CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: November 9, 1956 Released: November 14, 1956

NORTHWEST AIRLINES, INC., BOEING 377, N 74608, IN PUGET SOUND, NEAR SEATTLE, WASHINGTON, APRIL 2, 1956

The Accident

Northwest Airlines' Flight 2, a B-377, N 74608, was ditched in Puget Sound, 4.7 nautical miles southwest of Seattle-Tacoma Airport, April 2, 1956, at 0810,1/ approximately four minutes after takeoff. All occupants successfully evacuated the aircraft but four of the 32 passengers and one of the crew of six drowned. Two passengers incurred minor injuries during the ditching. The aircraft, although later recovered, was a total loss.

History of the Flight

Flight 2 was scheduled daily between Seattle, Washington, and New York, New York, with intermediate stops at Portland, Oregon, and Chicago, Illinois. It departed Seattle-Tacoma Airport at 0806 on an IFR flight plan to Portland, Oregon, via Victor Airway 23 to cruise at 6,000 feet. There were 32 passengers and a crew of six consisting of Captain Robert Reeve Heard, First Officer Gene Paul Johnson, Flight Engineer Carl Vernon Thomsen, Flight Service Attendant David V. Razey, Senior Stewardess Elinor A. Whitacre, and Junior Stewardess Dorothy L. Oetting.

Takeoff was made on runway 20 and the flight climbed to an altitude of 1,000 to 1,200 feet. At this time power was reduced and the wing flaps, which had been set at the normal 25-degree takeoff position, were retracted at an airspeed of 145 knots. Immediately the crew became aware of severe buffeting and a strong tendency of the aircraft to roll to the left. Because the buffeting began almost immediately after the flaps were retracted, the captain believed that it was due to a split-flap condition, i. e., the wing flaps on one side of the aircraft being retracted while the flaps on the other side remained partially or fully down. Power was reduced momentarily in an attempt to alleviate the buffeting but this was not effective and maximum continuous power was again restored. After being cleared by the Seattle tower for return, the captain decided not to turn the aircraft because of control difficulty and advised that he would proceed to McChord Air Force Base at Tacoma. Thereafter, the captain testified the trouble became worse and the aircraft continued to lose altitude. The captain elected to ditch and did so at approximately 0810.

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

Touchdown was on smooth water at an airspeed of approximately 120 knots and there was no abrupt deceleration. Passengers and crew members, except the captain and first officer, left the aircraft through the main cabin door and emergency exits. The captain and first officer, after a passenger count, left the aircraft through cockpit windows and swam to the left and right wings, respectively. The aircraft sank in approximately 15 minutes and by that time all persons on the wings had been supplied with buoyant cushions from the cabin seats. Those who survived were rescued by surface craft from the 42-degree F. water within 30 to 35 minutes from the time of ditching.

Investigation

Seattle-Tacoma Airport 0730 weather was: Measured ceiling 1,200 feet; visibility 10 miles; altimeter setting 30.12; wind east-northeast 7 knots.

With the load properly distributed the gross weight of the aircraft at takeoff was 118,576 pounds, the maximum authorized takeoff weight is 124,000 pounds.

The ditching site was 4.7 nautical miles from the end of runway 20 and on a magnetic heading of 198 degrees. The water at this point is approximately 72 fathoms (432 feet) deep.

Personnel of the Board, Northwest Airlines, and maritime agencies participated in recovery operations. Underwater television was used after the wreckage was located and before raising commenced. Owing to the depth of the water and inability to immobilize the surface suspension, the results of using television were not satisfactory. The wreckage was then moved to water 40 feet deep where divers, one aeronautically experienced, made an initial inspection. This inspection revealed that the No. 1 engine had been torn off, that the wing flaps of both wings were fully retracted, and that the cowl flaps of the three remaining engines were fully open. The aircraft was then raised and placed on a barge for detailed examination. Examination confirmed that the wing flaps of both wings were fully retracted and that the cowl flaps of the three remaining engines were fully open.

The cowl flaps were open approximately eight inches as measured between the No. 7 cowl flap shingle and the accessory cowling. Full cowl flap opening is eight inches, plus or minus one-fourth inch. Cowl flap actuators of all four engines were one-eighth inch from contacting the full-open limit switches. The cowl flap jack screws were extended approximately 6-1/2 inches; full-open jack screw extension is approximately seven inches. Functional bench testing of the cowl flap actuators, relays, and indicators revealed normal operation.

