visual cues solely. Use of the altimeter is a necessity in such circumstances. The course taken by the pilot, after departing the inbound course from the VOR, took him over terrain higher than that at the accident site. Therefore, a descent had to have been initiated. This could have occurred after he began his turn back to an easterly heading, towards the final portion of the approach. If the pilot elected to proceed visually from this point on, he could have believed that he was higher than he really was. With the runway in sight, the first officer may not have been calling or observing the altitude. The aircraft, prior to beginning the descent from the circling approach, could have been at any altitude between the 600 feet minimum and 800 feet, the height of the measured ceiling. It is not known which altimeter the first officer was watching, but since the circling approach was to the left, it would have been likely for the first officer to have been looking out the left side of the cockpit toward the airport at times, while monitoring the instruments. In such a case, he may have been obtaining his altitude information from the captain's altimeter.

(2) The Captain's Altimeter and Night Illusions

On a 2.5° glidepath, an aircraft would be at an altitude of 230 feet above the runway when 1 mile from the touchdown point. On a 2° glidepath, the altitude above the runway would be 184 feet at the same

6/ "Elusive Illusions," Captain R. L. Kuhlman, The MATS Flyer, June 1955.

distance. N434EJ first struck trees at an altitude of 800 feet, or 166 feet above the elevation of the airport. Although, as pointed out earlier, the illusions at night due to lack of visual cues could lead the pilot to believe that he was higher than he actually was. However, it must be considered that the pilot may have known his location and was determining his vertical position, during the approach, from his altimeter. For the sake of this argument, lack of visual cues for altitude determination must bc considered to have had little effect. In such a situation, a pilot would not have flown at an altitude of 166 feet above the runway elevation on a heading of approximately 50° from the runway heading so far from the threshold, since this would require a turn toward the runway at a dangerously low altitude, particularly at night. However, an altimeter which rcad too high could have caused the pilot to have believed that he was sutficiently high so as to safely traverse the area. In view of the condition of the captain's altimeter, such a situation is highly possible, provided the first officer also looked at the captain's altimeter during this critical portion of the approach.

Thus, two factors are present in this case, either of which could have been the sole reason for the flight to descend too low while turning toward the final portion of the circling approach. The Board believes that both factors were involved, and that the pilot probably received inaccurate altitude information from the illusions associated with darkness, as well as from a faulty altimeter. The degree of contribution of each factor cannot be fully determined. However, considering that a pilot must receive altitude information from an altimeter during a circling approach, then any illusion received by the pilot from visual cues, which would cause him to believe that he was at a safe altitude, would be even more acceptable when supported by an altimeter reading which, unbeknown to him, was erroneous.

2.2 Conclusions

(a) Findings

1. The aircraft was properly certificated and airworthy with the exception of the captain's altimeter, which was not airworthy.

2. The flight crewmembers were properly certificated and current with their requirements.

3. There was no malfunction of the aircraft prior to the accident except that the captain's altimeter could have been indicating erroneously as much as 250 feet too high.

4. The weather conditions were adequate for a circling approach to Runway 5, under the existing regulations. However, scattered clouds at 400 feet could have caused the pilot to extend his flightpath outside the circling area.

5. None of the Emmet County Airport runways was equipped with visual approach aids, such as VASI or VAPI, or approach lights except for REIL's on Runway. 23 and 32. The runways are equipped with medium-intensity runway lights.

6. The approach area to Runway 5 contained few, if any, visual cues to assist in determining vertical and horizontal positions during a night circling approach.

7. An altimeter malfunrtion, illusions because of the lack of visual cues at night, or a combination of both could have resulted in the pilot's being unaware of his dangerously low position during his approach.

(b) Probable Cause

The Board determines the probable cause of this accident to be illusions produced by the lack of visual cues during a circling approach over unlighted terrain at night to a runway not equipped with approach lights or other visual approach aids. These illusions, which made the pilot think that he was higher than his true position, were made more acceptable to him because of a strong possibility of an erroneously high indication on his altimeter.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

December 22, 1970.

