CIVIL AERONAUTICS BOARD

ACCIDENT INVESTIGATION REPORT

Adopted: August 13, 1954 Released: August 18, 1954

RESORT AIRLINES, INC., LOUISVILLE, KENTUCKY,
SEPTEMBER 28, 1953

The Accident

At 1618,1/ September 28, 1953, a Resort Airlines' C-46F, N 66534, operating as CAM No. 1081 2/ crashed during landing at its destination, Standiford Airport, Louisville, Kentucky. There were 25 fatalities, including the crew of three, and 16 passengers received serious injuries. The aircraft was destroyed.

History of the Flight

The flight was operating between North Philadelphia, Pennsylvania, and Louisville. It departed North Philadelphia Airport at 1303 on a Visual Flight Rules flight plan. The crew consisted of Captain W. E. Moller, First Officer J. D. Pickel, and Stewardess D. J. Bush.

At departure the gross weight of the aircraft was 44,940 pounds (allowable 45,300 pounds), with 775 gallons of fuel aboard. Distribution of the load was within prescribed center of gravity limitations.

The trip between North Philadelphia and Louisville was normal and in good weather. In the vicinity of Standiford Airport, the pilot requested landing instructions and was cleared for landing on Runway 24 by the tower. The clearance was acknowledged by the pilot.

One of the three controllers on duty observed that the approach appeared normal until the flare-out when the aircraft "ballooned" slightly, power was applied, and about 500 feet farther on entered a steep climb. The aircraft then yawed to the left and climbed with a steadily increasing angle of attack. At this point he noticed that a portion of the left elevator was hanging down and immediately advised the aircraft but received no acknowledgment of his warning. The aircraft continued in a steep climbing left turn until it reached an altitude of about 300 feet, stalled, fell off to the left, and struck the ground on the nose and left wing.

The fuselage burst open upon impact. A number of the occupants were thrown free and emergency equipment immediately took survivors to nearby hospitals. Due to the severity of impact and the extent of damage, there

1/ All times herein are Central Standard and based on the 24-hour clock.

2/ CAM is the designation for Civil Air Movement flights, contract operations between the military services and civil air carriers.

was no organized evacuation by the occupants.

Fire broke out upon impact but was extinguished by fire fighting equipment at the airport.

Investigation

The other two controllers in the tower as well as several witnesses on the ground also saw the left elevator dangling. A number of these witnesses testified that the approach to landing was normal and the wheels had almost touched the runway when power was applied. All the witnesses were in agreement that the aircraft entered a steep climb which culminated in a stall. These ground witnesses stated that it was apparent that something was wrong with the left elevator, as it appeared to be hanging down. None of them saw anything fall from the aircraft.

Statements were obtained from surviving passengers who advised that prior to landing the seat belt sign came on and the stewardess went through the cabin to ascertain that all passengers had their seat belts fastened. They also stated that, to their knowledge, there was no abnormal operation or malfunction of the aircraft at any time during the flight until the flare-out for landing at Standiford Airport.

Board investigators ascertained that the aircraft struck the ground approximately 50 degrees nose down with the left wing depressed approximately 30 degrees and coming to rest on a heading of about 140 degrees. The wreckage was localized to the left of Runway 24. The forward section of the fuselage was crushed back to the wing leading edge. The left wing separated from the aircraft at the fuselage; the leading edge was severely damaged and the tip was torn off. Both wing flaps were found in the full-down position. The manner in which the main landing gear was torn off indicated that it was in down and locked position at impact. The tail wheel was undamaged and was found in the down and locked position. Examination of the engines and propellers indicated no malfunction. The rear section of the fuselage buckled and was partially severed several feet forward of the main cabin door and several feet aft. All passenger seats were torn from the floor with the exception of three unoccupied seats in the rear of the cabin.

Although a thorough examination was made of the wreckage, investigation was primarily centered on the empennage group in view of the obvious structural failure of the left elevator. Examination of the flight control systems revealed no evidence of malfunction or failure prior to impact. The right stabilizer and elevator, as well as the vertical fin and rudder, were undamaged. The left horizontal stabilizer was buckled upward at two stations but was still attached to the fuselage. The inboard two-thirds of the left elevator was found still attached to the stabilizer by hinges Nos. 3 and 4 (numbering the hinges 1 through 4 from left outboard to left inboard). The outboard third of the left elevator was found in the immediate area.