Search for the missing No. 1 engine, with the use of sonar[2/] and other methods, continued for more than a week without success. A metallurgical examination of the No. 1 engine mount revealed no evidence of fatigue failure.

2/ A device used in underwater search operations.

Marks on the shank of a bolt in an upper outboard member indicate a load in an upward inboard direction. This is unlike previous failures in flight. Examination of the Nos. 2, 3, and 4 engines, which remained intact on the aircraft, gave no evidence of malfunctioning prior to impact. This was further substantiated by testimony of the three crew members that normal power from all four engines was available at all times until contact with the water.

The No. 1 engine top accessory cowling section was not found. This part is believed to have been forced off by hydraulic action during the ditching. Confirmation of this belief is indicated by the buckling rearward of the No. 1 firewall and also by the lack of wing surface damage in the No. 1 nacelle area. No crew member or passenger recalls observing any parts leaving the aircraft prior to impact.

Examination of the aircraft disclosed no failure or irregularities in any of the aircraft controls, control indicators, or limit switches prior to the ditching. This was substantiated by testimony of the flight crew that the aircraft was ditched under full control.

The captain stated that loss of control was believed imminent because of excessive buffeting, inability to maintain altitude, and a tendency of the aircraft to roll to the left which required nearly full use of aileron to correct. His statement reads (in part), "In electing to ditch I predicated my decision on the probability of a split flap condition and a firm conviction that the aircraft was not going to stay in a controlled condition much longer." At this time Flight Engineer Thomsen asked Captain Heard if he should go to the cabin and visually check the wing flap positions. The captain advised him to remain at his station because of the impendent ditching.

Boeing 377 aircraft operated by Northwest Airlines are equipped with a wing flap unbalance detection system which gives a signal in the cockpit of five degrees' flap differential between the left and right flaps. The wing flap position indicator in the cockpit is operated from the right wing flap. According to the crew, the normal and emergency wing flap drive systems and the wing flap unbalance detection system were checked before takeoff and all functioned normally. Also, the crew stated that when the flaps were retracted from the 25-degree takeoff position the wing flap indicator showed full-up or retracted position. There is also a propeller unbalance system that was checked before takeoff and all crew members testified there was no signal of propeller unbalance during the flight.

Crew members testified that all ground checks were accomplished. After the runup, which was made near the start of takeoff, the departure clearance was heard by all crew members and then the flight engineer made his challenge and own response to the item: "Cowl flaps-Set for takeoff." He then called to the captain, "Set for takeoff," according to the captain's testimony.

It is the flight engineer's responsibility to close the full-open engine cowl flaps prior to takeoff. The flight engineer stated he was not certain the

cowl flaps had been closed at that time. Flight crew members testified that a visual check of cowl flap position was not made prior to the ditching or after the buffeting commenced.

The flight engineer was qualified on three different types of aircraft: DC-6, L-1049, and B-377. His B-377 time in the 90 days preceding the accident was one hour and 40 minutes during a requalification check on March 16, 1956. He testified that most of his flight time had been on L-1049's and DC-6's the preceding year. His flying hours as of April 1, 1956, totaled 1,384, 236 of which were in B-377 equipment.

During the hearing the flight engineer was asked if he remembered actuating the cowl flap switches during the before-takeoff check. His answer was, "I can't actually, honestly tell you that I really did or did not." The cockpit cowl flap controls on the B-377's and L-1049's move in opposite directions for the closing of cowl flaps and at the hearing the flight engineer testified that it was possible he had moved these controls in the wrong direction prior to takeoff, thus leaving the flaps in their already open position.

Following the accident a special check flight was made in another Northwest Airlines B-377 with the crew of Flight 2 operating the aircraft and the Superintendent of Flying Western Region, Northwest Airlines, acting as observer. In addition to the check flight, simulation of the conditions experienced on Flight 2 was also conducted. Four takeoffs were made with the engine cowl flaps in various positions. Control was normal until the wing flaps were retracted. The final takeoff was with fully open cowl flaps on all four engines. There was no distinguishable effect on control, or buffeting, until the wing flaps were retracted. As the flaps retracted, buffeting and control difficulty commenced and reached a degree that, in the opinion of the crew, was very similar to that experienced by them during the flight of April 2.