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The Board received notification of the accident approximately 2300 e.d.t., on May 9, 1970. The Iuvesrigator-in-Charge was dispatched immediately to the scene from Washington, D. C. Working groups established were operations, witnesses, air traffic control, structures, powerplants, aircraft and maintenance records, systems, and human factors. Parties to the investigation were Executive Jet, Inc., Lcar Jet Industries, Inc., the Federal Aviation Administration, and the General Electric Company. The on-scene phase of the investigation was completed in 4 days. Tests and research continued at other locations thereafter.

2. Hearing

There was no public hearing.

3. Preliminary Report

An Aircraft Accident Preliminary Report was published on June 18, 1970.

APPENDIX B

CREW INFORMATION

Captain George Ollie Evans

Captain Evans was born November 22, 1921. He held Air Transport Pilot Certificate No. 439500, with ratings in Lear Jet models 23/24, airplane multiengine land. He formerly held an instructor's rating which expired February 28, 1969. He was issued a first-class medical certificate with the restriction to wear correcting lenses for near vision while exercising the privileges of his airman Certificate.

He was employed by Executive Jet, Inc., on May 1, 1967, and upgraded to captain on August 18, 1967.

Flight Time in Hours:

Total in Lear Jet:	2,142
Pilot-in-command, previous 90 days:	143.4
Pilot-in-command, previous 30 days:	73.6
Pilot-in-command, previous 24 hours:	2.1
Total night time, all makes:	2,449.7
Instrument: Actual, 800.2 - simulated, 465.3	
Total time, all makes:	7,760

First Officer Joseph U. Karaffa

First Officer Karaffa was born April 28, 1929. He held Commercial Airman Certificate No. 736095, with airplane single- and multiengine land, and instrument ratings. He was issued a first-class medical certificate on April 11, 1970, with no limitations.

He was employed by Executive Jet Aviation, Inc., on April 6, 1970.

Flight time in hours:

Total in Lear Jet:	36.7
Total time, previous 90 days:	36.7
Total time, previous 24 hours:	2.1
Total night time:	1,100
Total actual instrument:	550
Total time, all makes:	6,533
Total jet time:	3,036.7

APPENDIX C

AIRCRAFT INFORMATION

N434EJ was one of 13 Lear Jet aircraft operated in the U. S. domestic air taxi service by Executive Jet Aviation, Inc. Much of this service was provided on a contracted annual mileage basis. The United Auto Workers International Union (UAW) was one of several business organizations and corporations contracting for this service.

N434EJ was a Lear Jet model 23 aircraft. Its serial number was 056 and it was powered by two General Electric engines, model CJ-610-1.

The total time on the aircraft was 3,530.6 hours. The date of the last annual inspection was April 1, 1970, at which time the aircraft had a total time of 3,417.0 hours. It had flown 114.5 hours since the last 100-hour inspection.

The No. 1 engine, S/N 241-157, had been flown 830.5 hours since overhaul. The No. 2 engine, S/N 241-139, had been flown 611.0 hours since overhaul.

