PB 81-910411

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

CASCADE AIRWAYS, INC.
BEECHCRAFT 99A, N390CA
SPOKANE, WASHINGTON
JANUARY 20, 1981

NTSB-AAR-81-11

UNITED STATES GOVERNMENT

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16. Abstract

About 1127 P.s.t., on January 20, 1981, a Cascade Airways, Inc., Beech 99A, operating as Flight 201, crashed during an instrument approach in instrument meteorological conditions at Spokane International Airport. The aircraft hit a hill about 4.5 miles from the runway threshold at an elevation of 2,646 feet. The minimum descent altitude for the instrument approach procedure was 2,760 feet. Of the nine persons aboard Flight 201, seven were killed and two were injured seriously.

The instrument approach procedure the flightcrew used required that an altitude of 3,500 feet be maintained until the aircraft passed the final approach fix, located 4.5 miles from the runway threshold. The aircraft impacted the ground near the location of the final approach fix, which was about 1,600 feet southeast of the Spokane VORTAC.

The National Transportation Safety Board determines that the probable cause of the accident was a premature descent to minimum descent altitude (MDA) based on the flightcrew's use of an incorrect distance measuring equipment (DME) frequency and the flightcrew's subsequent failure to remain at or above MDA. Contributing to the cause of the accident was the design of the DME mode selector which does not depict the frequency selected and the failure of the flightcrew to identify the localizer DME facility.

17. Key Words
Instrument approach; descent below minimum descent altitude; DME mode selector; hold button; localizer instrument approach; misinterpretation of approach chart, incorrect DME frequency, design of DME mode selector, identification of DME frequency, brace position, human performance.

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WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: July 21, 1981

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SYNOPSIS

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The instrument approach procedure the flightcrew used required that an altitude of 3,500 feet be maintained until the aircraft passed the final approach fix, located 4.5 miles from the runway threshold. The aircraft impacted the ground near the location of the final approach fix, which was about 1,800 feet southeast of the Spokane VORTAC.

The National Transportation Safety Board determines that the probable cause of the accident was a premature descent to minimum descent altitude (MDA) based on the flightcrew's use of an incorrect distance measuring equipment (DME) frequency and the flightcrew's subsequent failure to remain at or above MDA. Contributing to the cause of the accident was the design of the DME mode selector which does not depict the frequency selected and the failure of the flightcrew to identify the localizer DME facility.

1. FACTUAL INFORMATION

1.1 History of the Flight

On January 20, 1981, Cascade Airways, Inc., Flight 201, a Beech 99A, N390CA, was being operated as a scheduled 14 CFR 135 passenger flight between Seattle, Washington, and Spokane, Washington, with intermediate en route stops at Yakima, Washington, and Moses Lake, Washington.

The flightcrew reported to the Cascade Airways operations facility in Walla Walla, Washington, about 0500 1/ and conducted the preflight activities according to Cascade Airways procedures. They departed Walla Walla at 0604 as the flightcrew of Flight 930 and made one scheduled en route stop at Richland, Washington, before arriving at Seattle at 0730.

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

Flight 201 departed Seattle on schedule at 0805 on an instrument flight plan; however, it was 13 minutes behind schedule when it stopped at Yakima and 25 minutes late when it arrived at Moses Lake, Washington, at 0950. Both late arrivals were the result of weather delays. Although Flight 201 had been scheduled to depart Moses Lake at 0935, the departure was delayed until 1055 because of weather conditions at Spokane. Two crewmembers and seven passengers were on board when Flight 201 departed Moses Lake. Based on radio transmissions of Flight 201, it was determined that the first officer was probably flying this flight segment.

The en route portion of the flight to Spokane was uneventful. At 1116:15, Flight 201 contacted the Spokane Approach Control West Arrival Controller and reported 6,000 feet and ATIS 2/ information MIKE. Information MIKE was: "Spokane International information MIKE 1903 special observation, measured ceiling 200 broken, visibility 1/2 mile, fog, temperature 31, dew point 31, wind 020 degrees at 7, altimeter 30.19, expect vectors for ILS approach landing runway 21, advise on contact you have information MIKE."

The west arrival controller responded: "Cascade 201, Spokane approach, ident, fly heading 050 vector ILS (21) final approach course maintain 6,000."

At 1116:46, the controller transmitted, "Cascade 201, we just changed the runways, sir, runway 3 is in use, wind 030 at 8, turn right heading 070." Flight 201 acknowledged this transmission. At 1118:35, the controller said "Cascade 201 turn right heading 090, be a vector for spacing, they still got aircraft lined up for 21." Flight 201 acknowledged and was instructed to descend to 4,000 feet.

At 1121:08, the controller said, "Cascade 201, you'll be vectored across final for spacing." At 1121:50, the west arrival controller handed off Flight 201 to the local controller. The position of Flight 201 was given by the west controller as 10 miles southwest of the Spokane VORTAC. 3/

At 1122:10, Flight 210 asked, "Spokane, 201, are they gonna turn the back course on?" The controller responded, "Yes sir, they will here shortly, they still got a United jet on final about a 4 mile final for 21." Flight 201 acknowledged this transmission. At 1122:23, the controller said, "Cascade 201, turn left heading 030."

At 1123:35, the controller instructed, "Cascade 201 turn left heading 360" and at 1124:12, he said, "Cascade 201, localizer should be up 6 miles from OLAKE, 4/ cleared for the approach." At 1124:16, Flight 201 replied, "There it is, we're cleared for the approach, 201."

At 1125:45, the controller instructed Flight 201 to contact the Spokane tower. At 1125:50, Flight 201 replied, "Roger." This was the last transmission from Flight 201.

About 1127, the aircraft crashed into a plowed field at latitude 47°33'40" N and 117°37'30" W longitude. The initial point of impact was on slightly rising terrain at an elevation of 2,646 feet. The aircraft became airborne again, went over a hilltop, and came to rest 1,380 feet from the initial point of impact, at an elevation of 2,455 feet. The initial impact point was about 1,770 feet southeast of Spokane VORTAC.

2/ Automatic Terminal Information Service
3/ A colocated very high frequency omnirange station and ultra-high frequency tactical air navigation aid.

One ground witness saw the aircraft hit the ground and become airborne again. A second witness saw the aircraft when it became airborne after the initial impact. Both witnesses saw the aircraft burst into flames after it came to a halt. The witnesses, who were below the impact area, said the hilltop was obscured by clouds and fog.

Both surviving passengers had boarded the aircraft in Yakima. One survivor was seated on the right side of the aircraft opposite the main exit with his seatbelt fastened securely. He said the flight had been routine, the visibility at altitude was good, and he saw patches of fog on the ground. He said that he was not aware of the nearness of the ground until the initial impact. He felt the aircraft "lurch-up" and the right wing went up. As he looked out he could see trees but not the ground. The aircraft was in a nose-level attitude after the initial impact, but shortly after, the nose went down. He braced himself for the crash. After the aircraft came to rest he was not in his seat but was in the aisle facing the rear. His seat had separated from the mounting brackets on the cabin wall. The aisle floor legs were not found.

The second survivor was seated in the third seat aft of the cockpit on the left side of the aircraft. He said the flight was uneventful en route to Spokane and he could see patchy ground fog. He recalled that he heard no public address announcements from the flightcrew during the flight, although there was a series of clicks from the speaker. Neither he nor the other survivor recalled the seatbelt sign in the cabin. He stated that the aircraft made a series of turns during the arrival in the Spokane area, and at one point he heard what he thought was the landing gear being recycled twice before it was finally put down. He also heard a loud buzzing sound from the cockpit and saw a red light on the instrument panel. He believed the light came from the cockpit area where the landing gear handle was located.

According to the second survivor, there were no unusual engine noises during the series of turns, and the flightcrew appeared to perform routine duties in an unhurried manner. He had his seatbelt fastened with about 1 inch of slack in it. The aircraft was in the clouds, and he had no ground reference until just before the first impact with the ground, when he saw the ground and trees and was surprised at the low altitude of the aircraft. He felt a scraping under the aircraft and immediately put his head in his lap in a brace position. Before he could bend over completely, the aircraft made the first impact with the ground. There was no warning from the flightcrew, nor was there an abrupt pull up of the aircraft before the impact. Engine noise levels remained unchanged. The initial impact was severe, and he stated that he saw two passengers who did not have their seatbelts fastened, thrown from their seats. The aircraft became airborne again and went straight ahead in a nose level attitude. The nose went down, he felt scraping again, and the aircraft hit the ground for the second time. His head was thrown into his knees, and his body was shoved forward. When he recovered from the crash, he found that he was still strapped in his seat, but was on his back in the aisle. His seat was attached to the cabin floor, but the wall mounts had separated. He crawled out of the wreckage and was about 15 feet from the aircraft when he saw the engine blowup and flames and smoke engulf the cabin interior. At the same time, he saw the other surviving passenger move, and he returned to the aircraft to help drag him out of the wreckage. As they rolled away from the wreckage, he saw the aircraft in flames. Both passengers stated that they believed that the fire started in the right engine.

4/ OLAKE - OLAKE Intersection is the final approach fix for the localizer 3 instrument approach procedure and is located on the centerline of the approach course, 4.5 miles from the runway 3 threshold.

1.2 **Injuries to Persons**

Injuries	Crew	Passengers	Others	Total
Fatal	2	5	0	7
Serious	0	2	0	2
Minor/None	0	0	0	0
Total	2	7	0	9

1.3 **Damage to Aircraft**

The aircraft was destroyed.

1.4 **Other Damage**

There was some damage to the wheat field where the aircraft made the initial ground impact.

1.5 **Personnel Information**

Both pilots were qualified and certificated for the flight and had received the training required by current Federal regulations. (See appendix B.)

Both pilots had reported for duty at 0500, and each pilot had 15 hours of off-duty time since the previous workday. They had been on duty for 6 hours 27 minutes and had flown 3 hours 20 minutes when the accident occurred.

1.6 **Aircraft Information**

The aircraft, a Beech 99A, was certificated and maintained in accordance with applicable regulations. (See appendix C.) The Mode C altitude encoding capability of the altimeter had become inoperative during an earlier flight on January 20, 1981, and had not been repaired when the accident occurred. However, a Mode C reporting capability was not required for Cascade Airways operations.

The aircraft was equipped with two Pratt & Whitney Aircraft of Canada, Ltd, PT6 A-27 turbopropeller engines and two Hartzell Model No. HC-B3TN-3 propellers. The aircraft was within center of gravity limits, was below the maximum allowable weight limit, and was carrying 1,350 pounds of jet-A fuel when it departed the Moses Lake airport.

1.7 **Meteorological Information**

The area forecast for Eastern Washington, issued by the National Weather Service (NWS), called for ceilings and visibilities below 1,000 feet and 3 miles in fog at the time of the accident. The terminal forecast between 0800 and 1200 for Spokane International Airport was for visibilities varying from 1/4 to 5 miles in fog. There were no in-flight weather advisories applicable to the time or the location of the accident.

