CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: November 9, 1955 Released: November 15, 1955

PAN AMERICAN WORLD AIRWAYS, INC., OFF THE COAST OF OREGON IN THE PACIFIC OCEAN, MARCH 26, 1955

The Accident

A Pan American World Airways Boeing 377, N 1032V, was ditched in the Pacific Ocean, approximately 35 miles off the Oregon coast, at 1112,1/ March 26, 1955, after No. 3 engine and propeller tore loose and fell free, followed by control difficulties. All 23 occupants were evacuated but four fatalities and one serious injury occurred. The aircraft sank after an estimated 20 minutes, in water about one mile deep.

History of the Flight

Trip 845/26, a scheduled flight from Seattle-Tacoma, Washington, to Sydney, Australia, departed Seattle-Tacoma Airport at 0815 for Portland, Oregon, the first intermediate stop. There were 13 passengers and a crew of 8 consisting of Captain H. S. Joslyn, First Officer A. G. Kendrick, a Navigator M. F. Kerwick, Flight Engineer D. R. Fowler, Assistant Flight Engineer S. Bachman, Purser Natalie R. Parker, Stewardess Elizabeth M. Thompson, and Steward J. D. Peppin.

The flight to Portland was normal in all respects with arrival at 0910. There the aircraft was serviced and two additional passengers boarded. Only routine inspections and service were accomplished.

The flight left the ramp at 1010 and took off for Honolulu, Territory of Hawaii, at 1021 on an IFR clearance. Weather conditions at time of takeoff were VFR. There were 15 passengers and the same crew of 8. Takeoff gross weight was 139,494 pounds (maximum allowable was 145,800 pounds) and the center of gravity was located within limits.

The flight plan was via Newberg and Newport, Oregon, and thence to Honolulu to cruise at 10,000 feet. Estimated flight time was 11 hours and 3 mimutes. The flight reported over Newberg at 1031 at 7,000 feet climbing, reached 10,000 feet at approximately 1039, and reported over Newport at 1048 at cruising altitude. The aircraft was then headed to make good the initial track of 221 degrees true.

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

Forty-two minutes after takeoff, severe vibration occurred while cruising at 10,000 feet under VFR conditions. This lasted for five to eight seconds following which No. 3 engine and propeller tore free and fell from the aircraft. The captain immediately disconnected the autopilot. Severe buffeting ensued, the nose went down and the aircraft swung to the right sharply. At this point, the emergency "Mayday" signal was broadcast on both VHF and HF. Direct return to Portland was authorized by Seattle Air Route Traffic Control.

The captain, in the left seat, tried to get the airplane under control. Airspeed was about 220 knots and going higher, so he closed the throttles to keep the airspeed down. He still could not get the nose up; it felt to him as though the elevators were still on automatic pilot. He tried the elevator trim tab and could not turn it.

After rapid loss of altitude to about 5,000 feet, the captain directed the first officer to assist him with the controls. Their combined efforts finally brought the nose up very rapidly but the aircraft then went into a steep climb. It turned sharply to the right about 180 degrees and, according to the captain, appeared to be on "the verge of a spin." Level attitude was regained by pushing the yoke forward, and by use of the rudder and aileron trim the turn was stopped. At an airspeed of 150 knots, flaps extended 25 degrees, buffeting decreased immediately, however, the aircraft continued to descend rapidly. Attempts to get rated power were futile and a message was broadcast that ditching was imminent. This message was sent at approximately 1106.

The aircraft was then at an altitude of 500-1,000 feet. Ditching was imminent. Cabin attendants, realizing the emergency, assumed their respective stations for ditching. All passengers had been seated in the upper deck of the cabin with seat belts fastened and life jackets donned.2/

The aircraft touched down under near ideal sea conditions with little swell. Contact with the water was severe and the impact dislodged life rafts from their storage bins and some seats were torn loose. The aft portion of the fuselage and empennage broke off at impact.

