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16. Abstract About 1650 P.s.t. on February 10, 1978, Columbia Pacific Airlines, Inc., Flight 23, a Beech 99, crashed in VFR conditions on takeoff from runway 36 at the Richland Airport, Richland Washington. Flight 23, a regularly scheduled passenger flight to Seattle, had 15 passengers and 2 crewmembers on board. After liftoff, the aircraft climbed steeply to 400 feet above the runway, then stalled and crashed 2,000 feet beyond the end of the runway. A severe fire erupted after impact. All persons on board were killed, and the aircraft was destroyed. The National Transportation Safety Board determines that the probable cause of the accident was the failure or inability of the flightcrew to prevent a rapid pitchup and stall by exerting sufficient push force on the control wheel. The pitchup was induced by the combination of a mistrimmed horizontal stabilizer and a center of gravity near the aircraft's aft limit. The mistrimmed condition resulted from discrepancies in the aircraft's trim system and the flightcrew's probable preoccupation with making a timely departure. Additionally, a malfunctioning stabilizer trim actuator detracted from the flightcrew's efforts to prevent the stall. Contributing to the accident were inadequate flightcrew training, inadequate trim warning system check procedures, inadequate maintenance procedures, and ineffective FAA surveillance.					
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NATIONAL TRANSPORTATION SAFETY BOARD  
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: December 21, 1978

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COLUMBIA PACIFIC AIRLINES  
BEECH 99, N199EA  
RICHLAND, WASHINGTON  
FEBRUARY 10, 1978

SYNOPSIS

At 1650 P.s.t. on February 10, 1978, Columbia Pacific Airlines, Inc., Flight 23, a Beech 99, crashed in visual flight rules conditions on takeoff from runway 36 at the Richland Airport, Richland, Washington. Flight 23, a regularly scheduled passenger flight to Seattle, had 15 passengers and 2 crewmembers on board. After liftoff, the aircraft climbed steeply to 400 feet above the runway, then stalled and crashed 2,000 feet beyond the end of the runway. A severe fire erupted after impact. All persons on board were killed, and the aircraft was destroyed.

The National Transportation Safety Board determines that the probable cause of the accident was the failure or inability of the flightcrew to prevent a rapid pitchup and stall by exerting sufficient push force on the control wheel. The pitchup was induced by the combination of a mistrimmed horizontal stabilizer and a center of gravity near the aircraft's aft limit. The mistrimmed condition resulted from discrepancies in the aircraft's trim system and the flightcrew's probable preoccupation with making a timely departure. Additionally, a malfunctioning stabilizer trim actuator detracted from the flightcrew's efforts to prevent the stall.

Contributing to the accident were inadequate flightcrew training, inadequate trim warning system check procedures, inadequate maintenance procedures, and ineffective FAA surveillance.

## 1. FACTUAL INFORMATION

### 1.1 History of the Flight

Columbia Pacific Airlines Flight 23, a Beech 99 (N199EA), was operated under the provisions of 14 CFR 135 as a regularly scheduled passenger flight from Richland to Seattle, Washington. The crew arrived at Richland at 1525 P.s.t. 1/ on Flight 18 from Seattle. When they arrived, N199EA was being inspected to fulfill the requirements of an Airworthiness Directive. The aircraft was not available to the crew for preflight inspection until 1630; Flight 23 was scheduled to depart at 1640.

At 1628, the captain was briefed on weather by the Walla Walla, Washington, Flight Service Station (FSS), and he filed a dispatch release which contained aircraft weight and balance, route of flight, and weather information. About 1630, the aircraft was fueled and 600 lbs of baggage was loaded. About 1635, the first officer left the terminal building and connected the auxiliary power unit to the aircraft. He then inspected the aircraft and boarded; the captain boarded shortly thereafter. When the passenger boarding call was made, the captain left the aircraft to obtain magazines for the passengers. He was seen getting into his seat when the first passenger boarded.

At 1646, the first officer contacted the Pasco Airport Traffic Control Tower, using Flight No. 29, and advised that they were taxiing and would request an instrument flight rules clearance to Seattle via Yakima, Washington, when airborne. The Pasco Control Tower received no further calls from Flight 23. The first officer informed operations on company frequency that they would be departing shortly and would relay their estimated time of arrival in Seattle when airborne. There were no further radio communications with the crew. The aircraft daily flight log for February 10 showed that the aircraft left the ramp at 1645 and took off at 1648.

In general, witnesses described the aircraft's attitude at liftoff as normal and estimated the point of liftoff between 1,173 and 1,486 ft; however, immediately thereafter the aircraft began a steep climb at an angle of 20° to 45" to an altitude of 300 to 400 ft above the runway and then appeared to decelerate. The wings rocked or wobbled at the top of the climb, and the aircraft turned or yawed to the left. The nose dropped and the aircraft descended to the ground at a flightpath angle estimated to have been 45°. Fuel from ruptured fuel tanks caught fire after the aircraft hit the ground. Fire consumed the aircraft within 7 minutes.

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

The accident occurred during daylight hours at 1650:12 at latitude 46° 19'N and 119° 18'W. The elevation of the impact site was 393 ft m.s.l.

1.2 Injuries to Persons

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	Other
Fatal	2	15	0
Serious	0	0	0
Minor/None	0	0	0

1.3 Damage to Aircraft

The aircraft was destroyed by impact and fire.

1.4 Other Damage

None

1.5 Personnel Information

The captain and first officer held Airline Transport Pilot certificates, although not required for the operation conducted. (See Appendix B.) They were trained by the airline and currently flight checked in accordance with the requirements of 14 CFR 135.122, 135.131, and 135.138. Their records disclosed no unsatisfactory performance during their employment.

The captain and first officer had flown together frequently for about 6 months. The captain had not flown on the 2 days before the accident. The first officer successfully completed his Airline Transport Pilot flight check on February 9 before he finished his normal duty shift which ended at 2200. Both pilots reported for duty about 1300 on February 10, and both had flown together 1.3 hours before the accident.

Five Columbia Pacific Airline's pilots were interviewed regarding the work habits of the captain and first officer. These pilots rated the captain as a good pilot who always used the checklist and would get upset if the first officer called an item out of sequence. They stated that he was a "take-charge" type individual who performed those first officer duties which he felt were performed too slowly. They said that, with a fully loaded Beech 99, he would trim it nose light for takeoff-- he would position the trim indicator from 2/3 to the aft edge of the green band. They could not recall his ever positioning the stabilizer to the nosedown and noseup extremes while performing the trim check. They reported that he was concerned about meeting time schedules. One pilot stated that if departure from the ramp occurred at 1300 and takeoff

occurred at 1305, the captain would believe he **was** 5 minutes late. They also believed that in an emergency situation, the captain would be reluctant to ask for assistance' from his first officer.

The five pilots rated the first officer as a good pilot and an "easy going" individual who enjoyed flying with the captain. The five pilots thought that the first officer would not initiate action in an emergency but would wait for instruction from the captain.

## 1.6 Aircraft Information

The aircraft was certificated under delegation option procedures in accordance with the airworthiness requirements of 14 CFR **23** in May 1968. It was the first aircraft with a moveable horizontal stabilizer certificated under this regulation.

N199EA had been operated by three operators before Columbia Pacific Airlines. From October 1968 to August 1971, five discrepancies were reported concerning trim system components. During this period, the trim actuator was replaced three times. From August 1971 to May 1975, seven discrepancies concerned the trim system, and from May 1975 to June 1977, eight discrepancies concerned the trim system. During this last period, the standby pitch trim was found to be unsatisfactory, and the main and standby motors were replaced after 11,471 total aircraft hours--7,790 hours after the actuator had been replaced. (See Appendix C) The out-of-trim warning system was found on four occasions to be improperly rigged, and **on** a fifth occasion it was found to be inoperative. The trim-in-motion system was unsatisfactory on two occasions.

The 'last operator of N199EA before it was acquired by Columbia Pacific was Atlantic Central Airlines of New Brunswick, Quebec, Canada. It was purchased by Maine Aviation of Portland, Maine, on May 17, 1977, who sold N199EA and another Beech 99 to Columbia Pacific in June 1977. In the interim, Maine Aviation performed a phase-4 inspection on N199EA in accordance with Beech Aircraft Corporation's continuous maintenance inspection procedures and as required by 14 CFR **91.217(b), (4)**. The phase-4 inspection does not include the stabilizer trim system. **On** that day, the local Federal Aviation Administration's General Aviation District Office (GADO) issued a standard airworthiness certificate on the aircraft in accordance with **14 CFR 21.183(d)**.

When Columbia acquired the aircraft, N199EA had accumulated 12,638 hours, and the stabilizer trim actuator had accumulated 1,167 hours since it was last replaced. Maine Aviation had not operated either aircraft.

The owner of the facility that provided contract maintenance to Columbia Pacific Airlines had accompanied the first flightcrew to Portland, Maine, and had discussed the Beech 99's systems and related

Airworthiness Directives with Bar Harbor's chief of maintenance. (Bar Harbor is a subsidiary of Maine Aviation which operated nine Beech 99's.) The owner reported that he did not perform an acceptance inspection of the aircraft before the Airline took possession of them. He stated that Maine Aviation had conducted all the necessary maintenance up to that time, and he had reviewed the maintenance records.

Columbia Pacific Airlines was authorized to use the Beech 99 in its commercial operation on July 15, after its Beech 99 proving test on July 11; the proving test is required by 14 CFR 135.32. Effective July 20, Columbia Pacific Airlines began the FAA-approved continuous maintenance inspection program with its contract maintenance facility in Pasco, Washington--9 miles southeast of Richland.

On February 10, 1978, the aircraft had made two flights, Flight 13 and then Flight 10, before being sent to maintenance between 0900 and 0930 for the routine inspection and servicing of the nose landing gear required by Airworthiness Directive 72-10-4. This work did not involve the trim system. The crew who had flown the aircraft before it was sent to maintenance reported that all aircraft systems operated normally. However, one of the crewmembers noted that, while setting the horizontal stabilizer to the full noseup trim position before the first flight, the trim indicator on the control pedestal appeared to be slightly forward of the normal aft limit. He did not record his observation in the daily flight log.

The mechanic who inspected the nose landing gear stated that the aircraft was run up initially to determine the operational status of its systems. The runup was conducted with reference to the checklist. Although he could not remember how many items of equipment were checked, he stated that everything checked functioned normally,

A review of N199EA's maintenance records disclosed that all required modifications to the stabilizer trim system had been performed. N199EA's daily flight log sheet for February 10, 1978, contained a mechanic's signature authorizing the aircraft's release for the first flight of the day. There were no mechanical discrepancies recorded by the crew of Flights 13 and 10. The log sheet did not show a signature releasing the aircraft for flight following the inspection of the nose landing gear, and there were no entries in the deferred maintenance portion of the log.

The investigation disclosed that the stabilizer trim system failed to operate in flight on three occasions within the 2 weeks preceding the accident. On January 29, the daily flight log showed that the main trim system functioned intermittently. The captain, who made the report, stated that on two occasions the main trim failed to respond when the switches on the control wheel were activated--once on the first officer's wheel and once on his wheel. The flight was completed by using the standby trim system. The actuator jackscrew, trim-stop limit switch was readjusted, and the aircraft was released.

During the week before the accident, the actuator failed to respond the second time during a training flight; however, the failure was attributed to the first officer's lack of experience in the Beech 99. No corrective action was taken. The switches on the control wheel are dual-element, thumb switches and must be pressed simultaneously to activate the trim. The captain and mechanic who discussed the problem concluded that the trainee had not pressed the switches properly. Another captain interviewed stated that the same type incident occurred for the third time during the week before the accident and he did not report the incident.

The daily flight logs also disclosed 12 writeups in which the trim-in-motion aural system was either intermittent or inoperative. A part had been ordered to repair the trim-in-motion aural system, but it had not been received. The last report, "trim-in-motion audio stays on when CB is in," was made on October 17, 1977, but was deferred until November 11, when maintenance found it "checked okay." The out-of-trim warning horn was reported as inoperative on November 9, 1977, but was deferred until November 11, when the microswitch was readjusted. There were four entries in the daily flight log about the deicer boots being partially to fully inflated constantly. The last remark was recorded February 6, 1978, and records showed no corrective action.