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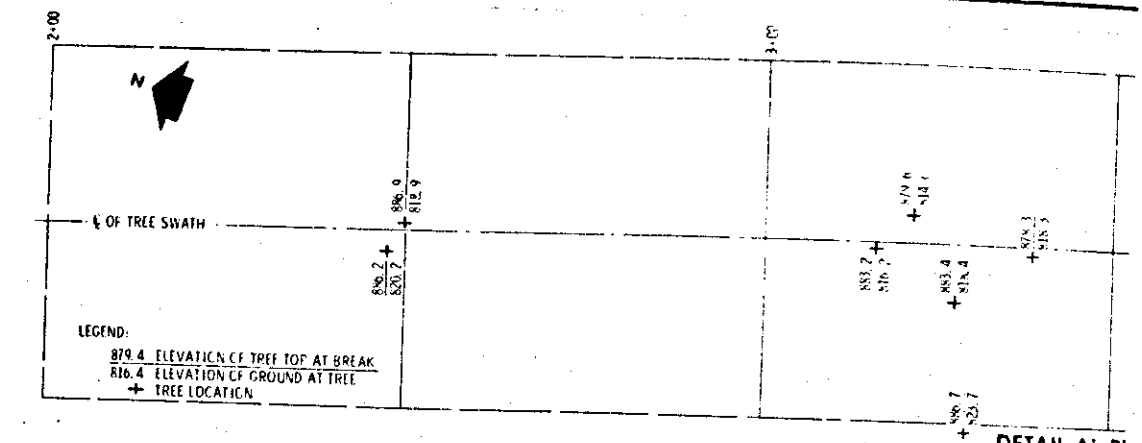
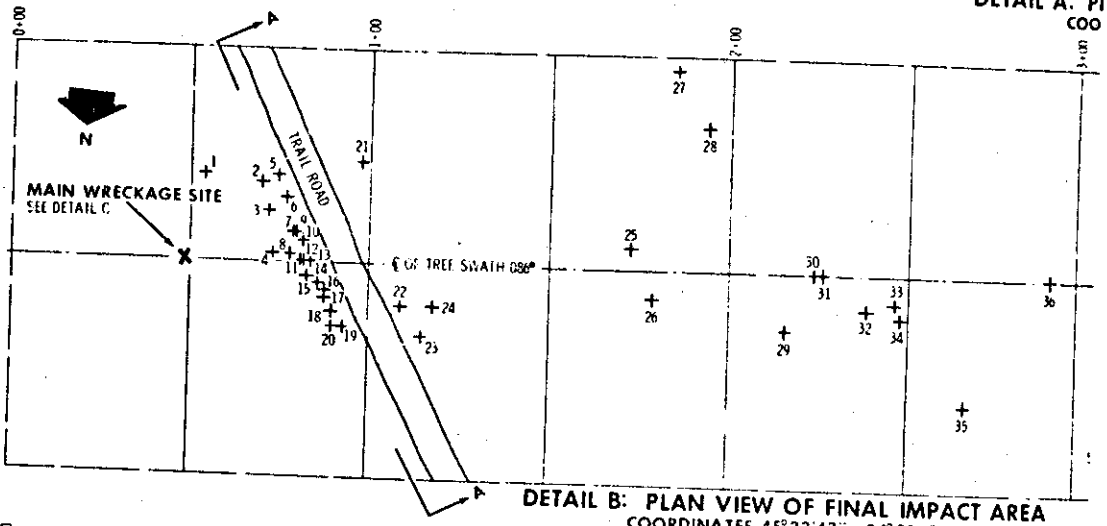
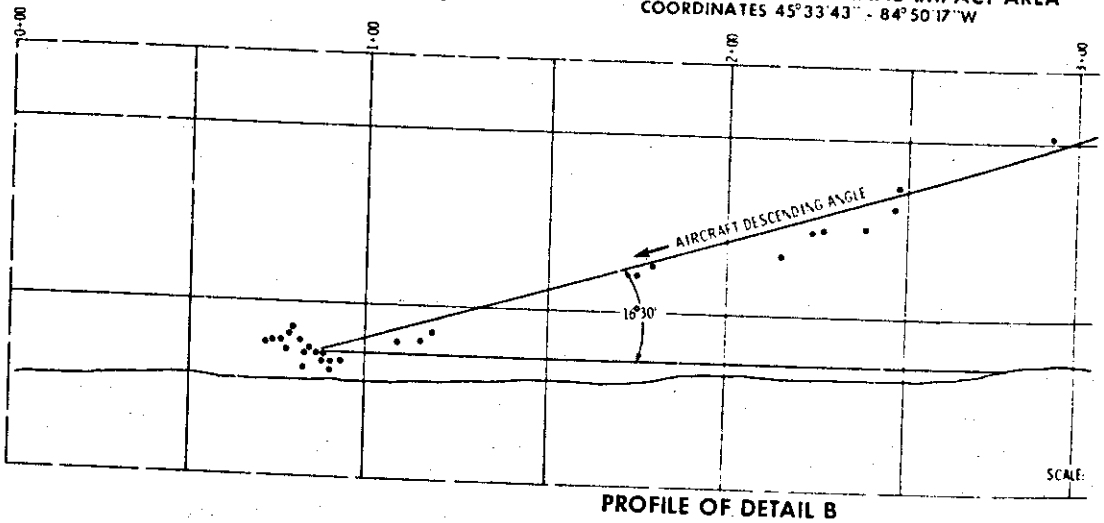