Evacuation was orderly and the three rafts, although dislodged from their stowage receptacles, were launched without undue delay. The lanyards of all three life rafts were temporarily held at the cabin door by crew members. However, when one of the rafts was endangered by sharp metal of the broken fuselage its lanyard was released. Another was released by a crew member who then swam to that raft to right it. The lanyard of the third raft was released for unknown reasons. Consequently the rafts were carried away by the light surface wind. Passengers and crew left by both the main cabin door and escape hatches on both sides of the fuselage over each wing. Some crew members and passengers were able to swim to and board the rafts. Three of the four fatalities, including the copilot and first engineer, were unable to do so and were lost. Members of the crew and passengers tried in vain to paddle to these persons.

2/ Passengers were given a life jacket demonstration by the steward at Portland, prior to departure and each handed a folder, "Just in Case" (of a ditching).

One other passenger later died in a raft from exposure and shock. The purser, a woman, although suffering from shock swam and towed the only seriously injured passenger to the nearest raft, some 200 feet distant.3/

The time of ditching was determined as 1112 and the position at lat. 43°48'15" N., long. 125°12'40" W., approximately 35 miles off the Oregon coast. The U.S.S. Bayfield, en route to Seattle, changed course toward the site and by aid of search aircraft reached the life rafts some two hours later.

Investigation

Investigation disclosed that the dispatching of this flight was in full conformity with all government and company requirements. Up to the point of no return the alternate was Portland, Oregon.

Water approximately one mile deep precluded recovery of the wreckage. Small light portions of no significance to the investigation were subsequently washed ashore on the coast.

Because the failure originated in the No. 3 engine or propeller, followed very quickly by that power package wrenching free, investigation was aimed at ascertaining the nature of the malfunction and reason for the failure.

The aircraft was powered with four Pratt and Whitney R-4360-B6 engines and equipped with Hamilton Standard model 24260 propellers and model E2J17Z3-8W nickle-plated blades.

Loss of the engine and propeller could have been caused by, (1) failure of the engine mount, (2) sudden stoppage or seizure of the engine, or (3) an unbalanced propeller caused by failure of a blade. Since the engine and propeller could not be recovered there was no opportunity to examine them.

The first possibility - failure of the engine mount - seems unlikely as testimony indicates that when the engine left it took its mount with it leaving nothing forward of the firewall except small parts such as wires and lines.

Regarding the second possibility - that of sudden engine stoppage or seizure - investigation disclosed that there have been no known cases in which an engine has torn free from this model aircraft as a result of sudden stoppage.

The third possibility - an unbalanced propeller - must therefore be the cause of the failure. Other blade failures of this propeller-engine combination have produced similar results.

There have been five previous instances of total powerplant separation from like aircraft and one of partial separation. Of these six, two were definitely caused by propeller blade failure, and the remaining four (where engines were not recovered) undoubtedly resulted from the same cause.

3/ Vice Chairman Adams of the Civil Aeronautics Board, serving as a panel member at the Board's accident hearing, publicly praised Miss Parker, the purser, in these words, "I think that it was most inspirational and on behalf of the Board I would like to personally commend you for your work. I think that all of us feel inspired that a fellow citizen, or just a fellow human being, can rise to such an occasion in the manner in which you did. It is most commendable, Miss Parker."

During the service life of this propeller, the manufacturer developed modifications and more restrictive inspection and maintenance procedures, all of which were aimed at improving the integrity of the blade. The most recent modification was to nickle-plate the blade surface to minimize service-incurred nicks and gouges. Blades on the PAWA fleet of B-377 aircraft were nickle-plated and maintained in accordance with the manufacturer's latest service instructions.

The investigation of this accident included a study of the results of special inspections that were initiated subsequent to the accident to determine the integrity of service blades. These inspections included X-ray, magnaflux, and detailed visual examinations of blades externally in areas normally not readily accessible, i. e., under rubber fairings. Hitherto this area had not been suspect.

This comprehensive program disclosed nicks and gouges beneath the garter caused during a manufacturing operation following plating. Furthermore, as the program proceeded, a cracked blade, not nickle-plated was found on the aircraft of another carrier. Study of this crack revealed that it resulted from fatigue and that it originated at a corroded area under the rubber fairing.

Until March 26, the date of the accident, no cracks had been reported as being found on nickle-plated blades. However, the intensive inspection program revealed three cracked model 2J17 blades that were associated with corrosion and one blade failed from the same cause while undergoing fatigue testing at the factory. The X-ray program revealed one new blade at PAWA cracked beneath the rubber boot. This crack had occurred during blade manufacture but had remained undetected.

