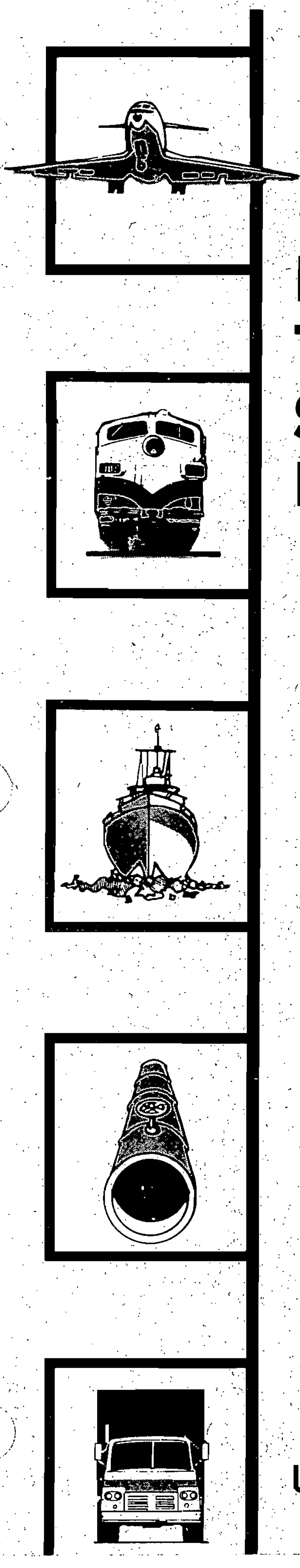

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

**NATIONAL JET SERVICES, INC.,
DOUGLAS DC-3, N51071
EVANSVILLE DRESS REGIONAL AIRPORT, INDIANA
DECEMBER 13, 1977**

REPORT NUMBER: NTSB-AAR-78-10

UNITED STATES GOVERNMENT

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16. Abstract

At 1922:22 c.s.t. on December 13, 1977, a Douglas DC-3, N51071, operated by National Jet Services, Inc., as a passenger charter flight to transport the University of Evansville basketball team and associated personnel from Evansville, Indiana, to Nashville, Tennessee, crashed within the boundaries of the Evansville Dress Regional Airport, Indiana. The aircraft departed runway 18 in instrument meteorological conditions. The crash occurred less than 1 minute 30 seconds after takeoff. All 29 persons aboard died in the crash.

The National Transportation Safety Board determines that the probable cause of the accident was an attempted takeoff with the rudder and right aileron control lock installed, in combination with a rearward c.g., which resulted in the aircraft's rotating to a nose-high attitude immediately after takeoff and entering the region of reversed command from which the pilot was unable to recover. Contributing to the accident was the failure of the flightcrew to insure that the passenger baggage was loaded in accordance with the configuration contained on the load manifest. Their failure resulted in a rearward center of gravity that was aft of the optimum range, but forward of the rearmost limit.

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TABLE OF CONTENTS

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AIRCRAFT ACCIDENT REPORT

Adopted: August 17, 1978

NATIONAL JET SERVICES, INC.
DOUGLAS DC-3, N51071
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SYNOPSIS

At 1922:22 c.s.t. on December 13, 1977, a Douglas DC-3, N51071, operated by National Jet Services, Inc., as a passenger charter flight to transport the University of Evansville basketball team and associated personnel from Evansville, Indiana, to Nashville, Tennessee, crashed within the boundaries of the Evansville Dress Regional Airport, Indiana. The aircraft departed runway 18 in instrument meteorological conditions. The plane crashed less than 1 minute 30 seconds after takeoff. All 29 persons aboard died in the crash.

