File No. 1-0003

CIVIL AERONAUTICS BOARD

AIRCRAFT ACCIDENT REPORT

ADOPTED. October 30, 1964 **RELEASED:** November 5, 1964

SLICK AIRWAYS DIVISION
THE SLICK CORPORATION
DOUGLAS C-54B-DC, N384
CASTLE ISLAND
BOSTON, MASSACHUSETTS
MARCH 10, 1964

SYNOPSIS

Slick Airways Flight 12, a Douglas C-54B-DC, N384, operating as a scheduled cargo flight from John F. Kennedy International Airport, New York, New York, to Logan International Airport, Boston, Massachusetts, with a stop at Bradley Field, Windsor Locks, Connecticut, crashed at 0821:35, March 10, 1964, while making an instrument approach to Runway 4R at Logan International Airport. The aircraft crashed in a lumberyard approximately 7,000 feet from the displaced threshold of Runway 4R and on the extended centerline of that runway.

Boston weather at the time was: scattered clouds at 400 feet, overcast at 700 feet, surface visibility 1-1/2 miles in moderate sleet and fog, wind 050° (true), 22 knots, gusts to 28 knots, temperature 32°, dewpoint 32°.

The captain, first officer, and freight handler, the only occupants, were killed. The aircraft was demolished by impact forces and the ensuing fire.

The Board determines the probable cause of this accident was loss of balancing forces on the horizontal surface of the aircraft's empennage, due to ice accretion, causing the aircraft to pitch nose down at an altitude too low to effect recovery.

Slick Airways, Flight 12, a C-54B-DC, N384, a scheduled cargo flight of March 10, 1964, crashed at 0821 35[1/] in a lumberyard on Castle Island, while making an instrument Landing System (ILS) approach to Runway 4R at Logan International Airport at Boston, Massachusetts, during inclement weather. Three crew members, the only occupants, were killed and the aircraft was destroyed by impact and fire.

Flight 12 originated at John F. Kennedy International Airport, New York, New York. It was scheduled between New York and Logan International Airport, with a stop at Bradley Field, Windsor Locks, Connecticut.

In preparing for the flight a representative[2/] of Slick Airways, received a weather briefing by telephone from the U. S. Weather Bureau. This briefing included

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

2/ The person did not identify himself, however, he was presumed to have been a crew member of N384.

the Boston terminal forecast for the period 0200 to 1200 which indicated expected ceilings 400-600 feet, overcast, visibilities 1-3 miles, fog, light drizzle or rain. The weather briefer said that he also included the latest pertinent weather sequences and advised that freezing or frozen precipitation would occur north of the intended route. The company's station clearance and flight plan form for this flight contained weather sequence reports and forecasts; no mention of freezing or frozen precipitation was made.

No discrepancies were noted on the preflight inspection. The flight departed New York at 0613. The trip to Bradley Field was routine.

N384 arrived at Bradley Field approximately 0650. While on the ground, a crew member telephoned the FAA Flight Service Station at the airport and requested and received the Bradley and Boston sequence reports and the Boston terminal forecast. The Boston 0657 weather observation was Record special, measured 500 overcast, 2 miles, light snow, light sleet, fog, temperature 34°, dewpoint 32°, wind 060°, 18 knots, altimeter setting 29.76. Sleet began at 0615, rain ended at 0632, snow began 0645. It is believed he was also given the following Worcester, Massachusetts, weather sequence report of 0700 Estimated 100, overcast, visibility 1 mile, light freezing rain, fog, temperature 31°, dewpoint 31°. Freezing rain began 0655. It is likely that the Boston terminal forecast given was the same as that given the crew at the John F. Kennedy International Airport.

N384 departed Bradley Field at 0735. According to company records the gross takeoff weight of the aircraft was 57,048 pounds, well below the maximum allowable gross takeoff weight of 73,000 pounds. The cargo was properly secured. The center of gravity of the aircraft was within prescribed limits.

Tower en route control service is provided between Bradley Field and Boston under the terms of currently effective Letters of Agreement.3/ (Normally used altitudes for northeast-bound flights are 3,000 feet and below.)

At 0801:49, Flight 12 contacted Boston Approach Control and was cleared to the Walpole Intersection via Franklin and Victor 16 to maintain 3,000 feet and to expect a clearance for an approach to Runway 4R. The 0800 Boston weather observation was given as 400 feet scattered, measured 700 feet overcast, visibility 2-1/2 miles, light sleet and fog, temperature 32°, dewpoint 32°, wind 050° 20 knots, gusts to 30 knots, altimeter 29.73. This message was acknowledged.