Corrosion which is known often to serve as foci for fatigue failure was found on 13.5% of the PAWA-Pacific-Alaska Division blades.

The routine intransit service maintenance on Trip 845 at Portland consisted of a visual inspection of propellers, landing gear wheels, tires, control surfaces, engine cowling, etc. The inspection was made by two mechanics, one examining the cambered side of each blade, the other the flat side. No imperfections were found.

The propeller speeds of the aircraft were electrically controllable. Control could be individual or simultaneous. The electrical system employs fuses for the four individual engine circuits and master circuit breakers, both of which are common to all four circuits. One master circuit breaker is in the automatic synchronization circuit and the second one is in the circuit for manually selecting engine r. p. m. In this instance, the tearing away of No. 3 engine obviously created a short in that portion of the system serving No. 3 engine. A subsequent attempt by the flight engineer to increase r. p. m. by use of all switches simultaneously (for rated power) resulted in opening of the master circuit breaker so that the r. p. m. of none of the remaining three engines could be changed. Testimony indicates that the engineer closed the circuit breaker and again attempted unsuccessfully to get simultaneous increase of r. p. m. By this time the aircraft was nearly to the water. The captain stated that the r. p. m. never increased.

Flight Engineer Fowler attended two classes in 1955 on propeller control circuity. It has been established, however, that the specific contingency that occurred in this accident was never taught in any of these classes, nor had the company issued any specific instructions in regard thereto. Nor could this particular type of situation be approximated precisely in the Dehmel flight engineer simulator course.

Flight Engineer Fowler had been employed by PAWA since December 1938. After serving in various capacities he was classed as a flight engineer in April 1942. Mr. Fowler had served as a flight engineer in B-377 aircraft some 4,530 hours.

Assistant Flight Engineer Bachman, who was occupying the jump seat at the start of the emergency, for a while stood behind the engineer and observed that the aircraft's behavior was similar to that previously described; i. e., heavy aerodynamic buffeting and difficulty of the captain and copilot in controlling the aircraft. He recalled that the three engines were running smoothly.

At this point Bachman suggested to Engineer Fowler that the pilots would have less difficulty in raising the right wing if he would give them more power from No. 4 engine. Fowler replied he was unable to get any r. p. m. change. Bachman then reached over and advanced No. 4 throttle several inches. At this time he observed the altimeter reading to be 600 feet.

Bachman then watched him actuate the propeller toggle switches, also with no effect, and saw him reset the propeller control circuit breakers. Bachman then went to the passenger cabin for ditching.

The manufacturer of this aircraft had prepared performance curves for three-engine flight of the Boeing 377. These performance curves were based upon actual flight tests and wind tunnel tests of the aircraft to verify flight conditions that existed following the loss of No. 4 engine from a sister ship.4/ The curves depict the flyability of this model aircraft with No. 3 torn free, as happened in the subject case. They show, assuming landing gear up, flaps extended 25 degrees, an airspeed of 130 knots, which is the airspeed for minimum power requirements, that the aircraft, grossing 131,000 pounds, would have been flyable at takeoff power, 2,700 r. p. m., (131,000 pounds is the computed gross weight after separation of the No. 3 power package). These deductions by the manufacturer are premised upon there being no structural deformation of the aircraft (as from impact by part or parts at time of failure). If such existed, additional power requirements of unknown degree, would have been imposed.

Testimony also indicates that the subject aircraft would require a weight reduction of 11,000 pounds to reach 120,000 pounds, the weight necessary to sustain level flight in the vicinity of sea level with the power obtainable at 2,040 r. p. m.

Captain Joslyn testified that prior to extending flaps about one minute before ditching there was not sufficient time to consider dumping fuel.

The three 20-man life rafts were loaded with 13, 5, and 2 occupants. One crew member and one passenger were in one raft. In the second were the second engineer and four passengers, and the third carried the captain, second officer, purser, stewardess, and passengers to make a total load of 13. The nearest raft

4/ See Civil Aeronautics Board Accident Investigation Report, PAWA, Between Honolulu and Wake Island, December 6, 1953.

to any of the three persons who were not rescued was estimated to be 100 feet or more. The heaving lines in all three rafts were 25 feet long.