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1. FACTUAL INFORMATION

1.1 History of the Flight

About 1759 1/ on December 13, 1977, National Jet Services, Inc., Douglas DC-3, N51071, operating as Air Indiana 216, departed Indianapolis, Indiana, for Evansville, Indiana. The aircraft had been chartered by the University of Evansville's Athletic Department to transport its basketball team to Nashville, Tennessee. In addition to the captain, first officer, and flight attendant, two National Jet Services, Inc., officials were on board. The flight landed at Evansville Dress Regional Airport about 1900, taxied down the ramp past the passenger terminal, and parked in front of Tri State Aero, Inc., to load passengers. Both engines were shut down after the aircraft stopped. The flight had been delayed by weather at Indianapolis and, based on the school's schedule for the trip, it was about 3 hrs late when it landed.

The boarding passengers carried their luggage and team equipment from Tri State Aero, Inc.'s, lounge to the aircraft. After the baggage was loaded and the passengers were boarded, the doors were closed, and the engines were started. Ground witnesses stated that the start was normal with no difficulties.

At 1912:17 Air Indiana 216 requested its IFR clearance from Evansville ground control. (From the ATC tower tapes, the company's director of operations determined that the first officer was conducting all communications between the flight and the tower.) At 1912:41 the flight requested taxi clearance and was cleared to runway 18. The route of taxi was via taxiway F.

At 1915:53 Evansville ground control informed Air Indiana 216 that the weather was "measured four hundred overcast, visibility three quarters, light rain and fog." The flight acknowledged the transmission. At 1916:11, Evansville ground control called the flight and delivered an IFR clearance to Nashville; the first officer's readback was correct.

At 1919:32 Air Indiana 216 was cleared into position on runway 18 and was told to hold until Delta Flight 619, a Douglas DC-9-30, departed from runway 22. Runways 18 and 22 intersect at the southwest portion of the airport. (See Appendix E.)

At 1919:50 Delta 619, then airborne, was cleared to contact departure control. At 1919:54 the local controller cautioned Air Indiana 216 about wake turbulence from the departing DC-9 and issued takeoff clearance. At 1920:00 the flight acknowledged the clearance and began the takeoff roll. At 1921:33 the local controller cleared Air Indiana 216 to departure control; 3 secs later Air Indiana 216 answered "standby." This was the last known transmission from the flight.

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

At 1922:12 and 1922:18 the local controller, after noting what he described as an "abnormal" roar of engines, made two unsuccessful attempts to contact Air Indiana 216. He stated that he initiated the crash alarm after he saw the fireball. At 1922:24, one of the controllers shouted "Oh, he's crashed." Since this remark was made after the impact, the plane crashed about 1922:22.

The local controller testified that Air Indiana 216 had not reached the runway when he turned his attention to the DC-3 after visually clearing the DC-9 through the intersection of runways 18 and 22. He said that the DC-3 was not on the runway when he cleared it to take off. The DC-3 turned directly to the runway from taxiway F, and was taxied slowly. According to the controller, the pilot "took some time" aligning the aircraft with the runway centerline, "and I noted the aircraft fishtail. The tail moved laterally once or twice." He testified that the total time to taxi onto the runway and start the takeoff was 30 to 35 secs.

The local controller did not see the DC-3 turn while he had it in sight. He said that he saw the aircraft rotate and, "it was out of sight almost instantaneously." He cleared Air Indiana 216 to departure control after he lost sight of the aircraft, and he estimated that the flight was about 1/2 to 1 mi south of the field when the clearance was issued.

Several witnesses saw and heard Air Indiana 216 take off. The majority of these witnesses stated that the aircraft was airborne and about 20 to 50 ft high in front of the terminal building. Two witnesses, located in Tri State Aero's line shack about 2,000 ft from the threshold of runway 18 stated that the DC-3 was airborne when it passed their position. One witness, located about 750 to 1,000 ft south of the terminal, said that the DC-3's tail came up, and that it "broke ground" before reaching the terminal building. He said that the aircraft "popped" off the ground. In response to further questioning regarding the liftoff, the witness said the aircraft was "pulled off."