The gross weight of the aircraft before takeoff was close to the maximum allowable ramp weight of 10,455 lbs. The most probable weight range calculated was 10,439 to 10,491 lbs. The difference in weights was related to a fuel load which ranged from 1,048 lbs to 1,100 lbs. The center of gravity (c.g.) was within limits at 193.4 inches; the aft limit was 195 inches. Fuel burnoff for taxi, runup, and takeoff was about 55 lbs.

#### 1.7 Meteorological Information

The captain was given the weather by the Walla Walla FSS at 1628; it is summarized below:

Seattle transcribed weather en route broadcast synopsis-- Freezing level west of Cascades near 2,000 ft and east of Cascades near 4,000 ft, except locally at surface. Clouds west of Cascades 2,000 to 3,000 ft scattered, variable broken, 25,000 ft broken, tops 10,000 ft. Clouds east of Cascades 8,000 ft scattered, becoming clear by midnight.

Washington area forecast: Icing not specifically forecast; freezing level--2,000 to 4,000 ft.

The 1500 Seattle terminal forecast: Ceiling 2,000 ft broken; 5,000 ft broken, slight chance of light rain showers; scattered, variable, and broken by 1700.



The 1700 Richland surface weather observation: Estimated ceiling 15,000 ft broken; **25,000** ft broken; visibility--50 **mi**; **temperature--43° F; dewpoint--34° F; wind--270°** at 6 kns; altimeter--29.74 inHg.

1.8 Aids to Navigation

Not applicable

1.9 Communications

There were **no** reported communications difficulties.

1.10 Aerodrome Information

The Richland Airport was an FAA-designated commuter service airport and was served regularly only by Columbia Pacific Airlines. The airport has no traffic control facilities; UNICOM <sup>21</sup> is available. Richland Airport is owned by the Port of Benton, Benton County, Washington, and is operated by Richland Flying Service. At least **2,500** passengers per year embark from the airport via the commuter airline and air taxi operations.

The airport elevation is 393 ft m.s.l. There are two asphalt runways, the longest of which, 18/36, is **4,000** ft.

1.11 Flight Recorders

No flight data recorder or cockpit voice recorder was installed in N199EA, nor was either required.

1.12 Wreckage and Impact Information

The aircraft first hit the ground 1,669 ft beyond the end of runway 36 and 1,031 ft to the left of the runway extended centerline. Examination of the wreckage disclosed that the aircraft struck level ground in a slightly left wing-low, nose-level attitude. The landing gear were fully extended, and the flaps were extended 30 percent. The empennage separated from the fuselage and moved down the crash path 30 ft from the point of initial impact. The landing gear separated as the aircraft skidded 78 ft along a magnetic heading of 272°. The aircraft came to rest without changing direction. (See figure 1.)

Although the forward outboard wing fitting failed on impact, the left wing remained attached to the fuselage. The aileron and flaps remained attached to the wing. The left engine including the propeller, remained attached to the wing, and the propeller blades were bent opposite the direction of normal rotation.

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<sup>21</sup> A non-government aeronautical advisory station.

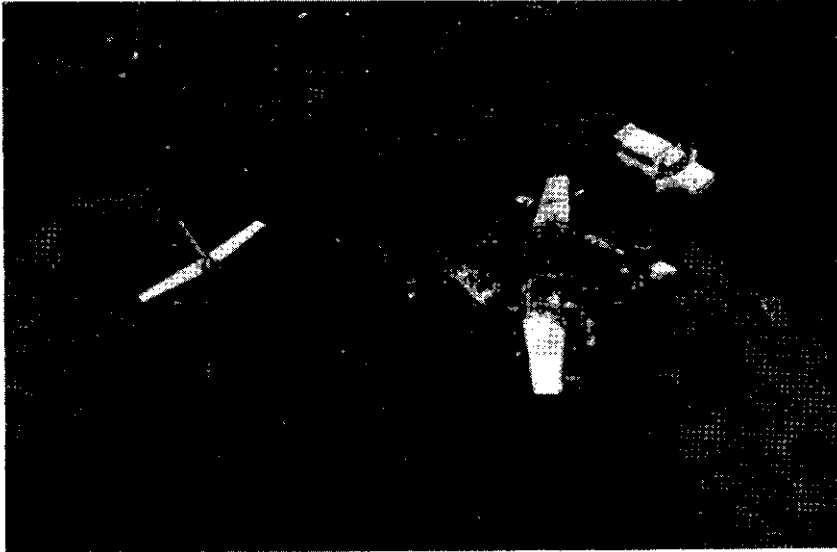


Figure 1. Aerial view of wreckage site.

The bolt on the forward outboard right wing failed on impact. The aileron and flaps remained attached. The right engine separated from its mounts and pivoted outboard parallel to the wing. The propeller blades were also bent opposite the direction of normal rotation.

Control cables remained connected to their respective controls in the flight compartment and on all flight-control surfaces. The Beech flight control lock assembly was found stowed in its normal location beneath the captain's seat.

The empennage separated at fuselage station (FS) 409.50. It had broken circumferentially because of compressive forces--the lower half was deformed more than the top half. The torque tube in the horizontal stabilizer, its largest structural member, contained a transverse fracture at its midpoint in the tube-box assembly. Normally the stabilizer has a 7° dihedral angle. The torque tube was broken by impact forces, allowing the stabilizer to droop. (See figure 2.)

Fire destroyed the fuselage above the floor level. The inboard portions of the wings from the fuselage to the engine nacelles were also destroyed by fire. There was no evidence of fire or smoke damage to the empennage.

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Figure 2. Front view of separated empennage.

The remains of the airstair door to the cabin, located behind the left wing, was found inverted on the ground adjacent to the cabin entrance. The front support cable showed evidence of having been pulled from its fuselage attachment, and a **small** mound of soil, deposited at the entrance to the cabin, indicated the door was dragged along the ground. No significant impact marks were formed on the two latching striker plates which secure the upper door latches. The safety chain was not latched. The cargo door adjacent to the airstair door was destroyed by fire.

The two overwing emergency exits were closed. The cockpit hatch at the captain's station was closed. Although the left side door to the nose baggage compartment was nearly destroyed by fire, the remains showed some evidence of impact distortion. The right side nose baggage door also showed evidence of impact distortion.

The flight compartment was mostly destroyed by fire. The throttles and propeller levers were full forward, and the fuel levers were in the high idle position. The landing gear handle was in the down position. The flap handle and indicator were set at the 30-percent flap position. The aileron trim position indicator was set at zero, the rudder trim indicator showed 3° left trim, and the electrical horizontal stabilizer trim indicator was in the "parked" position (full nosedown trim). A portion of the crew's flight bag was melted over the toggle switches for main and standby stabilizer trim power. The main trim power switch was "Off," and the standby power switch was "**On.**" (See Figure 3.)

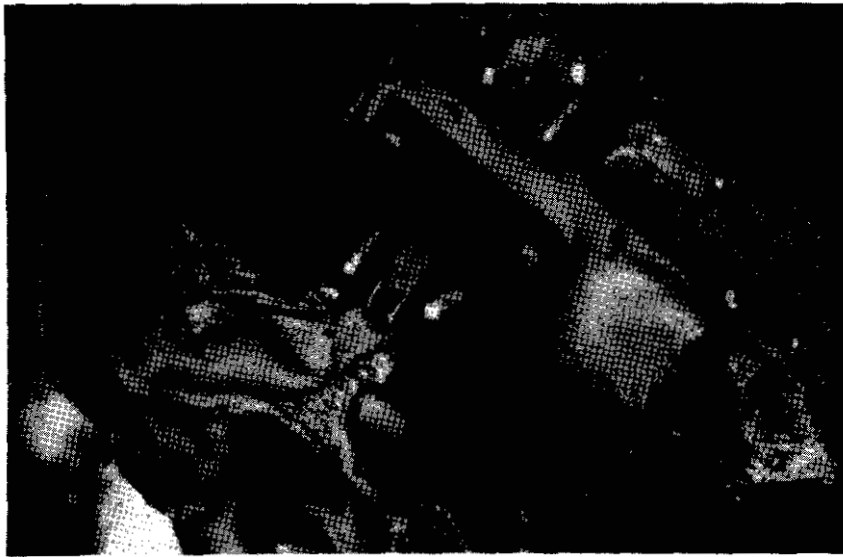


Figure 3. Closeup of trim switches — main off and standby on. Note switch imprints in burned flight bag.

The circuit breaker panel was damaged by impact and fire. Many of the circuit breakers were tripped, including those associated with the main and standby trim systems. The aircraft battery and the engine-driven starters had not malfunctioned electrically.

The horizontal stabilizer's trim actuator jackscrews were extended 6 1/32 inches, which corresponded to 1.0° noseup trim (stabilizer leading edge down 1.0°). (See Figure 4.)

Examination of the deicer system injector valve disclosed that the pressure side of the valve had a continuous leak causing partial inflation of the wing and empennage deicer boots.

1.13 Medical and Pathological Information

Post-mortem and toxicological examinations of the flightcrew disclosed no evidence of factors which would have affected their ability to operate the aircraft.

Medical examinations of four passengers and the flightcrew disclosed that they died from impact trauma. Autopsies were not performed on the remaining passengers.

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Figure 4. Installation of stabilizer trim actuator in empennage.

1.14 Fire

Fuel from ruptured fuel tanks caught fire after ground impact. Local firefighting units responded 3 1/2 minutes after the crash. Firemen extinguished the fire 4 minutes after the first unit had arrived, however, fire had already consumed the aircraft.

1.15 Survival Aspects

The accident was not survivable because of the intolerable impact forces and postcrash fire.

The crew's seatbacks had bent rearward and had separated from the seat structure. The adjustable seat support frames remained locked and anchored to the floor track. All of the seat adjustment locking pins were engaged, and there was no evidence that the seats had slipped.

Most of the passenger seats were floor mounted, and they revealed pronounced compression rather than lateral deformation. The floor tracks were separated and displaced downward in numerous locations. Many of the seatleg, floor-track retention devices separated from the seatlegs and remained in the floor track assemblies. All of the track-mounted seats had slid forward. The last three seats in the cabin were

not track-mounted; they also had been dislodged by impact forces. The five passengers in the last three seats were thrown forward. Some seatbelts were burned, and therefore, it could not be determined if they *had failed.*

1.16 Tests and Research

1.16.1 Powerplants

Following the on-scene examination of both engines and their associated components, the safety Board's powerplant group conducted a detailed examination at the Product Support Division of Pratt & Whitney Aircraft of Canada, Ltd., Longueuil, Quebec, Canada., The group further examined the propellers at Hartzell Propeller, Inc., Piqua, Ohio.

Examination disclosed that power turbine shafts from the compressors and power turbine assemblies of both engines had been scored and distorted. This evidence suggested that both engines were operating when the aircraft crashed. The exact power output of the engines, however, could not be established. No mechanical discrepancies were found that would have prevented the engines from operating normally.

Examination of the Hartzell propellers disclosed that they were operating in the low pitch (high rpm) regime. Since the method by which the blade angles were determined was not precise, only a blade-angle operating range could be established. Except for one blade on the left propeller, all others showed evidence of having absorbed a substantial amount of impact energy. No mechanical discrepancies were found that would have prevented the propellers from operating normally.

1.16.2 The Horizontal Stabilizer Trim System

The horizontal stabilizer trim system in the Beech 99 consists of two electrical systems with no mechanical backup. The trim system is actuated by two motors which are mounted in the empennage. A two-position (On/Off) power switch for each motor is mounted on the center control pedestal and is placarded MAIN or STDBY. The main system is operated by dual-element trim switches on each control wheel, and the standby system is operated by dual-element trim switches on the center control pedestal. A trim position indicator is located on the center control pedestal.

