

CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: July 8, 1957

Released: July 11, 1957

PAN AMERICAN WORLD AIRWAYS, INC., BOEING 377, N 90943
IN THE PACIFIC OCEAN, BETWEEN HONOLULU AND SAN FRANCISCO,
OCTOBER 16, 1956

The Accident

A Pan American World Airways Boeing 377, N 90943, was ditched in the Pacific Ocean because of powerplant difficulties near Ocean Station "November"^{1/} located between Honolulu, Territory of Hawaii, and San Francisco, California, on October 16, 1956, at 0615.^{2/} All 31 occupants were evacuated safely; the aircraft sank in deep water and could not be recovered.

History of the Flight

Trip 6 of October 13 was a regularly scheduled "around-the-world" flight eastbound from Philadelphia, Pennsylvania, to San Francisco, California, with en route stops in Europe, Asia, and various Pacific Islands. All prior segments had been routine and the flight departed Honolulu on the last leg of the trip on October 15. It was cleared to San Francisco Airport via Green Airway 9, then track to position 30° N. 140° W. at 13,000 feet, then 21,000 feet to San Francisco. There were 24 passengers aboard, including 3 infants, and a crew consisting of Richard N. Ogg, Captain; George L. Haaker, First Officer; Frank Garcia, Jr., Flight Engineer; Richard L. Brown, Navigator; Patricia Reynolds, Purser; Mary Ellen Daniel and Katherine S. Araki, Stewardesses. The 8-hour, 54-minute flight was planned IFR and the aircraft carried sufficient fuel for 12 hours, 18 minutes. The gross takeoff weight of the aircraft was 138,903 pounds (maximum allowable 144,000) and the center of gravity was located within limits.

N 90943 departed Honolulu at 2026. The climb to initial altitude was normal and the flight proceeded in a routine manner. At 0102, the approximate midpoint of the flight, a request for VFR climb to its secondary altitude of 21,000 feet was approved by ATIS.

After reaching 21,000 feet and simultaneously with the reduction of power, the No. 1 engine oversped. Airspeed was immediately reduced by the use of flaps and reduction of power. Attempts were also made to feather the No. 1

^{1/} "November" is a U. S. Ocean Station vessel located approximately midway between the Hawaiian Islands and the west coast of the United States. The U. S. Coast Guard Cutter "PONTCHARTRAIN" was "on station" at the time of the ditching.

^{2/} All times referred to herein are Hawaii standard and are based on the 24-hour clock.

propeller. It was impossible to control the engine or to feather the propeller and the captain decided to freeze the engine by cutting off the oil supply. Shortly after this was done there was a momentary decrease in the r. p. m., followed by a heavy thud. The propeller continued to windmill. At this time airspeed had slowed to 150 knots and the aircraft was losing altitude at a rate of approximately 1,000 feet per minute.

The captain contacted the U. S. Coast Guard weather station "November" at 0122, alerted it to a possible ditching, and asked assistance. He also alerted the passengers to the emergency and told them to prepare for a possible water landing.^{3/}

The flight course was altered to "home in" on station "November" and climb power applied to engines Nos. 2, 3, and 4 to check the rate of descent. At this time it was noticed that No. 4 engine was only developing partial power at full throttle. At 0125 the flight notified "November" that ditching was imminent and received a ditching heading from the cutter. During the descent the crew found they could maintain altitude at an airspeed of 135 knots with rated power on engines Nos. 2 and 3 and the partial power on No. 4. About 0137 the flight overheaded the cutter.

Prior to overheading the cutter the maximum range with the fuel remaining had been computed and it was determined to be insufficient either to complete the flight to San Francisco or return to Honolulu. Mortar flares had been fired by the cutter and electric water lights laid to illuminate a ditching track for the aircraft. However, it was decided to postpone the ditching until daylight, if possible, meanwhile remaining close to the cutter.

About 0245 the No. 4 engine backfired and power dropped off. Its propeller was feathered normally. The flight was still able to maintain altitude and continued to orbit "November" to burn the fuel aboard down to a minimum while awaiting daylight.