Surface weather observations for Spokane International Airport, taken by a NWS observer were, in part, as follows:

> 1108--Measured ceiling--300 feet broken; visibility--2 mi, fog; wind--020° at 7 kns; altimeter setting--30.18 inHg.

1129--400 feet scattered; visibility 2--mi, fog; wind--040° at 9 kns; altimeter setting--30.18 inHg.

1.8 Aids to Navigation

Flight 201 was making a localizer instrument approach to runway 3 at the Spokane International Airport. The localizer and distance measuring equipment (DME) information for the approach procedure is provided by the localizer transmitter at the airfield, 0.3 mile from the runway 3 threshold. The Spokane (GEG) VORTAC is located about 4.5 miles from the runway 3 threshold and is about 1,800 feet northwest of the localizer 3 centerline. (See figure 1.)

An aircraft can be vectored to the localizer course by air traffic control (ATC), in which case, the pilot would not have to tune the Spokane VORTAC, except for orientation to the area. If a pilot is intercepting the 10 DME arc to proceed to the localizer course, he would have to use the Spokane VORTAC DME information for navigation guidance to intercept and fly the DME arc.

As soon as an aircraft is cleared for the instrument approach, the procedure requires the flightcrew to tune and identify both the localizer and DME frequencies (109.9 IOLJ). Course guidance and distances from the airport would be derived from the localizer frequency. Once the aircraft is on the localizer centerline, the only use for the Spokane VORTAC would be for general orientation or identification of the OLAKE intersection with the 115° radial, which would be applicable if the pilot had no DME, chose not to use the DME, or elected to use the VORTAC crossing radial as a backup to the DME.

A pilot is required to maintain 3,500 feet until the 4.2 DME point (or the 115° radial) is reached. At that point, the aircraft can be descended to the minimum descent altitude of 2,760 feet. If the runway environment for runway 3 is not in sight by the 0.2 mile DME point, a missed approach is required. At the missed approach point, an aircraft would be 393 feet above the runway touchdown zone and 0.5 mile from the runway threshold. The approach procedure contains a visual descent point (VDP) which is signified by a "V" in the profile view of the chart. Descent should begin at this point, located at the 0.8 mile DME, to fly a 3° descent to the runway provided the aircraft is at MDA. However, no descent is authorized unless the runway or the runway environment is seen by the pilot.

The instrument approach navigation equipment for runways 3 and 21 is designed so that the navigation aids for both runways cannot operate simultaneously. For example, the instrument landing system (ILS) to runway 21 was in use when Flight 201 arrived in the Spokane area. As a result, the localizer 3 instrument approach aids could not be activated until the ILS approaches were completed, and the ILS equipment was shut down. An interlock device precludes the activation of one instrument approach system while the other equipment is operational. The transition from one system to the other can be accomplished in less than 15 seconds.

Federal Aviation Administration (FAA) flight and ground checks of the Spokane VORTAC and localizer facilities on the day of the accident found that all components were operating properly.

1.9 Communications

There were no known communications difficulties.

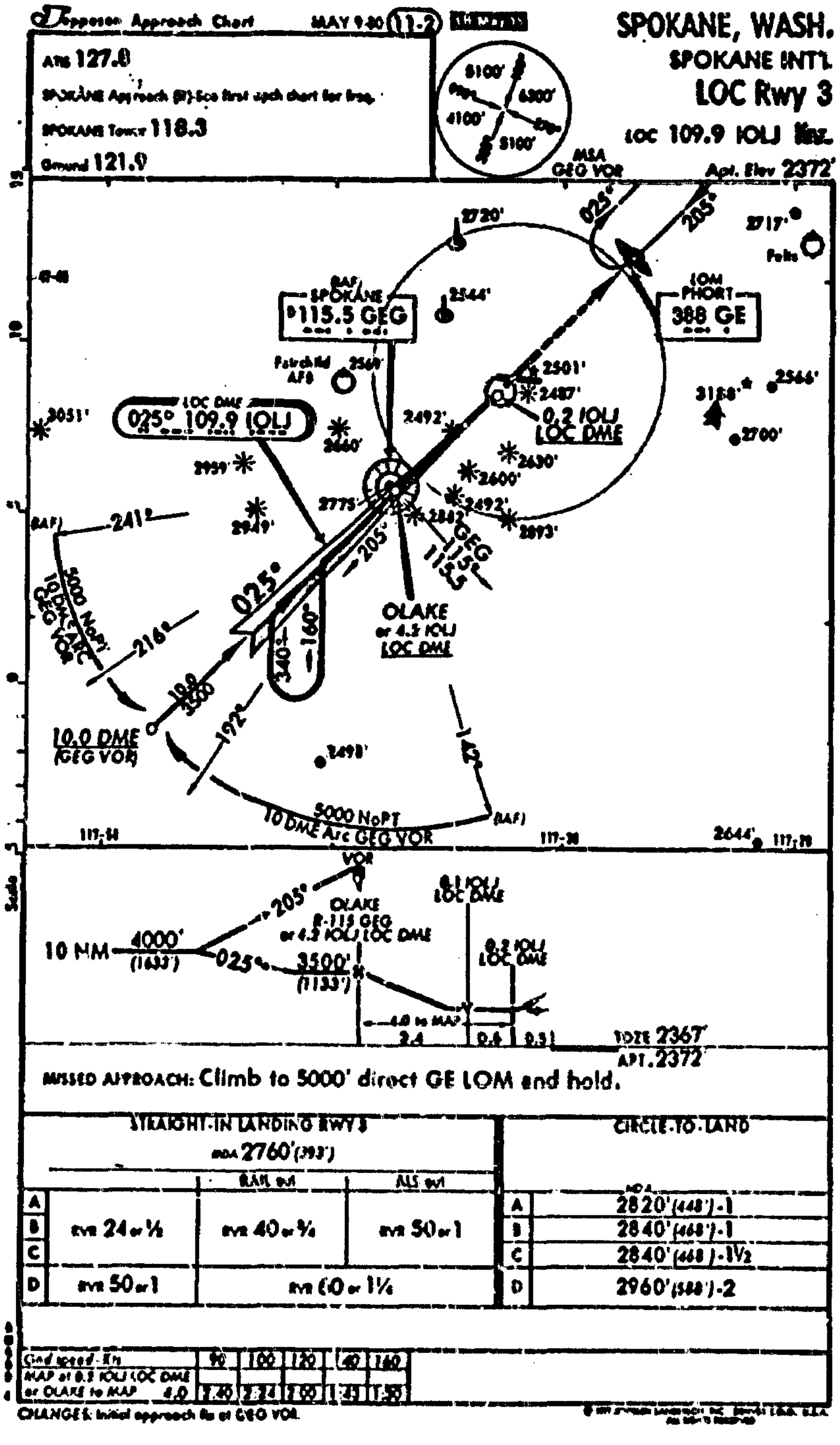

Figure 1.-- Localizer runway 3 approach chart.
(Not to be used for navigational purposes.)

1.10 Aerodrome and Ground Facilities

Not applicable.

1.11 Flight Recorders

The aircraft was not equipped, nor was it required to be equipped, with flight recorders.

1.12 Wreckage and Impact Information

The aircraft struck the ground at an elevation of 2,646 feet. The hilltop elevation was 2,670 feet. The initial impact was in a plowed wheat field on a magnetic heading of 35°. The ground marks in the field were three parallel, shallow tracks, about 52 feet long and 6 1/2 feet apart. The track widths correspond to the landing gear widths of a Beech 99A aircraft.

All three landing gears, the landing gear assemblies, and pieces from the lower part of the fuselage were scattered along a line extending about 275 feet beyond the ground tracks. A measurement of the main gear actuators indicated that the gears were in the full down position at impact. In addition, a tip from the left engine's propeller, a wing spar strap cover which had been in the lower baggage pod, and the lower fuselage rotating beacon were found in the same general area.

The main wreckage was located on the opposite side of the hill, about 1,380 feet from the initial impact point, at an elevation of 2,455 feet. After the aircraft made final ground contact on a heading of about 35°, it slid about 75 feet before the left wing struck a rock which caused it to turn left to a heading of about 350°.

The wings remained attached to the fuselage, but the upper right wing forward attach bolt was stripped, and the fitting for the bolt was broken. The empennage had separated partially from the fuselage and was positioned about 45° to the left of the fuselage. All flight control surfaces were intact and attached to the aircraft. The aileron, rudder, and elevator flight control cables were intact and exhibited no preimpact damage. The flaps were attached to the wings and were in the 30 percent down position, which was determined by a measurement of the flap actuator screwjacks.

The fuselage was relatively intact after impact, although there was a break aft of the point where the right wing joined the fuselage. The cockpit and cabin areas were burned severely in the postcrash ground fire. The entire upper portion of the fuselage from the cockpit aft was destroyed by fire. The side walls were burned down to the cabin and cockpit floor on the left side and to the bottom of the window line on the right side of the fuselage. In addition, the cockpit instruments, navigation radios, and the DME mode selector were burned severely.

The navigation communications units mounted in the center instrument panel were recovered. The No. 1 communications receiver was tuned to the Spokane approach control frequency of 124.3, and the No. 2 unit was tuned to the company frequency, 131.3. Both navigation receivers were tuned to 109.9, which was the Spokane localizer 3 frequency. The No. 2 DME switch on the DME mode selector was engaged; the No. 1 DME, the HOLD, and the RNAV switches were in the off position. Both altimeters were destroyed and no information could be derived from them.

The engines had separated from the wings but were connected to the wings by cables. Both propellers, including the individual blades, remained attached to their respective engines. The blades of both propellers were intact and complete with the exception of one blade of the left propeller. The blade damage was generally bending in the aft direction with some torsional twisting. There was a small amount of leading and trailing edge blade damage. Both engines received ground fire damage.

The left engine's exhaust duct displayed some torsional-type counter propeller rotational twisting and some compressive buckling. The right engine exhaust duct did not exhibit any notable torsional-type counter propeller rotational twisting. However, an internal examination of the power turbine rotating labyrinth seal of the right engine indicated heavy circumferential rubbing over 360°.

The complete examination of the engines and propellers disclosed no evidence of any preimpact malfunctions. All engine components were in normal condition except for the effects of impact and/or ground fire damage.

1.13 Medical and Pathological Information

Postmortem examinations were conducted to determine the extent of the injuries and preexisting or incapacitating disease for the flightcrew and the injuries to the passengers. Toxicological examinations of the flightcrew were negative for basic, acidic, and neutral drugs. No ethyl alcohol was present. Test results for carboxyhemoglobin concentration did not exceed 3 percent (a trace level) for any of the seven fatalities.