DETAIL A: PI
COO

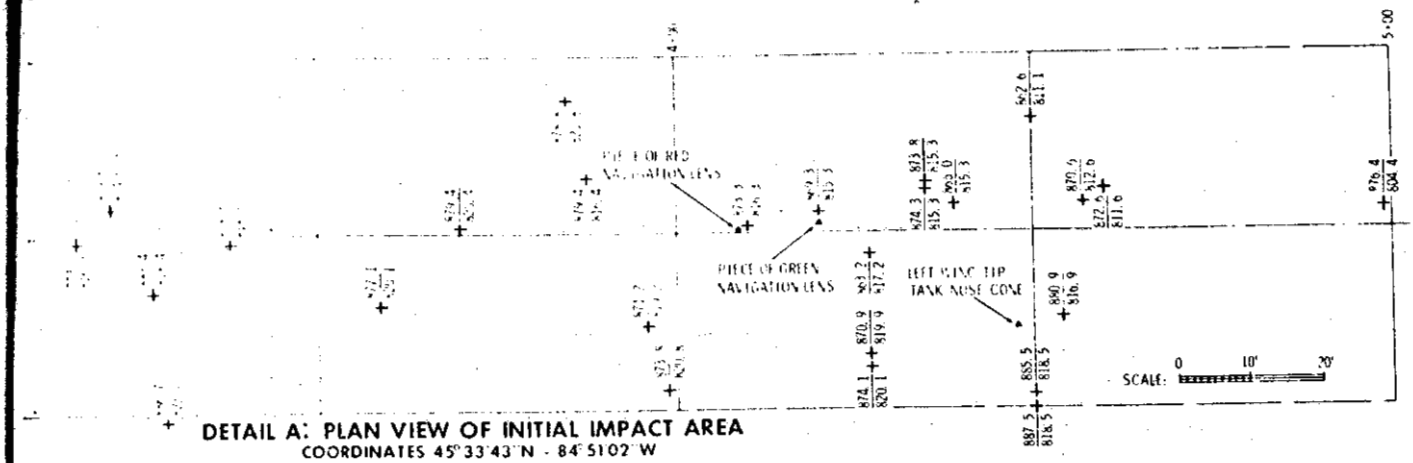


DETAIL B: PLAN VIEW OF FINAL IMPACT AREA
COORDINATES 45°33'43" - 84°50'17"W

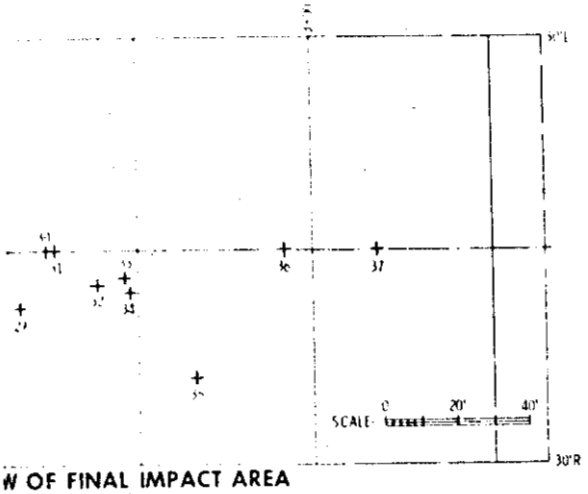


PROFILE OF DETAIL B

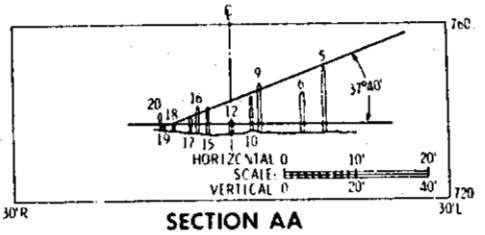
B



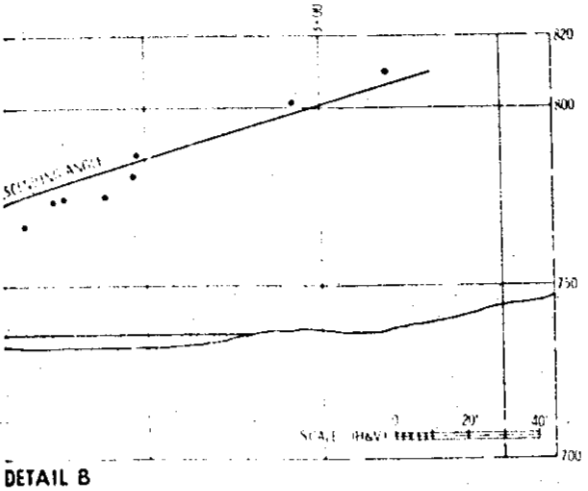
DETAIL A: PLAN VIEW OF INITIAL IMPACT AREA
COORDINATES 45°33'43"N - 84°51'02"W



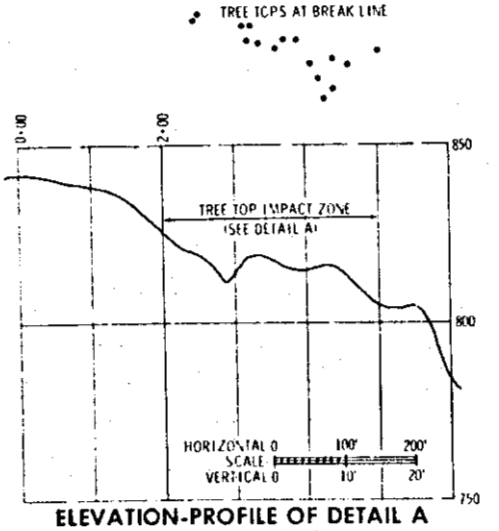
W OF FINAL IMPACT AREA
45°33'43" - 84°50'17" W



