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C I V I L A E R O N A U T I C S B O A R D
ACCIDENT INVESTIGATION REPORT

Adopted: June 12, 1951 Released: June 12, 1951

AMERICAN AIRLINES, INC., NEAR EAGLE, COLORADO, AUGUST 22, 1950

The Accident

A propeller blade failed on American Airlines' Flight No. 14 of August 21, 1950, near Eagle, Colorado, at about 0237 MST*, on August 22. A portion of the blade pierced and depressurized the cabin, and the resulting unbalance tore loose the engine which fell from the aircraft. A safe emergency landing was made about 19 minutes later, and about 84 miles to the east, at the Stapleton Airport, Denver, Colorado. Medical examination, made shortly after the landing, showed that five passengers and one stewardess had sustained minor injuries and one male passenger, age 56, had died, presumably from heart failure. The aircraft was extensively damaged.

History of the Flight

Flight 14, a DC-6, N-90705, was scheduled to depart Los Angeles, California, at 2300 on a non-stop flight to Chicago, Illinois. It left the ramp at 2302 and was off the ground at 2312. A Visual Flight Rule Plan specified a cruising altitude of 19,000 feet above sea level. At the time of departure the aircraft weighed 88,647 pounds, 978 less than the allowed maximum, and the cargo was distributed so that the location

*All times referred to herein are Mountain Standard and based on the 24-hour clock.

of the aircraft's center of gravity was within allowable limits. There were 54 passengers, including 2 infants, and a crew of 5.

The cruising altitude of 19,000 feet was reached and the flight proceeded uneventfully on course making its routine position reports. At 0128, Air Route Traffic Control issued the flight a new clearance, to cruise under instrument flight rules at 21,000 feet, and the flight level was changed to this altitude. At 0229 Flight 14 reported over Eagle, Colorado, at 21,000 feet altitude, estimating arrival over Denver at 0252.

At approximately 0237, the flight crew sensed an engine roughness and immediately checked engine instruments in an attempt to locate the cause. This check did not disclose the source of the roughness and the first officer reached to retard the throttles. As he did so, No. 3 propeller failed and part of a blade was thrown into the side of the fuselage, passing upward and leaving through the top of the fuselage. Simultaneously, the cabin lost its pressure, almost instantly. No. 3 engine fuel pressure and oil pressure warning lights came on, No. 3 engine wrenched free and fell from the aircraft and the cabin lights went out. Considerable damage occurred to the fuselage at this time. An estimated five seconds elapsed from the first sensing of the roughness until the failure.

Power was reduced, descent was started from the cruising level of 21,000 feet, and the engine-out procedure was applied to No. 3 engine. At approximately the 18,000-foot level, power was increased to the three engines and flight toward Denver was continued at that level. The

captain called the Denver Airways Communication Station at 0237, using the emergency word "Mayday", established contact, and said, "Have had an explosive decompression, apparently No. 3 engine exploded and hole in right side fuselage. Have fire equipment and ambulances stand by." Denver acknowledged this message. At 0240 the flight reported, "Everything under control. Give me your altimeter setting."

Radio contact was then established between the aircraft and the Denver Control Tower. A series of messages resulted in the flight obtaining the surface wind direction, the altimeter setting and other landing instructions. During this time the tower cleared the area and the runway of traffic. The flight held its altitude of about 18,000 feet for a few minutes until past the mountains, and then descended and landed "straight-in" on Runway 8 at 0256. The landing was made without flaps, as there was no hydraulic pressure to operate them, although the Captain testified that he was dubious about the structural integrity of the damaged aircraft and would not have used them had it been possible to do so. Reverse pitch on the three propellers and an application of emergency compressed air to the brakes stopped the aircraft on the runway. It was met by fire-fighting equipment and ambulances that had been alerted by the control tower.

Investigation

Until the blade failed, the flight had been routine and no turbulence or icing conditions had been encountered.

Inspection of the aircraft structure revealed a nearly vertical slit through the ice striker plate on the right side of the fuselage. This slit was approximately 36 inches long by 2 inches wide and was located slightly

below the center of the fuselage and slightly to the rear of the plane of rotation of No. 3 propeller.