Both flightcrew members died of extensive impact trauma caused by multiple fractures and internal injuries. The examinations of the flightcrew did not reveal any preexisting or incapaciting disease which would have affected their ability to conduct the flight. Four passengers who received fatal traumatic injuries also evidenced thermal burns, while all occupants received various fractures of the extremities. Two passengers received skull fractures, and five passengers evidenced pulmonary hemorrhages.

One survivor had fractures to both ankles, a fractured fibula, and facial lacerations; the other survivor had a fracture of the ribs and a compression fracture of the back, a fractured femur, multiple soft tissue injuries, and burns to his left leg.

1.14 Fire

The aircraft was burned severely during the postcrash fire, and flames singed a tree about 65 feet above the wreckage.

According to one survivor, the fire did not start until the aircraft came to rest. Although the exact ignition source was not determined, the fire started in the area of the right engine and spread throughout the entire fuselage.

A state trooper who reached the aircraft about 18 minutes after the accident stated that he saw only smoke coming from the aircraft until he moved closer to the fuselage and saw the interior of the cockpit on fire.

1.15 Survival Aspects

All seven fatalities received extensive impact injuries. Thermal injuries occurred from the postcrash fire but were not the cause of death. The aircraft fuselage remained relatively intact and its shape was maintained. However, several seats and the restraint system failed in the crash sequence. The injuries to the occupants and the aircraft damage indicated high vertical and longitudinal g-forces.

The captain's and first officer's seats failed in a downward and forward direction. Both seat bottom frames separated from the leg structures. The legs of the captain's seat remained attached to the floor tracks, while the legs of the first officer's seat separated from the floor tracks. The captain's lap belt buckle was found latched and with the shoulder harness metal fittings attached. Although the first officer had not used the shoulder harness, the lap belt was latched in place.

Most of the passenger seats had separated from the floor mounting tracks and were found in the forward area of the cabin. Structural damage to the passenger seats indicated high downward and longitudinal decelerative forces, which inflicted download damage to seat frames and leg structures. Seat legs typically separated from floor tracks and showed evidence of bending in a forward direction. Wall attach points for the seats showed evidence of separation in a forward direction.

The cabin interior was burned severely. As a result, no intact seatbelts were found. Two metal-to-metal passenger seatbelt buckles were found in the latched condition while two others were found unlatched; the other buckles were not found.

The survivor who received the least serious injuries stated that he anticipated the first impact and was almost completely bent over with his head in his lap. His seatbelt was fastened securely. He stated that some of the passengers did not have their seatbelts fastened and he saw two passengers thrown from their seats during the first impact.

1.16 Tests and Research

The Safety Board disassembled and inspected the aircraft's engines and propellers. The left and right engines were also inspected for evidence of rotational contact between the various rotating and stationary engine components. The left engine exhibited rotational contact marks on the following components: the propeller shaft oil transfer tube snap ring, the threaded forward edge of the first stage reduction gear carrier, the rear face of the turbine disc and blade disc fir trees, the outside edge of the power turbine disc hub, the power turbine blade knife edge seals, the forward face of the power turbine disc, the stator housing assembly of the power turbine, the inner and outer interstage airseal baffle; the outer periphery of the rear side of the stator vane outer platform; the front interstage airseal baffle plate and outer baffle edge; the compressor turbine disc; and blades at the disc/blade fir tree attach points. The right engine exhibited rotational contact marks on the following components: the power turbine rotating labyrinth seal, the rear face of the turbine disc, the remaining attached blade fir trees, the rear side of the inner and outer rings of the power turbine stator, the turbine interstage sealing baffle and plate rims, and the centrifugal compressor impeller and impeller housing.

There was no evidence of any impact or preimpact malfunctions or damage in either propeller's internal operating components, except for a fractured right propeller feathering spring retainer cup sleeve and a bent pitot tube. No impact marks were found on either propeller's piston, cylinder, or counterweight which could be related to blade angles at impact. However, the location of the contact marks of the hub spider arm on one of the right propeller's blade butt face was consistent with the blade being in the low pitch operational regime at impact.

1.17 Additional Information

1.17.1 Cascade Airways, Inc., Operating Procedures

Cascade Airways, Inc. was authorized to conduct air taxi operations as an air carrier engaged in air transportation utilizing aircraft of 12,500 pounds or less maximum certificated gross weight in accordance with 14 CFR 135. The company had been operating for about 11 years and operated 12 Beech 99A aircraft and 3 Bandeirante EMB-110 aircraft. Cascade Airways employed about 90 pilots and transported about 280,000 passengers in 1980.

The following procedures and policies were extracted from the Cascade Airways, Inc. Flight Operations Manual:

RESPONSIBILITY OF ALL CREWMEMBERS

A. All crewmembers are responsible for bringing to the attention of other crewmembers, particularly the pilot-in-command, any condition, occurrence, procedural error or malfunction which may affect the safe conduct of the flight. Crewmembers shall never assume that other crewmembers are also aware of such matters without verification.

* * *

AIRPORT/ROUTE FAMILIARIZATION

A. Notwithstanding maintenance of route/airport qualification requirements of FAR and company policy, the captain shall be responsible for assuring himself that he is familiar with current airport conditions, applicable instrument approach procedures, departure procedures, arrival procedures and the enroute procedures which may be used in the conduct of the planned flight. The captain shall discuss with Flight Control any such matters in question before the dispatch release is signed.

* * *

III. INSTRUMENT APPROACHES

A. Approach check list shall be completed 5 to 10 minutes before beginning the approach.

B. Both pilots shall be responsible for reviewing instrument approach chart, or charts, well before beginning the transition to the approach, or the actual instrument approach. The approach chart shall be retained in a position of ready reference by both pilots while the approach is being conducted.

* * *

E. Pilots in command are reminded that the landing and takeoff minimum provided by the Instrument Approach Chart are the lowest legal minimums under normal flight conditions. Flights shall not operate at lower minimums without exercising the pilot's emergency authorit.. Pilots in command are responsible for evaluating the prevailing flight conditions at the time the instrument approach is being conducted and for adjusting the published minimum upward in the interest of safe completion of the flight when those conditions dictate.

According to its Director of Training, the Cascade Airways procedure in preparing for the localizer 3 approach was that the No. 1 NAV receiver should have been tuned to the localizer facility (109.9 IOLJ), and the frequency would have been identified. The No. 2 NAV receiver could have been tuned to the same frequency, or to the Spokane VORTAC (115.5 GEG), to mark the passage of the final approach fix.

The Cascade Airway Flight Standards Manual contains the following procedures:

APPROACH

When practical, usually 5 minutes from airport of intended landing, the pilot flying will order the "Approach" Checklist.

APPROACH

PILOT NOT FLYING (challenge) & (respond)

1.	Heading and Altimeters	Cr-CKD/SET
2.	Radios & MKRS	Cr-SET
3.	Pax Briefing	COMPLETE
4.	Cabin Sign	BOTH
5.	Prop Sync	OFF
6.	Autofeather	C-ARMD

The Cascade Airway crew coordination procedures required that once the "Approach" checklist was completed, the pilot not flying would announce the following information concerning the LOC 3 instrument procedure:

The Spokane field elevation - 2,372 ft.
Inbound Heading and Check OBS Setting - 025°
Minimum Descent Altitude - 2,760 ft.
Missed Approach Point - .2 DME
Missed Approach Procedure - Climb to 5,000 ft.
Direct to PHORT
OM and Hold.

The crew coordination section of the Flight Standards Manual required the following procedures:

A. Preparation for Instrument Approach

1. All instrument approaches have certain basics in common.

a. Good descent planning
b. Careful review of the approach plate
c. Accurate flying and good crew coordination

2. Approach checklist should be completed approximately five minutes before beginning approach so that the pilot can give his undivided attention to flying the airplane.

3. Prior to reaching the Initial Approach Fix (IAF), both pilots will review the approach plate and it will be left out and visible to the nonflying pilot through out the approach procedure. The pilot flying will specify the radio aids required and will crosscheck that the correct aids have been selected, tuned and identified.

* * *

D. Approach Clearance

When cleared for an approach, descend to the lowest MEA or initial approach altitude as soon as possible. If in holding pattern at final approach fix descend to procedure turn altitude.

* * *

F. Pilot Duties During the Approach

1. Flying the Aircraft

Duty - Fly the aircraft in normal procedures for type of approach being flown.

Callouts - As appropriate for gear and flap management, power settings, checklists, etc.

2. Altitude Awareness During Non-Precision Approaches

Duty - Advise the non flying pilot of altitude changes during the approach.

Callouts - When vacating altitudes, callout for example leaving procedure turn altitude for minimum altitude, inbound for crossing the final approach fix "Leaving 4,000 for 3,500" etc. as appropriate.

G. Non Flying Pilot Duties During the Approach

1. Final Course Interception

Duty - When the localizer or glide slope starts moving in from full deflection, callout to flying pilot.

Callout - "Localizer Alive" and "Glide Slope Alive."

2. Instrument Monitoring

Duty - After final approach fix inbound, crosscheck flight instruments and monitor navigation instruments. Report any discrepancies, flags or warnings to flying pilot.

Callouts - As appropriate.

3. Flight Path and Performance Deviations

Duty - During the approach, advise the flying pilot when more than one dot deviation exists in localizer or glide slope, when airspeed is more than 5 knots from desired approach airspeed, and when the descent exceeds 1,000 FPM.

Callouts - "Localizer" for more than one dot deflection, "Glide Slope" for more than one dot deflection, "Airspeed" for more than 5 knot deviation, "Sink Rate" descent exceeds 1,000 FPM.

The landing checklist should have been completed at the final approach fix. At that point, the flaps should have been positioned according to the particular situation, but normally would be in the 30 percent down position. The landing gears should have been extended and the landing and taxi lights turned on as required.

4. Altitude Awareness

Duty - Standard Callouts made to flying pilot as appropriate from "STANDARD CALLOUTS" chart.

CONDITION/LOCATION	STANDARD CALLOUT
Final Fix inbound (Altimeter and instrument crosscheck)	Beacon, VOR, etc. ____ft Time No flags (or ___flags)
500 ft above minimums	500 ft instruments and altimeters X-check
400 ft above minimums	400 ft
300 ft above minimums	300 ft
200 ft above minimums	200 ft
100 ft above minimums	100 ft
Minimum altitude	Minimums, runway in sight (or no runway in sight, time, missed approach.

5. Establishing Visual Contact

Duty - The non flying pilot will look for visual cues outside the aircraft when calling out the last 200 feet of altitude change. Cues will normally come from seeing the runway, runway threshold, approach lights, sequence flashes, lead in lights or other markings. Advise flying pilot of visual cue insight.

Callouts - "Minimums - no contact" or "Approach Lights 12:30," "Runway in Sight," etc.
NOTE: Call out exactly what is seen. Do not report "runway in sight" until the runway is actually in sight.

6. Failure to Establish Contact

Duty - Advise flying pilot that published altitude minimums have been reached and/or missed approach point has been reached and there are no visual cues.