Normally, the system is activated with the pedestal-mounted "MAIN" power switch and is operated by pushing the dual-element trim switches on the control wheel fore and aft. If the trim switches are moved forward, the leading edge of the stabilizer will move up; if the trim switches are moved aft, the leading edge of the stabilizer will move down. The standby system is activated with the pedestal-mounted "STDBY" power switch and is operated by the pedestal-mounted, dual-element trim switches. All of the trim switches are spring-loaded to a

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center position, and stabilizer movement stops when the switches are moved to the center position. Each pair must be moved together in order for the circuit to be completed. Part of the pretakeoff check requires movement of all of the dual-element switches individually to insure that no one switch will operate the system. The trim indicator must also be monitored while individual switches are being operated. Any movement on the indicator indicates a malfunction in the system, and takeoff should not be made.

If the motor for the main trim system continues to operate after the trim switches on the control wheel are released, a button on the side of the control wheel grip, placarded "TRIM REL," should be pushed to interrupt the circuit until the main trim power switch can be turned off. The standby system does not incorporate this trim release feature and must be deactivated by turning the power switch "OFF." The trim-release feature is also required to be checked before takeoff.

The horizontal stabilizer trim system also includes two aural warning devices: A trim-in-motion warning and an out-of-trim warning. The trim-in-motion system advises the pilot of stabilizer movement. The aural signal is intermittent tones amplified through a speaker or headphone. This system is independent of the radio system.

The out-of-trim warning system advises the pilot of mistrim during takeoff. A switch installed on the throttle quadrant at the 90-percent left throttle lever position will activate the warning horn when the trim is set outside the takeoff range, as shown by the green band of the indicator. A microswitch on the landing gear will deactivate this feature following takeoff to permit use of the full trim range without activating the horn. The procedure for checking the out-of-trim warning system is not included in the Airplane Flight Manual (AFM) before-takeoff checklist.

To check the entire trim system before takeoff, the procedures call for first activating the standby system and then operating the pedestal-mounted dual element switches individually, while simultaneously monitoring the trim position indicator and listening for the trim-in-motion aural tone. Next, the main system is checked in a similar manner, except for the addition of the trim-release feature. When the trim is set in the green band, the check is complete. Moving the stabilizer from the full nosedown to the full noseup position, or vice versa, is only required on the first flight of the day.

When the main stabilizer trim power switch is "ON," the stabilizer moves 0.15 inch per second. The time required to move the stabilizer from full nosedown to full noseup is 18.33 seconds. In the standby mode, the stabilizer will move at one-third that speed, or 0.05 inch per second, and will take 55 seconds to travel from one trim limit to the other.

The Safety Board's investigation disclosed that there were several discrepancies within the aircraft's stabilizer trim system which could not be related to impact damage.

(1) Actuator clutch

The dual-motor actuator incorporates a twin jackscrew and a clutch mechanism designed to slip if electrical power is applied to either of the motors after the jackscrew reaches the end of its travel. The clutch consists of two plates separated by six metal ball bearings restrained in defents by a spring load. Torque is transmitted through the ball bearings during normal operation. If an excessive load is imposed on the jackscrew as it reaches the end of its travel, the jackscrew will react against the spring load, separate the plates, and allow the ball bearings to move freely. Thus, torque is not transmitted, and the motor is protected.

Safety Board investigators examined the actuator manufactured by the Talley Corporation of Newbury Park, California, at Talley's facility. Four of the ball bearings were loose and were outside the clutch detent plate--all exhibited little to no wear. Two ball bearings within the detent plate were worn to an oval shape. Engineering specifications require a 0.045-inch clearance between the spacer and the clutch output gear. When the clearance was measured with four unworn balls installed in the clutch, there was not sufficient clearance to allow a normal size ball bearing to miss the detent plate. (See figures 5 through 8.)

During bench tests of the actuator, microswitches which limit jackscrew travel were found properly rigged. Under simulated air loads the clutch slipped with applications of hydraulic pressure of 150 psi. The clutch was installed in a replacement actuator, and it slipped under loads from 150 to 650 psi. A normal actuator clutch should not slip below 650 psi. The clutch itself normally has a breakout load of 3 to 4 inch-pounds, but the clutch in question slipped at 14 to 18 inch-ounces. Manufacturer's flight test data show that in a takeoff with 30 percent flaps and the stabilizer in a full noseup trim position, the air loads measured at the jackscrew 5 seconds after liftoff were 380 lbs with a corresponding control wheel push force of 37 lbs.

(2) Trim position indicator

The pointer in the trim position indicator moves as a function of magnetic force influenced by d.c. voltage from a variable potentiometer housed in the horizontal stabilizer actuator and driven by the gearbox. A wiper rotates from one end of the potentiometer to the other, receiving an increase or decrease in voltage corresponding to the position of the stabilizer. Ten volts are required to move the indicator pointer full deflection from full nosedown trim to full noseup trim. The indicator in N199EA gave an erroneous reading when tested. When 10 volts were applied, the pointer stopped halfway within the green band, or takeoff range. This meant that, in order to position the pointer in the green band for takeoff, the stabilizer would have moved to an adverse noseup trim position.



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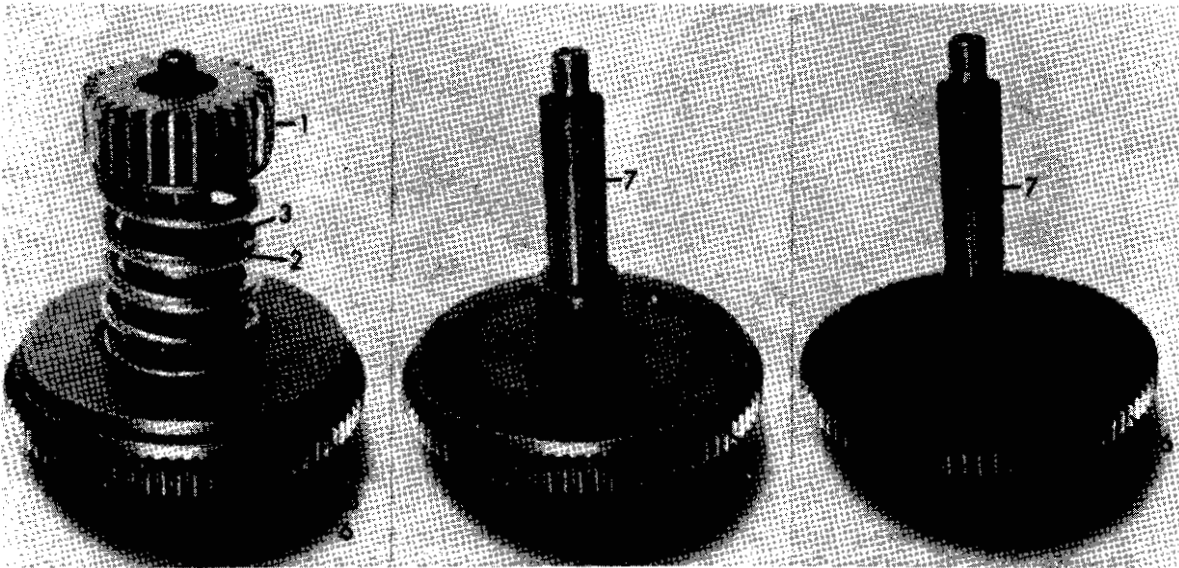


Figure 5. Clutch assembly in various stages of disassembly, 1) output gear, 2) spring, 3) spacer, 4) ball retainer, 5) detent plate, 6) torque limit gear, 7) shaft. All photos X2

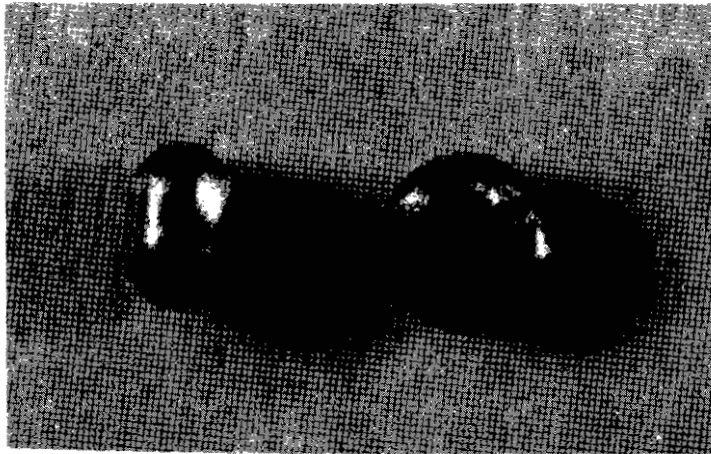


Figure 6. Balls taken from the clutch assembly. X10

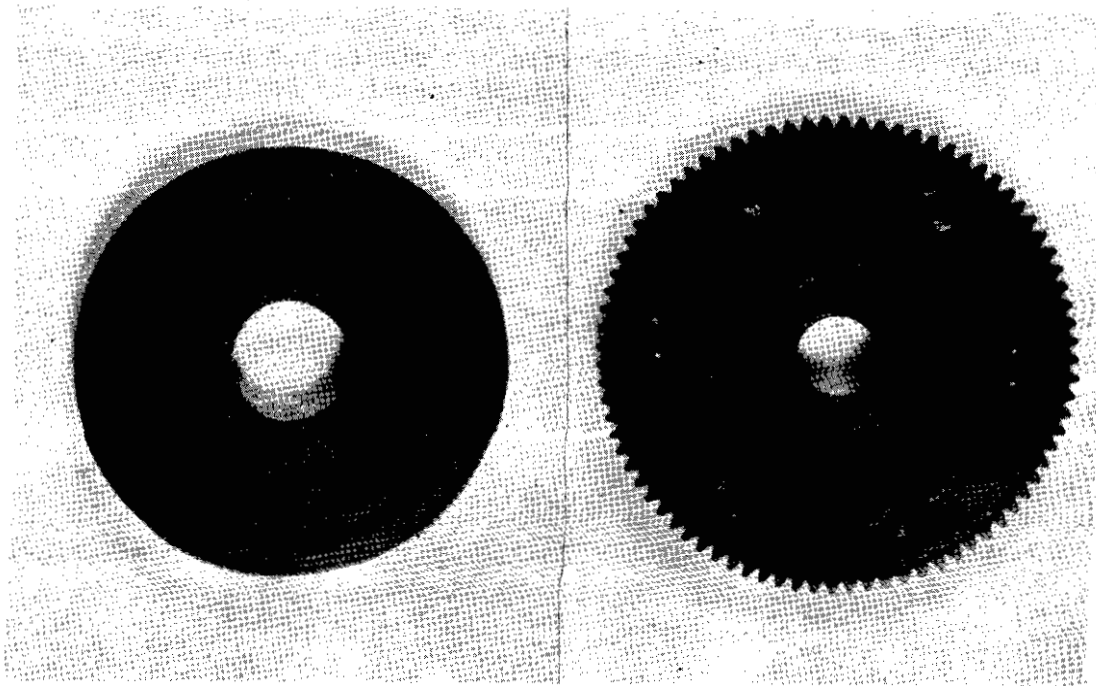


Figure 7. Bearing faces of the ball retainer (left) and torque limit gear (right). Brackets indicate rings of *ball* material deposited on these components. X2

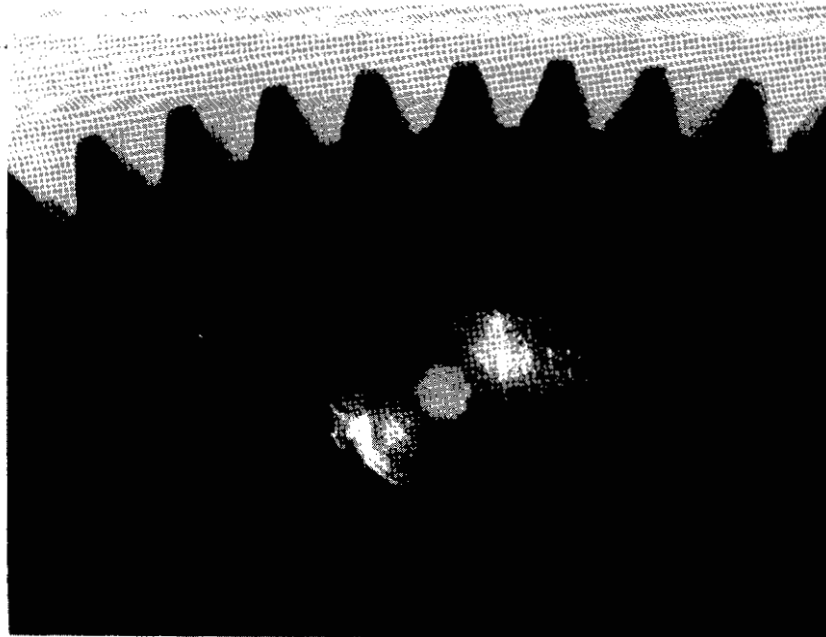


Figure 8. One of the ball depression holes on the torque limit gear showing areas of wear. X10

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The Safety Board also found this condition on a Beech 99 it used for flight tests during this investigation. During a conformity inspection, Beech Aircraft found that the trim position indicator reacted in a similiar fashion. Investigators discovered that, when the indicator was tapped or vibrated, it registered a reliable reading. A survey of other Beech 99 operators disclosed that three reported experiencing the same difficulty with the indicator occasionally.