The flight reported at 0803:27 that it was encountering moderate rime icing at 3,000 feet; that the outside temperature was "about 4°, rain and rime".

At 0806 47 in response to a request for the flight's estimated time of arrival at Franklin Intersection, Flight 12 replied they were "coming up on Franklin right now". Approach Control then instructed the flight to turn to 090° for a radar vector for an ILS approach. This instruction was acknowledged.

A new heading of 070° was given the flight at 0809·36, and in acknowledging this the crew requested a lower altitude. The aircraft was immediately cleared to des-

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3/ These Letters of Agreement are between Bradley Air Traffic Control Tower and Quonset Point, Rhode Island, Radar Air Traffic Control Center (RATCC) (Navy) and between Quonset Point and Logan International Air Traffic Control Tower, and consequently involve control of all such flights by these three facilities.

cend to and maintain 2,000 feet. The flight reported leaving 3,000 feet and that there was "moderate to heavy" rime icing.

At 0811 34 the flight reported reaching 2,000 feet whereupon the controller advised the flight that radar contact had been established 18 miles southwest and cleared the flight for an ILS approach to Runway 4R. This was immediately acknowledged by the flight.

At 0813·56 the flight was vectored to 050° and the flight's position was given as being 9 miles southwest of the outer marker.

At 0815.05 the local controller in the Boston tower advised the approach controller that the visibility was now 1-1/2 miles. The information was not given to N384.

Tne flight was advised at 0816 29 that its position was 5 miles southwest of the outer marker, that radar advisory services would be provided on 110.3 mc (the voice feature of the ILS localizer), and was instructed to contact the tower on 118.1 mc. Ten seconds later contact was established with the local controller who instructed the flight to report passing the outer marker and provided information concerning field conditions and braking action.

After reporting the outer marker inbound at 0818:52, the flight was cleared to land and was requested to report when the field was in sight.

The following advisory information was transmitted by the Precision Approach Radar (PAR) controller on 110.3 mc to the flight at the times indicated: passing outer marker course and glidepath OK (0818:57), 5 miles from touchdown 125 feet above glidepath (0819 12), 4 miles from touchdown, 100 feet above glidepath (0819·42) 3 miles from touchdown, course and glidepath OK (0820:11); 2 miles from touchdown, 150 feet right of course, 50 feet above glidepath (0820 46).

At 0821:09 the PAR controller advised N384 that it was "passing the stacks at Castle Island."4/ The controller later stated that at this point in time and space, the aircraft was on course and glidepath. At about 1 to 1-1/2 miles from touchdown N384's target disappeared from both the elevation and azimuth radar scopes. At 0821.20 the PAR controller transmitted the following. "Slick 384, I've lost radar contact with you. Radar advisories terminated."

Tne local controller observed a large ball of flame emanating from the ground at Castle Island

The weather observation at Boston taken subsequent to the accident was. scattered clouds 400 feet, overcast 700 feet, visibility 1-1/2 miles, moderate sleet, fog, wind 050°, 22 knots, gusts to 28 knots, temperature 32°, dewpoint 32°. The company's minimums for a straight in approach to runway 4R were ceiling 200 feet, visibility 1/2 mile.

The point of impact was determined to be 7,000 feet from the displaced thres-

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4/ A well-known landmark, tall stacks on an industrial plant.

hold5/ of Runway 4R in a lumberyard on Castle Island. (See Attachment 1.) The lumberyard is located on the extended centerline of Runway 4R. All the witnesses who saw the aircraft (and they only saw it for a few seconds) were persons who were in the lumberyard. The lumberyard has a number of floodlight towers which are 116 feet high. The consensus of these witnesses was that the aircraft was flying toward the airport and that it passed to the right of one of the light towers. It then suddenly pitched nosedown steeply and struck the ground. Witnesses differed as to engine noise.

Investigation revealed that at the time of the accident, the captain was seated in the right or first officer's seat and the first officer was in the captain's seat. The medical examiner did not find any indication that the crew was incapacitated prior to the accident. The activities of the crew prior to, and during the flight, did not indicate anything out of the ordinary other than that their on-duty time had been 15 hours and 33 minutes. According to Civil Air Regulations a pilot cannot be on duty more than 16 hours in any 24-hour period.