SECTION AA

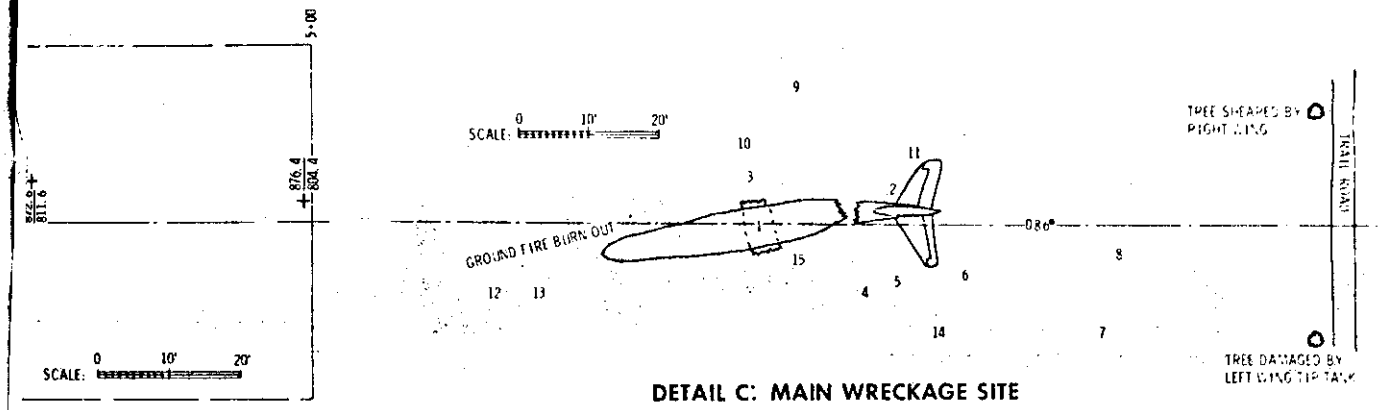


DETAIL B



ELEVATION-PROFILE OF DETAIL A

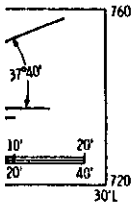
TREE	STATION	DIST OFF ℄	BA
1	0+54	12'L	
2	0+70	11'L	
3	0+72	7'L	
4	0+74	12'L	
5	0+75	9'L	
6	0+77	1'L	
7	0+78	4'L	
8	0+79	4'L	
9	0+80	3'L	
10	0+82	10'L	
11	0+82	℄	
12	0+83	℄	
13	0+84	℄	
14	0+83	2'R	
15	0+86	3'R	
16	0+88	4'R	
17	0+88	5'R	
18	0+90	7'R	
19	0+93	9'R	

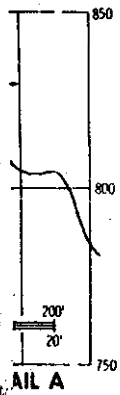


DETAIL C: MAIN WRECKAGE SITE

COMPONENT IDENTIFICATION

1. FUSELAGE - PASSENGER CABIN
2. EMPENNAGE
3. RIGHT WING
4. LEFT TIP TANK FIN
5. LEFT MAIN GEAR
6. NOSE GEAR
7. LEFT TIP TANK
8. LEFT WING LEADING EDGE
9. RIGHT FLAP
10. RIGHT TIP TANK FIN
11. RIGHT MAIN GEAR
12. NOSE GEAR ACTUATOR
13. DIRECTIONAL GYRO
14. NOSE GEAR UPPER STRUT & STEERING HOUSING
15. LOCATION OF BURNED LEFT WING