Examination of the left elevator and its hinge fittings, details of which will follow, indicated that the No. 1 hinge bolt worked free from the hinge fitting and thus resulted in the outboard third of the elevator being unsupported. This section then bent downward during flight at No. 2 hinge station; therefore, the hanging portion of the elevator observed by witnesses was this outer third of the left elevator.

Both the elevator and stabilizer portions of the No. 1 elevator hinge bracket were attached to their respective surfaces but the No. 1 hinge bolt was missing. This bolt was found inside the crumpled leading edge of the left elevator tip, but the nut and cotter pin could not be found. Since the bolt had not failed, it was evident that the nut had backed off, allowing the bolt to work out.

Upon examining this steel bolt, an AN5-13 type, it was ascertained that it was not specified for this installation. The proper type bolt was NAS55-14. The bolt was severely worn about the shank and the portion most reduced in diameter was found to be that section which bore on the steel bushing installed in the inboard lug of the hinge fitting. Laboratory examination showed that wear on the bushing and the bolt shank matched, proving that this bolt was the last one installed in No. 1 hinge bracket. The wear and markings on the bolt shank and the hinge bushing indicated that the bolt had been loose in the bracket for a conservatively estimated 50-100 hours of flight.

The cotter pin hole of the bolt was clean and microscopic examination of the hole showed no noticeable distortion of the hole other than a small deformed area at one end. This distortion indicated that a cotter pin had been installed at some time. A flake of brass was found in the hole, but no brass deposit was found at either end of the hole. A laboratory report stated that its presence could have been an indication that a brass cotter pin had been used at some time. Since only one small particle of brass was found, it appears improbable that a brass cotter pin was installed during the pertinent period.

When the interposer and left stabilizer bracket for No. 3 elevator hinge were removed for laboratory examination, a brass cotter pin was found securing a nut on the vertical bolt in the interposer block. All other cotter pins were of steel. Slick Airways' personnel (who conduct maintenance on Resort aircraft) stated that they do not use brass cotter pins and none had been purchased by Slick for five years. Resort Airlines likewise has standing instructions that only steel cotter pins are to be used.

Laboratory examination of the steel bushings in No. 1 hinge bracket revealed, through hardness tests, that they did not meet the minimum required 125,000 p.s.i. tensile strength by 40,000 p.s.i. Being softer, they were more subject to battering and wear by the bolt. The holes of both bushings were beaten out of round.

There are four elevator hinge bracket assemblies on each elevator. Upon disassembly, it was found that the bolts installed in the right elevator were of the specified type, but all four on the left elevator were not.

The correct bolt to be used on all certificated C-46 aircraft was specified in CAA Airworthiness Directive 47-51-2, which was in force at the time the elevators were last overhauled. The correct and incorrect bolts are so nearly alike that it is difficult to tell them apart by cursory inspection except for the designations on the head.

The incorrect bolt was shorter than the correct bolt by one-eighth of an

inch and its tolerances permitted a smaller diameter than the approved type bolt. Being shorter, the improper bolt installed in No. 1 hinge had less grip length and several threads rested on the bushings of the hinge bracket. The approved bolt, if used, would have had a tight fit in the assembly; the diameter of the nonapproved bolt could have resulted in greater clearance than desirable and thus induced greater vibration loads on the assembly.

Examination of the interposer ball bearings of the elevator hinge assemblies disclosed that only one of the four bearings on the left side was of the approved type. This is a self-aligning bearing, type KS5. The three incorrect type bearings were type K-5, a non-self aligning bearing. All four bearings for the right elevator were the approved type.

Overhaul and maintenance on Resort Airlines' C-46 aircraft was conducted under contract with the carrier by Slick Airways, Inc., in addition to other CAA-approved repair stations which handled minor maintenance on a contractual basis. The records of all work performed by Slick or these other agencies were forwarded to the headquarters of Resort for review to ascertain that the work had been performed in compliance with Resort's continuous maintenance and inspection procedures. Maintenance checks on Resort aircraft were to be performed at intervals of 70 hours for a No. 1, 125 hours for a No. 2, 250 hours for a No. 3, 500 hours for a No. 4, and 1,000 hours for a No. 5.