In addition, test flights made by the Boeing Aircraft Company in a similar aircraft, using open engine cowl flap positions on takeoff, produced the same results when wing flaps were retracted. In all of these flights, buffeting ceased and aircraft control became normal when the engine cowl flaps were moved to the normal flight position.

Following the takeoff Flight 2 was observed by the Seattle-Tacoma Airport tower controllers directly and on the ASR (Airport Surveillance Radar) scope. The visual controllers testified there was no change in heading of the aircraft from runway 20 until it disappeared below the tree line. Other ground witnesses near the scene observed the descent and ditching and, with one exception, stated that they did not observe any part separate from the aircraft prior to water contact. One witness, who stated he saw a part come from the aircraft while it was in the air, was stationed approximately four statute miles to the east of the line of flight. This witness was subsequently accompanied by Board investigators to his point of observation and through an actual flight path reenactment it was determined that the subject aircraft could not have been seen from that location. This witness described the part

as being similar to the size of a door and coming from the area of the lower forward baggage compartment. Examination of the wreckage accounted for all such parts as having been in place when the ditching occurred. A wide search of the ground was made and no parts were found. In addition, a door check was made before takeoff and the crew stated no door warning light came on during the flight.

All of the flight crew members had several years and many hours of experience in B-377 aircraft. They stated that buffeting from excessively positioned cowl flaps had never been experienced by any of them either in check or regular flights. However, their testimony indicated that all three crew members were familiar with the pages of the flight operations manual covering the subject of buffeting. The manual notes open cowl flaps as a cause of buffeting in cruise configuration and prescribes the extension of wing flaps as a corrective measure.

The NWA Manual (Flight Operations - Boeing 377 Aircraft) is issued individually to all flight crew members. It is then their responsibility to be entirely familiar with the contents and keep the manuals current as additions are issued to them.

There have been other previous instances where other operators of B-377 aircraft have experienced flight difficulties because of cowl flaps being inadvertently opened. Details of these instances were disseminated (in 1952) by request of the CAB to all operators of B-377's through the medium of CAA alert bulletins, notices from the manufacturer, and the Air Transport Association. Investigation revealed that this information was received by NWA and distributed to their flight personnel.

At the Board's request, the airframe manufacturer prepared a study of the effect of full-open cowl flaps on the performance and controllability of the B-377 aircraft. This study indicates that the use of full-open cowl flaps during takeoff, with the normal 25 degrees of wing flaps, does not result in abnormal takeoff characteristics.

Further, the study indicates that when wing flaps are retracted and cowl flaps are fully open, no noticeable buffeting is experienced until the wing flaps are within about 10 degrees of the fully retracted position. Vibration and buffeting then builds up rapidly and becomes severe as wing flaps reach full-up. This vibration is more regular than buffeting in a full stall but is not as violent. With the increase in turbulence over the wings associated with the buffeting, lateral stability is reduced and tends to give the impression that the airplane is being balanced on a pedestal. Lateral trim requirements will more than likely be abnormal but not excessive. Performance capabilities of the airplane in the cruise configuration with all cowl flaps ride open and operating all engines at maximum continuous power may be likened so that with one engine inoperative and the cowl flaps in the normal setting. In this regard, positive rates of climb in excess of 600 feet minimum would be possible, and turns in either direction could be made without undue difficulty.

The data further indicate that buffeting with flaps up, although considered severe, is not of immediate concern as a cause of structural damage. The most pronounced effect on control or stability is in a lateral direction and a moderate amount of aileron control for trim may be required, probably to the right, even though all cowl flaps may be open the same amount.

Analysis

All evidence indicates that the cowl flaps on all four engines were approximately full-open during the entire period of the subject flight. Test flight results proved conclusively that in the above aircraft configuration buffeting occurs when the wing flaps are retracted. It is believed that the cowl flaps remained in the full-open position during and after the before-takeoff check for the following reasons: The NWA operations manuals direct that the flight engineer, after hearing the takeoff clearance in his own headset, shall then make his own challenge and response to the item; "Cowl flaps- SET FOR TAKEOFF." To accomplish this requires that he actuate the four cowl flap switches forward, either individually or by the gang-bar, and then monitor the movement of each cowl flap on its respective indicator in front of him on the engineer's pedestal and above the cowl flap switches. This monitoring ensures that the flap openings shall be the recommended amount, temperature wise, and in no event more than three inches.