At 0540 Captain Ogg notified the U. S. S. Pontchartrain he was preparing to ditch the aircraft. A foam path was laid along the ditching heading of 315° by the cutter and the aircraft was ditched at 0615. Passengers and crew safely evacuated the aircraft, boarded liferafts, and were completely clear of the aircraft at 0632. The aircraft sank at 0635 at position $30^{\circ}01.5' N. 140^{\circ}09' W.$

Investigation

Investigation showed that the crew of this flight was properly qualified and certificated, and that dispatching of the flight was in accordance with government regulations and company procedures. All of the members of the crew had completed ditching training conducted by the company or Coast Guard.

The weather encountered en route was substantially as forecast and was not a factor in this accident. The weather and sea conditions at the time of ditching were: Wind calm; skies partly cloudy; major swells from 80 degrees, height 3

^{3/} Passengers were given a life jacket demonstration by the cabin attendants at Honolulu prior to departure. In addition, each passenger had been provided with a folder describing ditching procedures entitled "Just in Case."

to 4 feet, speed 24 knots, distance between swells 500 feet; minor swells from 130 degrees, height 2 to 3 feet, speed 13 knots, distance between swells 75 feet; barometer 30.28; seawater temperature 74 degrees F.

Complete overhaul and maintenance records of N 90943 were kept at San Francisco, headquarters of the Pacific-Alaska Division. A study of these records disclosed that the aircraft had been maintained in an airworthy condition according to CAA-approved maintenance procedures, and was properly certificated and equipped. No discrepancies were noted in any of the records of N 90943.

Approximately 25 minutes before reaching e. t. p. (equitime point), calculated to be 0131, a climb to the secondary altitude was initiated. At 0119 the aircraft was leveled off at 21,000 feet and speed allowed to increase to about 188 knots. When the first officer, who was flying the aircraft, called for cruise power he noted a vibration in the controls and an increase in the propeller noise; until this time the flight had been routine. Upon noticing the tachometer for No. 1 engine reading about 2,900 r. p. m., he immediately depressed the feathering button for that propeller, and then lowered 30 degrees of flaps. The flight engineer actuated the No. 1 fire switch gangbar, closed the No. 1 throttle, and cut the mixture control. He then reduced power on the other three engines to help reduce airspeed. At this time the No. 1 engine r. p. m. had exceeded the highest calibration on the tachometer.

The captain, who had been performing duties at the navigator's table, had by this time regained his seat and, after several unsuccessful attempts to feather, called to the engineer to cut off the oil supply to the engine and to freeze it. About 2-3 minutes after this was done the crew noted a momentary decrease in the r. p. m., then a heavy thud, followed by an immediate increase again in the propeller speed. They thought this indicated that the engine had frozen; that the propeller uncoupled through a failure in the propeller drive mechanism and was windmilling in the airstream.

Several subsequent attempts were made during the remainder of the flight to feather the No. 1 propeller. It was then noted that the tachometer indicated zero and that the circuit breaker in the No. 1 feathering system would not remain closed. The No. 1 oil quantity gauge indicated empty while prior to feathering attempts the quantity had been normal. No external oil leaks were noted.

During the short interval of this emergency (2-3 minutes) the captain had called ocean station "November," alerted it for a possible ditching, altered course slightly so as to "home" on the station, and alerted the passengers to the emergency, instructing them to prepare for a water landing.

When the emergency call was received the aircraft's position was determined by radar aboard "November" to be approximately 38 miles from the ship on a bearing of 256 degrees. This information, along with a recommended ditching heading, was transmitted to the flight.