Resort's maintenance manual prescribed that the elevators were to be removed and overhauled at each 2,000-hour interval. At overhaul the interposer, bearings, and fittings for the elevators were to be removed and inspected. These items were to be replaced as necessary and new bolts and cotter pins were to be installed at each elevator overhaul.

The maintenance manual further prescribed that empennage control surfaces were to be checked for security and attachment on all numbered checks. On all checks above a No. 1, the manual required inspection of all elevator fittings, attachments, and component parts.

With regard to pre-flight checks the maintenance manual prescribed that the fuselage and empennage were to be inspected for structural damage.

Between July 8 and 11, 1953, Slick Airways conducted a No. 3 inspection of the subject aircraft at San Antonio. This included removal and overhaul of the elevators owing to time requirements. Since this was the last overhaul of the elevators before the accident, the records of the overhaul were given careful study and personnel involved in the overhaul of the elevators were questioned regarding the work they performed. It was ascertained that the right and left elevators were both removed but there was only one work and parts replacement sheet. Testimony indicated that the repairs and replacements listed on this sheet related only to the right elevator. Although a work sheet for the left elevator would normally have been completed to accompany the elevator overhaul sheet, none was found. None of the mechanics or inspectors had any recollection of having done any work or completed any inspections on the left elevator.

After the overhaul was completed, the aircraft underwent a pre-flight inspection before being test flown. This was accomplished by Slick Airways' mechanics and inspectors and included inspection of the elevator and fittings

for proper attachment and safety.

In view of the fact that investigation disclosed a number of discrepancies in the left elevator; namely: nonapproved bearings, nonapproved bolts, and a brass cotter pin, these discrepancies were either the result of improper attention to assembly and inspection of the left elevator by Slick personnel, or the left elevator was worked on by some other agency between the time of this overhaul and the day of the accident. Therefore Resort Airlines maintenance records relating to this aircraft were carefully searched and a number of Resort, Slick, and Airline Services personnel were interviewed for any information on further work on the left elevator after July 11. These reviews of the maintenance records and the interviews failed to reveal any indication of additional work on the left elevator. Further, the carrier's accounts applicable to N 66534 were carefully checked for bills from any source for work on the left elevator. This check also proved negative. Resort Airlines furnished the Board with an affidavit stating that no work was performed on the left elevator of the subject aircraft since the date of the last No. 3 inspection at San Antonio.

Slick Airways had also overhauled the elevators in June 1952. The records reflected the left elevator serial number for N 66534 as 2-65M. During inspection of the left elevator at the accident site, it was ascertained that the left elevator bore this same serial number. This therefore negated the remote possibility that there was replacement or removal of the left elevator after the No. 3 inspection at San Antonio in July 1953.

Following the No. 3 inspection, the aircraft underwent three No. 1's, two No. 2's, and one No. 5 inspections in the 412 hours it acquired to the time of the accident. The No. 2 and No. 5 inspections were conducted by Slick Airways and one of the No. 1's by Airline Services, Inc., of Oakland, California. The Slick inspections were conducted at Miami, Florida, and Burbank, California; the last numbered inspection was a No. 2 only 53 flight hours before the accident. No. 2 inspections include examination of the elevators, including the hinge bolt assemblies. Several work items on the elevators were performed during this last No. 2 check, but none of these items related to the hinge assemblies. A review of the records for these checks and testimony indicated that no discrepancies were found in inspections of the left elevator. If the No. 1 hinge bolt had begun to wear to an appreciable degree at the time of these inspections, it should have been found.

Between July 11 and the day of the accident the aircraft underwent almost daily pre-flight inspections. These pre-flight records were reviewed by Board investigators. Of the last six pre-flight inspections, two were signed by Captain Moller, the latter prior to departure from North Philadelphia. None of the pre-flight inspections reviewed contained a report of discrepancy on the left elevator. Resort Airlines pre-flight inspection forms included an item that the elevators are to be inspected for structural damage, distortion, and security of attachment.

The company, the aircraft, and the crew were currently certificated.

Analysis

The ultimate failure of the left elevator was preceded by a series of

events which permitted the No. 1 hinge bolt to work out of the assembly. This had to be preceded by the nut backing off the bolt.