Callout - "Minimums/Time Up - No Contact."

7. Executing Missed Approach

Duty - Assist flying pilot in managing power, flaps, gear and checklist per normal operating procedures. Advise flying pilot if aircraft descends below minimums. Set radios to missed approach procedures.

Callouts - As appropriate.

MISSED APPROACH

A. A Missed Approach Will be Executed When:

1. No visual cues are available after reaching DH on the Missed Approach Point (MAP) as appropriate.

2. Visual cues are lost after descending below DH or MDA.

3. With reference to the runway, the aircraft is not positioned and tracking such that a safe landing can be accomplished.

14 CFR 91.117(b): Limitations on use of instrument approach procedures (other than Category II) states:

(b) Descent below MDA or DH. No person may operate an aircraft below the prescribed minimum descent altitude or continue an approach below the decision height unless-

(1) The aircraft is in a position from which a normal approach to the runway of intended landing can be made; and

(2) The approach threshold of that runway, or approach lights or other markings identifiable with the approach end of that runway, are clearly visible to the pilot.

1.17.2 Cascade Airways Training Program

Cascade Airways training program consisted of initial ground and flight training and recurrent ground school. In addition, regular flight checks were administered to pilots by company check airman and FAA inspectors. Some instrument flight training was conducted at Spokane International Airport.

Cascade Airways administered an airport qualification program for its pilots. The program was reviewed by each pilot during recurrent training. Viewgraphs were made for each instrument approach procedure at each of the 17 airports served by the company. The program was updated periodically to include new procedures, or to reflect changes in existing procedures. The localizer 3 procedure was a part of the program.

1.17.3 Previous Incidents Related to the Localizer 3 Instrument Approach Procedure

Several pilots contacted the Safety Board's investigation team to relate incidents in which they were involved in procedural errors during the localizer 3 instrument approach procedure. None of the pilots filed an Aviation Safety Reporting System (ASRS) report with the National Aeronautics and Space Administration (NASA) before the accident. The pilots stated that they did not report the incidents because each was embarrassed and believed his was an isolated incident. Furthermore, many of the pilots were not aware of the ASRS reporting system or did not know where or how to file ASRS reports. Additionally, the Safety Board requested that NASA search the ASRS files for similar incidents. The records search revealed that there were two similiar incidents where the wrong DME was used, but neither incident was at Spokane International Airport.

- o An air taxi pilot with more than 6,000 total flight hours and accompanied by an instructor pilot was flying the localizer 3 procedure in simulated instrument conditions. The pilot stated that he had tuned the Spokane VORTAC, placed the DME in the "hold" position to retain the Spokane DME information, and then tuned the runway 3 localizer. He descended to the minimum descent altitude of 2,760 feet after he reached 4.2 miles from the Spokane VORTAC. The instructor pilot advised him of the error. He stated he was not prepared for a localizer with a DME and was expecting the VORTAC to read the distance from the airport. He also stated that he had flown all the instrument approaches in the Spokane area that day in two different aircraft.

- o A U.S. Air Force instructor pilot was administering instrument flight training to an experienced pilot. During the localizer 3 approach, the pilot tuned the Spokane VORTAC instead of the localizer DME and began a descent 4.2 miles before reaching OLAKE intersection. The instructor pilot recalled that the air traffic controller twice questioned their report that they had passed OLAKE. However, both Air Force pilots believed they were following the procedure correctly, so the controllers inquiries did not cause concern. The instructor pilot cautioned the pilot about the terrain. The descent was stopped and the approach was completed under visual conditions. The instructor pilot stated that the incident had occurred on a hot day at the end of a tiring flight. He believed that fatigue and workload may have contributed to the error. Once on the ground the two pilots discussed the procedure and determined what error had been made. Later, classroom discussions with 11 other experienced Air Force pilots indicated that all 11 pilots were confused with the procedure.

- o A chief pilot for a major public utility company tuned the Spokane VORTAC and began a descent to 2,760 feet while about 8 miles from the Spokane VORTAC. The pilot was flying a localizer 3 approach in instrument meteorological conditions. An air traffic controller observed the aircraft's position and altitude data block, and he advised the pilot to pull up. The pilot climbed back to a safe altitude, and a normal landing was made. As a result of the controller's prompt actions, he received a letter of commendation from his supervisors.

- A Washington State Aeronautics official descended prematurely during a localizer 3 procedure when he used the Spokane VORTAC for distance information. He stated he was advised by ATC of this distance from OLAKE, and that he had the feeling something was wrong. He reported OLAKE and descended. When he broke out of the undercast, he realized he was in the wrong position. He attributed his error to being rushed and his inattention to the approach chart.

- An Air Force pilot, flying under the hood during a instrument training flight, selected the Spokane VORTAC rather than the localizer channel during a localizer 3 instrument approach. He began a premature descent to MDA but was advised by the safety pilot of the error when the aircraft approached the terrain west of the VORTAC. The pilot discussed the approach with six other Air Force pilots later, and most of them expressed some confusion with the procedure.

1.17.4 Air Traffic Control

The west arrival air traffic controller and the assistant Spokane tower chief stated that the ATC handling of Flight 201 was standard. The decision to change runways was made because of the wind conditions and because the visibility was improving so that the lower minimums afforded by the ILS for runway 21 were not needed. The assistant chief stated that traffic conditions made the runway switch just before Flight 201 a logical decision.

The Director of Training for Cascade Airways stated that he expected Cascade pilots to understand and adhere to the ATC instructions issued to Flight 201. He did not believe the ATC instructions caused significant additional workload. However, he stated that the preparation for the new instrument approach procedure, coupled with the maneuvering for the approach, would increase the cockpit workload.

Three ATC personnel testified that they had been aware of only one previous incident involving a procedural error on the localizer 3 approach. No ASRS report or FAA internal report was submitted by any of the individuals. The assistant chief stated he was surprised to learn of the other incidents involving the localizer 3 procedure. Further, he stated that if he had been aware of the incidents he would have informed the local General Aviation District Office and his ATC superiors.

1.17.5 Human Performance

Flightcrew Behavioral Profile.--The captain was considered knowledgeable, capable, and confident by his peers and superiors. He had a reputation as a professional who always operated his aircraft according to established procedures. He reportedly was conservative and firm in his cockpit decision-making process. Pilots who had flown with him said he was always ahead of the aircraft and the ATC situation, and readily adapted to changing events. The pilots also said he had an even disposition and did not exhibit frustration or anger in stress situations. He did not talk much in the cockpit because he believed the cockpit noise level in the Beech 99A precluded normal conversational speech.

The captain was considered a good manager of the cockpit who relied on crew coordination to accomplish flight duties. When he was not flying, he would handle the first officer duties. It was the consensus of the other Cascade pilots that he probably would not overrule the first officer, except in questions of safety, when the first officer was flying the aircraft.

The captain and his family lived in Seattle, Washington. However, he shared an apartment in Walla Walla, Washington, during the week to meet his flight schedule. He normally spent weekends at home.

There were no indications that the captain had any significant health, family, or personal problems. On a professional level, the captain had been concerned with a satisfactory performance report that he had submitted to the company on a Cascade first officer. The captain felt he should have submitted a poor performance report which would have resulted in the termination of the first officer, rather than allowing him to continue beyond his probation time. He discussed these concerns with his peers on the night before the accident.

On the day before the accident, the captain flew in the morning and went off duty at 1430. The captain stayed at the airport for part of the afternoon and conversed with other Cascade employees. That evening he played racquetball with another Cascade pilot before returning to his apartment. According to the Cascade employees he had contact with, the captain appeared to be depressed and had stated that he had had a "bad" day. The "bad" day started with "crummy" flying that day and extended to his poor performance in racquetball. In addition, he had had mechanical problems with his motorcycle and his bicycle.

Cascade employees who had contact with the captain on the day of the accident stated that he appeared normal and that he was "in good spirits." He called his wife during the stop in Seattle. She stated that he sounded fine and he related no worries or concerns.

The first officer, who lived in Walla Walla, Washington, with his family, had no significant family, professional, or personal problems. According to his peers and supervisors, he was very quiet and was content with his position with Cascade Airways. Cascade employees who had contact with him on the day of the accident stated that he appeared normal and was cheerful and in good spirits. He had planned a trip to visit his parents on the following day and had traded 2 workdays for one in order to arrange his schedule.

Flightcrew Operational Behavior.--When Flight 201 departed Yakima at 0911, the captain did not sign the weight and balance form. According to the station manager, "...it wasn't like him to miss that." When Flight 201 arrived at Moses Lake, the weather conditions were, in part: indefinite ceiling 300 feet, sky obscured, visibility 2 miles, fog. The tower controller instructed Flight 201 to report the outer marker inbound during its ILS approach to a landing on the runway. The flightcrew did not report the outer marker to the tower, nor did they request or receive landing clearance at Moses Lake. Departing Moses Lake, the flightcrew misread their clearance and used the wrong flight number on several occasions during the flight. Cascade Airway management and other pilots stated that the flightcrew was very professional in the conduct of their duties and they could not explain their performance on Flight 201 at Moses Lake and Yakima.

Distance Measuring Equipment.--The aircraft was equipped with a single-unit DME and a Collins Avionics Company TCR-451 DME Mode Selector. (See figure 2.) The pushbutton mode selector allowed a pilot to select mileage readings from either navigation receiver by selecting the DME NAV Selector 1 or 2. In addition, a pilot could select the DME "Hold" position, which would allow him to display DME mileage from one station while receiving navigation course guidance from a second station. When the "Hold" function was selected, an amber light would illuminate above the depressed hold selector. For example, if the No. 2 navigation receiver was tuned to the Spokane VORTAC with the No. 2 DME selector in use, DME mileage would be displayed from the Spokane VORTAC. If the pilot then selected the "DME Hold," the DME information would continue to come from the Spokane VORTAC, regardless of the selected frequency in the No. 2 navigation receiver. The pilot would have to select the "DME NAV 1" or "DME NAV 2" position to get DME information from the stations tuned in each receiver. When the "Hold" position was selected, the pilot had no indication displayed on the instrument panel of the source of the DME information; he was required to remember the navigation aid used for the DME readout. Neither the FAA nor Collins Avionics required that a readout of the "Hold" (previously selected) frequency be displayed in the cockpit.

A Collins Avionics spokesman stated that the TCR-451 DME Mode Selector was designed to meet FAA criteria. However, there is no requirement in FAA Technical Standard Orders for human factors or human engineering tests of approved equipment. Collins Avionics employs two human performance specialists who, in addition to other duties, look at equipment for human engineering criteria. The spokesman stated that Collins studies each piece of avionics equipment for logic, readability, flyability, cockpit placement, and practical pilot interface. The company reportedly had received no complaints from users on inadequacies or confusing aspects of the TCR-451 DME Mode Selector.

