File No. 1-0040

CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: November 7, 1957 Released: November 12, 1957

AMERICAN AIRLINES, INC., DOUGLAS DC-7, N 316AA,
NEAR MEMPHIS, TENNESSEE, MARCH 5, 1957

The Accident

American Airlines Flight 87 of March 5, 1957, a Douglas DC-7, N 316AA, lost the nose section and propeller of its No. 1 powerplant while in flight near Memphis, Tennessee, on March 5, 1957, about 1127.1/ Parts struck and pierced the pressurized fuselage causing explosive decompression. Flying debris within the cabin and the abrupt pressure change resulted in several personal injuries. The aircraft was landed at the Memphis Airport about seven minuted later without further difficulty.

History of the Flight

Flight 87 originated at New York International Airport (Idlewild) for San Francisco, California, with one stop scheduled at Dallas, Texas. There were 41 passengers with a crew of Captain Leroy T. Hansard, First Officer Adrian B. Crimmins, Flight Engineer Leonard C. Bowers, and Stewardesses Barbara Kearney and Mary Marsh. The aircraft's gross weight was less than the allowable maximum and its center of gravity was located within prescribed limits.

Departure from Idlewild was at 0815 on an IFR flight plan. Routine position reports were made over Charleston, West Virginia; Nashville, Tennessee; and Graham, Tennessee. At 1106 Air Route Traffic Control cleared the flight, then at 12,000 feet, to climb to and maintain 14,000 feet. At 1113 the flight reported over Jackson, Tennessee, at 14,000 feet.

About 1127 the captain noticed vibration in the cowling of No. 1 engine. He started checking engine instruments and told the flight engineer to use the ignition analyzer. Vibration increased; the captain quickly decided to feather the engine and started closing No. 1 throttle. When it was halfway back engine speed rose to about 3,300 r. p. m., whereupon he closed all throttles, disengaged the autopilot, and nosed the aircraft up to lose speed. Engine speed of No. 1 continued to rise to an estimated 4,300 r. p. m. and as the captain was using the toggle switch to reduce this r. p. m. the propeller and nose section separated from the engine. The rotating propeller struck the top of the fuselage causing a large area to blow out. This was 20 to 25 seconds after the vibration was first noticed. Just about that moment the flight engineer had pressed the No. 1 feathering button and pulled No. 1 mixture control to idle cutoff.

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

Captain Hansard told his first officer to report an emergency; descent and landing clearance at Memphis was quickly coordinated by company radio, ARTC, and the tower. Descent was started at a rate of about 2,000 feet per minute with airspeed about 200 knots. The aircraft came below clouds and into weather conditions allowing visual flight at an altitude of 2,500 feet when some four miles southeast of the Memphis Airport. An uneventful landing was made on runway 27 at 1134 in light rain with three miles visibility while previously alerted but unneeded emergency apparatus stood by.

All occupants were examined by a physician the same day. All passengers and crew members were found to be affected by the sudden decompression; five of the passengers had received contusions, lacerations, and abrasions from fuselage parts and debris.

Investigation

At the time of the failure and blowout the aircraft was pressurized 5.1 pounds per square inch above the external pressure. This pressure differential caused a violent out-rush of air greatly enlarging the initial rents into a jagged, and irregular, large hole, approximately 17 feet long by 4 feet laterally, in the forward cabin roof and tearing off and hurling both lavatory doors and cabin flight deck door about the cabin. Numerous unsecured articles, blankets, pillows, personal effects, etc., were also thrown about. There was considerable deformation and bulging of panels and bulkheads and damage of other nature which, although widespread, did not significantly impair control of the aircraft.

When the captain told the first officer to report an emergency the latter called the company saying that they were declaring an emergency and were going to make an emergency descent to land at Memphis. The company immediately coordinated with ARTC and all aircraft under approach control jurisdiction were provided radar separation from American 87. The first officer declutched both cabin superchargers, called out the altitude of 12,500 m. s. l., and tuned his omni receiver to Dyersburg to get a cross check on position. The flight was between Williston and Fisherville, according to this check. He changed over to the tower frequency and was advised that all runways were available. The captain said he would land straight in on runway 27. The first officer tuned his ADF to the Memphis middle marker and advised the captain accordingly. The flight broke out contact and the captain called for landing gear down. Shortly he called for 30 degrees flaps, then full flaps. The first officer called out altitude and airspeed during the approach.