(3) Out-of-trim warning system

The out-of-trim warning horn was reported to be inoperative on November 9, 1977, and the microswitch was reportedly adjusted 2 days later to correct the discrepancy. There were no further discrepancies of the warning system recorded in the maintenance records. During postaccident examination, the microswitch was found improperly positioned. It is installed near the actuator and rides on a cam which rotates as the jackscrew is moved. The position of the switch was such that movement of the stabilizer from the takeoff range to its extreme limits did not activate the switch which would have allowed voltage through the landing gear microswitch to sound the warning horn. There was no evidence that the switch had slipped from impact forces.

The out-of-trim warning system, including the actuator, trim position indicator, and trim-in-motion indicator, is a minimum equipment list item. Pilots are also required to visually check stabilizer trim position with reference to the external indicator on the side of the empennage before takeoff. The indicator on N199EA was not readily visible because the pointer, used to line up the leading edge of the stabilizer to the zero reference mark (rivet) on the fuselage, was partially hidden by the deicer boot.

Neither assistant chief pilot included the out-of-trim warning system as a check item when asked to recall their procedures for checking the trim system. In fact, one reported that he did not check the system at all. Also, most crews relied on the system to the extent that, if the horn warning did not sound when full power was applied for takeoff, it meant the stabilizer trim was correctly set. Finally, trim system check procedures varied between pilots, and the captain decided how the check was to be conducted.

1.16.3 Aircraft Performance

Based on the weight and balance and c.g. of N199EA and on weather conditions at the time of the accident, calculations disclosed that, with flaps extended 30 percent, a Beech 99 would require a ground roll of 1,750 ft in order to lift off at an airspeed of 94 kns indicated airspeed (KIM).

Four witnesses who were located at several vantage points at the airport, estimated the liftoff point of N199EA. Based on their estimates, the average liftoff point was after a 1,364-ft ground roll which was 386 ft, or 22 percent, short of the calculated ground roll.

The Safety Board examined the following possibilities to determine what effect they would produce on aircraft pitch control during takeoff: (1) Inadvertent opening of cabin/cargo door(s) during takeoff, (2) a jammed elevator; (3) an untimely inflation of deicer boots, (4) runaway noseup trim, and (5) takeoff with an extreme noseup trim.

On May 8 to 10, 1978, a Beech 99, owned and operated by Rio Airlines of Killen, Texas, was instrumented and flown at the manufacturer's facility through flight profiles derived from accident data. These flight tests were conducted to determine which of the above factors or combination of factors could have produced the accident takeoff profile, and to identify the handling characteristics of a Beech 99 under the various conditions.

The tests included flight to various aircraft pitch attitudes at different configurations of weight and c.g. and at different stabilizer trim settings. First, these tests were performed at altitude and then on takeoff from a runway. The objectives were to determine: (1) Time, altitude, and control wheel forces required to establish a desired pitch attitude; (2) time and altitude required to decelerate to a stall and reach zero rate of descent, and the airspeed at the apex; (3) time required to return to original altitude; and (4) techniques and control wheel forces required to avoid a stall. Three series of tests were conducted with configurations incorporating: (1) As close as possible, the weight and c.g. of N199EA, (2) a "worst case" c.g. position, and (3) a c.g. position that permitted a comparison of the sensitivities of performance parameters and control wheel forces to changes in the vertical distribution of the load in the aircraft. These tests also made it possible to study the effect of various mass moments of inertia on the aircraft's longitudinal handling characteristics.

The flight profile of N199EA based on witnesses' observations and confirmed by the flight tests follows:

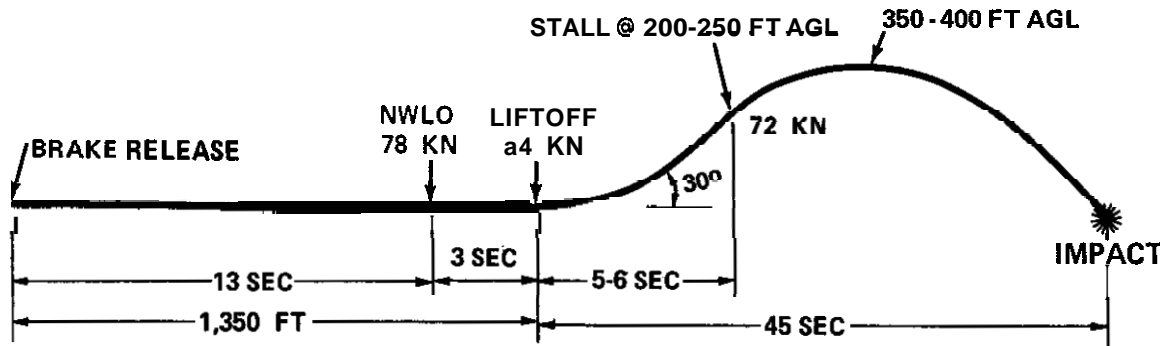


Figure 9. Flight profile of N199EA.

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The tests disclosed that the nosewheel lifted off at **78 KIAS** and the aircraft lifted off at **84 KIAS** with the stabilizer in the full noseup trim position. The aircraft flight manual requires a liftoff speed of **94 KIAS** for a maximum gross weight takeoff. Ground roll distance from brake release to liftoff was 1,350 ft--nearly the same distance averaged from witness statements. Control wheel push forces did not become significant until after liftoff.

The tests also disclosed that airspeed would increase when the pitchup attitude was less than  $15^\circ$ . Airspeed would decrease at pitch attitudes of more than  $15^\circ$ . When no restraining control wheel force was applied, pitch would reach  $30^\circ$  in about 1.5 seconds. If the aircraft was permitted to increase to a pitch attitude of **30"** and if this steep attitude was not corrected within 5 to 6 seconds of initial pitchup, wing stall was certain, and recovery before descent to the initiating altitude was unlikely. At pitch attitudes of about  $30^\circ$  sufficient elevator authority was available to avoid a stall if immediate and positive control forces were applied before the aircraft decelerated to stall speed. Although sufficient elevator authority existed to prevent rotation to high noseup pitch attitudes after takeoff, attitude awareness had to be maintained to restrain the rapid pitchup tendency of the Beech **99** in the test configuration after liftoff. If the main trim system was inoperative, the longitudinal control wheel forces required could reach **50 to 65** pounds of push force before the standby trim system could be selected and the out-of-trim conditions corrected.

In summary, the Safety Board's performance evaluation revealed the following:

(1) Inadvertent door opening during takeoff was eliminated after calculations indicated an open door would not cause the aircraft to pitch up on takeoff as N199EA did. Also, witnesses did not see an open door.

(2) A jammed elevator was considered improbable, because the flight tests simulating a takeoff with the control column lock pin installed did not produce a reasonable approximation of the accident profile. The standard control locking device was stowed, and there was **no** evidence that foreign objects had obstructed the control system.

(3) **An** untimely inflation of the deicer boots was duplicated in flight and was found to produce negligible pitchup at airspeeds less than **100** kns.

(4) Although not impossible, runaway noseup trim was considered improbable. For the stabilizer trim to have run from a takeoff setting to an extreme noseup trim would require either 9 or 27 seconds, depending on whether the main or standby motor was in operation. If it began at liftoff when trim corrections are most likely to be first applied, it **is** unlikely that pitchup after liftoff would have been as abrupt as that

reported by witnesses. The main trim system incorporates a trim release switch to disengage the system in the event of runaway. Also, the stabilizer was not found in an extreme noseup position. Fault analyses of the electrical and mechanical design of the trim system performed by the manufacturer and the FAA indicated that the likelihood of a runaway trim was remote.

(5) Takeoff with an extreme noseup trim was determined to be the most probable condition which, combined with a center of gravity near the aft limit; would have caused the flight profile of N199EA. The aircraft was rotated and lifted off about 10 kns earlier than normally expected; however, pilot technique could vary the point at which rotation would begin. There were no abnormally high control wheel push forces generated before liftoff to warn a pilot of mistrim. Flight tests indicated that the Beech 99 is controllable on takeoff with full noseup trim and with the center of gravity near or at the aft limit. Although the control forces are high, they are manageable and within the limits specified by Federal Aviation Regulation Part 23.143. If, through inattention or for some other reason, the pilot permits the Beech 99 to rotate to a pitch attitude of 30" or greater during a climb after takeoff and if he then does not promptly correct the aircraft attitude, a stall will occur from which recovery is essentially impossible.

1.17 Additional Information

1.17.1 Columbia Pacific Airlines' Operational and Maintenance Practices

Operations

The Airlines' original corporate entity was Execuair, Inc., which flew its first scheduled flight between Richland and Seattle on December 21, 1971, with a six-passenger Piper Navajo (PA-31). Execuair, Inc., was purchased by Columbia Pacific Resources in March 1974.

In early 1977, Columbia reported that the Navajo's seating capacity was not adequate to handle the increasing traffic growth. At that time, it operated four Navajos. Because of its greater seat capacity and its favorable cost considerations, the Beech 99 was chosen to augment the operation.

From May 23 through 27, 1977, the Airlines' Director of Operations, who was also its chief pilot, and a line captain attended Beech 99 ground school at the Beech Aircraft Training Center at Wichita, Kansas. According to the chief pilot, the training consisted of 30 hours of audio-visual instruction with little classroom instruction because instructors were not available. Since the Beech 99 was no longer being manufactured, flight training was not available from Beech Aircraft Corporation.

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From June 12 through 15, 1977, Columbia's chief pilot and another line captain visited Bar Harbor Airlines to obtain flight instruction and to take delivery of a recently purchased Beech 99 (N1034S). They received some informal ground instruction and 6 hours of flight training covering normal and emergency procedures. N1034S was flown to Richland on June 15. On July 6, two other line captains received flight training from Bar Harbor and returned to Richland along with the chief pilot in N199EA.

The chief pilot was given check pilot approval by the FAA July 11, 1977, and he was the only check pilot in the company. As of July 1977, the company employed 33 pilots.

Since acquiring the Beech 99, the Airline conducted 125 hours of pilot training. About 8 hours out of the 25 hours of proving test flights were observed by an FAA inspector along scheduled routes. According to the proving test report of the 13 simulated emergency procedures observed on those flights, none concerned the trim system.

On August 24, 1977, the Chief of the Spokane GADO sent a letter to the President of Columbia Pacific Airlines stating his concern that the Airline may not be sufficiently staffed with supervisory personnel to meet its rapid growth in size and complexity. He stated that a past incident indicated that better management of aircraft maintenance was needed and that its chief pilot's duties in both operations and maintenance far exceeded the capabilities of one man. He was encouraged by the changes being made in maintenance recordkeeping and assignment of responsibility in this area, the planned development of its own maintenance facility at Richland, and the proposed addition of two assistant operations supervisors to reduce the burden on its chief pilot.