Cockpit Noise Levels.--The Safety Board investigators supervised the measurement of the cockpit noise levels in a Cascade Airways, Inc., Beech 99 using General Radio Precision Sound Level Meter and Analyzer. The measurements were taken at a point just to the right of the captain's head. A power setting of 95 percent revolutions per minute (rpm) and 1,100 pounds of torque were used during the measurements.

The cockpit noise level was measured at 97 decibels dB(A) 5/ which equates to a speech interference level (SIL) 6/ of 85.5 dB. The dB(A) and SIL valves measured in the B99A fall with the range where face-to-face communications are difficult, and a voice range between shouting and maximum vocal effort are required. Beech Aircraft Corporation stated that the cockpit "inflight" SIL of 85.5 compared favorably with Beech data, and the "Speech communications should not be a problem at two feet." Beech data also indicated a noise level of 94.1 dB(A) at power settings used during an approach. This dB(A) level requires the same voice range as 97 dB(A).

5/ Quantative noise level measurement.
6/ The sound pressure level the speech signal at the listener's ear must be for a given noise condition to be heard reliably.

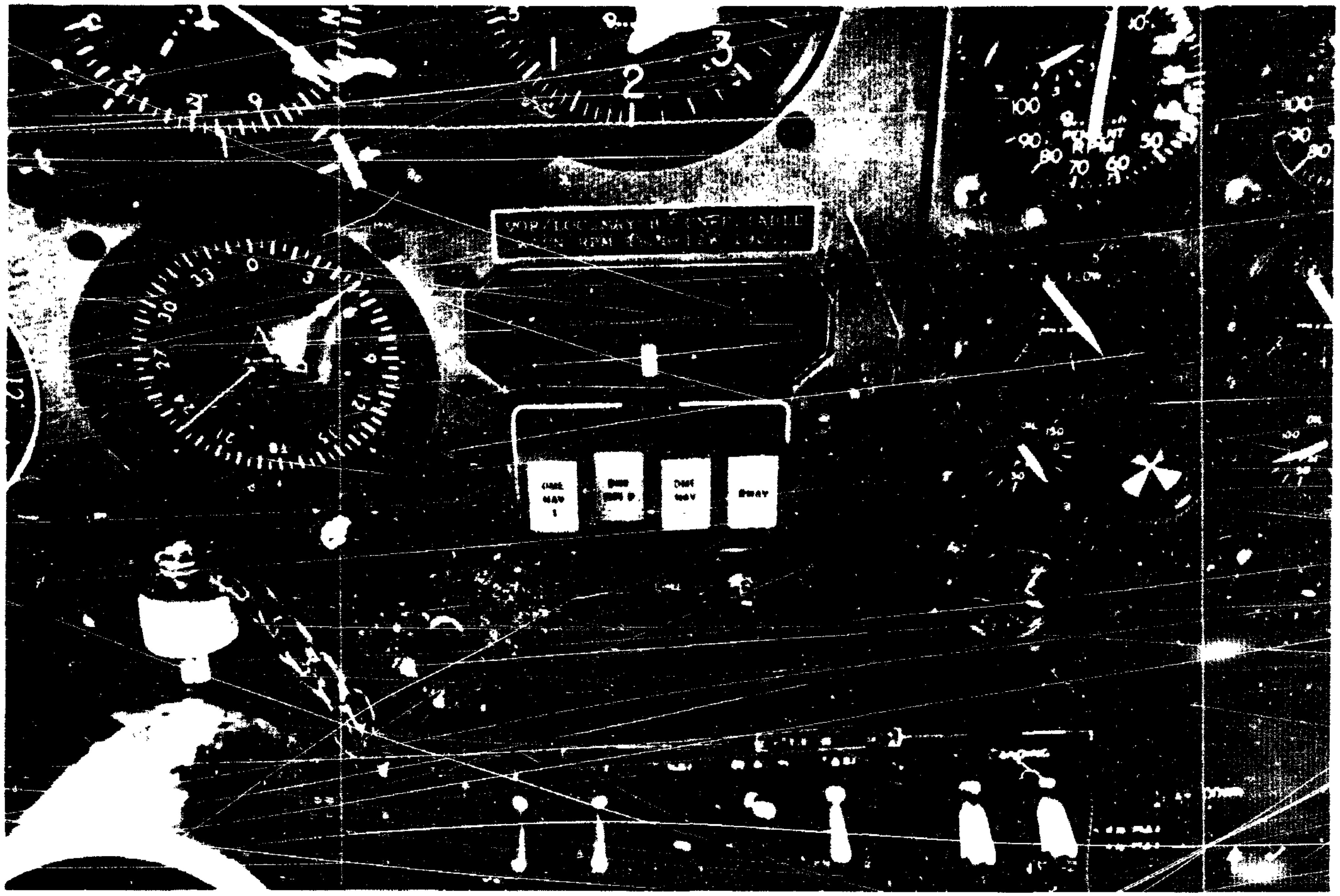

Figure 2.-- DME mode selector.

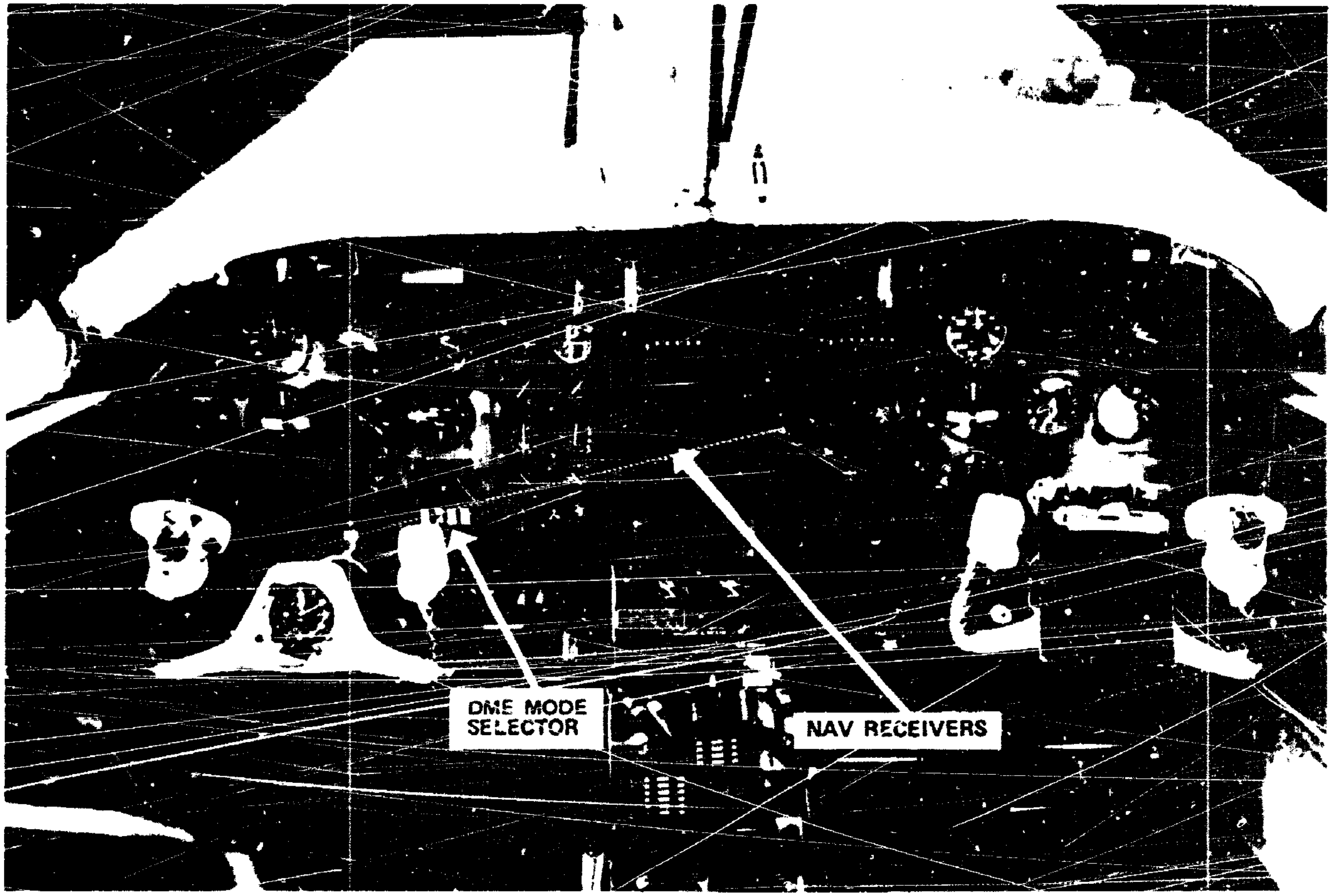

Figure 3.--Beech 99A instrument panel.

1.18 Useful or Effective Investigation Techniques

None

2. ANALYSIS

2.1 The Aircraft

The aircraft was certificated, equipped, and maintained in accordance with regulations and approved procedures. There was no evidence of a failure of the aircraft's flight controls, systems, structure, or powerplants. Although the Mode C function of the altimeter was inoperative, it was not required for the flight, and it had no effect on the accuracy of altitude displays in the cockpit. Since the flightcrew had flown the aircraft on four flights before the accident and had made four instrument approaches without an apparent altimeter error, including an ILS at Moses Lake, the Safety Board concludes that the altimetry system on Flight 201 functioned properly.

2.2 The Flightcrew

The flightcrew was certificated properly and was qualified for the flight. They had had the off-duty time required by regulation. The flightcrew had received the ground and flight training required by regulation. In addition, they had undergone the company airport qualification program which included a review of the instrument approach procedures at Spokane International Airport. The program included a review of the localizer 3 procedure.

2.3 Operation of the DME

The configuration of the aircraft with the landing gear down and the flaps in the approach position indicates that the landing checklist had been completed. Cascade Airways procedures require that this checklist be accomplished at the final approach fix, which was OLAKE intersection. OLAKE intersection was also the point after which Flight 201 could descend below 3,500 feet, to the minimum descent altitude of 2,760 feet. Based on these facts, the Safety Board concludes that the flightcrew descended to MDA at some point before OLAKE intersection because of the incorrect identification of OLAKE intersection. The incorrect identification of OLAKE intersection could have resulted from any one of three errors made by the flightcrew:

(1) Both navigation radios could have been tuned to the localizer frequency (109.9) but retained the Spokane VORTAC DME mileage display through the selection of the "Hold" button. The No. 2 selector may have been selected just before impact when the error was noted but before corrective action was taken.

(2) The No. 2 navigation radio could have been on the Spokane VORTAC during the entire approach with the No. 2 NAV selected. The first officer could have been using the No. 1 NAV receiver for localizer guidance until just before impact when the frequency on the No. 2 navigation receiver was noted and retuned to the localizer frequency.

(3) The flightcrew could have misinterpreted the approach chart and descended using the Spokane VORTAC mileage. The navigation radios could have been retuned properly when the error was noted just before impact.