Two of the life rafts were of one make, the third of another. The first two had less distinct and more limited stenciled instructions for use than had the third. Crew members were acquainted with these instructions but passengers were not and consequently were handicapped in their efforts to assist in rescue efforts.

The first two rafts had small nylon lifelines, extending completely around the outside circumference, to assist in boarding. Passengers stated this cord was not visible after being coated with oil on the water. The third raft had a fabric braided strap which was more readily seen.

These rafts had inflatable center chambers to provide extra buoyance, rigidity, and to prevent occupants from sliding toward the center. The center chambers had to be inflated after launching with a hand pump carried in the raft. Until this was done, occupants slid toward the center because it was depressed and the surface was oil covered. Moreover, the action of occupants slipping toward the center raised the rim which made boarding even more difficult, and prevented those in the raft from helping persons in the water. The equipment bags containing paddles, heaving lines, etc., are outside the raft after inflation, and it is necessary to reach the edge of the raft to recover them.

Both passengers and crew members testified that the evacuation was orderly and conducted in an expeditious manner, with the exception of the difficulties heretofore mentioned.

Pan American had an established Aircraft Emergency Equipment Training Course for crew members. Prior to taking this Emergency Equipment training all flight personnel must have completed a course of aircraft familiarization, including a complete knowledge of the aircraft's doors, emergency exits, etc.

The flight was under surveillance of ground radar. A plot of its observed positions confirms the crew's testimony as to the aircraft's maneuvers while descending. It shows, specifically, that starting from cruising altitude of 10,000 feet on a southwesterly course, the aircraft made a full 360-degree turn to its right and then turned rather sharply about 180 degrees, also to its right, and was then lost to the radar as it went below 500 feet. (Just prior to ditching.) The direction of ditching was about opposite that of the initial cruising flight; about a full turn and a half to the right was made between the start of the trouble and the ditching; the total elapsed time was recorded as nine minutes.

Analysis

In the consideration of this accident and its results there are a number of factors, which are discussed as follows:

(a) Initial failure

(b) Control difficulty and its probable reason

(c) Inability to increase r. p. m. of other three engines

(d) Nondumping of fuel

(e) Ditching, survival, and rescue

(f) Corrective action

(a) Initial failure

The vibration which occurred immediately before No. 3 power package wrenched free followed a familiar pattern of known propeller blade failures. Despite the power package not being recoverable, the Board has no reason to doubt that the trouble was due to blade failure. This belief is based on the known history and subsequent examination of model 2J17 blades. This examination disclosed hitherto unsuspected corrosion beneath rubber fairing on the shanks of 13.5%, or 43, of the fleet's 318 blades. One of these 43 was cracked. Examination of blades in other service revealed one cracked on a military aircraft and one cracked on another air carrier aircraft.

This basic blade is, as demonstrated by its service history, prone to crack at surface irregularities. This fact dictates meticulous inspection during manufacture and while in service. Corrective action is now under way, as will be shown later in this report.

(b) Control difficulty

The Board is unable to determine the reason for the initial control difficulty. It may have been aggravated by an indeterminable irregularity of air flow over the empennage caused by the large, flat plate area of No. 3 firewall. It may also have been due to some deformation of the airframe, particularly of the empennage, caused by some violently slung object or objects from the No. 3 power package. This possibility is strengthened by the difficulty the pilot had in moving the yoke which necessitated his calling on the first officer for assistance. However, no impact at the time of or immediately after the failure was sensed by any occupant. Whatever the cause, effective control was regained after rapid loss of considerable altitude and the aircraft was ditched under control.

(c) Inability to increase r. p. m. of other three engines

The flight engineer on duty at the time of the accident did not survive. Consequently, the nature of the difficulty that he experienced in attempting to increase engine speeds can only be learned from other testimony. This testimony is largely that of the assistant flight engineer and, to a lesser extent, of the captain. There was no evidence that there was mechanical or electrical impairment of the control system of Nos. 1, 2, and 4 propellers. There had been no trouble of any sort prior to the emergency. In view of the known characteristics of the protective devices in the propeller control circuity, it can be concluded that the inclusion of the No. 3 toggle switch in the simultaneous actuation of the toggle switches was the responsible factor in not getting increased r. p. m.