It will be recalled that the cotter pin and nut were not recovered. Thus there are four possibilities with regard to the cotter pin: (1) it is possible that it was not installed at the time of the San Antonio overhaul, (2) not properly installed which would have permitted it to work out, (3) correctly installed but later removed by an unknown party, or (4) properly installed but worn away by the nut. This last possibility is considered the most probable starting point of this sequence.

Owing to the deep circumferential grooving of the hinge bolt, wear on the bore of the steel bushings in the elevator fitting lugs, and wear on the faces of the inboard lug, it is apparent that the hinge bolt was subjected to vibrational pounding over a considerable period of time. It is probable that during this period the nut was safetied by a cotter pin. The pounding would have included a very large number of small torque loadings of the nut which would have tended to wear away the cotter pin. It appears probable that a steel cotter pin was in place during this period, for a brass cotter pin would have coated the cotter pin hole with particles of brass.

The nature of the hinge bolt grooving and wear on the fitting indicated that the bolt worked out very shortly after the nut started backing off, and further, that the nut backed off very shortly after it was no longer safetied. In light of this evidence it is highly improbable that the cotter pin was missing for a long period of time. Any numbered check or pre-flight inspection which failed to disclose the excessive wear of the hinge fitting or absence of the cotter pin, if it were missing at any of those times, must have been performed in a perfunctory manner.

Calculations entered in the record indicated that with the tip hinge bolt missing, the elevator could be expected to fail in smooth air at the second hinge from the tip due to loads resulting from elevator deflections within the normal operating range at all speeds from cruise to approach. It can therefore reasonably be deduced that the hinge bolt did not work from the hinge until the latter part of the flight from North Philadelphia to Louisville, and the flare-out for landing was the first moderately large elevator deflection after the bolt freed itself from the hinge fittings.

Many factors combined to produce the large amount of wear on the No. 1 hinge bolt, bushings, and lugs. Although the relative influence of these factors cannot be determined exactly, it appears that the use of the improper bolt contributed to accelerated wear in two ways. First, since the threads of the bolt extended into the inboard bushing, the bearing area was appreciably reduced and bearing stresses were increased for any given load. Secondly, the permissible smaller minimum diameter of the incorrect bolt can result in larger clearances than are desirable, with the result that vibration produces larger bearing loads. Another factor in the excessive wear in the assembly was the use of steel bushings with a lower tensile strength and hardness than that specified. Still another appears to have been the use of the improper bearing; the K-5 type is a rigid bearing whereas the specified KS5 is a self-aligning type. The wear pattern showed misalignment of the fittings; bearing stresses would thus be higher than when a self-aligning bearing was used. The worn condition of the parts indicated that there was insufficient torquing of the nut on the hinge bolt to clamp

the bearing tightly enough between the steel bushings to prevent relative rotation between these parts; all rotation should take place within the bearing. In addition to these, several other variables affected the service time which would have been required to produce the amount of wear. Among these are engine roughness, propeller disturbances, weather conditions, surface conditions of the airports from which the airplane was operated, and technique of the flight crews.

With such a large number of variables, it is impossible to determine with any degree of accuracy how long the wear progressed. However, a reasonable estimate appears to be a service period of 50-100 flight hours. In any event, it is obvious that excessive wear of the No. 1 hinge should have been detected in pre-flight inspections.

In view of the above discussion, a probable sequence of events can be established. It appears that accelerated wear in the tip hinge was the result of a combination of nonconformities and other factors. This probably caused the nut to work on the hinge bolt and wear away the cotter pin until it separated and worked out of the cotter pin hole. This probably occurred during the flight from North Philadelphia. With the nut no longer safetied, vibration quickly caused it to back off the hinge bolt and the bolt worked out of the hinge fitting. The bolt probably worked out as the aircraft was approaching Louisville. When the crew applied up elevator in the flare-out for landing, the resultant down load on the left elevator was sufficient to cause downward failure in line with the second hinge from the tip. The balance area of the elevator ahead of the hinge line on the failed portion then interfered with the second hinge bracket and jammed, preventing the pilots from applying down elevator to counteract nose-up pitch of the aircraft. Application of power produced a steep climb which terminated in a stall and the crash.