The Safety Board was not able to determine precisely which event was the primary reason for improper use of the DME and the incorrect identification of OLAKE intersection. Each error would have been influenced equally by cockpit workloads and distractions, and each error would have placed the aircraft in the identical physical location just before impact. However, the use of the Spokane VORTAC frequency in the No. 2 navigation receiver and the misinterpretation of the approach chart were less likely to have occurred for several reasons. Both navigation radios were tuned to the localizer frequency at impact. This would not have been possible if the Spokane VORTAC was being used for DME information unless the flightcrew discovered the error and retuned the No. 2 navigation radio to the localizer frequency. If this did occur, either because the Spokane VORTAC was used mistakenly or because the approach chart was misinterpreted, it is not likely that the flightcrew would have noted the error and retuned the navigation radio(s), and yet remained below MDA without making any attempt to climb.

The incorrect use of the Spokane VORTAC in the No. 2 navigation receiver and the misinterpretation of the approach chart cannot be completely discounted. However, the Safety Board believes that the incorrect use of the DME mode selector and the "Hold" function, and thereby the use of the wrong DME, is a more plausible analysis of the accident sequence.

The flightcrew anticipated an instrument approach to runway 21 when they first contacted Spokane Approach Control. In accordance with company procedures the No. 1 navigation receiver would have been tuned to the ILS 21 frequency and the No. 2 receiver would have been tuned to the Spokane VORTAC. After the flightcrew was informed of the runway and approach change, the No. 1 receiver would have been tuned to 109.9 for the localizer 3 approach procedure. The second receiver probably would have remained on the Spokane VORTAC for orientation to the airport and the approach course. The Spokane VORTAC was the only navigation aid available to the flightcrew since the localizer was not operational until Flight 201 was vectored onto the localizer course.

The series of vectors given to Flight 201 between 1116:46 and 1124:12 was in accordance with ATC procedures, although Flight 201 was ultimately placed on the localizer course at 4,000 feet. The flightcrew had ample opportunity to review the localizer 3 approach chart during the vectors, although they were not able to identify the localizer facility because it was not operational until about 1134:12. Under these circumstances it would have been reasonable for the captain to select the "Hold" position on the DME mode selector after the flight received a vector of 360° at 1123:35 since the aircraft was within 2 miles of the localizer course and was on an intercept vector to that course. The No. 2 navigation receiver could have been tuned to the localizer, and the aircraft's distance position from the VORTAC and the airport would still have been retained through the Spokane VORTAC DME information displayed in the cockpit. This configuration also would have reduced the workload once the localizer was activated by the Spokane ATC facility because the flightcrew would have had to select only the DME No. 1 or No. 2 position on the mode selector to receive the proper DME information.

The Safety Board believes that two key events probably caused the flightcrew to omit selecting DME NAV 1 or 2 and to begin the premature descent below the minimum authorized altitudes. The first occurred at 1124:12 when Flight 201 was at 4,000 feet and was less than a mile from the localizer course centerline. The controller transmitted "Cascade 201, localizer should be up, 6 miles from OLAKE, cleared for the approach." Four seconds after the controller started the transmission, the crew responded, "There it is, we're cleared for the approach, 201." At that point the flightcrew's attention was probably on the movement of the localizer indicator and the approach clearance. The actual position of the aircraft as given by the controller --

6 miles from OLAKE intersection -- could not have registered with the crew because otherwise they would not have descended below 3,500 feet until reaching OLAKE intersection, which would require a flying time of at least 3 minutes. The Safety Board concludes instead that the flightcrew aligned the aircraft with the localizer course and began an immediate descent once the approach clearance was received because they mistakenly believed they were almost at OLAKE intersection, rather than being several miles short of it.

The second key event which distracted the flightcrew's attention from the operation of the DME was the landing gear and the landing gear warning horn. When the approach clearance was received, the normal Cascade Airways procedure for Flight 201 was to descend from 4,000 to 3,500 feet. As the first officer reduced power to begin the descent, the captain should have put the DME mode selector in the No. 1 or No. 2 position and identified the localizer frequency. However, according to one survivor, a few minutes before the crash, a buzzer sounded in the cockpit and a red light illuminated. He described the light as coming from the area where the gear handle was located. The gear handle contains a red light which illuminates and which is accompanied by the sounding of a buzzer if the landing gear is not extended when the throttles are reduced below 79 percent of the engine speed. The survivor also stated that these events were followed by two cycles of the landing gear. It is likely that the two landing gear cycles were actually the gear lowering into place, which would have silenced the gear warnings, and the flaps lowering into place. The distraction caused by the landing gear and the gear warning devices would have occurred at the time the captain should have configured the navigation radios and the DME mode selector. Since the landing gear handle was located in front of the captain, he probably lowered the gears and flaps and his attention was probably temporarily diverted to the landing gear and the landing checklist and away from the DME mode selector and the navigational radios.

With the landing gear down and the flaps positioned for the approach, the cockpit would have appeared to be configured properly. Both navigation radios would normally have been tuned to the localizer frequency and the aircraft would have been on the centerline of the localizer. However, the Safety Board believes that the DME mode selector was in the "Hold" position and that the mileage displayed was the mileage from the Spokane VORTAC. The flightcrew would have had to remember the source of the DME mileage since the use of the "Hold" button is not accompanied by a frequency display. As a result, shortly after the gear situation was resolved, the DME mileage would have read 4.2, which apparently indicated to the flightcrew that the aircraft was at OLAKE intersection and further descent to 2,760 feet was authorized.

This sequence of events is plausible and explains how the error in the use of the DME could have occurred. The entire sequence likely occurred in less than 1 minute since the aircraft would have moved 6 miles from the Spokane VORTAC to the 4.2 DME point from the VORTAC in 54 seconds or less. A most persuasive aspect of the sequence, however, is that the only indication available to the flightcrew that the aircraft had arrived at OLAKE intersection was a 4.2 DME reading. Since both radios were tuned to the localizer frequency, the 4.2 DME indication would have had to come from the Spokane VORTAC, with the mode selector in the "Hold" position. Finally, it is probable that once the descent from 3,500 feet was started, the captain would have devoted most of his attention outside the cockpit and probably would not have noticed the position of the mode selector. Since the first officer was flying the aircraft, he would have been occupied initially with establishing the aircraft on the localizer centerline, and thereafter, he would have been concentrating on the flight instruments and left the operation of the radios to the captain.

A plausible explanation, and one which would explain why the DME mode selector was found in the No. 2 position after the accident, is that as Flight 201 neared the DME point where a missed approach would be required, the captain realized that he should have the approach lights in sight. He would have rechecked the DME mileage display, if only to determine the point where the missed approach was to commence. In checking the DME display, he could have discovered the improper position of the "Hold" button, and then selected the No. 2 button. The same logic could be applied to the use of the VORTAC frequency in the No. 2 receiver. However, the captain could have selected the No. 1 button on the DME mode selector and then retuned the No. 2 navigation radio to the localizer frequency. If this had occurred, it is unlikely that the first officer would have continued to fly the aircraft below MDA without starting a climb. Since the aircraft was traveling 0.2 mile each 6 seconds and was near the hill when such an error was noted, there was too little time for corrective measures to be made before the impact. The impact marks on the aircraft and the observations of the survivors indicate that no attempt was made by the flightcrew to climb in the seconds before impact. However, even this series of events also does not justify a descent below MDA of 114 feet.

The events of the accident established that a premature descent to MDA was made by the flightcrew. Therefore, the Safety Board attempted to determine why a well-trained, professional flightcrew would fail to utilize a critical piece of equipment.

When Flight 201 arrived in the Spokane area, several events occurred that increased the flightcrew's workload, or could have distracted them during required cockpit procedures. The change of runways and the new instrument approach procedure would have resulted in a new approach chart review and briefing. Although the cockpit workload was increased, there was ample time to complete the approach chart familiarization. During the ATC vectors, Flight 201 was given turns for spacing, which included vectors across the final approach course and then away from the course. It is possible these vectors led the flightcrew to believe that the aircraft was too close to the final approach fix, or at least closer than desirable. This perception would have made it easier later for the flightcrew to accept the DME mileage from the Spokane VORTAC as the mileage from the localizer DME transmitter. Testimony from other pilots who have made similar errors illustrates that they failed to realize their situation even when questioned by ATC. Perceptions are formed by sensory inputs, past experiences, and expectations, or probable occurrences. These processes form the basis for decision-making. Associated with expectations is familiarity with the environment, and the flightcrew of Flight 201 was familiar with the Spokane environment. The fact that, after the landing checklist was completed, the cockpit appeared to be configured properly may well have reinforced the pilots' expectations regarding their position on the approach.

Finally, since the localizer frequency was not activated until the aircraft was nearly on the localizer course, a situation was created that required the flightcrew to navigate on the course before the navigation aid was identified. The normal procedure was to tune and identify the localizer frequency and then intercept the localizer course. Flight 201 was on the course when the localizer was activated. In a short period of time, the flightcrew had to establish the aircraft on the course centerline, identify the localizer facility, and begin a descent to the final approach altitude. During this time, the flightcrew failed to identify the proper DME facility, which resulted in the incorrect DME frequency not being discovered. The Safety Board believes that this accident, as well as similar incidents involving other pilots, could have been avoided if the localizer had been identified properly before the approach procedure was commenced.

Despite the premature descent to MDA, Flight 201 would have cleared the terrain if that altitude had been maintained. However, the elevation of the point of impact was 2,646 feet, 114 feet below MDA. The Safety Board examined several possibilities which could explain why the aircraft was below MDA, but could not determine the reason with certainty. It is possible the first officer allowed the aircraft to descend below MDA as a result of poor piloting technique. It is also possible that the flightcrew had acquired intermittent ground contact and decided to descend below MDA to acquire visual contact with the approach light system which they believed to be directly ahead. Finally, the descent could have been intentional when the aircraft had reached the 0.8 DME point from the Spokane VORTAC which the flightcrew may have erroneously believed was the visual descent point shown on the approach chart. However, even at the visual descent point, descent was authorized only if the runway environment was in sight. There is no factual basis to support any of these reasons for descent below MDA. However, descent below MDA under the conditions existing for Flight 201 was contrary to regulations and company procedures.

2.4 Cockpit Voice/Flight Data Recorders

As in other cases involving commuter aircraft, the Safety Board's analysis of the accident was hindered by the lack of a cockpit voice recorder (CVR) on the aircraft. On April 13, 1978, the Safety Board issued safety recommendations A-78-27 through -29, which called for the development of CVRs and flight data recorders (FDR) on complex general aviation aircraft. These recommendations were reiterated in the Safety Board's special study on commuter airline safety on July 22, 1980. 7/ The FAA has proposed rulemaking on this subject, but to date no requirement has been established for CVRs and FDRs on complex multiengine aircraft used by commuter air carriers.