It was determined that the aircraft first struck the ground while in a nosedown attitude of approximately 60° and on a magnetic course of 48°. The wreckage was spread over an area 375 feet long and 200 feet wide. At the main impact area which was approximately 20 feet in diameter the cockpit and its components were found. Adjacent to this area a portion of the fuselage 26 feet long was found lying inverted along a line of 127° magnetic. The left wing, also inverted, was found to the right and south of the fuselage. The right wing tip and outer panel were found inverted. There was heavy fire damage. Lumber was placed in large stacks throughout the yard. A slash mark from one of the propeller blades formed an included angle of approximately 30° to the face of the board making the angle of the aircraft's attitude at the time of impact approximately 60° nosedown.

All of the aircraft and its components were found in the area. The aircraft was severely broken up and damaged by fire.

From the extension of the elevator jackscrew it was determined that the elevator trim was 5-6° nosedown at time of impact. The extension of the flap and its actuating strut pistons indicated that the flaps were extended about 30°. The full down position of the flaps is 45°

The landing gear was down and locked No evidence was found to indicate any malfunction or failure prior to the accident.

All engines were separated from the wings and badly damaged. Nos. 1 and 2 powerplants were buried vertically into the rocky soil with their propeller blades protruding up around the cylinder heads. Nos 3 and 4 initially struck a lumber stack separating the propellers through the reduction gear housing. The No. 3 engine was lying on top of the lumber stack. Its propeller was wedged horizontally into the slashed lumber. Two blades were broken off through the shank and the third blade was intact in the hub.

5/ The displaced thresnold of Runway 4R is located 2,523 feet from the approach end and the approach lights extend this distance on both sides. The displaced threshold and a glideslope angle of 3.03° are necessary to provide proper clearance above the ship channel when ILS approaches are made.

The No. 4 engine was found some distance southeast of the fuselage. It had been moved during the firefighting activities. The No. 4 propeller was found under a stack of slashed lumber near the No. 3 propeller. One blade of this propeller was broken off through the shank; the other two were in the hub. The oil coolers of all engines were inspected and found free of any air passage blockage. The regulators were removed and they indicated oil in each cooler without signs of malfunction; the oil was free of sludge and metal chips. The impact and fire damage was so extensive it was impossible to determine if the de-icer system was capable of normal operation prior to the accident.

Based on the testimony of the PAR controller, the communications transcript and the geometry of the ILS, the position of the aircraft with respect to altitude and linear distance when last seen by the PAR controller on the glideslope was 480 feet m.s.l. and 780 feet out from the impact point or approximately 7,800 feet from the displaced threshold.

An airline captain whose aircraft was obliged to hold at the outer marker at 2,000 feet altitude because the accident had just occurred testified that they were in an icing condition. He said they commenced holding southwest of the outer marker and that the holding pattern was a one minute pattern with the outer marker at one end. The captain wanted to look back at the aircraft's wings to determine the extent of ice buildup he was getting when a peculiar thing occurred. On the southwest end of the pattern the ice on the unheated side windows slid off and the windows were clear. However, as the aircraft approached the outer marker these windows again became covered with ice. This sequence repeated on each of four or five complete circuits of the pattern.

Another airline captain who took off from Logan International Airport at 0820 the day of the accident said that during his climbout he immediately encountered moderate to severe freezing precipitation which continued to an altitude of about 4,000 feet.

In order to determine what another pilot who had considerable flying time in this type of aircraft might do under conditions conducive to airframe icing, the Chief Pilot of Slick Airways' Eastern Division was asked how he would fly an ILS approach under the prevailing conditions of March 10, 1964. He said that when flying with similar icing conditions prevailing, he would increase airspeed, through additional power, to possibly 130 knots, lower flaps no more than the 15° position after passing the outer marker and when he could see the approach lights he would extend flaps to the 30° position. This would be the maximum flap position he would use throughout the remainder of the flight.

A review of the aircraft's records indicated that maintenance had been performed in accordance with approved company and FAA procedures and that the aircraft was in an airworthy condition at the start of this flight. All ground radar, radio, and navigational equipment was tested by the FAA following the accident and found operating within prescribed tolerance.