The absence of records relating to overhaul of the left elevator by Slick Airways is indicative of poor maintenance practices. Further than this, it will be recalled that Board investigators were unable to ascertain through interviews with Slick personnel which mechanics worked on the left elevator. Careful review of all Resort Airlines' records relating to work performed on this aircraft following the No. 3 inspection failed to reveal that anyone had worked on the left elevator between that inspection and the time of the accident. The Board therefore feels it may reasonably assume that the discrepancies which were found in the left elevator at the scene of the accident were overlooked by Slick Airways' personnel at the time of the July overhaul and subsequent numbered checks.

In view of the importance that the proper hinge bolts be installed, the CAA conducted a survey on all commercially operated C-46 aircraft immediately following the accident. It was found that a number of C-46's, including one owned by Resort Airlines, did not have the specified NAS-55 hinge bolts installed at all hinge positions. In all cases where improper bolts were installed at various hinge positions, it was found that the most wear had occurred at the outboard hinges. Although this special inspection covered all control surfaces and systems, unsatisfactory conditions were found only in the elevators and hinges.

Findings

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

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

2. The flight between North Philadelphia and Standiford Airport, Louisville, was routine and in good weather.

3. The aircraft crashed on Standiford Airport when the left elevator failed at No. 2 hinge station.

4. The No. 1 hinge bolt worked free from the hinge fitting and thus resulted in the outboard third of the elevator being unsupported.

5. The four hinge bolts in the left elevator were a nonapproved type for this installation, as were three of the four interposer ball bearings; the bolts and bearings in the right elevator were approved types.

6. Major maintenance on Resort Airlines' aircraft was performed under contract by Slick Airways.

7. The left and right elevators were removed by Slick Airways' personnel during a No. 3 inspection of N 66534 at San Antonio, July 8-11, 1953.

8. Excessive wear and other deficiencies were not noted in any inspection by Slick Airways, Airline Services, or the carrier's personnel during the period between the No. 3 inspection and the day of the accident.

Probable Cause

The Board determines that the probable cause of this accident was structural failure of the left elevator in flight, causing loss of control. This structural failure was brought about by the left outboard hinge bolt backing out of the assembly. The underlying cause was improper maintenance which resulted in the installation of hinge bolts and bearings not meeting specifications, and inadequate inspection which failed to detect this condition.

BY THE CIVIL AERONAUTICS BOARD:

/s/ CHAN GURNEY

/s/ HARMAR D. DENNY

/s/ JOSH LEE

Oswald Ryan and Joseph P. Adams, Members, did not participate in the adoption of this report.

SUPPLEMENTAL DATA

Investigation and Hearing

The Civil Aeronautics Board was notified of this accident at 1305E, February 26, 1954. An investigation was immediately initiated in accordance with the provisions of Section 702 (a)(2) of the Civil Aeronautics Act of 1938, as amended. A public hearing was ordered by the Board and was held in Denver, Colorado, on May 26 and 27, 1954.

Air Carrier

Western Air Lines, Inc., is a scheduled air carrier incorporated in the State of Delaware, with its principal offices in Los Angeles, California. It operates under a currently effective 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 company to transport by air persons, property and mail between various points in the United States and Canada.

Flight Personnel

Captain Milton R. Cawley, age 39, held a currently effective airline transport certificate with the appropriate rating for the subject aircraft. Captain Cawley was employed by Western Air Lines on October 14, 1942. He had a total of 10,565 hours, of which 899 were in the type of equipment involved. His last instrument check was accomplished December 12, 1953, and his latest physical examination was on November 19, 1953.

First Officer Robert E. Crowther, age 35, held a currently effective airline transport certificate with the appropriate rating for the subject aircraft. He was employed by the company on July 28, 1950. His total time was more than 3,738 hours, of which 2,018 were in the Convair 240. First Officer Crowther's latest physical was taken July 18, 1953, and his last route check was on September 11, 1953.

Stewardess Mary Grace Creagan was employed by the company May 6, 1950.

The Aircraft

N 8407H, A Convair 240, was manufactured September 22, 1948, and delivered to Western Air Lines October 3, 1948. The manufacturer's serial number was 37 and the aircraft had accumulated a total time of 12,145 hours. It was currently certificated by the Civil Aeronautics Administration. The aircraft was equipped with Pratt and Whitney Model R-2800-CB-16 engines and Hamilton Standard 23260-15 propellers.