Inspection of the No. 1 powerplant showed that the propeller and most of the nosecase assembly had torn away just forward of the front cam gear train assembly. The front oil sump remained in place attached by its external oil lines. The left distributor and the propeller governor pad were intact on a section of the front nosecase; all other portions of the engine's front section were missing. The forward 18 inches of the antidrag cowling was cut off flush with the front row of cylinders by the spinning propeller; the remaining portion of the cowling assembly remained on the engine. After this initial contact the propeller struck the fuselage in three distinct places.

The aircraft control systems and surfaces were undamaged. Slight damage to the leading edge and underside of the left wing was caused by contact with turbine blades which failed and were slung off by the overspeeding No. 2 power recovery turbine of No. 1 engine, Nos. 1 and 2 blades of the No. 2 propeller were gouged deeply on their face (back) surfaces by thrown parts although the operation of this powerplant was unaffected. Nos. 3 and 4 powerplants were undamaged.

Numerous pieces of all four blades of No. 1 propeller were recovered after tedious ground search. The outboard 23 inches of three blades and 40 inches of the fourth were not found. Parts of the blade which had its outer 40 inches missing were found in the engine nosecase cavity and cylinder assemblies. All fractured sections of all blades exhibited impact failures, with no indication of fatigue cracks.

There were four distinct cuts made by the spinning propeller. These followed a pattern from left to right and to the rear. The first was in the engine antidrag cowling 23 inches aft of the plane of rotation of the propeller and in line with fuselage station 281; the other three were quite evenly spaced in the fuselage at stations 394, 421, and 460.

A study of the service history of this model propeller and model engine combination to date has failed to reveal any evidence of in-service blade failures.

No. 1 engine was thoroughly inspected for evidence of inflight fire; none was found. The crew stated that during the emergency they received no fire warning and did not observe any inflight fire.

All of the major components of the front crankcase assembly were recovered with the exception of the roller thrust bearing, a section of the hollow propeller shaft, and part of the nosecase. Examination of the recovered parts revealed excessive operating temperatures of the propeller shaft where the ball and roller thrust bearings are seated. The shaft which had failed aft of the roller bearing journal was blackened by heat and was necked down under high-tensile loading on one side. On the opposite side of the shaft the wall thickness had been increased due to high compression loads. The propeller shaft flange had a circumferential sheer overload fracture which had detached the flange from the shaft with metal adjacent to the fracture deformed forward. The shaft flange also was blued due to excessive temperatures. All fractured surfaces of the propeller shaft sections were of the overload type of failure; none of these fractures showed any evidence of fatigue.

The ball thrust bearing was severely damaged by overheating. Its inner and outer races were scuffed and flattened, and contained metal deposits from the melted bronze bearing retainer. All balls were in place but were flattened and blackened by overheating. The operating temperature of this bearing had reached a point high enough to melt the bronze ball retainer as well as to weld the inner races together. Destruction of the ball thrust bearing was so extensive that the possible presence of fatigue could not be learned.

The fit of these bearings at the time of engine assembly is very critical. Engine overhaul records reflect that these components were built up according to the manufacturer's recommended procedures. The last engine overhaul was 346 hours prior to the accident. At that time the ball thrust bearing used was a serviceable unit and the roller thrust bearing was new. The engine itself had a total service time of 6,609 hours which embraced ten overhauls. The ball thrust bearing had been inspected, reworked as necessary, and reinstalled following these overhauls.

