A 82 Revised

SA-164

File No. 1-0010

CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: October 20, 1949 Released: October 20, 1949

EASTERN AIR LINES, INC., BUNNELL, FLA., FEBRUARY 7, 1948

The Accident

Eastern Air Lines' Flight 611 of February 7, 1948, a Lockheed Constellation, Model 649, NC-112A, experienced a propeller failure while offshore about 155 miles east-southeast of Brunswick, Ga., at about 1309.[1] A portion of a propeller blade pierced the fuselage, fatally injuring a crewman and depressurizing the cabin. A rapid descent was made from the cruising altitude of 22,000 feet to 12,000 feet, and the aircraft was turned toward shore, landing at Bunnell, Fla., approximately 1 hour and 30 minutes later. Several passengers were slightly injured in the ensuing emergency deplaning.

History of the Flight

Flight 611 originated at Boston, Mass., for Miami, Fla., with stops scheduled at LaGuardia Field, N. Y., and West Palm Beach, Fla. Between Boston and LaGuardia the flight was routine. At LaGuardia an instrument flight plan was filed and approved specifying the proposed route which included direct flight from the Ambrose Intersection located about 15 miles south of Floyd Bennett Airport, N. Y., to West Palm Beach via Wilmington, N. C.

Leaving LaGuardia the aircraft carried 60 revenue passengers, 3 babies in arms, the usual crew of 5, and a company check pilot who occupied the left pilot seat with the regular captain in the right seat. The gross weight of the aircraft and location of its center of gravity were within the prescribed limits. Takeoff was at 1009, after a 19-minute loading delay.

The aircraft climbed to the planned cruising level of 20,000 feet and proceeded uneventfully, the usual en route position reports being made. At 1251 the flight requested of Air Route Traffic Control permission to climb to 22,000 feet to be above clouds and turbulence. This was granted at 1253 and the flight next reported its position at 1259 as abeam Savannah, Ga., at 22,000 feet. At about 1309, No. 3 propeller failed and a portion of one blade was thrown through the fuselage. It entered the lower right side at the galley section, severing control cables, electrical wires and engine controls, came up through the floor, fatally injuring Purser G. P. Folz, and left through the upper left side. A momentary fogging of the cockpit resulted due to the sudden depressurization of the fuselage from its former 9,800-foot equivalent. Heavy vibration was felt and all of the flight and engine instruments became either inoperative or impossible to read. Power was reduced and a rapid descent was started. An attempt was made to feather No. 3 engine and orders were given to prepare for ditching.[2]

An estimated one or two minutes after the failure of the No. 3 propeller the front portion of No. 3 engine and some of its cowling fell free of the aircraft. Concurrently the heavy vibration stopped. A fire followed in No. 3 nacelle but quickly extinguished itself.

The company's ground station at Jacksonville, Fla., was advised of the emergency in a series of three messages. They indicated, first, that there was heavy vibration and that a course was being flown for the Florida Coast; second, that there was loss of power from two engines and damage within the fuselage; and, third, that preparations were being made to ditch. Following this third message, at 1312, the aircraft could no longer transmit because of failure of electrical power. Rescue procedures were started when the company's ground station at Jacksonville heard nothing more from

[1] All times stated herein are Eastern Standard and based on the 24-hour clock.

[2] A premeditated landing of a land aircraft at sea.

the aircraft, with the result that aircraft of the Coast Guard, Air Force and Navy were dispatched on search missions to the area and Coast Guard surface vessels put to sea.

At the 12,000-foot level the descent was stopped. It was then found that controlled power was available from Nos. 1 and 2 engines, that No. 4 engine was running, although it could not be controlled by its throttle, and that No. 3 engine had stopped. A strong yawing tendency to the left was found to be controllable. Accordingly, the course for shore was held while crewmen laid out life rafts, helped passengers into life vests and readied emergency exits.

Near the coast low clouds prevailed and the aircraft was let down visually to about 1,000 feet altitude, as most of the flight instruments remained inoperative. Weather prevented a landing at Daytona Beach and the aircraft was flown north up the coast. Shortly, the airport at Bunnell, Fla., was sighted and circled. The flight crew decided that it was suitable for landing, established the wind direction and prepared to land.