Two witnesses on the passenger terminal ramp stated that the DC-3 entered a nose-high, steep climbing left turn shortly after lift-off. One witness estimated that the aircraft was in a 15° to 18° nose-up attitude and said that he "didn't think he could make it, he was going to stall from the attitude of the airplane." Both witnesses stated that the aircraft entered a steep climbing left turn at a 45° bank angle about 25 ft above the runway, and the turn began about 2,500 ft beyond the threshold of runway 18. The witnesses agreed that the aircraft was on an east-southeast heading when it reached the intersection of taxiway B and runway 22. (See Appendix E.)

Most of these witnesses agreed that the engine noise was normal. One witness, a Delta Airline mechanic with extensive DC-3 experience, stated that he could hear "the engines good, at what I would call good normal takeoff power, no overspeed. They were in 'sync' and nothing I could hear was wrong." Another witness, who saw the DC-3 right after liftoff, stated that he saw the landing gear retracting.

Some witnesses agreed that the aircraft climbed up into the overcast. Only two witnesses on the ramp were able to see either the aircraft or its navigation lights throughout its entire flight. According to one of these witnesses, the aircraft entered a left bank shortly after liftoff and climbed to about 50 ft a.g.l. The left bank remained fairly constant, and the plane turned inside of a housing development southeast of the airport. Its highest altitude was about the height of the top of the water tower west of the field. The tower is 135 ft above field elevation. This witness stated that he heard an explosive noise, like a shotgun blast, followed by a power reduction while the aircraft was in its left bank and "was going away from me at the time." He believed the aircraft was over the railroad tracks when this occurred. (See Appendix D.)

The second of these two witnesses stated that the aircraft completed a left turn before reaching taxiway B, "and was (on) a heading of approximately 110° to 120°." He then heard an "extreme amount of power" being added, the aircraft assumed an "extreme nose-high, tail-low attitude," climbed into the overcast, and disappeared for an instant. The aircraft reappeared in a nose-low attitude on "approximately a northbound heading and swooped low into the housing project around Twickingham, then made another control correction, came up above the trees just north of what would be Twickingham...." (See Appendix D.) The aircraft then turned eastbound away from the airport and disappeared from his view 1 to 2 secs later. Shortly thereafter, he saw the aircraft on a westbound heading descending toward the airport. As it approached the eastern boundary of the airport, "the engine rpm and the engine intensity seemed to increase, and about 1 to 2 secs after the engine increase, the aircraft struck the ground and burst into flames; about a half a second later there was a muffled explosive noise."

Two witnesses in the housing development east of the field saw and heard the aircraft just before it crashed. One witness stated that when she heard the plane, it sounded like it was too low. When the DC-3 came into view, it was descending, and was "dipping wildly from side to side." The aircraft was flying low along the west border of the housing development. The plane then veered to the right and was lost from her view. Seconds later, the witness stated that the engine noise increased, it became "tremendous," then ceased; there was "total silence" followed by a "thud--very dull." The other witness, who was located in the northwest corner of the housing development stated that he saw a DC-3 approach from the southwest. It appeared to have either struck or just cleared the trees in his backyard. He said the aircraft had its landing lights on, and he saw the cabin lights. The plane was in a left bank, had its nose up, and was trying to get over and away from the house and trees. He noted that the engines were making a strange noise, "like they were pulling against each other," and that the noise continued for about 10 secs to 15 secs; then, "it was as if the engines were turned off like a radio. Complete silence. I heard no crash or explosion."

The aircraft struck two trees almost due east of the airport's passenger terminal. (See Appendix D.) Pieces of landing light lens, strobe light lens, and the green right wing navigation light were found around these trees. The elevation at the site was 400 ft m.s.l. The trees were oriented on an east-west line and were about 40 ft apart. The midpoint between them was about 2,815 ft east of the centerline of runway 18. The top of the broken branches on the eastern-most tree was 52 ft above the ground; the top of the broken branches of the other tree was 44 ft a.g.l., and the angle formed by the breaks was about 11.3°.