A large irregular opening on the top of the fuselage started at a point approximately in line, laterally, with the slit in the right side. This opening continued back along the top and both upper sides of the fuselage for about 12 or 14 feet. In width it ran from slightly less than one-third down the left side of the fuselage, to about one-third down the right side. The boundaries of this opening were jagged and irregular and carried parts of the internal structure draped around its trailing edge. The opening was not readily measurable, but was about 250 square feet in area and located generally above the forward 3 rows of passenger seats.

No damage was evident on either surface of both wings.

No damage was evident on the empennage although small pieces of sound proofing material had adhered to the leading edge of the left stabilizer.

Within the fuselage the left forward bunk was missing and the right forward bunk was distorted and projected part way out of the large opening in the top of the fuselage. Elsewhere throughout the cabin were signs of distortion caused by rapid decompression. Bulkheads, surfaces, doors, ceilings and floors were bulged in varying degree, in the direction that air behind those surfaces would flow to escape through the large fuselage opening. There was no damage evident to any of the cabin seats or to their safety belts.

Examination of the No. 3 engine nacelle showed that the engine carried away from the aircraft at the mount ring. Vibration isolators Nos. 1, 2, 5 and 6 had separated at their cup threads. Sections of the mount ring

between No. 1 and No. 6 vibration isolators and from No. 3 to No. 4 vibration isolators were broken out. All fluid lines, electrical conduits and controls which had been attached to the engine had separated. The outboard upper, middle and lower accessory cowl panels and the oil cooler scoop and front fairing were missing. The electrical circuits for No. 3 propeller were checked to the point of separation; this check showed no irregularity up to the point of separation. The propeller synchronizer checked normally when functionally tested.

An intensive search was conducted for the missing engine and the portion of the failed blade. The carrier offered a reward of $2,500 for their recoveries and notices to that effect were posted in the general area of the failure as computed on a basis of the flight's speed and elapsed time to Denver.

Two local men found the engine on September 1, 1950, in a mountainous and heavily wooded area at an altitude of about 10,000 feet. Its location was approximately 84 miles west of Stapleton Field near the town of Avon, Colorado. A Board investigator accompanied by other interested parties proceeded to the scene and they supervised the removal and transportation of the engine to American Airlines' Maintenance Base at Tulsa, Oklahoma, for disassembly and inspection under the supervision of a Board representative. The outer portion of the failed blade was located on September 4, 1950, four days after the engine was found, and about 1½ miles to the west of it. It, as well as the shank end of the blade which was with the engine, was shipped to the Board's Washington, D. C. office for examination. The shank portion of the blade was approximately 25 inches long; the outer

portion was approximately 48 inches long, and the break was substantially at right angles to the longitudinal axis of the blade.

These two blade portions were carefully examined and gouges were found, plainly evident, on the inner side of the flat (rear) surface at the place of failure. The National Bureau of Standards analyzed the failure and summarized its report as follows, "The failure was caused by a fatigue fracture which originated at one of several defects which were points of stress concentration on the inside surface of the flat side of the blade. These defects, which occurred prior to heat treatment and painting on the inside of the blade, appeared to have resulted from a gouging or galling action due to rubbing against another surface such as a mandrel."

This propeller blade was manufactured by the Propeller Division of the Curtiss Wright Corporation. It is steel, hollow, Model 744-6C2-0, Serial No. 292695.

In the fabrication of this model blade, the two surfaces are formed and shaped separately and then welded together. During the welding the two parts are positioned by a mandrel within the blade controlling the distance between the two surfaces. This mandrel has extendable side mandrels controlling the weld locations. The entire device is rigid in use but is necessarily made collapsible so that it may subsequently be withdrawn from the relatively small opening in the shank end of the blade. The positioning of the side mandrels is by means of two cam adjustments in the center mandrel. These cams are locked in position by Allen head set screws. Two parallel and longitudinal gouges found in the inside surface of the flat (rear or thrust) side of the failed blade were located

and spaced closely corresponding to the location and spacing of these Allen head set screws. The bottoms of these gouges were irregular, the maximum depth of gouge being approximately one-sixth of the blade's wall thickness at that station.

At the time the subject blade was manufactured, it was subjected to a number of tests and inspections. One such inspection was by means of X-ray photographs. These original X-ray negatives were on file with the manufacturer. On examination, they bore faint marks indicating internal defects. These marks corresponded in size, location and spacing to the two gouges evident on the failed blade and to the location and spacing of the Allen head set screws of the center mandrel.