About 0124, approximately five minutes after the propeller emergency and when the situation had stabilized somewhat, climb power was placed on engines Nos. 2, 3, and 4 to check the rate of descent. The No. 4 engine failed to respond with normal power. When full throttle was applied the engine instrument

readings were as follows: 2,350 r. p. m.; 80 BMEP; 23 inches manifold pressure; oil and fuel pressures normal; fuel flow was 600 pounds per hour; oil temperature, carburetor air temperature, and cylinder head temperature were lower than normal; turbo supercharger operation appeared normal. There was a slight rise in manifold pressure and in cabin airflow when the No. 4 turbo calibrating control was rotated to the "full on" position. When the crew reduced r. p. m. to 1,750, closed the oil cooler and intercooler, and closed cowl flaps to one-half inch, the BMEP increased to 90 with 26 inches of manifold pressure at the same fuel flow. All patterns on the engine ignition analyzer were normal, oil temperature, carburetor air temperature, and cylinder head temperature increased slightly, and the engine continued to operate.

By this time the aircraft had descended to about 5,000 feet. It was found that this altitude could be maintained at an airspeed of approximately 135 knots with flaps up, rated power on engines Nos. 2 and 3, and the partial power available from No. 4. However, the aircraft was allowed to descend slowly to about 3,000 feet before overhauling the cutter.

Prior to overhauling "November" the flight had called Honolulu and apprised them of the situation. It was also in constant contact with "November" and had received the latest weather, wind, and sea conditions for the probable ditching. The cabin attendants had issued instructions to all passengers to remove eyeglasses, shoes, and sharp objects from their pockets, and to put on life jackets. Adult-sized life jackets were improvised for the children. Locations of life rafts were pointed out and several passengers assigned to assist in launching them. All loose gear was stowed in the lower lounge. Passengers were relocated in the safest seats, forward of the tail section (which the captain believed would break off upon landing), and were instructed to bend over with arms clasped around their legs. The children aboard were placed on the floor and held tightly between their parents' feet. By the time the aircraft overhauled "November" the ditching preparations were complete.

It was found that the r. p. m. of the windmilling propeller could be kept under control if the airspeed was kept below 140 knots. This airspeed is about 20 knots less than that required for efficient two-engined flight. The range of the aircraft was seriously impaired by the additional drag of the windmilling propeller and necessarily low airspeed. With the remaining fuel aboard, maximum range under these conditions was computed to be 750 miles. The distance to either San Francisco or Honolulu was over 1,000 miles.

A shuttle pattern had been set up over "November" on the ditching track of 240 degrees during the latter part of the descent. The cutter had laid out a string of electric water lights along the track and was standing by for the rescue. After careful evaluation of the situation the captain elected to delay the ditching, when daylight and other conditions would be more favorable. Meanwhile, the flight continued to shuttle over the cutter. The passengers were advised of the decision and more complete detailed preparations for the ditching were made.

About 0245 No. 4 engine backfired and its power dropped off. An engine analyzer check at this time showed many low resistance shorts and no combustion pattern on the "B" row of cylinders. The propeller was feathered normally.

Engines Nos. 2 and 3 at this time were maintaining the aircraft at 2,000 feet at an airspeed of 140 knots, with 2,550 r. p. m., 190 BMEP, and 2,000 pounds per hour fuel flow.

As the fuel weight burned off the aircraft was allowed to climb to about 5,000 feet, where several practice approaches were made to determine the controllability of the aircraft at low speeds. The flight continued to circle over the cutter to burn out the fuel weight so that at touchdown the aircraft would be as buoyant and light as possible.

As daylight arrived Coast Guard personnel removed the water lights and requested that they be notified 10 minutes prior to the time the flight intended to ditch. This would enable the rescue team to be in absolute readiness and allow sufficient time for them to lay a foam path to mark the revised ditching path and heading, 315 degrees.

At 0540 Captain Ogg notified the cutter of the intended ditching time. He also notified the passengers, who had been allowed to smoke and move about during the several intervening hours, to take their ditching positions, as instructed. The captain descended to 900 feet to establish a landing pattern and later gave a final warning to the passengers, one minute before landing.