The crankcase front flange and seal assembly was thoroughly examined as a possible source of primary failure. If this assembly had failed first, it would allow bearing lubricating oil to be lost resulting in oil starvation to the propeller thrust bearings. Examination of the front flange and seal assembly revealed it to be dished rearward and enlarged so that its inner diameter was approximately one inch more than normal. The bearing liner flange was cracked at each cap screw position and did not exhibit any indications of overheating. The front flange assembly cap screw bushings had pulled out of the case and several bushings had filled with molten magnesium. The bearing liner flange fractures were circumferential and radial in nature due to overloading with no evidence of fatigue. This bearing liner was also free of indications of high operating temperatures, apparent in other sections of the nosecase. Enlargement of the inner diameter of the front flange assembly probably occurred just prior to and with the propeller shaft failure due to the entire propeller assembly rotating off center after failure of the thrust bearings.

Numerous metal particles were found in the front oil sump and the front pressure and scavenger oil pumps. The rear sump and oil pumps had similar metal particles but in much less quanity. Metallurgical examination of these particles revealed them to be from the thrust bearing balls or rollers, the ball retainers, and bearing surface plating.

In order to determine whether any other failure may have caused the loss of the propeller and front nosecase assembly, the entire engine was disassembled. This examination revealed no conditions which could have caused the subject failure.

The power recovery turbines had thrown some of their blades during the overspeeding of the engine. Their speed at an engine speed of 4,000 r. p. m. would have been 26,000 r.p.m. They are designed to fail at approximately 24,000 r.p.m. because failure at greater speed could endanger the integrity of other parts of the aircraft.

Examination of the flight logs and flight engineer's log indicated that the subject powerplant had been operating normally. There were no pilot complaints and the flight engineer's log showed that all engine pressures and temperatures were within normal operating limits. Overhaul records indicated that the powerplant had been properly overhauled according to the manufacturer's specifications. At the time of the trouble the engines were operating, according to the crew, under the following conditions: All at 2,400 r. p. m.; all having fuel flow at 740-750 pounds per hour; all in low blower at 35 to 35-1/2 inches of manifold pressure and drawing 170, 180, 168, and 170 pounds BMEP for Nos. 1, 2, 3, and 4, respectively. These conditions

were within operating limits set by the manufacturer and practiced by the carrier.

Prior to the accident the ball bearing was installed ahead of the roller bearing. This was done to reduce the radial load on the roller bearing. As a result of this accident the manufacturer issued service bulletins for the improvement of the inspection of the propeller thrust bearings and for the interchanging of the position of these bearings. The CAA has issued Airworthiness Directive 57-6-4 which covers the same items.

Analysis

Of all the possible causes of losing the propeller and engine nose section the two most likely were either a failure of one of the propeller thrust bearings or a fatigue failure of a section of a propeller blade.

Because the outer sections of the propeller blades were not recovered, the possibility of a fatigue failure in one of these missing sections cannot be entirely disproved. In analyzing this possibility the Board concludes that there was not a blade failure due to fatigue. This belief is supported by the following reasons. First, when a blade fails due to fatigue or other reasons, the unbalanced condition generally results in severe vibration before the propeller tears free.

In this case there was no severe vibration; the only vibration was a slight visible shaking of the engine cowling which was not transmitted to the structure and was not sensed on the controls. Second, when a blade failure is the initial occurrence the entire engine is apt to be wrenched violently and quickly from the firewall or its ring mount. In this accident the engine came apart just forward of the mating surface of the front crankcase section indicating that there were no large unbalanced centrifugal forces. Also, the propeller shaft was extremely overheated, stretched, and necked down in the vicinity of the fracture. If a blade had failed as a result of fatigue this extensive overheating and softening of the propeller shaft would not have had time to materialize in the short interval of 20 to 25 seconds between the first vibration and the loss of the propeller assembly. Also, the four rather evenly spaced cuts made by the propeller were quite obviously made by the four blades while still attached to their hub. Past propeller blade failures have not resulted in this pattern of damage. The difference in the length of the missing blade tip (3 of 23 inches, 1 of 40 inches) could have resulted from the longer portion being broken off when that blade struck the speed ring and engine.