Close examination of the maintenance records of the subject blade disclosed no accidents or incidents in which it had contacted snow or excessive water on runways, or struck or been struck by any maintenance equipment. There is no record of it ever having been nicked on its surface to an extent requiring reworking. The blade was first installed, when new, by the carrier in November 1948. It had subsequently been installed on the subject propeller in April 1950. At the time of the accident it had had 4,636 hours of service, of which 1,036 hours had been since overhaul.

No. 3 engine was disassembled at Tulsa. Although it had been severely damaged by impact with the ground, it was possible to determine its internal condition with reasonable accuracy. All components were checked for wear

or failure. No failure of any part was found. The only significant wear appeared in both dynamic dampers, as follows:

Front, second order, dynamic dampers, bushing wear was: Front Counterweight Bushings: Front face trailing, .0008"; Aft face trailing, .0020"; Front face leading .0008"; Aft face leading, .0013". Crankshaft Bushings: Trailing, .0026"; Leading, .0050".

Rear, 4½ order, dynamic damper, bushing wear was: Rear Counterweight Bushings: Front face trailing, .0055"; Aft face trailing, .0085"; Front face leading, .0090"; Aft face leading, .0039". Crankshaft Bushings: Trailing, .0025"; Leading, .0035".

The specified allowable wear on all of the above bushings is. .001".

Maintenance records of the engine did not disclose any sustained operation with one or more inoperative cylinders and no "cylinder-out" operation was apparent during the subject flight.

Early in the investigation of this accident, before the No. 3 engine and the failed blade portion had been found, the propeller manufacturer took rapid steps to examine all blades of like model on aircraft of U. S. registry. The manufacturer's X-ray photographs, made at the time of blade manufacture, were reexamined scrupulously. Equipment was designed and built to take X-ray photographs of blades while in place on their power plants (for blades of which the original X-ray pictures had been misplaced). This program was started on September 24, 1950, and was finished, including some additional re-photography, on October 10, 1950.

Examination of these X-ray photographs revealed that an extremely small percentage of all blades bore indications suggesting significant defects. These were discarded immediately.

Analysis

The size of the large hole in the fuselage top and the attendant damage can be readily accounted for. When the blade failed, the part that pierced the fuselage had a linear velocity (at the instant of failure and at its center of gravity) of several hundred feet per second. The blade portion struck the fuselage edgewise, as evidenced by the shape and size of the entrance hole. Apparently the blade turned while traversing the fuselage and in leaving struck when more or less flatwise. As the cabin pressure was lost through this hole, the out-rushing air carried away and bent outward much more of the structure. These distorted and protruding parts were then subject to further bending and tearing from the high speed of the aircraft itself. The result was the large and extremely irregular hole in the fuselage roof.

At the time of the failure the aircraft was cruising at an indicated altitude of 21,000 feet, and the cabin was pressurized to the maximum allowable pressure differential of 4.16 pounds per square inch, amounting to an equivalent cabin altitude of about 8,600 feet.

The practically instantaneous depressurization, with its extreme velocity of out-rushing air, caused other cabin damage, such as loosening of sound proofing and buckling of metal surfaces at considerable distances from the ruptured area.

As stated under Investigation, wear of all bushings in both engine dampers was more than the allowable tolerance and enough to make both dampers inoperative. The function of these dampers is to lessen engine vibration allowing the engine to run smoother. In doing so, they prevent certain vibratory stresses from being transmitted to, and imposed upon,

the propeller blades. However, this model engine is prone to develop excessive damper wear and that fact was taken into consideration in the design of the subject propeller blade as well as in the Civil Aeronautics Administration's type certification of the subject blade. (The additional stress on this blade because of inoperative dampers is only in the order of 20%.) Thus it appears that the damper wear cannot be considered as the cause of the blade failure and at the most, may merely have hastened its occurrence.

There is no doubt that the blade failure stemmed from the gouges on the inner side of the rear surface. The depth of the gouges and their sharp and serrated edges and bottoms permitted a stress concentration at that point, which failed the blade because the blade vibratory stresses exceeded the fatigue limit of the metal. That this failure occurred during level cruising flight rather than during takeoff, when blade stresses are greater, appears to be merely coincidental.