Touchdown was made at 0615 with full flaps at a speed of 90 knots with the landing gear retracted. First contact with the water was slight, followed almost immediately by a tremendous impact. The aircraft was partially driven under water but bobbed quickly to the surface and stopped with very little forward travel.

As anticipated, the fuselage broke off aft of the main cabin door. Several unoccupied seats remained in this section. A number of seats forward of the fracture were torn loose and several passengers were hurled to the floor. Two children who were being held were thrown from their mothers' arms. There were no fatalities or major injuries and no occupants were incapacitated by the crash; however, five people received minor injuries.

After the aircraft stopped, members of the crew and the passengers assigned to assist removed the emergency exit doors. Two 20-man liferafts were launched through the emergency exits over the wing and one raft was launched through the main cabin door. All occupants then evacuated the aircraft successfully through these exits. The liferaft that had been launched from the main cabin door was trapped against the wing and fuselage by the broken tail section, which had swung to the left. Some of the occupants transferred over the wing to another raft, enabling the first raft to be freed. The raft launched between Nos. 1 and 2 engines did not inflate properly and filled with water while it was being pulled clear by a Coast Guard rescue launch. All of the occupants of this raft were immediately transferred to the rescue boat without further mishap. The remaining passengers and crew, who evacuated the aircraft on the starboard side, were then transferred from the raft to the cutter Pontchartrain. The aircraft sank at 0635.

Analysis

Since there was no opportunity to examine the aircraft engines and propellers, this analysis must be based on the most logical conclusions drawn by experience and knowledge from the evidence available.

The Board is of the opinion that two separate and unrelated mechanical malfunctions occurred during this flight and the relationship of each failure to the accident should be treated separately.

N 90943 was powered by four Pratt and Whitney R4360-B6 engines and equipped with Hamilton Standard, model 24260, propellers. The initial difficulty encountered resulted in the overspeed of No. 1 engine and inability to feather its propeller. Engine r. p. m. is normally maintained by engine oil at boosted pressure which is directed by the propeller governor to either side of a piston in the propeller dome. Movement of this piston changes propeller blade angle to maintain the desired r. p. m. Feathering is normally accomplished by auxiliary pump oil taken from the engine oil supply tank and directed by the governor through passages used for r. p. m. control to the outboard side of the piston. Consequently, a portion of the governor and the increased pitch side of the dome piston are common to both feathering and constant speed operation. It is considered most likely that the inability to feather was caused by the same malfunction which resulted in the original overspeed. If the auxiliary pump had failed there would have to have been a second near-simultaneous failure in the propeller system. This possibility is considered to be remote. Furthermore, depletion of the oil supply from the No. 1 tank, subsequent to the overspeed, with no external signs of leakage, is most logically attributed to operation of the auxiliary pump during attempts to feather following the stoppage of the engine by freezing.

The most likely causes of the overspeed and inability to feather are that oil was being misdirected at the governor pilot valve or that there was insufficient oil pressure at the dome piston. Improper direction of the oil would involve governor malfunctions, caused either by a fault within the unit itself or by contaminated oil being supplied to the governor. Contaminated oil would indicate some failure within the engine which would most likely be of a progressive nature. No such failure was evident to the crew prior to the overspeed. Insufficient oil pressure at the dome piston is most generally due to excessive leakage. Leakage usually involves seals, passages, transfer tubes, or bearings in the propeller, propeller control, or the engine.

The Board believes that a single failure occurred which affected the portion of the system common to the constant speed and feathering portion of the propeller control system. Oil was being delivered to the system by the feathering pump and then dumped into the engine. A more specific reason for the overspeed cannot be determined.

Subsequent to this accident PAAWA Pacific-Alaska Division experienced two uncontrollable engine overspeeds and inability to feather propellers due to failure of the propeller oil transfer bearing. A redesigned propeller oil transfer bearing has been provided by the manufacturer and its use was made mandatory by CAA Airworthiness Directive issued March 25, 1957.