AIL A

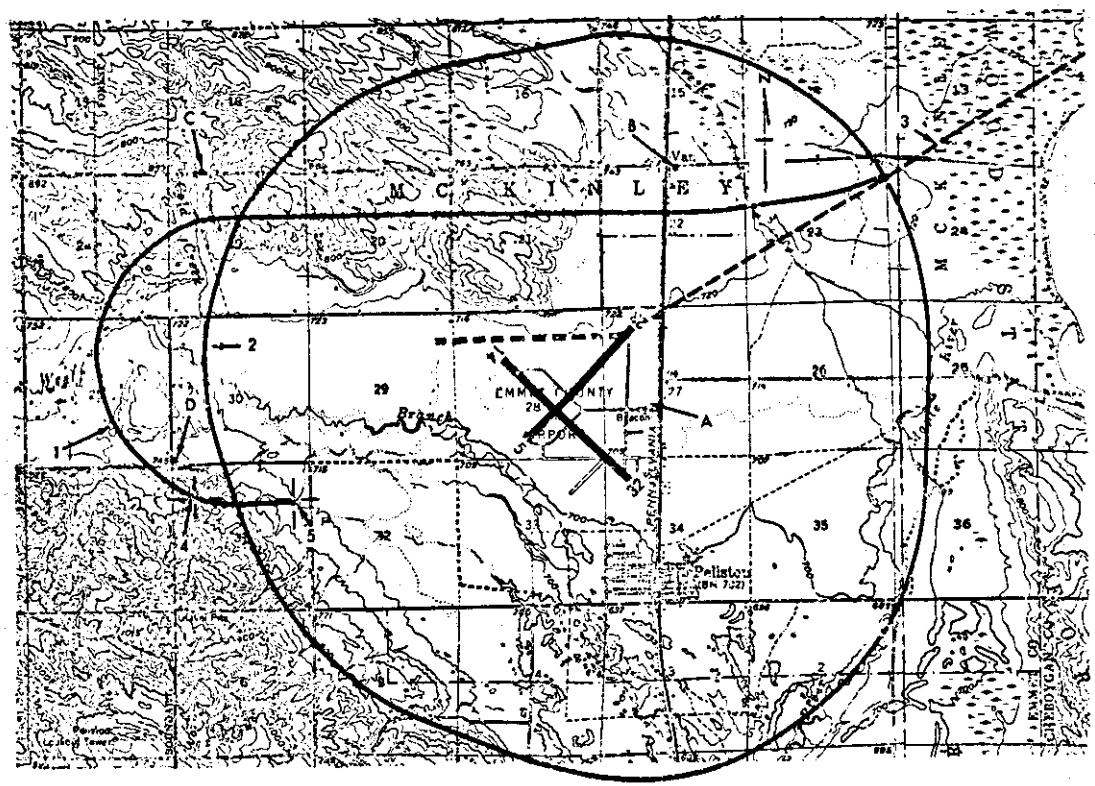
TREE ELEVATIONS FOR DETAIL B

TREE	STATION	DIST OFF ℄	BASE ELEV.	TOP ELEV.	TREE	STATION	DIST OFF ℄	BASE ELEV.	TOP ELEV.
1	0+54	12'L	726.3	740.3	20	0+90	9'R	728.5	730.5
2	0+70	11'L	728.4	743.9	21	0+98	14'L	728.2	751.2
3	0+72	7'L	728.5	738.0	22	1+09	6'R	728.7	739.7
4	0+74	12'L	728.8	738.8	23	1+15	10'R	728.5	740.0
5	0+75	9'L	728.3	746.3	24	1+18	6'R	729.1	742.1
6	0+77	1'L	728.3	728.8	25	1+73	3'L	730.0	756.5
7	0+78	4'L	728.3	736.3	26	1+79	4'R	729.7	761.7
8	0+79	4'L	728.5	740.5	27	1+85	28'L	731.4	771.4
9	0+80	3'L	728.3	742.3	28	1+94	20'L	730.6	768.6
10	0+82	10'L	728.4	738.4	29	2+15	8'R	731.1	766.1
11	0+82	℄	727.3	735.3	30	2+23	℄	731.6	772.6
12	0+83	℄	727.4	731.4	31	2+26	℄	731.7	773.7
13	0+84	℄	727.4	736.4	32	2+38	5'R	731.9	773.9
14	0+83	2'R	728.1	735.1	33	2+46	4'R	732.3	780.3
15	0+86	3'R	728.3	735.3	34	2+47	6'R	732.9	785.9
16	0+88	4'R	728.5	735.5	35	2+66	18'R	734.1	786.1