The second possibility remains and is strongly indicated as the reason for the loss of the propeller and nose section. Extreme temperatures were localized on the thrust bearing journals of the propeller shaft and separation of the propeller shaft occurred due to excessive overloading in the area aft of the centerline of the roller thrust bearing. Examination of the crankcase front flange and seal assembly indicated that its failure did not precipitate the sequence of other failures.

As to the cause of the probable failure to the thrust bearings several possibilities exist: Lack of lubrication; improper bearing fit at time of engine overhaul; improper bearing inspection relative to ball to race, or roller to race, clearance; or manufacturing defects. Of these possibilities there is very little concrete evidence available to support any one possibility over others.

The first oil jet in the engine which directs oil to the thrust bearings was in good condition as were other nose section components. It is most likely that the oil supply to the bearings was adequate since these bearings had operated 346 hours. The specific cause of the thrust bearing assembly failure cannot be determined due to the nonrecovery of the roller bearing and the extreme damage to the ball bearing.

Findings

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

1. The air carrier, the aircraft, and the crew were properly certificated.

2. The aircraft's weight and center of gravity were within the prescribed limits.

3. A thrust bearing in the nose section of No. 1 engine failed without warning.

4. This failure occurred during level cruising flight with stabilized engine operation.

5. The failure set off a train of other failures culminating in loss of No. 1 propeller and engine nose section.

6. Propeller blades pierced the pressurized cabin at stations 394, 421, and 460, causing explosive decompression creating a hole approximately 17 feet by 4 feet.

7. Control was retained and the aircraft was landed without untoward difficulty.

Probable Cause

The Board determines that the probable cause of this accident was failure of the propeller thrust bearing assembly, which resulted in separation of the propeller and subsequent penetration of the fuselage causing explosive decompression of the aircraft in flight.

BY THE CIVIL AERONAUTICS BOARD:

/s/ JAMES R. DURFEE

/s/ CHAN GURNEY

/s/ HARMAR D. DENNY

/s/ LOUIS J. HECTOR

Member G. Joseph Minetti did not take part in the adoption of this report.

SUPPLEMENTAL DATA

Investigation

The Civil Aeronautics Board was notified of the accident immediately after occurrence. Investigation was started immediately in accordance with the provisions of Section 702 (a) (2) of the Civil Aeronautics Act of 1938, as amended.

Air Carrier

American Airlines, Inc., is a Delaware corporation with general offices in New York, New York. It operates as an air carrier under currently effective certificates 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 company to transport by air persons and property over many routes within the continental limits of the United States, including the route being flown in this instance.

Flight Personnel

Captain Leroy T. Hansard, age 43, was properly certificated for the subject flight. He had been employed by American Airlines for more than 15 years. His flying time was in excess of 17,000 hours, of which 2,380 hours had been in DC-7's. His required periodic examinations and checks were current.

First Officer Adrian B. Crimmins, age 35, was also properly certificated for the subject flight. He had flown a total of 5,480 hours, of which 17 had been in DC-7's. All of his required periodic examinations and checks were also current.

Flight Engineer Leonard C. Bowers, age 36, held a current flight engineer certificate. His total experience was some 4,800 hours, of which only 3 hours and 34 minutes had been in DC-7's.

Both stewardesses, Miss Mary Marsh and Miss Barbara Kearney, had satisfactorily met all company requirements in regard to emergency training and procedures.

The Aircraft

The aircraft, a Douglas DC-7, serial number 44137, had been acquired new by American Airlines in February 1954. Since that time it had been flown 8,803 hours. The last periodic maintenance check was a No. 17 check performed on February 26, 1957; at that time the aircraft had accumulated 8,732 hours. The aircraft had received a service check the day before this accident.

The engines were Wright model 972TC18DA-2. The subject engine, No. 1, serial number 548235, had had a total of 6,609 hours, of which 346 had been since its last overhaul.

The propellers were Hamilton Standard model 34E60, blade model 6921C-8. The subject propeller hub, No. 1, was serial number 179953. The four blades were serial numbers 597614, 15, 16, and 17. The hub had had 8,548 hours total time and all four blades had had 5,973 hours total time. Time since overhaul of hub and all four blades was 2,035 hours.