All emergency doors and exits were opened and as the aircraft passed over the boundary of the runway and landing seemed assured, the ignition switch of No. 4 engine was cut. Brakes were applied hard during the landing roll causing one of the left tires to blow out. When the aircraft stopped, fires started in No. 4 engine and in the right landing gear. Both were quickly extinguished.

All passengers were then evacuated hastily, but orderly, a few by a knotted rope from the front door, some by an emergency exit, the others by the emergency ladder from the rear door. One received a broken ankle while a number of others received bruises.

Investigation

No. 23 Runway, the one used at the Bunnell Airport, is 5,000 feet long and surfaced with asphalt. First contact with the runway was by the aircraft's right wheel at a point about 900 feet from the approach end. About 950 feet farther the left main landing gear and the nosewheels made contact. Some 1,320 feet farther one of the left tires blew out and the aircraft was stopped when 400 feet short of the end of the runway.

Damage to the fuselage from the object which had pierced it indicated conclusively that that object was the tip of a propeller blade approximately eighteen to 20 inches long. This fact is established by the shape and size of the holes in the fuselage side and flooring and by color marks and metal left on various parts of the galley section as the object traversed the fuselage. Also, the point of entrance was in the plane of No. 3 propeller disc. Adjacent and slightly forward of this hole was a much larger tear in the fuselage covering. This hole was roughly the size and proportion of the major part of a blade. In the close vicinity of this damage were other marks on the fuselage. One, under the fuselage, appears to have been caused by the tip of a propeller blade. The others appear to have been caused by the aforementioned large portion of a blade as it glanced following its original impact.

Damage within the fuselage was confined to the galley section. Under the right side of the galley floor section pass three bundles of electrical wiring containing some 500 individual wires, cables controlling throttle and mixture settings, etc., of all four engines, and the cables controlling the elevator and rudder trim tabs. Nearly all of the wires were severed as were all the tab control cables and the throttle control of No. 4 engine. Food containers, etc., above the galley floor were likewise cut and broken.

An examination of No. 3 engine showed that the complete propeller and propeller shaft with connected stationary reduction gear, pinion and forward front sections were missing and had fallen into the sea. Thus, it was impossible to make a physical examination of the propeller or of the front section of this engine.

The propeller was a 3-bladed Hamilton Standard with blades designated by the manufacturer as Model 2C15B-1-0B, hereinafter referred to as the 2C15 blade. These blades are hollow, with a steel covering supported by a central steel member and a portion of their interior is filled with rubber to inhibit diaphragming. The propeller had been used 1,616 hours at the time of the accident. Inspections and overhauls on this propeller had been carried out in accordance with approved practices. It had last been overhauled 461 hours prior to the accident and last inspected before the flight left Boston, about four flying hours prior to the accident. That inspection

was purely visual but thorough, inasmuch as the runways of the northern fields in winter are often littered with gravel used to avert skidding on snow and ice, and gravel sometimes causes superficial damage to propeller blades. The inspection was routine and no dents, nicks or other imperfections were reported.

Had there been a manufacturing defect of any consequence in any blade it is highly probable that such defect would have manifested itself in the early part of the propeller's 1,600 hours of service. The subject blades were subjected to X-ray scrutiny during inspection following their manufacture. No abnormality was found at that time and subsequent inspection of the original X-ray negatives revealed no abnormality.

Thus, all available records fail to reveal any defect or external damage to the blades or any unusual service other than being used on an engine with an operational history of unusual irregularity.

This engine was a Wright Model 749C18BD-1. It had a total service of 1,186.25 hours and had last been through an approved overhaul 461:45 hours prior to the accident. The figure for total service is substantially the same as for the other three engines installed in the aircraft. However, the time since overhaul, although within the maximum of 625 hours, was considerably more than for the other three engines; their times since overhauls being, No. 1, 144.33 hours; No. 2, 105.52 hours, and No. 4, 190.51 hours.