Effective as of approximately April 20, 1955, the 10 amp. magnetic circuit breakers were replaced by slower acting 5 amp. thermal type circuit breakers in both master circuits and the 5 amp. fuses in the individual circuits were replaced by 2 amp. fuses. This change allows the fuse associated with the malfunctioning circuit to blow and thus leave the remaining circuits unaffected. This modification was detailed in Hamilton Standard Service Bulletin No. 283 entitled, "Synchronizer Toggle Switch Circuit Protection," dated December 21, 1953. Compliance with this bulletin was not mandatory by the CAA although the importance of its text was effectively demonstrated by the circumstances of this accident and it was made mandatory by the CAA April 21, 1955. It may be pointed out that this modification was also applicable to the carrier's fleet of Douglas DC-6's and had been made on them; it was the company's intent to make similar modifications on its fleet of Boeing 377's as soon as practicable.

(d) Nondumping of fuel

As previously stated, engineering opinion is that the subject aircraft would have been flyable with No. 3 engine gone at 2,040 r. p. m. had its weight been reduced to a gross of 120,000 pounds. This would have required a weight reduction of approximately 11,000 pounds. The maximum rate of fuel flow during dumping at 165 knots indicated is approximately 2,160 pounds per minute. Thus it would have taken slightly more than five minutes to lose 11,000 pounds; from initial difficulty to ditching was approximately nine minutes.

It appears that if fuel dumping could have been started immediately after the failure the aircraft could have been lightened rapidly enough to have been more flyable on the three good engines. However, the captain's time was occupied in attempting to control the aircraft and the problem of the inability to increase r. p. m. Furthermore, the captain stated that there was not sufficient time to even consider dumping fuel.

(e) Ditching

The aircraft was ditched in daylight under near ideal sea conditions. This was the first ditching of a civil B-377 aircraft, consequently, there was no direct knowledge of its ditching characteristics. The aircraft remained afloat for approximately 20 minutes.

Under these favorable circumstances and with comparatively few passengers (15) it might be anticipated that little difficulty would be experienced in getting everyone aboard life rafts. Such was not the case.

For various reasons, the rafts were cast adrift after being launched, as explained. This necessitated most occupants getting into the water and swimming to the rafts which were being drifted by the light wind. Two of the crew members and one passenger were unable to reach them and perished.

The conduct of individual passengers and individual crew members was high. Purser Natalie Parker displayed courage and devotion to duty which was exemplary. However, the fact that the rafts had to be cast adrift undoubtedly made it extremely difficult to rescue all persons and was a contributing factor to the loss of life.

Search and Rescue facilities were put into effect speedily and efficiently.

(f) Corrective action

The occurrence and investigation of this accident resulted in a number of corrective measures being initiated, among which were:

(1) Life rafts were stowed more securely

(2) Additional inspections of the propeller blades were required and the periods between previously required inspections were in some instances shortened.

(3) The schedule of installation of propeller blade imbalance detectors which had previously been developed to warn the crew of an impending blade failure was expedited and their use made mandatory by the CAA as of July 30, 1955.

(4) The manufacturer resumed development of a solid aluminum propeller blade for use on B-377 aircraft. The CAB recommended to the CAA that all Hamilton Standard 2J17 hollow steel blades be removed from service on the B-377 aircraft at the earliest possible date consistent with the manufacturer's ability to supply satisfactory blades.

(5) The Administrator, by letter dated June 28, 1955, advised operators of the B-377 aircraft as follows: "As a result of this investigation, and of the investigations conducted following six other accidents or serious incidents, we have concluded that, in the interest of safety, the Hamilton Standard Model 24260 propellers having 2J17 series hollow steel blades presently used on Boeing B-377 aircraft should be removed from service and replaced with propellers having solid metal blades. This shall be done at the earliest possible date consistent with the ability of the propeller manufacturer to supply satisfactory blades."

(6) Special inspections as determined to be required were made mandatory by the Administrator, first by telegraphic alerts and subsequently by Airworthiness Directives dated April 11, 1955, June 6, 1955, and October 10, 1955.