The Safety Board's accident investigation experience with air carrier aircraft has proven that CVRs and FDRs are valuable tools in identifying aircraft design deficiencies, operational problems, and other subtle human factors influences which can contribute to an accident. In almost every accident investigation involving these recorders during the past 10 years, one or both of the recorders provided investigators with clues necessary to piece together the circumstances of the accident. The analysis of this accident would have benefitted greatly from a CVR in order to provide information regarding the activities and procedures of the flightcrew. As a result, the Safety Board again urges the FAA to expedite rulemaking to require recorders on complex general aviation aircraft in accordance with recommendation A-78-27 through -29.

2.5 Behavior Factors Affecting Performance

The Safety Board's human performance investigation revealed several events in the flightcrew's background which had concerned each pilot during recent days. These events were the captain's "bad" previous day and his expressed concern regarding a performance report that he had submitted on a first officer, and the first officer's planned trip to see his parents. The first officer had rearranged his work schedule to make the trip. The Safety Board was not able to determine if these events would have had a specific influence on the flightcrew's capabilities or served as a distraction to cockpit procedures on the day of the accident. However, for some reason the flightcrew failed to comply with ATC instructions when landing at Moses Lake, and they failed to request clearance to land at Moses Lake. These events, coupled with the failure of the captain to sign the dispatch release at Yakima indicates that the flightcrew was not performing consistently at a normal level of proficiency. The Safety Board was not able to define specifically the cause of the reduction of flightcrew efficiency.

7/ Special Study: Commuter Airline Safety (NTSB-AAS-80-1), July 22, 1980.

Any inherent human factor, such as preoccupation with personal problems or other events, could allow a distraction which would interfere with pilot performance. In this accident, however, it was impossible to relate precisely such human factors to the accident cause, especially without a CVR or a live crewmember to provide additional information.

The effect of the cockpit noise levels was also considered as a human performance factor which could have had an impact on the flightcrew. The measured sound level of 97 dB(A), or 85.5 SIL, requires a voice communication level which is in the range where face-to-face speech communication is difficult. Such a noise level discourages cockpit communications, which reduces the flightcrew's capability to efficiently correct operational or navigational problems. The Safety Board was not able to determine if the cockpit noise levels affected the crew of Flight 201. However, the noise levels in the Beech 99A and other similar aircraft can reach excessively high levels, and there are no regulations which safely limit the noise exposure levels to which a flightcrew is exposed. Therefore, the Safety Board believes that flightcrews should be required to use crew interphone systems in aircraft where the the cockpit noise levels are at or above the speech interference levels.

2.6 DME Presentation

The Safety Board analyzed the operation and the display of the DME mode selector used in the accident aircraft. The design of the mode selector allows a pilot to display a DME mileage through the use of the "Hold" position. However, when the "Hold" selector is used, a pilot has no visible reminder of the source of the DME mileage and both navigation radios could be tuned to other stations. As a result, the pilot is required to remember the navigation aid from which the distance information is derived. Although the use of the "Hold" function was signified by an amber light, it is possible the light may have been overlooked because of situational or pilot attention factors. Finally, the mode selector is one of the only switches or selectors which is not specifically labeled with regard to position or which information is displayed. While the "Hold" feature allows a pilot to manage his workload by preselecting navigation frequencies, the added memory load involved may be less desirable at another time, such as when the cockpit workload is heavy.

The Safety Board believes that the flightcrew of Flight 201 was familiar with the operation and capabilities of the Collins TCR-451 DME Mode Selector. However, the presentation of mileage information when the "Hold" selection is engaged did impose an additional critical workload requirement during a period of increased cockpit activity without providing an adequate visual reminder of the source of the mileage. As a result, the Safety Board believes that a different means of noting the selection of the "Hold" button, such as a readout display of the frequency in "Hold," should be considered by the FAA for all similar equipment.

2.7 Approach Chart Depiction

A major concern of the Safety Board in the field phase of the investigation and during the public hearing was the development and testing requirements for approach procedures and the depiction of the Spokane airport localizer 3 approach chart. After several pilots indicated that each had selected the incorrect navigation aid and had descended prematurely during a localizer 3 instrument approach, the Safety Board issued safety recommendations A-81-39 through -42 to the FAA on March 30, 1981. The analysis of the localizer 3 chart indicated that a pilot could misinterpret the procedure and use the wrong navigation facility for DME information. A note or a caution on the approach chart concerning the proper navigation facility was not included, although some similar instrument procedures did contain this aid to users.

The Safety Board initially suspected that the flightcrew may have misinterpreted the instrument procedure, and the testimony of several pilots did reveal an unsafe condition with the localizer 3 approach chart. However, the Safety Board now concludes that the facts involved with Flight 201 do not indicate that the flightcrew misinterpreted the procedure. The most persuasive fact in support of this conclusion is that both navigation radios were tuned to the localizer frequency. It is possible that the flightcrew descended initially with the Spokane VORTAC tuned on one navigation receiver. However, it is unlikely that the flightcrew would have noted the error and retuned the receiver to the localizer frequency and still remained below MDA. If the Spokane VORTAC had been set mistakenly, an immediate ascent would have been started at least in the time it took to retune the navigation receiver. Additionally, Cascade Airways procedures required that both navigation receivers be tuned to the localizer frequency at the final approach fix. Finally, the Spokane VORTAC probably would not intentionally be used during the localizer 3 instrument approach procedure as long as the DME associated with the localizer was operational and the aircraft was established on the final approach course.

Two aspects of the investigation of the previous incidents involving the localizer 3 instrument approach procedure and the development requirements for instrument procedures are still of concern to the Safety Board. First, none of the pilots involved in previous incidents submitted reports to the ASRS program. Each pilot testified that he thought his mistake was an isolated instance and a result of his own error. As a result, the potential safety hazard was never brought to the attention of the agencies which could take corrective action. The FAA and NASA have demonstrated the capability and willingness to respond in a positive manner to the safety deficiencies reported through the ASRS. However, the system can be effective only if pilots and controllers are aware of the procedures, have access to the reporting forms, and conscientiously submit the forms. The Safety Board's investigation of the accident revealed that many pilots are completely unfamiliar with the ASRS despite intensive efforts by NASA and the FAA to publicize the program. The Safety Board urges NASA and particularly the FAA to emphasize the ASRS program through the various general aviation programs. In addition, all certificated and commuter air carrier companies should be urged to review the ASRS program with pilots at scheduled training sessions. Finally, aviation organizations, such as the Aircraft Owners and Pilots Association, are encouraged to publicize the ASRS program through organizational publications.

The second concern of the Safety Board involves the lack of attention to human performance and human engineering standards in the development of instrument approach procedures. A review of the development program for instrument procedures indicates that the process used by the FAA is adequate to produce a high quality, technical document. However, our investigation revealed that the requirements regarding the incorporation of human performance standards in approach charts are not adequate, nor are the approach charts developed or reviewed by personnel who have training in human engineering and performance fields. FAA personnel who develop and review instrument approach procedures are highly qualified technicians and pilots. The Safety Board believes that these individuals may overlook procedural shortcomings or ambiguous chart instructions because of their familiarity with instrument procedures and their experience. The average pilot may not have the ability to deal with areas of potential confusion, as in the incidents involving the localizer 3 approach procedure at Spokane International Airport. As a result, the Safety Board concludes that the FAA should incorporate formal human performance and human engineering criteria into instrument approach procedure development and review.

2.8 Crashworthiness Survivability

The accident was technically classified as "not survivable" for the flightcrew or the passengers, despite the fact that two passengers did survive. Although the fuselage remained generally intact, the failure of the seats and the restraint system tiedown chain and the very high longitudinal and downward g-loads caused the total crash sequence to exceed the restraint system strength and human tolerances to g-loads for a seatbelt-only restrained occupant.

The primary factor which resulted in the injuries and fatalities to the occupants was the downward force vector that was generated at the second impact with the ground. The first impact was a strong, yet glancing contact which sheared the landing gears and damaged the fuselage cargo pod. The loss of flying speed and the resulting steep flightpath angle to the ground imposed forces on the occupants upon impact which were probably in the 30- to 45-g range. The magnitudes of the g-loads were indicated by the severe nature and degree of injuries to the occupants. The downward failure of the top wing attach fitting and fracture of the tailsection further substantiate the severity of the vertical g-loads that were transmitted to the fuselage and the occupants.

Despite the technically nonsurvivable nature of the accident, two passengers did survive. Both survivors testified that they were warned of the crash by the first impact and immediately took a brace position. Both survivors bent over and put their heads on their knees. In addition, they had their seatbelts fastened securely, although one stated he had about 1 inch of play in his belt. Both survivors were injured seriously, and both of their seats failed.

The value of the brace position as a positive lifesaving technique was demonstrated in this accident. The survivors, who reacted immediately in placing their bodies in the least vulnerable situation were able to both withstand the g-forces that were technically beyond human endurance for an up-right seated person. Furthermore, they were able to survive the failure of the seat and restraint system. Despite the failure of the seat and restraint system, the assumption of the brace position situated the body in a position where the vertical g-forces were transmitted longitudinally through the upper body. This rearrangement of the body axis relative to the aircraft allowed the passengers in the brace position to withstand higher g-forces in that direction.

The lifesaving potential of the brace position has also been demonstrated in other aircraft accidents investigated by the Safety Board. 8/ On October 4, 1979, the Safety Board issued safety recommendations A-79-76 through -78, which addressed the need to determine the optional brace position for various seat designs. Additionally, the recommendations urged the FAA to insure that information on the brace position is included in air carrier training and that the brace position is included on passage briefing cards and in the preflight briefings. The circumstances of this accident underscore the continued importance of the brace position. Therefore, the Safety Board reiterates the need for the FAA to take positive measures on this safety issue.

8/ Aircraft Accident Report-"Atlantic City Airlines, Inc., DeHavilland DHC-6, Twin Otter, N101AC, Cape May County Airport, New Jersey, December 12, 1976" (NTSB-AAR-77-12); Aircraft Accident Report-"Rocky Mountain Airways, Inc., DeHavilland DHC-6, Twin Otter, N25RM, Near Steamboat Springs, Colorado, December 4, 1978" (NTSB-AAR-79-6); Aircraft Accident Report-"New York Airways, Inc., Sikorsky S61-L, N618PA, Newark, New Jersey, April 18, 1979" (NTSB-AAR-79-14); and Aircraft Accident Report-"Downeast Airlines, Inc., DeHavilland DHC-6-200, N68DE Rockland, Maine, May 30, 1979" (NTSB-AAR-80-5).

All seven fatalities were the result of impact injuries, and no one died as a result of the postcrash fire.

The survivors' statements indicated that the aircraft's public address system was inoperative on the flight from Moses Lake to Spokane, although the flightcrew may have been unaware of that condition. Neither of the surviving passengers heard any briefings in the cabin, and no instruction was given to the passengers to fasten their seatbelts. One survivor stated that some of the other passengers did not have their seatbelts secured and that at least two passengers were thrown from their seats upon the first impact. The failure of these passengers to fasten their seatbelt undoubtedly reduced their survival opportunity since it was apparent that only a proper restraint system and a brace position would have reduced the chances of fatal injuries.