From the information available concerning the No. 4 engine, it would appear that the initial power loss resulted from a reduction of the airflow through the carburetor. Fuel to the engine is metered by the carburetor in proportion to the air-mass flow through the throttle body. Engine instrument readings reported by the crew indicate oil and fuel pressures were normal but that temperature indications and fuel flow were low. Turbo supercharger responses indicated that that system was at least partially operating. These conditions could result from an obstruction caused by a deformation or partial breakup and displacement of the carburetor inlet air duct system, or a failure of the engine-driven impeller drive assembly. Although the first possibility cannot be completely discounted, the latter appears to be more probable.

It is significant to the analysis that PAWA records indicate three engine-driven impeller drive failures on like engines prior to this accident. The BMEP and manifold pressure readings, taken subsequent to one of these failures, were almost identical to those on No. 4 engine in this accident. Also, in the prior engine failure the crew reported light backfiring approximately one minute after the impeller drive failure and the propeller was feathered immediately. In the subject accident the engine continued to run at reduced power for some time before backfiring commenced. Then, indications of many low-resistance shorts and the lack of combustion pattern on the "B" row of cylinders were observed on the engine analyzer. This evidence is not inconsistent with an impeller drive failure. With the failure of the impeller drive assembly, impeller rotation would stop thus reducing the airflow which in turn would reduce the fuel flow. Turbo supercharger air and normal engine breathing would provide a limited combustible air-fuel mixture to the cylinders; however, distribution of the mixture to the cylinders would be impaired. It is believed, therefore, that all of the indications reported by the crew of Flight 6 could result from the engine-driven impeller drive assembly failure.

Following these failures, the basic design of the Pratt and Whitney R-4360-B6 impeller drive was re-evaluated by the manufacturer and the CAA. No design deficiency was found to exist and it was concluded that this type of failure is not chronic with this model engine. As a result of this study, the Board concluded that the design of the impeller drive is adequate and that no corrective measures are necessary.

With the propeller windmilling the range of the aircraft was unquestionably reduced to less than that required either to return to Honolulu or continue to San Francisco. Required fuel for the subject flight was computed on the basis of two-engine operation; therefore, only if the crew had been able to feather the No. 1 propeller and maintain the most efficient two-engine airspeed (165 knots) could it have reached land.

Data received from Hamilton Standard and Boeing, and derived from calculation and tests of the subject type propeller, indicate that the drag resulting from this propeller with the blades on the low pitch stops, 21.3 degrees, at 145 knots, 2,000 feet m. s. l., would be:

- a. Uncoupled windmilling 520 lbs.
- b. Coupled windmilling 1,880 "
- c. Frozen 2,320 "

The additional power necessary to compensate for the additional drag in each of the above conditions is:

a.	520 lbs.	295 BHP (Brake Horsepower)
b.	1,880 "	1,060 "
c.	2,320 "	1,380 "

Since drag resulting from these conditions varies as the square of the velocity, it is evident that exceedingly higher drag forces would be encountered at speeds greater than 145 knots.

This drag information is extremely important because prior to the investigation of this accident it was not widely known. In fact, it is believed, many thought that the drag with the propeller windmilling and coupled was greater than that with the engine and propeller frozen, whereas the drag condition is greatest with the engine and propeller rotation stopped. It is noted, however, that the above data apply only to the subject aircraft and propellers.

The Board believes that this report would be incomplete without a word of praise concerning the handling of this emergency by all the personnel involved. The Board highly commends the crew members for their ability in recognizing the malfunctions and taking correct emergency actions consistent with all known procedures. Their calm and efficient control of the situation averted what could have been a major air disaster.

In addition, the prompt response by the Coast Guard to the emergency and the immeasurable assistance rendered to the flight are deserving of particular praise.

Findings

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

1. The company, the aircraft, and the crew were properly certificated and the flight was properly dispatched.
2. The aircraft was properly loaded with respect to gross weight and center of gravity limits.
3. The flight was normal until the control of the No. 1 propeller was lost and the engine oversped.
4. It was impossible to control the engine speed or to feather the propeller.
5. The engine was frozen; however, the propeller became decoupled from the engine and continued to windmill.
6. There was a partial power loss on engine No. 4; it subsequently failed completely and the propeller was feathered.