In conclusion and as stated, the subject blade had been X-rayed during its manufacture. The defects that failed the blade were evident in those X-ray photographs. However, testimony indicates that although the indications of defects were seen by inspectors at the factory, those defects were considered to be not serious enough to warrant rejection of the blade. As mentioned under Investigation, the blade manufacturers instituted a thorough reexamination of all blades in service immediately following this accident. This reexamination included a tightening of inspection procedures including X-ray photographs and closer tolerance specifications for the evaluation of any indicated defects.

In reviewing this accident, it is obvious that little warning was given the crew of the impending failure of the propeller of No. 3 engine. The evidence is clear that the propeller failure cannot be attributed to any act or omission on the part of the crew in operation of the aircraft. In fact, 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 information, the Board finds:

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

2. The flight had been uneventful until a blade of No. 3 propeller failed, and penetrated, depressurized and extensively damaged the aircraft.

3. This failure occurred at an indicated altitude of 21,000 feet, in clear weather, about 84 miles west of Stapleton Airport, Denver, Colorado.

4. An immediate descent was started toward Stapleton Airport where a safe landing was made approximately 19 minutes later.

5. The failed blade had not been damaged in service.

6. The failure occurred as a result of fatigue localized at a defect on the internal surface of the thrust side of the blade. This defect was a gouge, or gouges, inadvertently made during the fabrication of the blade.

7. Captain Robert K. Baker, First Officer Robert E. Reinicke, Flight Engineer Daniel J. Niemiec and Stewardesses Joan Robinson and Margie Peterson performed their respective duties in a highly efficient manner under an unforeseen combination of circumstances which called for immediate action.

Probable Cause

The Board determines that the probable cause of this accident was the internal gouging of a propeller blade during the manufacturing process which resulted in a fatigue fracture and subsequent failure during flight.

BY THE CIVIL AERONAUTICS BOARD:

/s/ DONALD W. NYROP

/s/ OSWALD RYAN

/s/ JOSH LEE

/s/ JOSEPH P. ADAMS

/s/ CHAN GURNEY

SUPPLEMENTAL DATA

Investigation and Hearing

The Civil Aeronautics Board's Investigator-in-Charge of the Denver area was notified shortly after the accident by the Civil Aeronautics Administration's Airways Communication System. An investigation was started immediately in accordance with the provision of Section 702(a)(2) of the Civil Aeronautics Act of 1938, as amended. A public hearing, ordered by the Board, was held at Tulsa, Oklahoma, on October 6, 1950.

Air Carrier

American Airlines is a Delaware Corporation with general offices in New York, New York, and 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, property, and mail over various routes within the continental limits of the United States, which include the route segment between Los Angeles, California, and Chicago, Illinois.

Flight Personnel

Captain Robert K. Baker, age 37, held a currently effective airline transport certificate with an appropriate rating for the subject aircraft, and had been employed by American Airlines, Inc., since August 1942. He was promoted to captain in September 1942. At the time of the accident he had had 1,200 hours as captain of DC-6 aircraft and a total time of about 10,000 hours.

First Officer Robert Reinicke, age 35, also held a currently effective airline transport certificate with an appropriate rating for the subject aircraft. He had been a first officer with American Airlines, Inc., since October 1945, and his total piloting time was about 7,500 hours.

Flight Engineer Daniel J. Niemiec held currently effective aircraft and engine mechanic, and flight engineer certificates. He had been continuously employed by the company since March 1942.

The two stewardesses were Miss Jean Robinson, who had been employed by the company since May 1948, and Miss Margie Petersen who had been employed by the company since April 1943.

The Aircraft

N-90705 was a Douglas DC-6, manufactured by the Douglas Aircraft Corporation and acquired by the carrier in March 1947, and was currently certificated by the Civil Aeronautics Administration. It was powered with four Pratt & Whitney engines, Model No. R-2800-34, equipped with four Curtiss Wright hollow steel propellers. The No. 2 propeller blade of the No. 3 engine had a total time of 4,636 hours, and all three blades of the No. 3 propeller had totals of 1,036 hours since last overhauled. The specified time between overhauls on this propeller is 1,300 hours.