On September 20 and 22, the Spokane GADO approved two Columbia captains as check pilots. On January 1, 1978, Columbia began operating its own maintenance facility at the Richland Airport and had hired the individual who had provided contract maintenance as its Director of Maintenance; he also continued to operate his own facility at Pasco, Washington.

According to the Airline's Operations Manual, all pilots were given initial and recurrent ground and flight training. The training was to be accomplished in accordance with the standards of 14 CFR 135.138 and FAA Advisory Circular Multi-Engine Flight Test Guide. There was also a provision for training in new equipment. The manual outlined the training subject matter but did not specify required numbers of hours. An oral or written test was required.

Regarding the Beech 99, the Airline made no determination on the minimum number of hours of training necessary to qualify its pilots. The Director of Operations reported that, aside from his training at

Beech Aircraft, he did not have sufficient information from which to establish a minimum hour requirement. He stated that the number of hours given each pilot depended on the pilot's background. Operational information on the aircraft was obtained from Bar Harbor Airlines. Training consisted of ground and flight instruction on subject areas outlined in the Operations Manual and the audio-visual course obtained from Beech Aircraft. The Airline could not provide the Safety Board with a syllabus showing the details of the training outlined in its manual.

*The training record of the captain involved in the accident*

did not show clearly the kind of initial training he received in the Beech 99. No dates were recorded on the three written tests in his record; none of the tests related to the Beech 99. Although a number of training accomplishments and dates had been recorded on a form, his flight-time record indicated that he was flying scheduled flights on those dates. According to records, he had received 2.3 hours of initial flight training before his check flight. The first officer's record showed he obtained 1.8 hours of flight training before receiving his check flight. Neither record showed they had received the audio-visual presentation. The records did not disclose whether either pilot had previous turboprop aircraft experience.

A review of all the Airlines' pilot training records showed that the Airline generally met the recordkeeping requirements of 14 CFR 135.43; however, the records did not contain the pilots' duty assignments and flight time as required by the regulation. Testimony at the Safety Board's public hearing on the accident disclosed that the Airline maintained flight time in a separate file. The records did not contain information from which to assess a pilot's training progress, and such information is not specifically required by regulation. Although all pilots had successfully passed the oral or written tests and flight checks, a comparison could not be made to assess a pilot's level of proficiency.

On January 28, 1978, Columbia's flight operations department issued a letter to all personnel stating that the Airline was again experiencing numerous late flights and cited some reasons for the delays. The letter stated, "An on time departure is a key to on time arrivals," and that the potential is greater for reducing the lost time during ground turnarounds rather than in flight. The letter required that flightcrews be in their aircraft at least 5 minutes before departure time. The letter urged teamwork in terms of one crew assisting another in obtaining weather information and in completing weight and balance forms. The letter also cautioned crews not to allow themselves to become rushed in the cockpit -- that once in the airplane they should relax and operate at their desired pace.

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## Maintenance

As of January 1, 1978, Columbia Pacific had seven persons, including the Director of Maintenance and a secretary, assigned to its maintenance department. The five mechanics held current airframe and powerplant ratings. Two mechanics had attended a Beech Aircraft maintenance course; one had attended the Beech 99 course before he was employed by Columbia, and the other had attended a Beech 90 course before he was employed by the Airline. There was no training program for maintenance personnel nor was one required.

The continuous maintenance inspection program consisted of five 100-hour inspections in accordance with the Airline's approved program and 14 CFR 91.217(b) (5). To control discrepancies and to schedule maintenance, the Airline used aircraft daily flight logs, an inspection form for each of the five inspections, and an intermediate inspection worksheet.

The daily flight log contained three color-coded sheets. One sheet was a permanent part of the log, one was removed for the maintenance department, and the other was removed for administrative purposes. The back of the log was designed for recording deferred maintenance items, but this portion was not used by the mechanics. All deferred items were transferred to the intermediate inspection worksheet which was maintained in the maintenance office. As a result, a flightcrew could not readily ascertain the airworthiness of an aircraft. Also, the Airline had no system for placarding various inoperative equipment nor had they established procedures to be followed in the event certain equipment became inoperative.

### 1.17.2 Aircraft Minimum Equipment List

FAA permits certain aircraft equipment to be inoperative to allow for uninterrupted operation of the aircraft in revenue service. The minimum equipment list was approved during the type certification of the Beech 99 and is a part of the FAA-approved aircraft flight manual designed to provide operators with this authority and to insure an acceptable level of safety.

Regarding the horizontal stabilizer trim system, the Beech 99 minimum equipment list provides the following:

- "2. Stabilizer Position Indicator - may be inoperative provided visual check is made prior to each T/O (takeoff) and both aural indicators are functioning.
- "3. Trim-in-motion Aural Indicator - may be inoperative provided position indicator is functioning and maximum operating speed ( $V_{mo}$ ) is restricted to 200 kns.

- "4. Out-of-trim Aural Warning Indicator - may be inoperative provided neutral position is visually checked prior to each takeoff and stabilizer position indicator is functional.
- "5. Stabilizer Actuator Motor - one trim system motor may be inoperative for flight limited to essential crew only, V<sub>mo</sub> restricted to 200 kns."

Inoperative items covered by the minimum equipment list are required to be brought to the attention of the flightcrew, either by placarding or by flight logsheet entry, and appropriate procedures are required to be established and followed by the operator if a flight is made with items inoperative.

The preamble to the minimum equipment list states:

"...The operator is responsible for exercising the necessary operational control to assure that no aircraft is dispatched with multiple MEL items inoperative without first determining that any interface or interrelationship between inoperative systems or components will not result in a degradation in the level of safety and/or undue increase in crew workload.

"...The exposure to additional failures during continued operation with inoperative systems or components must also be considered in determining that an acceptable level of safety is being maintained. The MEL was never intended to provide for continued operation of the aircraft for an indefinite period with airworthiness items inoperative."

The minimum equipment list does not specify time limits.

1.17.3 Federal Aviation Administration Certification and Surveillance

On June 30, 1969, a FAA multiple expert opinion team was formed to evaluate the flight characteristics of the Beech Models 99 and 100. Flight tests conducted to evaluate reported longitudinal oscillation had indicated that the one-hand controllability forces required by 14 CFR 23.145 were exceptionally high. FAA found that both models were not in compliance with 14 CFR 21.21, 23.143 with regard to a mistrimmed takeoff, or 23.145(b).

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As a result of the flight test evaluations on July 1 and 2, the FAA team of experts found:

"1. The possibility of takeoff with stabilizer trim at extremes of travel creates an unsafe condition in accordance with FAR 23.143 and FAR 21.21. This is applicable to both the Model 99 and 100.

"2. The longitudinal controllability forces observed during the flight evaluation were considered excessive for aircraft of this type and prevented making a smooth transition from one flight condition to another. This is not considered in compliance with FAR 23.143 and FAR 23.145(b). In particular, on the Model 99 at forward gross, conditions 23.145(b) (3), (4), (5) and (6) were in noncompliance. On the Model 100 at most forward regardless, conditions 23.145(b) (4) and (6) were in noncompliance. Other required conditions having similar forces would be considered in noncompliance. The forces noted and checked in the TIR were found to be accurate."

These flight tests, however, were concentrated primarily on nosedown trim.

Of the eight recommendations submitted, all team members agreed on two --

"1. That mistrim forces on takeoff be reduced or alternatively that a takeoff warning system be installed to warn the pilot that trim is beyond safe limits for takeoff.

"2. That the longitudinal control forces be lowered or alternatively that FAA require a letter of competency for each pilot-in-command of these aircraft."

On June 20, 1969, a Beech 99 crashed at Pasco, Washington, after a short takeoff roll and an abnormally steep climb, followed by a loss of control. The two crewmembers, the only occupants on board, were killed and the aircraft was destroyed by impact and postcrash fire. Investigation disclosed that the horizontal stabilizer actuator jack-screws were in the full aircraft noseup trim position. The actuator functionally tested and was found to be within manufacturer's tolerances. Examination of the aircraft showed that the flaps were extended 30 percent and the landing gear were retracted. The aircraft's gross weight was about 8,300 lbs and the c.g. was about 179 in. It was not determined if an unscheduled trim condition was involved. The Safety Board's determination of probable cause was the flightcrew's failure to maintain flying speed, improper operation of flight controls, and inadequate preflight preparation.

On July 6, 1969, a Beech 99 crashed at Monroe, Georgia, killing the 12 passengers and 2 crewmembers on board. The plane crashed during the en route phase of flight; the aircraft descended and struck the

ground in a near vertical dive. Investigation disclosed that the horizontal stabilizer actuator jackscrews were in the full nosedown trim position. The flaps were between the approach and retracted position, and the landing gear were retracted.

The Safety Board's determination of the probable cause was:

"...an unwanted change in longitudinal trim which resulted in a nosedown high-speed flight condition that was beyond the physical capability of the pilots to overcome. The initiating element in the accident sequence could not be specifically determined. However, the design of the aircraft flight control system was conducive to malfunctions which, if undetected by the crew, could lead to a loss of control."

On July 9, 1969, an FAA special investigation team was organized as a result of the foregoing accidents and the special flight tests that had been conducted on July 1 and 2, 1969. Two areas about the aircraft concerned FAA: "The powerful forces associated with the stabilizer mistrim, and the general controllability during configuration changes." The objective of the special investigation team was "...to make an overall review of the problem with the intent of exploring means to provide an acceptable level of safety." This action was in accordance with 14 CFR 21.21(a)1. The team examined the problem of a takeoff with the stabilizer in an extreme noseup trim position with the c.g. near the forward limit and found "...there was very little control problem and a relatively light push force (20-25#) to maintain normal climb speeds."

The special investigation team concluded in part:

"...that with specific modifications and procedures specified under the recommendations of this report, the Model 99 is a satisfactory airplane for the purposes approved.

"...that the complexities and individual characteristics of the airplane require that the pilot in command demonstrate his knowledge and skill to a competent authority on these features. For those at present in command, it be assured that they receive appropriate refresher training through formal training programs and future commanders be required to demonstrate competence.

"...that the trim changes with configuration change resulted in higher than desirable forces but could be readily alleviated by the pilot due to the trim control being on the control wheel. Though not meeting the intent of FAR 23.145(b) in the estimation of the evaluators, the airplane can be safely controlled and has compensating features."

The special team recommended, in part:

"All pilots presently operating the model 99 be subjected to an oral examination to assure their competence and knowledge on all

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essential systems and procedures for safe operation of the airplane. All new pilots be examined as to competence to command the airplane, prior to assuming command, by a representative of the Administrator or appropriately designated authority."

"The manufacturer to engage in a long range program to redesign the longitudinal control system **so** as to substantially reduce the forces required to maintain attitude and velocity without retrimming during configuration changes."

**On** August 1, 1969, the Safety Board recommended that the Administrator, FAA, establish emergency recovery procedures from unwanted or adverse longitudinal trim conditions and publish them in the FAA-approved flight manual. The Board also recommended that a horizontal stabilizer "in-transit" warning system be installed in Beech 99 aircraft and that the horizontal stabilizer trim range be restricted to prevent excessive aircraft nosedown trim while in flight.

The Administrator replied on August 6, 1969, that he had taken action to carry out the Board's recommendations.

The FAA also undertook a number of other corrective actions which related to the longitudinal control system. These actions incorporated those recommendations provided by the two flight test evaluations. The manufacturer reduced the nosedown control wheel forces by (1) limiting the stabilizer leading edge upward travel to  $3.5^\circ$  from  $5.5^\circ$  and (2) restricting the trim range when the flaps are up.

**N199EA** was equipped with all of the necessary recommended changes. However, no long-range redesign plans to reduce the noseup longitudinal control forces had been incorporated in **N199EA**, nor in any other Beech 99 manufactured.

**On** June 19, 1978, as a result of the Columbia Pacific Airlines accident, the Safety Board requested of FAA, the objective and the action taken to implement the letter of competency recommended by the team of experts. **On** August 15, FAA responded that the objective of the letter of competency was "...to increase the awareness of the BE-99 flightcrews to certain aircraft handling characteristics."