7. Airspeed was restricted to 145 knots to prevent the windmilling propeller from overspeeding.

8. Range of the aircraft was so reduced that it was impossible to reach land.

9. The passengers were thoroughly instructed in correct emergency procedures and the aircraft was ditched under control with no fatalities.

10. Evacuation of the aircraft was well planned and orderly.

Probable Cause

The Board determines that the probable cause of this accident was an initial mechanical failure which precluded feathering the No. 1 propeller and a subsequent mechanical failure which resulted in a complete loss of power from the No. 4 engine, the effects of which necessitated a ditching.

BY THE CIVIL AERONAUTICS BOARD:

/s/ JAMES R. DURFEE

/s/ CHAN GURNEY

/s/ HARMAR D. DENNY

/s/ G. JOSEPH MINETTI

/s/ LOUIS J. HECTOR

S U P P L E M E N T A L D A T A

Investigation

The Civil Aeronautics Board was notified of the accident at 0655 H. s. t., October 16, 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. Depositions, ordered by the Board, were taken in San Francisco, California, October 19, 20, and 26; San Mateo, California, October 22, 1956; Oakland, California, October 23, 1956; and Silver Spring, Maryland, November 19, 1956.

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 Richard N. Ogg, age 43, was employed by Pan American World Airways on February 20, 1941. He held a valid airman certificate with airline transport rating and rating for the subject aircraft. Captain Ogg had a total of 13,089:41 flying hours, of which 738:27 were in Boeing 377's. He had passed a CAA medical examination on September 21, 1956. He had completed an emergency equipment training course - dry ditching - on June 4, 1956.

First Officer George L. Haaker, age 40, was employed by PAWA on March 1, 1946. He held a valid airman certificate with airline transport rating and rating for the subject aircraft. Mr. Haaker had a total of 7,576:00 flying hours, of which 3,674:06 were in Boeing 377's. His last physical examination was passed on September 4, 1956. He completed an emergency ditching training course on August 2, 1956.

Navigator Richard L. Brown, age 31, was employed by PAWA on December 9, 1955. He held a valid airman certificate with commercial rating, and a temporary CAA navigation certificate issued August 24, 1956. Mr. Brown had a total of 1,283:16 flying hours, of which 446:00 were in Boeing 377's. His last physical examination was passed on February 28, 1956. He had completed the initial emergency equipment training course - dry drill - on January 13, 1956.

Flight Engineer Frank Garcia, Jr., age 30, was employed by PAWA on August 16, 1954. He held a valid flight engineer certificate, mechanic certificate with A&E rating, and radio operator certificate. He qualified on Boeing 377's on March 28, 1956, and had accumulated 1,728 flying hours in B-377's. He received his last CAA physical examination on June 29, 1956.

Purser Patricia Reynolds, age 30, was employed by PAWA on September 23, 1946. She had completed her latest B-377 emergency equipment recheck on February 10, 1956, and had completed the USCG wet drill in San Francisco on July 12, 1956.

Stewardess Mary Ellen Daniel, age 24, was employed by PAWA on June 23, 1954. She had completed the B-377 emergency equipment recheck on March 12, 1956, the USCG wet drill on September 18, 1956.

Stewardess Katherine S. Araki, age 23, was employed by PAWA on March 28, 1955. She had completed the B-377 emergency equipment recheck on May 7, 1956.

The Aircraft

N 90943, a Boeing 377, serial number 15959, was owned and operated by Pan American World Airways and was currently certificated by the Civil Aeronautics Administration. The aircraft had accumulated 19,820:51 flying hours. It was equipped with four Pratt and Whitney R4360-B6 engines, and four Hamilton Standard model 24260 propellers with model 24260-43/2J17 blades. The aircraft, engines, and propellers had been maintained in full compliance with prescribed methods and within all time limitations.