Analysis

It is believed that N384 began to accumulate airframe icing of moderate intensity because of freezing precipitation in the clouds at 3,000 feet between

Putnam and the Franklin Intersection shortly before 0800. At about 0803 the flight reported moderate icing. A short time after 0809 this icing condition would have increased in intensity from moderate to heavy rime ice and was so reported by N384 when leaving the 3,000 foot level for 2,000 feet. From this time until the aircraft was over Castle Island it is believed that moderate to heavy rime icing conditions continued. The surface temperature and dewpoint at Boston were 32°F.

There is evidence to indicate that a crew member of N384 solicited and received by telephone from the FSS at Bradley Field weather information relative to Boston, Worcester and Bradley as well as the Boston forecast. It is likely that the Boston forecast received was the same as that given the crew prior to departing New York. It should be noted, however, that due to the time of this briefing the Boston weather observation would have been the 0700 observation which showed that the rain previously reported had stopped and that a mixture of sleet and snow was falling; that the wind had increased in velocity and that the temperature had fallen three degrees since the briefing at New York. These observations should have alerted the flight crew that conditions were changing, that airframe icing might be expected at least near Boston, and that the Boston terminal forecast was out of date. The Worcester observation should have been an additional indication of airframe icing potential over eastern Massachusetts. Since it was obvious that the Boston terminal forecast was not giving a true picture because of deteriorating weather conditions, it is considered that the flight crew should have taken advantage of the availability of the services of the U. S. Weather Bureau's professional meteorologists (at Bradley Field) for an interpretation of these changes.

Services provided by all pertinent ground facilities were in accordance with existing procedures except that Boston Approach Control did not advise the aircraft that visibility had reduced from 2-1/2 to 1-1/2 miles; however, the Board does not consider this to be contributory to the accident.

It is known from a propeller slash mark in the lumber stack that the aircraft struck the ground at a nosedown pitch angle of approximately 60° with the horizontal: also, that the aircraft was approximately 480 feet m.s.l. when the pitchover began and that the horizontal distance from this point in space to the point of impact was approximately 780 feet. Timing of certain known investigative data produced a groundspeed of about 108 knots from the outer marker inbound. Applying the wind, the true airspeed was about 130 knots and with the existing temperature, calibrated airspeed would also be about 130 knots.

The motions of the aircraft and the reasons therefor can be analyzed on the basis of the laws of motion, basic aerodynamic principles, and on the known or estimated performance data of the aircraft. It has been calculated that the aircraft in order to attain a pitch attitude of 60° in the vertical and horizontal distance available had to execute a pitchover maneuver at or near its maximum capability. It has further been calculated that this maneuver, a negative accelerated stall, produces about -1.4g. The question: What was the mechanical or aerodynamic generator?

From witness' statements and physical evidence it is obvious that the aircraft did not just get too low on the approach. It can be said with equal

certainty that the aircraft did not execute a 1.0g stall or experience serious power failure because a stable aircraft would not, from such causes, assume the attitude it did. Furthermore, the aircraft struck the ground near the heading necessary to fly from the outer marker to Runway 4R, thus ruling out any appreciable roll or yaw in the final maneuver.

While changes in center of pressure of the wing may cause small perturbations in pitch, only changes in horizontal tail load can produce sustained and/or high normal accelerations (angular velocities). Since this aircraft was without sophisticated systems such as electric or hydraulic trim, pitch trim compensators, control boost or autopilot, the possible sources of the maneuver can be reduced to three.

1. Pilot action.

2. Separation or serious and widespread distortion of the horizontal tail.

3. Loss of lift (negative) on the horizontal tail by disturbance of the airflow.

A complete lack of motive eliminates No. 1 and physical evidence in the examination of the wreckage eliminates any possibility of No. 2.

There are several ways in which airflow on the stabilizer can be disturbed to the point of destroying lift, but only one seems to fit these circumstances and that is the formation of ice.

In general, icing of an airfoil at low angles of attack is detrimental to the aerodynamic characteristics. Icing causes large increases in section drag coefficient (increases as high as 350 per cent in 8 minutes of heavy glaze icing have been recorded), reductions in section lift coefficients (up to 13 per cent) and changes in the pitching moment coefficient from diving to climbing moments. Rotation of an airfoil to angles of attack higher than that at which icing occurred, generally creates an even greater loss of lift than if the airfoil iced when at higher angles of attack.