The Safety Board was not able to determine the effect of the lack of passenger briefings on the survivability of the accident. It is impossible to speculate what the other passengers would have done if they had been aware of the impending impact and if their seatbelts had been secured properly. Nevertheless, the Safety Board believes that the passengers should have the full benefit of all safety measures. Although 14 CFR 135.117 does require that oral briefing be made concerning safety of flight information, the pilot-in-command must insure that the passenger briefing is conducted properly. If the public address system is inoperative, the pilot-in-command must conduct a briefing in person. However, he must determine the status of the public address system before each flight to fulfill the briefing requirements.

3. CONCLUSIONS

3.1 Findings

1. The flightcrew was properly certificated, qualified, and trained for the flight.

2. The aircraft was properly certificated and maintained according to approved procedures.

3. The propellers, engines, and flight control systems operated properly.

4. The ATC handling of Flight 201 in the Spokane terminal area was proper.

5. The flightcrew was not performing at expected levels of professional proficiency on the day of the accident for unknown reasons.

6. The flightcrew had sufficient time to review the localizer 3 approach chart.

7. The flightcrew probably had both navigation receivers tuned to the localizer frequency just before the aircraft intercepted the localizer course.

8. The DME mode selector was probably set in the "Hold" position during the interception of the localizer course and the instrument approach.

9. The flightcrew did not realize the actual position of the aircraft when Flight 201 was cleared for the instrument approach.

10. The gear warning horn and light provided a distraction to the flightcrew at a time when the flightcrew should have been positioning the DME mode selector to the No. 1 or the No. 2 position.

11. The localizer 3 approach chart could cause confusion by portraying two DME frequencies without including a precautionary note to pilots about use of the correct frequency.

12. The flightcrew descended prematurely to the minimum descent altitude based on a 4.2 DME indication which emanated from the Spokane VORTAC.

13. The premature descent was a result of improper operation of the DME mode selector.

14. The flightcrew failed to identify the localizer DME facility.

15. The aircraft was in instrument meteorological conditions at impact.

16. The flightcrew apparently noted the DME mode selector error just before impact but not in time to initiate a climb to a safe altitude.

17. The reason the flight descended 114 feet below the minimum descent altitude is not known.

18. The public address system was inoperative, so the before-landing announcements were not heard in the cabin.

19. Some passengers did not have their seatbelt fastened.

20. The accident was nonsurvivable because of the impact forces which exceeded human tolerance for seatbelt-only restrained occupants and because of high g-forces and the disruption of the seat and restraint system.

21. The passengers who survived did so because they had fastened their seatbelts and assumed a brace position.

22. Many pilots are not aware of the ASRS or how to make ASRS reports.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was a premature descent to minimum descent altitude (MDA) based on the flightcrew's use of an incorrect distance measuring equipment (DME) frequency and the flightcrew's subsequent failure to remain at or above MDA. Contributing to the cause of the accident was the design of the DME mode selector which does not depict the frequency selected and the failure of the flightcrew to identify the localizer DME facility.

4. RECOMMENDATIONS

As a result of this accident, the National Transportation Safety Board issued the following recommendations to the Federal Aviation Administration on March 30, 1981:

Publish a Notice to Airman pertaining to the localizer approach to runway 3 at Spokane International Airport, Spokane, Washington, emphasizing the need to use the IOLJ distance measuring equipment once established on the final approach course to runway 3. (Class I, Urgent Action) (A-81-39)

Add a precautionary note in the plan view section of the chart for a localizer approach to runway 3 at Spokane International Airport, Spokane, Washington, such as:

CAUTION

Use 109.9 IOLJ DME (Channel 36)
For Final Approach Course
Distance Information
(Class I, Urgent Action) (A-81-40)

Review all approach procedures and identify those airports that have a localizer or instrument landing system approach with distance measuring equipment facilities at two points along the final approach course, leading to the possibility of erroneous tuning, and add a precautionary note on the pertinent approach chart. (Class II, Priority Action) (A-81-41)

Alert pilots of the potential for error in making approaches at airports equipped with distance measuring equipment at two points along the final approach course through publication of appropriate precautionary information in the Airman's Information Manual. (Class II, Priority Action) (A-81-42)

On June 26, 1981, the FAA responded:

We have reviewed the Spokane localizer procedure and find that the requirement to use the IOLJ distance measuring equipment (DME) when established on the final approach course to runway 3 is adequately reflected. Accordingly, we can find no justification for publishing a Notice-to-Airmen. In concert with this determination, we find no justification for adding a precautionary note relative to this procedure. Accordingly, the FAA intends to take no further action on Safety Recommendations A-81-39 and A-81-40.

With regard to recommendation A-81-41, the FAA stated:

Our evaluation of the procedures leads us to conclude that the chart portrayal is adequate. However, we share the Board's concern with respect to whether the best possible means of charting information on an approach plate is being used. Accordingly, the FAA has initiated an effort, in conjunction with the National Ocean Survey, to determine if we can improve on the existing method of depiction. We will inform the Board of our finding when this effort is completed.

With regard to recommendation A-81-42 the FAA stated:

> The FAA concurs in this recommendation and we are taking action to reemphasize the fact that multiple navigation aids may be required in the utilization of an instrument procedure. Concurrently, we intend to restate the importance of proper navigation aid selection, tuning, and identification. We will inform the Board when this action is completed.

In addition, on July 22, 1981, the Safety Board recommended that the FAA:

> Require in future radio navigation instrument installations, that all frequencies being received through navigational receivers that are providing essential navigational information (directional guidance or distance) be displayed so that the source of the navigational signal can be readily discerned by the pilot. (Class II, Priority Action) (A-81-74)

> Establish for aircraft used in commercial operation the maximum cockpit noise levels which will permit adequate direct voice communication between flight crewmembers under all operating conditions. (Class II, Priority Action) (A-81-75)

> Require the installation and use of crew interphone systems in the cockpits of those aircraft in which noise levels reach or exceed the maximum level established for adequate direct voice communication between flight crewmembers under all operating conditions. (Class II, Priority Action) (A-81-76)

As a further result of this investigation, the Safety Board reiterates the following recommendations to the FAA:

> Establish a research project to determine the optimal brace position for various seat designs and seating configurations on aircraft used in passenger-carrying operations. (Class II, Priority Action) (A-79-76)

> Issue an Air Carrier Operations Bulletin requesting principal operations inspectors to insure that the training of crewmembers include information on the appropriate passenger brace position for specific aircraft configurations during potential crash landings. (Class II, Priority Action) (A-79-77)

> Issue an Air Carrier Operations Bulletin requiring principal operations inspectors to instruct their assigned air carriers to describe the appropriate emergency brace position on the passenger briefing card and to require that preflight briefings include a reference to the proper brace position. (Class II, Priority Action) (A-79-78)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ ELWOOD T. DRIVER
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PATRICIA A. GOLDMAN
Member

/s/ G. H. PATRICK BURSLEY
Member

July 21,1981

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of the accident about 1530 e.s.t., on January 20, 1981, and immediately dispatched an investigative team to the scene. Investigative groups were established for operations/witnesses, air traffic control, meteorology, human factors, human performance, powerplants, and airworthiness.

Parties to the investigation were the Federal Aviation Administration, Cascade Airways, Inc., Beech Aircraft Corporation, Professional Air Traffic Controllers Organization, Hartzell-Propeller Inc., and Pratt & Whitney Aircraft Group.

2. Public Hearing

A 3-day public hearing was held in Spokane, Washington, beginning on April 7, 1981. Parties represented at the hearing were the Federal Aviation Administration, Cascade Airways, Inc., Professional Air Traffic Controllers Organization, and Teamsters Local 2707.

APPENDIX B

PERSONNEL INFORMATION

Captain David N. Weinberger

Captain Weinberger, 36, was employed by Cascade Airways, Inc., on April 29, 1973. He was upgraded to Beech 99A captain on March 19, 1976. He held Airline Transport Pilot Certificate No. 1736852 with an airplane multiengine land rating and commercial privileges in airplane single engine land with type ratings in the B-707 and B-720. His first-class medical certificate was issued on September 1, 1980, with no limitations.

Captain Weinberger was a member of the U. S. Air Force Reserve and he was qualified as an aircraft commander in the C-141 aircraft. He had accumulated about 11,680 total flight hours of which about 2,943 hours were military flying hours. He had flown about 7,000 hours in the Beech 99A, all of which was accumulated while employed by Cascade Airways.

Captain Weinberger had flown 5.1 hours in the 24 hours before the accident. In the last 90 days and 30 days, he had flown 220.5 hours and 72 hours respectively. During the 24 hours before the accident, he had 9 hours of duty time and 15 hours of crew rest.

Captain Weinberger passed his last proficiency check on September 16, 1980, and his last line check on March 11, 1980.

First Officer Paul H. Davis

Mr. Davis, 32, was employed by Cascade Airways Inc., as a Beech 99A first officer on September 11, 1978. He held Airline Transport Certificate No. 1760335 with an airplane multiengine land rating and commercial privileges for airplane single-engine land. He also held a flight instructor rating. His first-class medical certificate was issued on May 26, 1980, with no limitation. His medical certificate had reverted to a second-class certificate once the 6-month period had elapsed. However, it remained a valid certificate.

Mr. Davis had accumulated about 8,242 total flight hours, of which about 3,102 hours were in the Beech 99A. He had flown 257.0 hours in the preceding 90 days, and 85.9 hours in the preceding 30 days. He had flown 5.1 hours in the 24 hours before the accident. In addition, he had been on duty 9 hours and had 15 hours crew rest during the 24 hours before the accident.

Mr. Davis passed his last proficiency check on September 11, 1980.

APPENDIX C

AIRCRAFT INFORMATION

The aircraft was issued a standard airworthiness certificate on April 24, 1969. It was maintained under a continuous maintenance program which scheduled inspections each 110 hours. The aircraft had a total of 23,322.4 airframe hours.

N390CA was equipped with two Pratt & Whitney Aircraft of Canada, Ltd., PT6A-27 turbopropeller engines and two Hartzell Model No. HC-B3TN-3 propellers. Information pertaining to the powerplants and propellers is as follows:

	Left Engine	Right Engine	Left Propeller	Right Propeller
Serial No.	PCE-40339	PCE-40214	BU-1911	BU-2584
Total Time	17,757.2 hr	18,877.4 hr	UNK	UNK
TSO	4,657 hr	5,946.1 hr	2,159.4 hr	3,416.8 hr
Date of Installation	3-5-79	8-28-79	7-21-80	8-29-79

*U.S. GOVERNMENT PRINTING OFFICE : 1981 O-341-828/32