The Board can offer no explanation for the flight engineer's failure to set the cowl flaps properly in the takeoff position. During the investigation and public hearing the adequacy of Northwest's flight engineer training program was thoroughly explored. The training program was complete and complied with the applicable Civil Air Regulations in every respect. Furthermore, it was developed that Flight Engineer Thomsen had successfully completed the basic program and the subsequent periodic checks. In addition his total flying time and time in the equipment involved is impressive, and is, the Board believes, further evidence of his general competency. Airline flight personnel are trained to be deliberate and to follow prescribed check procedures. Had Flight Engineer Thomsen acted in accordance with his training and previously demonstrated capabilities, his original omission would not have been made, or, if made, would have been detected before the captain had committed the aircraft to a ditching.

The CAA approved manual recommends that in a water landing 25 degrees of wing flaps should be used to decrease airspeed and rate of descent. The fact that the wing flaps were not extended in the subject landing supports the captain's statement that, in his mind, a split flap condition existed. However, if his analysis of the difficulty had gone further, his knowledge of the B-377 would have made him aware that with the wing flap cockpit indicator showing full retraction and his thought of a failure of the flap unbalance system allowing an unsignaled extension of the left wing flap, the tendency of the aircraft would have been to roll to the right and not to the left as in the actual occurrence. Regardless of the incorrect analysis of the difficulty, a visual check of the wing flaps would have eliminated this factor and pointed to a check of other possible causes.

The majority of causes of buffeting listed in the NWA flight manual could have been checked by actual observation or cockpit indication. Nos. 1 and 4 nacelles could have been observed from the cockpit. Had this been done the open cowl flap condition would certainly have been detected.

Although the evidence shows that Captain Heard and First Officer Johnson could have leaned forward and looked out their respective side windows and have seen the cowl flap settings, this did not occur to them, since Flight Engineer Thomsen's challenge and response was, in itself, the customary assurance that the cowl flaps were set properly for takeoff. In addition, the captain was faced with a series of adverse conditions, such as low ceiling and unfavorable terrain, and it was his belief and decision that ditching was the safest action since he was convinced that any attempt to continue flight would result in complete loss of control of the aircraft.

The Board realizes that all of these events were occurring within an extremely short period of time and that the apparent urgency of the situation required a rapid decision by the captain. Captain Heard did act promptly as the situation demanded but his incorrect analysis of the control difficulty led to an unfortunate decision. The pressures of the situation and the limited time available to the captain to arrive at a decision no doubt had an important bearing on the action he initiated. However, the Board believes that flight manual information on the conditions created by excessive cowl flap openings was sufficiently stressed to allow the captain, and indeed the entire crew, to evaluate the difficulty properly within the time available.

Passengers on the flight were entirely in agreement that the use of the seat cushions for flotation avoided a greater loss of life. Testimony of the passengers indicates a high standard of professional conduct on the part of all crew members in their care of the occupants after the ditching of the aircraft. The subject flight being domestic, the carrying of flotation gear is not required by Civil Air Regulations. Although the use of seat cushions for buoyancy is not listed in the manual, the crew members were aware that they could be so used and their prompt action ensured that no passenger or crew member was in the water without means of flotation after the aircraft sank.

Every consideration has been given to the probability of a contributory factor to the buffeting such as loose cowling, engine mounts, open doors, etc. However, all phases of structure examination, witness statements, and ground search failed to support such a factor.

Findings

On the basis of all available evidence the Board finds that:

1. The carrier, the aircraft, and the flight crew were currently certificated.

2. The gross weight of the aircraft at takeoff was below its maximum takeoff weight and the load was properly distributed.

3. Two minutes after takeoff an emergency was declared because of severe buffeting and control difficulty.

4. The flight engineer did not close the cowl flaps to takeoff position.

5. The cause of the buffeting and control difficulty was not determined by the flight crew and the captain made a decision to ditch the aircraft in Puget Sound.

6. The ditching was made under favorable circumstances. The aircraft sank in about 15 minutes and all survivors were rescued from the water shortly thereafter.

7. The aircraft was recovered from over 400 feet of water and examination disclosed that all engine cowl flaps were approximately full-open.