17	0+88	5'R	728.5	733.0	36	2+91	℄	736.6	800.6
18	0+90	7'R	728.8	732.3	37	3+18	℄	737.7	809.1
19	0+93	9'R	729.1	734.1					

NATIONAL TRANSPORTATION SAFETY BOAR
DEPARTMENT OF TRANSPORTATION
Washington. D.C.

WRECKAGE DISTRIBUTION CHART
OCA-70-A-8 EXECUTIVE JET AVIATION, NC
LEAR JET, MODEL L-23A. N434EJ
Pellston. Michigan
May 9, 1970

ATTACHMENT NO 2



LEGEND

1. Approximate flight path according to witnesses.
2. Circling approach area (TERPS).
3. Inbound course from VOR.
4. Initial impact point.
5. Final impact point and main wreckage.

A. Thomas M. Sorrick, FSS Specialist.
B. Gary Minard.
C. Myron W. Drier.
D. Mrs. George Conrad.

NATIONAL TRANSPORTATION SAFETY BOARD
Department of Transportation
Washington, D. C.

ACCIDENT SITE AND WITNESS LOCATION CHART
EXECUTIVE JET AVIATION, INC. LEAR JET
MODEL i-23A N434EJ
Pellston, Michigan May 9, 1970

END

DATE FILMED

3-12-71