FAA established a requirement for the letter and it was outlined in FAA Order 8430.1A, Chapter 9, paragraph **222**, March 3, 1975. According to FAA, "This requirement provides evidence that the pilot has satisfactorily demonstrated competency to conduct specific maneuvers and procedures in a particular type, class, and category of aircraft."

A review of FAA Order 8430.1A showed that paragraph **222** provides inspectors with general guidance in enforcing the requirements

of 14 CFR 135, sections 122, 131, and 138. This paragraph does not include specific procedures to be incorporated during those required flight checks.

The June 1977 edition of FAA Order 8430.1A, Chapter 7, Pilot and Flight Attendant Crewmember Training Programs, paragraph 153, states that inspectors shall determine that each training program is adequate to prepare crewmembers to meet the testing requirements of 14 CFR 135.122, 135.131, 135.138, and 135.139. The Order encourages inspectors to "emphasize the potential problem areas induced through misuse of stabilizer trim, on those aircraft having trimable stabilizers, which can cause reduced elevator effectiveness and uncontrollable stick forces." The Order specifically uses the Beech 99 as an example in areas to be covered for ground and flight training. These areas concern longitudinal control of the aircraft with the use of the trim system as well as with various flight controls and engine power settings. The order stated that the procedures to be followed by inspectors to accomplish this training was contained in the referenced July 19, 1969, Airworthiness Directive, which revised the Beech 99 Aircraft Flight Manual.

Review of the Beech Airworthiness Directives disclosed that AD-69-16-3 and 69-18-6 had been rescinded by AD-71-12-2, dated June 3, 1971, because the objectives of these AD's and those six related AD's had been accomplished. The two AD's dealt with trim check and unscheduled pitch trim procedures. The revised trim check procedures in AD-69-16-3 had been incorporated into the flight manual. However, AD-69-18-6 did not describe how to cope with a mistrimmed stabilizer on takeoff, and this information had not been incorporated in the flight manual.

The FAA GADO at Spokane, Washington, assigned one principal operations inspector, one principal maintenance inspector, and one maintenance inspector to the Airline. A System Worthiness Analysis Program inspection of Columbia Pacific Airlines was conducted September 15 through 17, 1975; it disclosed no major discrepancies in the Airline's operation.

Since August 8, 1977, the principal operations inspector conducted three base inspections; the last was performed January 25, 1978. On August 2, 3, and 4, surveillance inspections were conducted as a result of a company pilot's complaint of a deficiency in communications between flightcrews and maintenance personnel which had resulted in maintenance being disregarded. As a result of that complaint, FAA assisted the company in establishing a new maintenance discrepancy record system. The second base inspection disclosed that all records were in proper order. The third base inspection disclosed that one Piper Navajo and one Beech 99 (N1034S) were found in good condition, that all pilots' records were in good order, and that the company manual was complete except for two revisions on hazardous materials.

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The Safety Board's public hearing on the accident disclosed that the principal operations inspector had never been given a flight check in the Beech 99. However, he had attended the FAA Academy where he was checked in the Beech King Air (Model 90) and North American Aero Commander--the model 90 is not the same type aircraft and does not have a moveable horizontal stabilizer that can be trimmed. When asked how many hours he thought would be required to qualify a pilot as captain in the Beech 99, he stated 6 to 10 hours depending on whether the pilot had any previous turbine-powered aircraft experience. Testimony at the public hearing concerning stabilizer mistrim disclosed that Columbia Pacific pilots had received only unscheduled (runaway) trim emergency training.

On September 16 and December 15, 1977, and on January 25, 1978, maintenance inspectors performed base inspections, the last of which revealed that the Airline's maintenance facility was in operation, a director of maintenance had been assigned, two maintenance shifts had been established, the maintenance manual had been updated, and a new airworthiness recordkeeping system had been developed.

From August 4, 1977, to January 31, 1978, six surveillance inspections were performed, four of which were ramp inspections of aircraft. During the various inspections, all four of the Piper Navajo aircraft had been examined--one twice and another three times. Only one Beech 99, N1034S, had been examined, and it had been examined on three different occasions; N199EA had not been examined. According to the principal maintenance inspector, they are not required to inspect all aircraft. The records of the various inspections did not disclose that the Airline was not recording aircraft discrepancies in the deferred section of the daily flight log.

#### 1.17.4 Investigator's Observations of a Company Flight

On February 23, 1978, a Safety Board investigator boarded Columbia Pacific Flight 11 (N1034S) at Richland to fly to Seattle. During the flight, the investigator noted that the crew had positioned their flight bag between their seats adjacent to the control pedestal. This is a normal procedure. The front left corner of the bag was against the horizontal stabilizer main and standby trim power switches. The seams of the front left and right rear corners of the bag were torn severely from placing or removing items such as the flight manual and daily flight log. (See figure 10.) Since the switches are only partially guarded, a crewmember can inadvertently turn the main power switch off by placing a flight log into the bag. During a survey of Beech 99 operators, investigators learned of eight reported instances of this; these pilots, however, immediately noticed the mistake.

#### 1.18 New Investigative Techniques

None

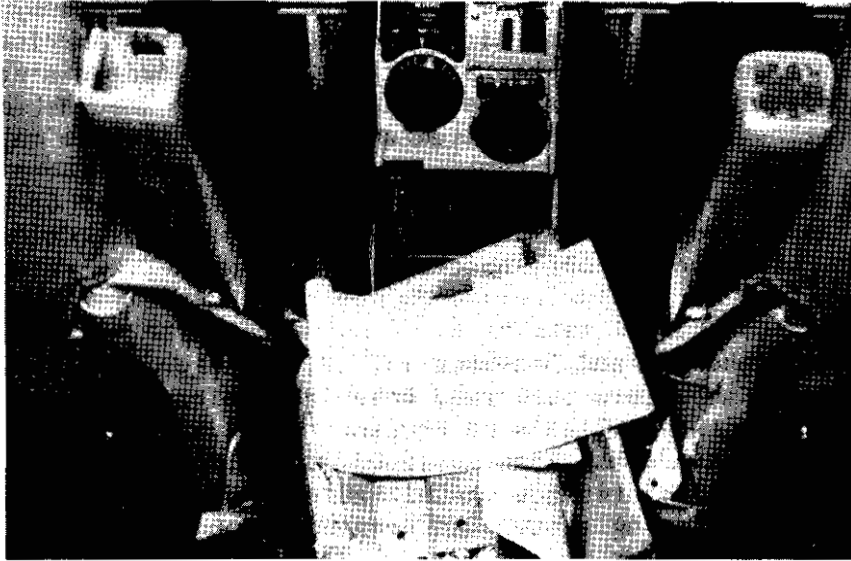


Figure 10. Closeup of flight bag with front left corner against main and standby trim switches. Note the torn seams of the bag.

## 2. ANALYSIS

The flightcrew was certificated, and each had received the off-duty time prescribed by regulations. There was no evidence of physiological problems that might have affected their performance.

Based on available evidence, the Safety Board concludes that an adverse noseup position of the horizontal stabilizer most probably produced the pitchup and steep climb after takeoff. Flight tests, during which this configuration of the horizontal stabilizer was reproduced, confirmed that an adverse position will produce the accident profile if the pitch attitude is allowed to increase to about 30° and is not immediately reduced. Although the control wheel push forces required to restrain the pitchup were high, they were manageable and were within the limits specified by regulations.

### Pilot Technique

It was a pilot technique among some of the Airline's pilots to ease back on the control wheel at 78 KIAS ( $V_{mc}$ ) to obtain control "feel" for the aircraft before liftoff. Standard callouts are made at 80 and 90 KIAS, at which time rotation would begin followed by liftoff at 94

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KIAS. The Safety Board could not determine if the captain used a similar technique at 78 KIAS. Reportedly, he trimmed a fully loaded Beech 99 "nose light." This would provide for low pull forces during rotation and a smoother liftoff; however, depending on the amount of trim used, push forces might be required. According to flight tests, control push forces would not have become noticeably high until after liftoff. Therefore, the captain may not have had an indication of a mistrim condition through control wheel pressures before liftoff because of the manner in which he trimmed the aircraft. His practice of trimming the aircraft nose light, combined with a stabilizer in an adverse noseup trim position, probably contributed to the early liftoff.

The abrupt pitchup of 30° within 1.5 seconds after liftoff required flightcrew action within 5 to 6 seconds to reduce the steep attitude before stall. Flight tests showed that sufficient elevator authority existed to reduce the pitch attitude had the flightcrew countered with 50 to 65 lbs of push forces.

The postcrash position of the stabilizer at a position near that of the correct takeoff trim setting indicates that the trim apparently had been corrected from an adverse noseup position; the time required to make the correction (20 seconds) using the secondary trim system alone exceeded the time (5 to 6 seconds) from liftoff to stall at a pitch attitude of 30°. However, the time from liftoff to the top of the climb would have been about 20 seconds, and it is reasonable that the captain continued trimming at least to that point. Once in the stall, the airloads on the stabilizer would have decreased and clutch slippage would have been reduced. In view of the short time interval, the crew probably responded immediately to correct the extreme pitchup by using the trim system instead of concentrating on applying the required push forces on the control wheel.

The abrupt climb probably prompted the captain to: (1) Attempt correction of the pitch attitude with the main pitch trim system (dual element switches on the control wheel) and then switch to the standby system when the main system was found to be ineffective because of the slipping actuator clutch; or, (2) select the standby system immediately after the pitchup, because he suspected a problem with the main system.

Another factor might have delayed the crew's attempt to reduce the pitchup with the trim system. The partially guarded main pitch trim switch could have been turned off inadvertently when the first officer placed the daily flight log into the flight case after he logged takeoff time. The captain then would have found both switches in the OFF position, and he probably would have turned the main switch ON after discovering the dual element switches on the control wheel were ineffective in reducing the control forces. After finding the main trim to be ineffective, he would then have switched the main trim OFF and the standby ON. These actions probably involved at least 6 to 7 seconds.

The flightcrew's reliance on the trim system to correct the pitchup probably diverted their attention from the outside visual references, which flight tests disclosed were essential in restraining the pitchup. A pilot's attitude awareness is particularly critical when he selects and operates the standby system while applying, with one hand, the forward control pressures required to prevent the stall. Based on the foregoing, the Safety Board believes the captain allowed the aircraft to rotate to the reported 30° pitch attitude while he attempted to solve the trim problem. Under these circumstances, the standby system would not have had a beneficial effect on the out-of-trim conditions, because of its relatively slow rate of operation and because of the slipping clutch.

Crew Training

The Safety Board believes that the flightcrew failed to take the proper action to reduce the pitchup because their training did not make them aware of the need for immediate and high opposing control forces of more than 60 lbs. They had not been trained to recover from the unusual attitude in the takeoff configuration produced by the mistrimmed stabilizer at takeoff airspeeds, attitudes, and power settings and were not aware of the urgency and forcefulness of the corrective action required to avoid the stall. Also, they were probably not aware of the short time (about 1 second) available from the onset of prestall buffet to stall in the takeoff configuration at a high pitch attitude. Once lateral control began to deteriorate in the stall, recovery in the remaining altitude was essentially impossible. Flight tests established the aircraft's strong tendency to yaw and bank to the left which provided reliable evidence of the onset of loss of lateral control. A similar yaw and left bank was reported by witnesses and was probably responsible for the aircraft's deviation to the left of the extended centerline of the runway.

Aircraft Airworthiness

The aircraft noseup trim position of the stabilizer could have been inadvertently set because of the faulty trim position indicator, or the stabilizer could have been mispositioned during maintenance. The reasons for the faults in the indicator could not be determined. The stabilizer's position is required to be noted during preflight inspection of the aircraft and correlated with the trim position indicator in the flight compartment during the before-takeoff checklist. Had the flightcrew conducted this check, they probably would have discovered the inaccuracy in the trim position indicator. Also, its inaccuracy would have been discovered during a full travel trim check. According to the Aircraft Flight Manual, these checks may be omitted during a turnaround at the captain's discretion; a full travel trim check is required only on the first flight of the day. Since the aircraft had been flown earlier that day and since the flightcrew had only about 10 minutes to conduct a preflight and depart on schedule, they evidently treated the flight as a

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turnaround. The first officer could have overlooked the mispositioned stabilizer during his preflight inspection, because he may have been preoccupied with making a timely departure and because the external indicator was not clearly visible. The Safety Board does not consider this flight a turnaround, because a new crew had been assigned to the aircraft and because it had just been released from maintenance. Therefore, the Safety Board concludes that a full travel trim check was required.