Development of solid aluminum alloy blades suitable for use on the Boeing B-377 has been a high priority project with the manufacturer, Hamilton Standard. As of October 20, 1955, four slightly differing experimental propellers have been built. Flight testing is required, and is scheduled for the immediate future, to determine the best of the four.

Findings

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

1. The company, the aircraft, and the crew were properly certificated.

2. The flight was properly dispatched.

3. The aircraft was properly loaded with respect to gross weight and center of gravity limits.

4. Weather was not a factor in this accident.

5. The aircraft and all its components functioned normally until a blade of No. 3 propeller failed.

6. The resulting imbalance wrenched free No. 3 power package.

7. Control difficulty resulted in rapid loss of altitude to low altitude.

8. Fuel was not dumped.

9. R. p. m. of the remaining three engines was not increased due to lack of specific training of the crew.

10. This aircraft had not been modified in accordance with Service Bulletin No. 283; however, this information was available to the company.

11. The aircraft was ditched under control approximately 35 miles off the Oregon coast.

12. There were no fatalities as a direct result of the ditching.

13. The three life rafts were launched without undue delay but were permitted to drift free.

14. The aircraft floated for an estimated 20 minutes.

15. Four persons succumbed as a result of shock, exposure, and/or drowning.

16. Search and Rescue facilities were notified promptly and responded quickly and effectively.

Probable Cause

The Board determines that the probable cause of this accident was loss of control and inability to maintain altitude following failure of the No. 3 propeller which resulted in wrenching free No. 3 power package.

BY THE CIVIL AERONAUTICS BOARD:

/s/ ROSS RIZLEY

/s/ JOSEPH P. ADAMS

/s/ JOSH LEE

/s/ HARMAR D. DENNY

Chan Gurney, Member, did not participate in the adoption of this report.

SUPPLEMENTAL DATA

Investigation and Hearing

The Civil Aeronautics Board was notified of the accident at 1145 p. s. t., March 26, 1955. 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 and held at Seattle, Washington, April 19, 20, and 21, 1955.

Air Carrier

Pan American World Airways, Inc., is a New York corporation with its main offices in New York, New York. Headquarters for the Pacific-Alaska Division are at San Francisco International Airport. The corporation operates as an air carrier under 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. These certificates authorize the carrier to engage in air transportation between various points in the United States and foreign countries, including the route involved in this instance.

Flight Personnel

Captain H. S. Joslyn, age 49, was employed by Pan American World Airways April 25, 1940. He held a valid airline transport pilot certificate with a rating for the subject aircraft. Captain Joslyn had a total of 17,872:12 flying hours, of which 1,588:77 were in Boeing B-377's, and 1,725 hours of instrument flying time. Captain Joslyn passed a CAA physical examination on January 21, 1955.

First Officer Angus Gustavus Kendrick, age 34, was employed by Pan American World Airways January 2, 1943. He held a valid airline transport pilot certificate with a rating for multi-engine land aircraft. Mr. Kendrick had a total of 10,125:22 flying hours, of which 1,293:42 were in Boeing 377's. His last CAA physical examination was passed on October 30, 1954.

Flight Engineer Donald Read Fowler, age 41, was employed by the company December 28, 1938. He held a valid flight engineer certificate and an A & E mechanic certificate and had accumulated 4,530 hours in B-377 aircraft. He received his last CAA physical examination on October 29, 1954, and latest emergency equipment recheck on November 2, 1954.

Assistant Flight Engineer Stuart Bachman, age 29, was employed by the company May 18, 1952. He held a valid flight engineer certificate and had accumulated 300 hours in B-377 aircraft. He received his last CAA physical examination on October 19, 1954, and latest emergency equipment recheck on February 28, 1955.

The Aircraft

N 1032V, a Boeing 377, serial number 15932, was owned and operated by Pan American World Airways and was currently certificated by the Civil Aeronautics Administration. The aircraft was manufactured May 18, 1949, and had accumulated approximately 13,655 hours. It was equipped with four Pratt & Whitney R-4360-B6 engines and four Hamilton Standard model 24260 propellers with model E2J17Z3-8W blades. The airframe and four engines and propellers had been maintained in full compliance with prescribed methods and within all time limitations.