The operational history of No. 3 engine was compared with the operational histories of six engines of the same model which had been used on the aircraft since No. 3 engine was installed after overhaul. The other six engines had a rather uniform number of reported irregularities. By comparison, the total of the irregularities reported on No. 3 engine numbered approximately three times the irregularities reported on any of the other six engines. The above-mentioned irregularities in No. 3 engine included a variety of malfunctionings, and this persisting condition should have constituted a warning that the engine might later develop more serious trouble. Those irregularities included roughness, overspeeding, and BMEP (brake mean effective pressure) drop which continued to the point that they were becoming chronic, despite routine attempts at their correction.

The crank case front section of this engine was lost overboard; however a careful inspection was made of the remainder. This inspection revealed:

1. That there had been "galling," i.e., a small but sustained relative motion between supposedly fixed metal surfaces, between the mating surfaces of the rear portion of the crank case front section and the crank case power section. The most marked evidence of galling appeared in two sections of the mated surfaces, one at the top, the other at the bottom. The crankcase front section broke near the limits of the lower galled area, in the rear portion of that section, the break being generally circumferential.

2. Oil tightness between the above-mentioned mating surfaces is maintained by a rubber seal pressed by a flange around the periphery of the crank case front section. This flange separated completely from the front section but remained otherwise unbroken despite the fact that the casting from which it had separated was broken.

3. Both front and rear second order balancers were extensively damaged. These balancers are internal parts of the engine designed to counteract engine vibration. Damage to the rear one was of a nature that could only have been caused by lack of oil due to oil being pumped out through the fractured nose section. This damage consisted of seizure of the balancer to its bushings and stripping of the teeth on the six drive pinions which engage the balancer. Three of the six pinion bearings had seized, the other three were burned out. It was noted that none of the pinion button heads showed any abrasion.

In comparison, the front balancer showed a quite different pattern of damage. Its bushings had not seized, and showed evidence of only slightly more than operational heat. As with the rear balancer, all the teeth on the six drive pinions were stripped. But unlike the rear balancer teeth, which were not stripped, the front balancer teeth were all stripped except for about one-eighth of their circumference. All six pinion bearings of the front balancer were burned to a lesser degree than the rear pinion bearings and none had seized. Again, in comparison with the rear balancer's condition, all six of the front balancer pinion button heads were

markedly worn by abrasion and two of them had broken off. The balancer itself, against which these button heads had rubbed, showed a matching abrasion, and the pinion carrier bushing flange showed matching scars corresponding to the missing button heads.

4. The ignition system, particularly spark plugs and individual ignition coils, showed a number of irregularities of a type that cause engine roughness. Specifically, of the 36 spark plugs, two were dead and three were defective, while of the 36 individual ignition coils, two were defective. The nature of the engine failure prevented obtaining the valve clearances, irregularities of which can cause high propeller stresses.

5. Throughout the engine, in all bearings and other moving surfaces, there was a varied but generally strong indication of overspeeding and oil starvation, due to loss of oil supply through the front section subsequent to the initial failure, causing severe damage. This damage was sufficient to preclude determination of any maladjustments or malfunctionings within the engine that could have caused roughness. However, tests of major accessories such as the magneto and the engine's fuel system disclosed no irregularities.

6. The engine is mounted by Lord mounts. There are six of these mounts, and each of their fittings attaches to the engine on four studs secured by elastic stop nuts. Of these 24 elastic stop nuts, two were missing from their studs and four were missing with their studs. Of the remaining 18, only one was tight, all the others being loose in varying degree. Company records disclosed no instance of these elastic stop nuts becoming loose in service on any engines of the same model.

At the time of the propeller failure the engine was operating at 2,300 r.p.m., and had been at that speed for about 2 1/2 hours. According to crew testimony there was no time interval during the subject flight when the engine had been run at either of its critical speed ranges of 1,700 to 1,800 r.p.m., or 2,050 to 2,150 r.p.m., except in passing through those ranges during the takeoff at New York. Nor, according to the crew, had the engine shown any undue vibration during that flight.