The crash site was almost due east of taxiway H about 4,450 ft east of the centerline of runway 18, and about 1,500 ft almost due east of the tree strike. The aircraft crashed during the hours of darkness, and the 29 persons on the aircraft were killed. The coordinates of the crash site are 38°02'N, 87°31'W.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	3	26	0
Serious	0	0	0
Minor/none	0	0	

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

Branches were broken off two trees, and localized ground fires destroyed small trees near the wreckage.

1.5 Personnel Information

The pilots and flight attendant were certificated and qualified for the flight in accordance with current regulations. (See Appendix B.)

1.6 Aircraft Information

The aircraft was certificated in accordance with current regulations. (See Appendix C.)

1.6.1 Aircraft Weight and Balance and Loading Information

The maximum allowable takeoff gross weight for the aircraft was 26,900 lbs. The fore and aft center of gravity (c.g.) limits were 11 to 28 percent MAC. The Civil Aeronautic Administration (CAA)-approved airplane flight manual issued in 1953 when the 26,900-lb takeoff weight and the higher performance engines were approved, states, "The airplane must be loaded within the limits of 11 percent to 28 percent of the MAC. The ideal loading would place the c.g. at between 20 percent to 23 percent."

The first officer computed the weight and balance for the flight using the company's passenger and baggage loading tables and load manifest (Form 105A). The takeoff weight was 26,748 lbs and the c.g. was 23 percent MAC. However, he used the wrong basic operating weight and index number and made mathematical errors.

The Safety Board recomputed the aircraft's weight and balance by using the company's documents and procedures, the aircraft's proper basic operating weight and index number, and the same additional data used by the first officer. The resultant takeoff weight was 26,716 lbs and the c.g. was 23 percent MAC.

Because the aircraft broke up and burned on impact, it was not possible to determine where the baggage was located on the plane and then weigh it. According to the company's director of operations, the University supplied them with the baggage weights and these weights were used on the Form 105A. The form for this flight disclosed that 500 lbs of baggage was to be loaded in compartment C, the forward baggage compartment, and 124 lbs in compartment H, the aft baggage compartment. According to the witnesses, all baggage, except for a few clothing bags carried aboard the aircraft by passengers, was loaded into the aft baggage compartment. These witnesses said that the aft baggage compartment was one half to three quarters full.

The University also supplied the actual passenger weights to the company; however, the passenger weights on this manifest had been added incorrectly. The actual passenger weight was 4,515 lbs, instead of 4,315 lbs. Since the passenger weight used on the Form 105A was 4,420 lbs, the new weight increased the takeoff weight to 26,811 lbs.

As a result of the evidence concerning the manner in which the baggage was loaded, the Safety Board made two additional weight and balance computations. The company's weight and balance computation tables were used and only the baggage loading configurations were changed. The takeoff weight for both computations was 26,811 lbs.

The first computation was based on 100 lbs of baggage in compartment C and 524 lbs in compartment H; all other data remained the same. The resultant c.g. was 26.8 percent MAC. The second computation was based on the entire 624 lb baggage load being placed in compartment H, and the resultant c.g. was 27.9 percent MAC.

1.7 Meteorological Conditions

The aircraft crashed in a south-southeasterly flow of air ahead of a cold front which was moving through Illinois and Missouri. The Evansville 1931 radar observation was, in part, as follows: An area 8/10 covered by weak echoes containing light rain, no change in intensity during the last hour.... Maximum echo tops are uniform at 12,000 ft, aircraft accident.

The pertinent surface weather observations taken by the National Weather Service at Evansville were, in part, as follows:

> 1852, Sky condition - measured ceiling, 400 ft overcast; visibility--2 mi.
> 1907, special: Indefinite ceiling 300 ft sky obscured, visibility--1 1/2 mi, light rain and fog, surface--wind 120° at 6 kns, altimeter setting--29.88 in., visibility northeast--3/4 mi., light rain occasionally moderate rain.
>
> 1915 special: Indefinite ceiling 300 ft sky obscured, visibility--3/4 mi., light rain and fog, surface wind--110° at 6 kn, altimeter setting--29.87 in., light rain intermittently moderate rain.
>
> 1925 local: Indefinite ceiling 300 ft sky obscured, visibility--3/4 mi. light rain and fog, temperature--47°F, dewpoint--46°F, surface wind--110° at 5 kns, altimeter setting--29.87 in., light rain intermittently moderate rain, aircraft mishap.