8. The buffeting and control difficulty was caused by the improper setting of the engine cowl flaps.

9. There was no failure or malfunction of the aircraft, the powerplants, or control systems prior to the ditching.

Probable Cause

The Board determines that the probable cause of the accident was the incorrect analysis of control difficulty which occurred on retraction of the wing flaps as a result of the flight engineer's failure to close the engine cowl flaps - the analysis having been made under conditions of great urgency and within an extremely short period of time available for decision.

BY THE CIVIL AERONAUTICS BOARD:

/s/ JAMES R. DURFEE

/s/ JOSEPH P. ADAMS

/s/ CHAN GURNEY

/s/ HARMAR D. DENNY

/s/ G. JOSEPH MINETTI

SUPPLEMENTAL DATA

Investigation and Hearing

The Civil Aeronautics Board was notified of the accident at approximately 0830, April 2, 1956. An investigation was immediately initiated in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. A public hearing was ordered by the Board and was held in Seattle, Washington, on May 21, 22, and 23, 1956.

Air Carrier

Northwest Airlines, Inc., is incorporated in the State of Minnesota, and maintains its principal place of business at Minneapolis, Minnesota. The Company possesses a certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Civil Aeronautics Administration which authorize the carriage of persons, property, and mail over the route described in this report.

Flight Personnel

Captain Robert Reeve Heard, age 38, was employed by Northwest Airlines as a pilot on April 3, 1941. He held a valid airman certificate with an airline transport rating and type ratings for Douglas DC-4 and DC-6, Lockheed Constellation, and Boeing 377 aircraft. Captain Heard had, according to company records as of March 24, 1956, a total of 14,030 flying hours, of which 1,557 hours were acquired in Boeing 377 aircraft. His last proficiency check on B-377 equipment was on January 2, 1956. His last first-class physical examination was successfully passed, with no limitations, on March 24, 1956. Time on B-377 equipment the last 90 days was 36 hours, with 95 hours on other equipment during the same period.

First Officer Gene Paul Johnson, age 32, was employed by Northwest Airlines as a pilot on July 7, 1949. He held a valid airman certificate with an airline transport rating and type ratings for Douglas DC-3 and airplane multi-engine land. Mr. Johnson had, according to company records, a total of 7,297 flying hours, of which 1,143 hours were in B-377 aircraft. He received his last proficiency check on February 20, 1956, and his last first-class physical examination was successfully passed, with no limitations, on February 21, 1956. Time the last 90 days on B-377 aircraft was 109 hours, with 60 hours on other equipment.

Flight Engineer Carl Vernon Thomsen, age 32, was employed by Northwest Airlines on July 19, 1941, and was assigned as flight engineer in December 1953. He held a valid flight engineer certificate and had, according to company records, a total of 1,384 flying hours, of which 236 hours were in B-377 aircraft. He successfully passed a second-class physical examination, with no limitations, on July 1, 1955. His last proficiency check on Boeing 377 aircraft was on March 16, 1956. His flight time for the 90 days preceding the date of accident was 168 hours, of which 1:40 hours were in B-377 aircraft.

Stewardess Elinor A. Whitacre was employed by Northwest Airlines on February 20, 1951. Miss Whitacre completed the stewardess training course and her last emergency training procedures were taken in February 1956.

Stewardess Dorothy L. Oetting was employed by Northwest Airlines on September 22, 1951. Miss Oetting completed the stewardess training course and her last emergency training procedures were taken in January 1956.

Flight Service Attendant David V. Razey, age 27, was employed by Northwest Airlines on September 10, 1954. Special courses completed were the Initial Flight Service Attendant Training at the time of employment, and his last Air Rescue Training Procedures taken in February 1956.

The Aircraft

Boeing model 377, N 74608, manufacturer's serial number 15954, was owned by Northwest Airlines, Inc., and was currently certificated. It had accumulated a total airframe time of 18,489 hours, with 1,324 hours since the last overhaul. The powerplants were four Pratt and Whitney model R4360-B6 engines equipped with Hamilton Standard propellers, with model 24260-43 hubs and F2J17H3-8W blades. Total time on the four engines was between 11,491 hours and 12,524 hours, and time since their overhaul was between 245 and 756 hours. Total time on the four propellers was between 685 and 10,264 hours, and time since overhaul was between 125 and 1,334 hours. Total time on the propeller blades was between 16 and 1,478 hours, and time since overhaul was between 16 and 1,334 hours.