On January 24, 1948, another air carrier experienced a propeller blade failure with the same model aircraft-engine combination, but with a propeller manufactured by Curtiss-Wright Corporation. This blade failed approximately 32 inches from the tip, resulting in a failure of the engine case at the mounting pads, with no indication of a nose section failure, the propeller remaining on the engine.

Findings obtained during the preliminary testing and research of this failure indicated that the cause of this blade failure, although of another manufacture, might be highly significant to the 2C15 blade investigation in that there were indications of engire excitations inducing propeller blade stresses.

On March 26, 1948, Eastern Air Lines experienced another blade failure near Washington, D. C., involving the same engine, aircraft, and propeller model combination as in the Bunnell accident. This failure occurred near the hub, resulting in the loss of the blade, which was never recovered. However, the propeller and blade shank end was retained on the engine and available for study. In this instance, the engine case at the mounting pads failed without a nose section failure. Immediately following this failure (on March 27), another blade of the same model on the same model aircraft was found defective during a turn-around inspection at Chicago.

Eastern Air Lines, the only carrier using the 2C15 model blades, already was in the process of replacing the blades with the 2F17 K-3-24R model, hereafter referred to as 2F17, when the incidents occurred on March 26 and 27. The 2F17 model blades were originally selected by Eastern Air Lines for this aircraft-engine combination; however, at the time of delivery of these aircraft to Eastern this model blade was not available. The 2C15 model blades were therefore used as they also were approved for use with this aircraft-engine combination at the time of installation. However, due to the difficulties experienced and the subsequent availability of 2F17 blades, all 2C15 blades were removed from service immediately and replaced with the 2F17 blades. As a result of the difficulties experienced with this series propeller CAA removed the 2C15 blade from this aircraft's specifications on March 30, 1948.

Subsequent to the above incidents, 71 2C15 blades which had been in operation and returned to the factory during

the replacement program were inspected. This included the blades from the propellers involved in the failure near Washington, D. C., and the defective blade found the next day at Chicago, Ill. Twenty-three of the blades were found defective. These blades, representing approximately one-third of the blades checked, indicated slight cracks near the shank of the blade of a pattern similar to the failure experienced near Washington on March 26.

Some two months after the accident, the manufacturer altered the design of the balancers of this model engine. The modified balancers are being installed by Eastern on all engines of this model.

As a result of the above incidents, an extensive testing and investigational program of this propeller-engine combination, and this propeller-engine-airplane combination, was made. Agencies of the U. S. Government, in conjunction with the engine manufacturer, the propeller manufacturer, the aircraft manufacturer, and the subject carrier, participated in these tests. The purpose of the tests was to ascertain the cause of the subject accident, but because of the technical complexities involved, the tests developed into an over-all attempt to determine if and to what extent extreme high propeller stresses could be induced by various combinations of flight and/or engine irregularities. Despite the fact that the subject blade was then no longer in use, these tests were carried to a conclusion in May 1949. The outstanding and highly important result of these tests and earlier test stand work was the discovery that various engine irregularities can induce hitherto unsuspected, dangerously high stresses in propellers. The tests also supplied additional knowledge on the subject of high propeller stresses during engine run-up in cross winds. As an over-all result of this extensive testing, the CAA is now requiring that various combinations of engine malfunctionings be checked during their type certification tests for propeller-engine combinations with the knowledge that a test of such a combination with all components in factory condition is not always a reliable indication of that same combination in daily use.

Analysis

As shown, the operational history of the subject propeller includes no instance that could have weakened the blade by impact with external objects. Therefore, and because it is known that undue propeller stresses can be induced by engine irregularities of such obscure nature that they are neither recorded on the instrument panel nor felt in the cockpit, it is probable that the subject propeller failed because of such induced stresses. In support of this probability are the known lengthy history of roughness and overspeeding of the subject engine and the fact that its balancers had failed in dissimilar manners. This is further supported by the physical evidence of the engine mounts and galling between nose section and the main case which indicates definitely that some form of vibration was present which would have been transmitted to the propeller. As previously stated, the balancers are designed to counteract engine vibration, which, if not counteracted, will cause dangerously high propeller stresses at certain critical speeds. If the front balancer had failed at an appreciable length of time prior to the propeller failure the crew would not have been aware of such failure and it could have caused the propeller to fail. As its appearance indicates, there is strong reason to believe that the front balancer had failed before the main failure, or before the rear balancer.