Testimony of the company's Eastern Division Chief Pilot was elicited with respect to procedures and techniques which would be employed when flying under conditions similar to those encountered by Flight 12. A buildup of ice on the wings would necessitate additional airspeed. This accounts for the excessive 130 knot airspeed held throughout the approach of Flight 12. He further said that ice of any magnitude on the wings would also cause the aircraft's nose to pitch up, and accordingly a nosedown trim would be in order. This condition was reflected by the position of the elevator trim jackscrew of N384. He also said that it is entirely possible that the crew of N384 lowered flaps to 15° at the outer marker and may not have lowered them further until assured of a completed approach by seeing the approach lights. Since the visibility at the time of the approach was reported to be 1-1/2 miles, the Board believes the pilot could see the approach lights from over Castle Island and in all probability did lower the flaps as suggested by the Chief Pilot.

With ice on the stabilizers, the increased negative angle of attack caused by flap extension to 30° could have been sufficient to destroy tail load. This would induce a serious nosedown pitching moment. If the ensuing aircraft rotation is severe enough, or for sufficient duration, recovery at low altitude would be impossible.

Considering all the factors involved the Board concludes

1. That the aircraft collected ice, particularly on its tail, during the flight to Boston and especially during the approach.

2. That 15° of flap extension was used from the outer marker inbound and that "abeam the stacks" the flaps were further extended to 30°.

3. That the increased downwash resulting from the latter flap extension changed the stabilizer angle of attack to a position which, coupled with ice formation, destroyed the tail lift, thereby disrupting the aircraft's necessary balancing tail loads.

4. That the resultant pitchover was too severe at the aircraft's altitude for the crew to effect recovery.

Probable Cause

The Board determines the probable cause of this accident was loss of balancing forces on the horizontal surface of the aircraft's empennage, due to ice accretion, causing the aircraft to pitch nosedown at an altitude too low to effect recovery.

BY THE CIVIL AERONAUTICS BOARD

/s/ ALAN S. BOYD
Chairman

/s/ ROBERT T. MURPHY
Vice Chairman

/s/ G. JOSEPH MINETTI
Member

/s/ WHITNEY GILLILLAND
Member

GURNEY, Member, did not take part in the adoption of this report.

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

Investigation

The Civil Aeronautics Board was notified of this accident on March 10, 1964, and an investigation was immediately initiated under the provisions of Title VII of the Federal Aviation Act of 1958, as amended. Depositions were taken in Boston, Massachusetts, May 5-6, 1964.

Air Carrier

Slick Airways, a Division of the Slick Corporation, is a Delaware corporation with its principal office in San Francisco, California. The company operates as a scheduled air carrier under a currently effective certificate of public convenience and necessity issued by the Civil Aeronautics Board, and an operating certificate issued by the Federal Aviation Agency.

Flight Personnel

Captain Irwin S. Zadwick, age 39, held a currently effective airline transport pilot certificate. He was qualified in Curtiss-Wright C-46, Douglas DC-4, DC-6, DC-7, and Lockheed Constellation aircraft. His last first class FAA physical examination was successfully taken February 13, 1964. He had a total of 6,000 flying hours, of which 814 hours were in DC-4 aircraft. His last proficiency check was accomplished October 5, 1963, and his last line check was accomplished on April 30, 1963

First Officer Salvatore J. Conilio, age 35, held a currently effective commercial pilot certificate with airplane single and multiengine land and instrument ratings. He had a total of 5,824 flying hours, of which 4,340 hours were in DC-4 type aircraft. His last first-class physical examination was accomplished August 14, 1963 His last proficiency check was accomplished September 17, 1963.

The Aircraft

The aircraft, a Douglas C-54B-DC, serial number 18379, was manufactured in 1943. Slick Airways purchased the aircraft May 5, 1963, having operated it under a lease agreement since June 30, 1959. It had accumulated a total of 40,233 flying hours The time since last major airframe overhaul was 7,915 hours. The aircraft was equipped with four Pratt & Whitney R-2000 engines and four Hamilton Standard 23E50 propellers. Engine data are as follows

Position	Serial Number	Time Since Overhaul	Total Time
R-2000-D5	107467	16:11	30,964 09
R-2000-7-7M2	102550	654:37	20,742 10
R-2000-11-7M2-9M4	104374	1526:49	25,526 49
R-2000-25D13G	107763	911:22	20,376 39

ATTACHMENT I