The flightcrew was not warned of the mistrimmed condition, because the out-of-trim warning system **was** inoperative. They were probably not aware of this discrepancy, because a check of the out-of-trim warning is not required by the Aircraft Flight Manual or Airline checklists. The flightcrew apparently did not conduct a check of the system or their check was not sufficient. The Safety Board believes the out-of-trim warning system to be an essential item, and it should be thoroughly checked prior to each flight. Had the system been operational, the accident would have been prevented, because the warning horn would have provided an unmistakable indication of the adverse position of the stabilizer and of the inaccurate trim position indicator.

The trim-in-motion aural warning system was determined to be unreliable. The flightcrew was not aware of the series of discrepancies concerning this system, because they were not entered in the deferred section of the daily flight log. The flightcrew could have easily detected its status during a full travel trim check.

The flightcrew should have been aware of the malfunctioning deicer boots, since the pressure gage would have shown continuous, partial inflation; therefore, the deicer boots would not have functioned properly. According to the minimum equipment list, this system may be inoperative provided the aircraft is not operated in icing conditions. Investigation disclosed that potential icing conditions prevailed along the route Flight 23 would have taken.

Other operators of N199EA had also experienced the same difficulties with the stabilizer trim system. The trim actuator assembly had been repaired or replaced several times. It was an "on-condition" item to be repaired or replaced as necessary. There is **no** specific overhaul period required, and there is **no** procedure in Beech Aircraft Corporation's service instructions for inspecting the airworthiness of the actuator clutch. A malfunction of the actuator required that it be removed and factory inspected. An aircraft operator may conduct a factory inspection if he has the necessary technical literature and tools available and has been certified for such by **FAA**. Columbia did not have this certification. The success of maintaining the actuator in an airworthy condition rested heavily **on** pilots accurately documenting their trim system discrepancies and on mechanics accurately troubleshooting and replacing the assembly before other complications developed.

The Safety Board could not determine why the metal ball bearings were loose in the clutch nor the length of time the clutch was in this condition. The balls were probably misplaced during repair. It is unlikely that excessive wear of the two remaining balls was caused entirely by airloads on the stabilizer. The wear was more likely the consequence of the actuator jackscrew having run against the stops because of misrigging of the limit microswitches. Excessive wear would be expected under these circumstances, because four of the balls were not present to absorb the loads placed on the clutch.

The Safety Board believes that the previous intermittent operation of the stabilizer actuator experienced by Columbia's other flightcrews was caused by the slipping clutch and that this condition existed during the accident flight. Slippage would have caused the actuator to stall or actuate at a slower-than-normal rate when the stabilizer was subjected to airloads during pitchup. The clutch would have slipped in both main and standby modes of operation. Thus, the pilot's ability to return the airplane would have been affected adversely.

Maintenance personnel did not properly diagnose the deficiency in the actuator clutch mechanism, and, again, the flightcrew would not have been aware of the deficiency, because the reported discrepancies had not been recorded in the deferred maintenance portion of the daily flight log and the stabilizer could have operated normally during ground checks.

Therefore, the Safety Board concludes that in view of the nature of the mechanical discrepancies, the aircraft **was** not airworthy.

#### FAA Surveillance

The Safety Board believes that the FAA had not effectively performed its regulatory functions related to aircraft and pilot certification. The team of experts' report attempted to describe the potential longitudinal control problem with the Beech 99. The team had recommended that the control forces be reduced by aircraft modification or that a letter of competency be required for each pilot-in-command. The Safety Board did not find during its flight tests that the control forces experienced in a takeoff with full noseup trim were substantially reduced by the modifications made by the Beech Aircraft Corporation.

The Safety Board agrees with the team's alternative--that a letter of competency be required. The letter would certify that the pilot is knowledgeable of those flight conditions judged to be most detrimental to the safe operation of the aircraft and had demonstrated his skill in controlling the aircraft under those conditions. However, the manner in which this certification was to be achieved was deficient, because the instructions in FAA Order 8430.1A, paragraph 153, were general and did not state how the flights were to be conducted. Also, it did not clearly state the problem that may be encountered with a mistrimmed stabilizer on takeoff, and this information was not listed in the Aircraft Flight Manual.

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The tests conducted by the special investigation team were conducted with the aircraft's c.g. near the forward limit rather than the aft limit. Consequently, the low control forces of 20 to 25 lbs of push force identified might have influenced the team of experts' conclusions and recommendations. Therefore, the FAA evidently concluded that the condition was not potentially dangerous and that the aircraft was equipped with features that would prevent unsafe operation. Therefore, only run-away pitch trim emergency training was emphasized.

The FAA evaluated, but did not adequately document, the problem of a takeoff with extreme noseup trim at aft c.g. Additionally, the FAA did not implement the letter-of-competency recommendation associated with the test evaluations and did not insure that its inspector was aware of this problem in the Beech 99. Also, the principal operations inspector had not been trained in either the Beech 99 or aircraft of similar type. Therefore, the Safety Board concludes that the FAA's principal operations inspector assigned to Columbia Pacific Airlines was not adequately prepared to insure that the Airlines' pilots were thoroughly trained in the potential hazards of extreme trim positions with an aft c.g. condition.

The Safety Board believes that the FAA had not effectively performed its regulatory functions related to maintenance practices conducted by the Airline. Although the GADO attempted to correct the deferred maintenance recordkeeping deficiency, the Airline continued using an unacceptable procedure. The unacceptable procedure should have been corrected during subsequent inspections. Further, the evidence shows that the FAA should have placed more emphasis on the Beech 99 in their maintenance surveillance activities.

### 3. CONCLUSIONS

#### 3.1 Findings

1. The flightcrew was certificated and currently flight checked for the intended operation.
2. The aircraft was certificated and within weight and balance limits at the time of the accident.
3. The horizontal stabilizer trim position indicator was unreliable.
4. The horizontal stabilizer trim-in-motion system was unreliable.
5. The horizontal stabilizer out-of-trim warning system was inoperative.

6. The horizontal stabilizer actuator clutch slipped.
7. The aircraft was not airworthy.
8. The flightcrew was probably preoccupied with making a timely departure and did not correlate the stabilizer's position with the indicator in the flight compartment.
9. The flightcrew probably mispositioned the stabilizer to an adverse leading edge down position by relying on an inaccurate trim position indicator and did not visually insure it was trimmed within the takeoff range.
10. The flightcrew was not aware of the inoperative out-of-trim warning system and therefore was not alerted to the adverse aircraft noseup trim condition.
11. According to the Aircraft Flight Manual and Airline checklists, an out-of-trim warning system check was not required.
12. The aircraft became airborne early and rotated rapidly to a steep noseup pitch attitude.
13. The flightcrew did not immediately apply sufficient forward elevator control force to prevent the aircraft from entering an excessively high pitch attitude and stall.
14. The flightcrew may have relied initially on the main trim system to reduce elevator control forces, but the system was not effective.
15. The flightcrew probably attempted to reduce the high pitch attitude and high control forces with the standby trim system, but the system was not effective.
16. The flightcrew was not adequately trained to recognize and recover from an extreme noseup pitch attitude after takeoff with the c.g. near the aft limit.
17. The flightcrew was not able to prevent the aircraft from stalling after which recovery was impossible in the altitude remaining.
18. The accident was not survivable.

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19. The airline's maintenance procedures involving the trim system in the aircraft was deficient and flightcrew training did not emphasize the hazard of a mistrimmed stabilizer on takeoff.
20. The FAA's certification and surveillance of the airline's maintenance procedures were ineffective and, as a result, did not insure that maintenance personnel had sufficient knowledge of the trim system and were capable of maintaining it in an airworthy condition, and certification and surveillance of flightcrew training in the aircraft were deficient because they did not emphasize the potential problems, other than runaway trim, induced through a mistrimmed stabilizer.

### 3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the failure or inability of the flightcrew to prevent a rapid pitchup and stall by exerting sufficient push force on the control wheel. The pitchup was induced by the combination of a mistrimmed horizontal stabilizer and a center of gravity near the aircraft's aft limit. The mistrimmed condition resulted from discrepancies in the aircraft's trim system and the flightcrew's probable preoccupation with making a timely departure. Additionally, a malfunctioning stabilizer trim actuator detracted from the flightcrew's efforts to prevent the stall.

Contributing to the accident were inadequate flightcrew training, inadequate trim warning system check procedures, inadequate maintenance procedures, and ineffective FAA surveillance.

### 4. RECOMMENDATIONS

As a result of this accident, on August 11, 1978, the Safety Board recommended that the Federal Aviation Administration:

"Issue an Airworthiness Directive applicable to all Beech 99, 99A, A99, A99A, and B99 model aircraft to require an immediate one-time inspection of the horizontal stabilizer trim system to ascertain that all components of the system and its associated position-indicating and -warning circuits are operational within specified tolerances. (Class I, Urgent Action)  
(A-78-53)

"Require an inspection to insure that the primary and secondary mode of the horizontal stabilizer actuator are capable of deflecting the stabilizer under specified airloads. The exact instructions should be furnished by the Beech Aircraft Corporation. The inspection should be made as **soon** as the Beech instructions are available and repeated at 2,000-hour intervals (Class II, Priority Action) (A-78-54)

"Change the minimum equipment list to make the out-of-trim warning system a mandatory requirement for flight. (Class II, Priority Action) (A-78-55)"

The investigation of this accident was difficult and time-consuming because of the lack of definitive information on the aircraft's performance and on the flightcrew's reaction to the emergency situation which arose immediately after takeoff.. Information from a flight data recorder and a cockpit voice recorder would have provided invaluable information in both of these areas, would have significantly reduced the investigative effort, and would have provided more direct evidence of causality. The Safety Board believes that these recorders are virtually a prerequisite to improvements in safety in commuter air carrier and corporate/executive operations involving complex multiengine aircraft. Therefore, we reiterate Safety Recommendations A-78-27, -28, and -29, dated April 13, 1978, and we urge the Federal Aviation Administration's early action on these recommendations:

"Develop, in cooperation with industry, flight recorder standards (FDR/CVR) for complex aircraft which are predicated upon intended aircraft usage. (Class II, Priority Action) (A-78-27)

"Draft specifications and fund research and development for a low cost FDR, CVR, and composite recorder which can be used on complex general aviation aircraft. Establish guidelines for these recorders, such as maximum cost, compatible with the cost of the airplane on which they will be installed and with the use for which the airplane is intended. (Class II, Priority Action) (A-78-28)

"In the interim, amend 14 CFR to require that no operation (except for maintenance ferry flights) may be conducted with turbine-powered aircraft certificated to carry six passengers or more, which require two pilots by their certificate, without an operable CVR capable of retaining at least **10** minutes of intracockpit conversation when power is interrupted. Such requirements can be met with available equipment to facilitate rapid implementation of this requirement. (Class II, Priority Action) (A-78-29)"

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BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING  
Chairman

/s/ ELWOOD T. DRIVER  
Vice Chairman

/s/ FRANCIS H. McADAMS  
Member

/s/ PHILIP A. HOGUE  
Member

December 21, 1978

5. APPENDIXES

APPENDIX A

INVESTIGATION AND HEARING

1. Investigation

The Safety Board was notified of the accident at about 1700, February 10, 1978. The investigation team went immediately to the scene. Working groups were established for operations, human factors, structures/systems, powerplants, maintenance records, and aircraft performance.

Participants in the on-scene investigation included representatives of the Federal Aviation Administration, Columbia Pacific Airlines, Inc., Beech Aircraft Corporation, Pratt & Whitney Aircraft, Ltd., and Hartzell Propeller, Inc.