In conclusion, the investigation of this accident brought to light enough additional knowledge concerning the potential hazard of accumulated engine malfunctioning, that, coupled with what is known of the history of No. 3 engine, the Board finds that the 2C15 propeller blades are marginal when used with this model aircraft-engine combination.

The evidence is clear that the failure of the propeller of No. 3 engine cannot be attributed to any act or omission on the part of the crew in operation of the aircraft. The flight crew is to be commended for the high type of professional airmanship they displayed in safely landing the badly damaged aircraft under conditions of extreme emergency.

Findings

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

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

2. On departure from New York the gross weight of the aircraft and the

location of its center of gravity were within prescribed limits.

3. A propeller blade of No. 3 engine failed during normal cruising flight causing the death of a crew member and seriously damaging the aircraft.

4. The damage to the aircraft necessitated an emergency landing which was accomplished at Bunnell, Fla.

5. The Hamilton-Standard 2C15 propeller blades were marginal when used with the Lockheed L-649 aircraft and the Wright 74 9C18BD-1 model engine combination.

6. Frequent and accumulative malfunctioning of No. 3 engine caused dangerously high stresses in the propeller blade.

—15725

Probable Cause

The Board determines that the probable cause of this accident was the failure of a propeller blade due to high stresses induced by accumulative engine malfunctioning.

BY THE CIVIL AERONAUTICS BOARD.

/s/ JOSEPH J. O'CONNELL, JR.
/s/ OSWALD RYAN
/s/ JOSH LEE
/s/ HAROLD A. JONES
/s/ RUSSELL B ADAMS

Supplemental Data

Investigation and Hearing

The Civil Aeronautics Board's Atlanta, Ga., office was notified at 1330, February 7, 1948, by the carrier, of the emergency existing aboard the aircraft. An investigation was started immediately in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended. As a part of the investigation, a public hearing was held March 3, 1948, at Coral Gables, Fla.

Air Carrier

Eastern Air Lines, Inc., a Delaware Corporation with headquarters in New York City, was operating under a certificate of public convenience and necessity and an air carrier operating certificate, both issued under authority of the Civil Aeronautics Act of 1938, as amended. These certificates authorized the company to fly persons, property and mail between specified points in the United States, including Boston, Mass.; New York, N. Y.; and West Palm Beach, Fla.

Flight Personnel

The captain of the aircraft was W. E. Johnson, age 33. He held a currently effective airline transport pilot rating and had flown a total of 8,150 hours, of which 254 hours had been in Lockheed Model 649's. He had been employed by the carrier since 1939 and had attended its L-649 Transition School.

The check pilot was H. T. Merrill, age 51. He held a currently effective airline transport rating and had flown a total of 20,700 hours, of which 347 hours had been in Lockheed Model 649's. He had been employed by the carrier since 1928 and had attended its L-649 Transition School.

The pilot, R. G. Burstrom, age 26, held a currently effective airman certificate with commercial pilot rating. He had flown a total of 1,971 hours, of which 322 hours had been in Lockheed Model 649's. He had been employed by the carrier since 1946 and had attended its L-649 Transition School.

The flight engineer was N. H. Turner, age 30. He held a currently effective flight engineer certificate and had been employed by the carrier in 1947.

The flight attendants were W. J. Hoy, age 23, and G. P. Folz, age 27, the latter fatally injured.

Aircraft

The aircraft was a Lockheed Constellation Model 649, NC-112A, and was currently certificated. It was purchased new by Eastern Air Lines on July 30, 1947, and at the time of the accident had been in service a total of 1,522:43 hours. At the time of departure from La-Guardia, the aircraft grossed 93,901 pounds as against a maximum allowable of 94,000 pounds, and its center of gravity was located within prescribed limits.