2. Public Hearing

A 3-day public hearing at Seattle, Washington, began May 23, 1978. Parties represented at the hearing were the Federal Aviation Administration, Columbia Pacific Airlines, Inc., Beech Aircraft Corporation, and The Talley Corporation.

APPENDIX B

PERSONNEL INFORMATION

Captain David C. Branford

Captain David C. Branford, 28, was employed by Columbia Pacific Airlines as a first officer on April 12, 1976. He was upgraded to captain on March 24, 1977. The captain held Airline Transport Pilot Certificate No. 544609600. He was rated in airplane single- and multi-engine land, and glider-type aircraft. He also held a flight instructor's certificate. His first-class medical certificate was dated September 17, 1977, with no limitations.

Captain Branford had a total of 3,250 hours, of which 2,000 hours were in multi-engine airplanes and 800 hours were in single-engine airplanes. Four hundred and fifty hours had been logged in gliders. He had accumulated 300 hours in the Beech 99. He had recorded 66 hours of flight time for December, 83 hours for January, and 21 hours for February. The captain had not flown the 2 days before the accident and had flown 1.5 hours on the day of the accident.

First Officer Michael D. Stanley

First Officer Michael D. Stanley, 23, was employed by Columbia Pacific Airlines as a first officer on May 9, 1977. He held an Airline Transport Pilot Certificate No. 531660255, dated February 9, 1978, with ratings for airplane single- and multi-engine land. He also held a flight instructor's certificate. His first-class medical certificate was dated November 28, 1977, with no limitations.

First Officer Stanley had a total of 1,800 hours, 1,061 hours of which were in multi-engine airplanes and 739 hours were in single-engine airplanes. He had logged 199 hours in the Beech 99. He recorded 65 hours of flight time for January and 30 hours for February. The day before the accident he had flown 3.6 hours and was on duty 6 hours. He also logged 1.5 hours on the day of the accident.

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APPENDIX C

AIRCRAFT INFORMATION

Beech Aircraft Model 99, serial No. U-37, N199EA, was owned by Columbia Pacific Leasing, Inc., of Richland, Washington, and operated by Columbia Pacific Airlines, Inc., under a lease back arrangement. It was approved for certification in the normal category on May 2, 1968, in accordance with the airworthiness requirements of 14 CFR 23, with amendments, equivalent safety findings, and special conditions with respect to Part 135 operations.

Previous operators of the aircraft were: Time Airlines, Benton Harbor, Michigan, which purchased the aircraft in October 1968 with 34.9 airframe hours; Midwest Commuter Airlines, Indianapolis, Indiana, from August 1971 to May 1975; Atlantic Central Airlines, New Brunswick, Quebec, Canada, from May 1975 to May 1977; and Columbia Pacific Airlines, from June 1977 until February 10, 1978.

At the time of the accident, the aircraft had accumulated 13,701 flight hours; 37 hours since its last continuous inspection.

Engines: Two Pratt & Whitney PT-6-A-20's

	<u>Serial No.</u>	<u>Total Time</u>
No. 1	PC-E-21196	2254.0 hrs
No. 2	PC-E-21958	2733.0 hrs

Propellers: Two Hartzel HCB-3-TN-3B's

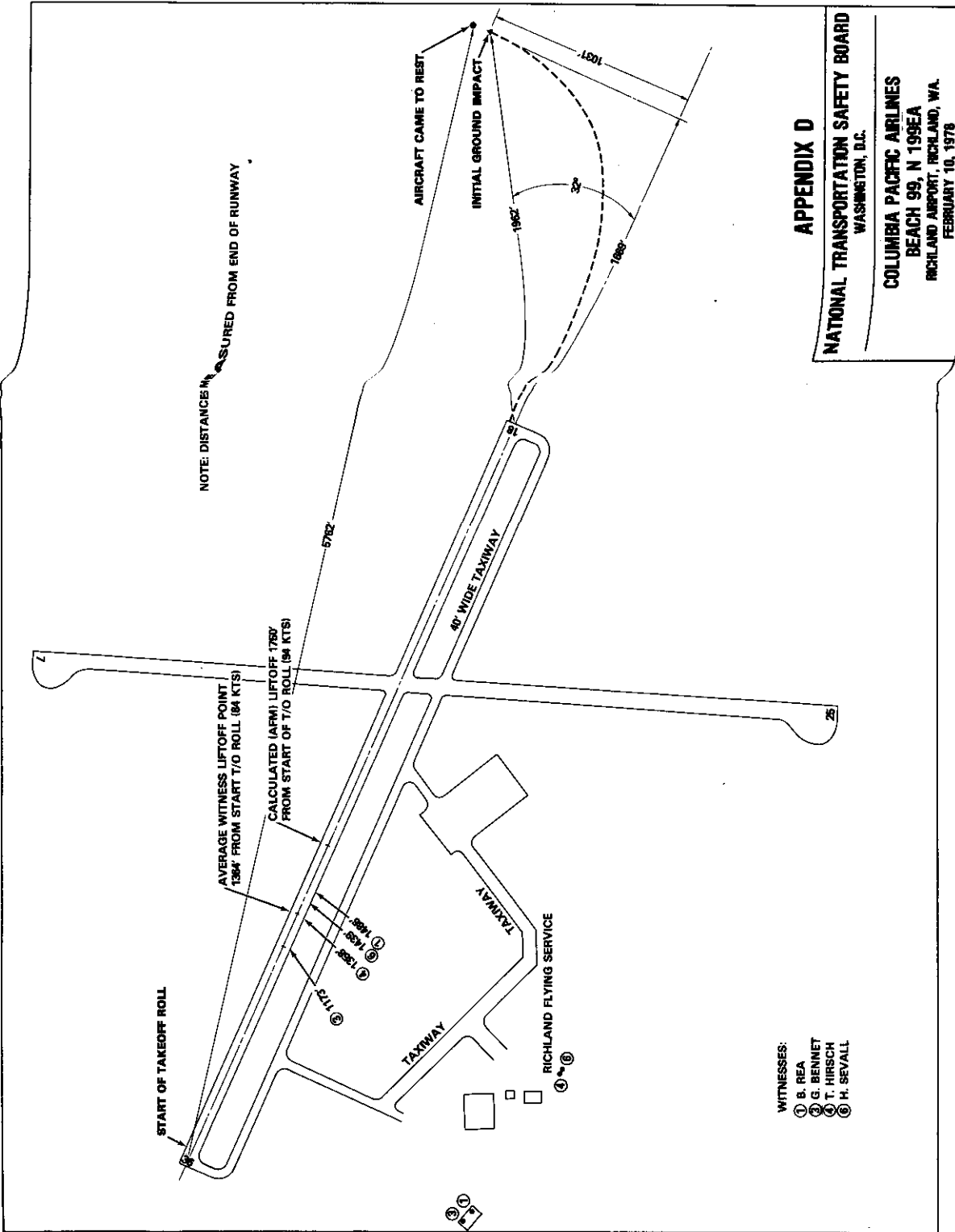
	<u>Total Time</u>
No. 1	3696.6 hrs
No. 2	3696.6 hrs

The maintenance records showed that the horizontal stabilizer trim actuator was replaced on the following dates and airframes times:

December 17, 1969	1605.8 hours
November 6, 1970	2744.7 hours
August 4, 1971	3681.0 hours
April 11, 1976	11,470.6 hours (motors replaced)

There were no entries in the aircraft log showing that either engine had ever lost power or was shut down in flight.

There were no entries to show that either propeller experienced an in-flight malfunction which resulted in shut down or loss of thrust.

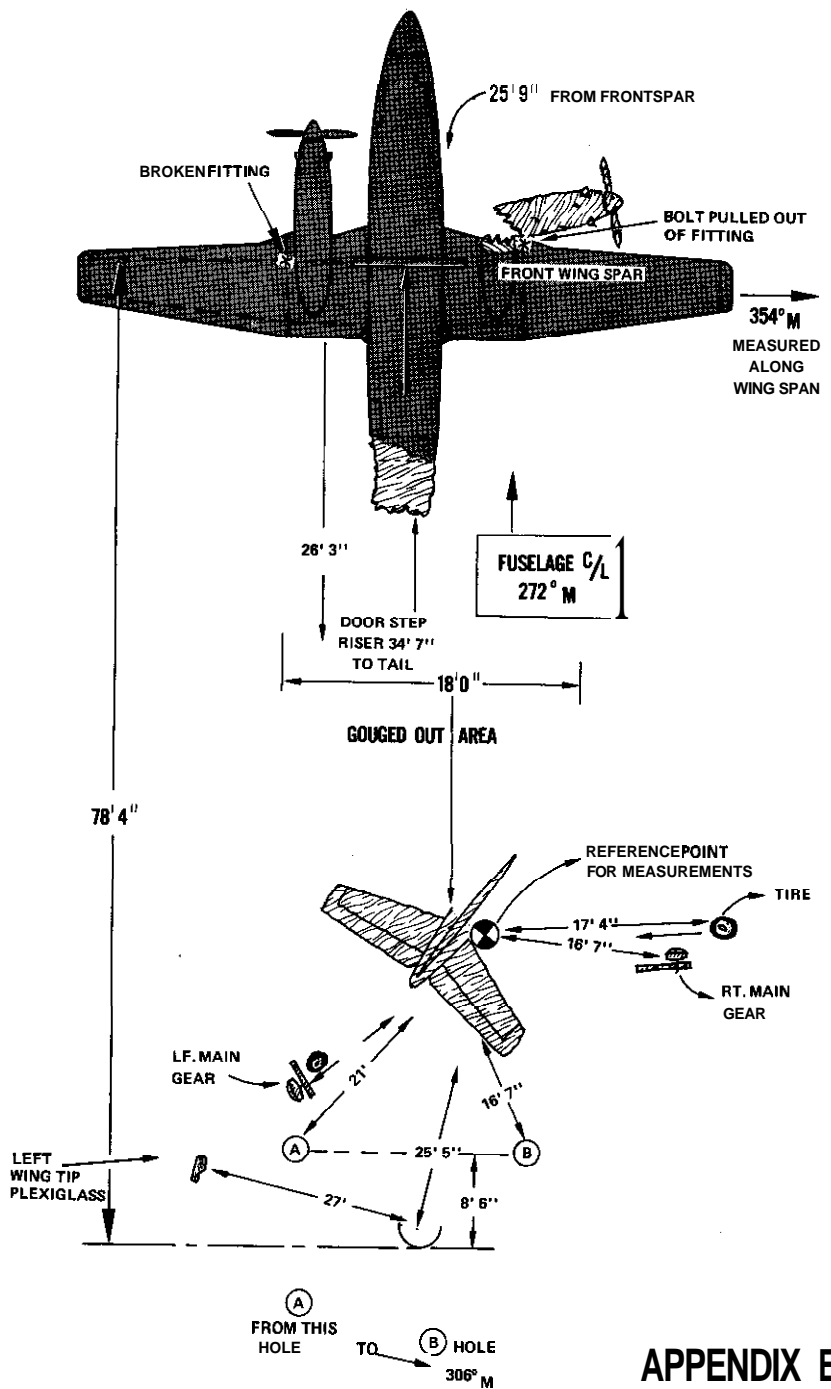


APPENDIX D

NATIONAL TRANSPORTATION SAFETY BOARD  
 WASHINGTON, D.C.  
 COLUMBIA PACIFIC AIRLINES  
 BEACH 99, N 199EA  
 RICHLAND AIRPORT, RICHLAND, WA.  
 FEBRUARY 10, 1978

- WITNESSES:  
 ① B. REA  
 ② G. BENNETT  
 ③ T. HIRSCH  
 ④ H. SEVALL

LEF WIN( PLE)



### APPENDIX E

NATIONAL TRANSPORTATION SAFETY BOARD  
Washington, D.C. 20594  
WRECKAGE DISTRIBUTION CHART  
COLUMBIA PACIFIC AIRLINES  
BEECH MODEL 99, N 199 EA  
Richland Washington Airport  
Richland, Washington  
February 11, 1978