The 1852 observation was being broadcast on the Automated Terminal Information Service (ATIS) "Information Quebec." The 1907 observation had been available to Evansville tower personnel on the Electrowriter equipment in the tower cab from 1910--2 min before initial contact with Air Indiana 216. The 1915 observation was available in the tower about 4 min before Air Indiana 216 was cleared for takeoff. The electro-writer equipment was not equipped with a visual or an aural alarm, a none was required. The tower personnel were not aware of the new weather observations, and as a result, Air Indiana 216 received incorrect takeoff weather. Although the weather conditions at takeoff were different from those given to the flight, the existing conditions were above the required IFR takeoff minimum of 1/4 mi. (See Appendix E.)

The pilot of Delta Flight 619 noted that the cloud base was about 400 ft a.g.l.; that there was light to moderate precipitation; and that he encountered no icing, turbulence, or airspeed fluctuations. He also stated that the visibility was more restricted on the "north one-half or one-third of the field than the south end.... It was as though the clouds were almost to the surface or it was foggy over the north 30 to 40 percent of the field."

Witnesses in the housing development east of the airfield stated that there was rain and fog in their area.

1.8 Aids to Navigation

Not applicable.

1.9 Communications

There were no communications problems relating to this accident.

1.10 Aerodrome Information

The Evansville Dress Regional Airport is located 5 mi northeast of Evansville, Indiana, at an elevation of 418 ft m.s.l. (See Appendix E.) Runway 18/36 is 5,088 ft long and 150 ft wide. Runway 4/22 is 8,021 ft long and 150 ft wide. Runway 9/27 is 2,968 ft long and 100 ft wide. All runways are asphalt surfaced.

Runways 18/36 and 9/27 are equipped with medium intensity runway lights; however, runway 9/27 was not lighted when Flight 216 crashed. Runway 4/22 is equipped with high intensity runway lights and runway end identifier lights (REIL) are installed on runway 4.

Runways 22 and 18 intersect at the south portion of the airfield about 7,200 ft from the beginning of runway 22 and 3,700 ft from the beginning of runway 18.

Runway 18 is intersected by four taxiways and runway 9/27. The approximate distances from the northern end of runway 18 to the midpoint of these intersections are as follows: To taxiway F--200 ft; to runway 9/27--1,600 ft; to taxiway H--2,200 ft; to taxiway D--2,700 ft; and, to taxiway B--3,125 ft. The distance from the centerline of runway 18 due east to Twickingham Drive is about 3,075 ft. (See Appendix D.)

1.11 Flight Recorders

Flight recorders were not installed on N51071, nor were they required.

1.12 Wreckage and Impact Information

The aircraft heading at impact was about 200° magnetic. The initial impact marks consisted of three elongated craters which were created when the aircraft's nose, left engine nacelle, and right engine nacelle hit the ground. The aircraft crashed on soft, muddy, but relatively level terrain. The major components of the aircraft came to rest at the edge of a ravine about 200 ft beyond the point of initial impact. (See Appendix F.) Some portions of the wreckage were moved by rescue workers before wreckage location could be documented.

The aircraft's fuselage separated into three main segments after impact. Postimpact fire consumed a major portion of the fuselage's forward left side, top, and right side skin and associated structure. The portion of the fuselage containing the cockpit structure had been subjected to severe impact forces and intense postcrash fire.

The aft portion of the fuselage, including the empennage forward to fuselage station (FS) 362 was upright, but lying partially on its left side. The fuselage bottom from FS 583 forward had been crushed, twisted to the right, and torn severely. A large hole had been torn in the floor of the aft baggage compartment. The portion of the fuselage containing the center wing section from wing station (WS) 142 on the left side to WS 85 on the right side had separated from the fuselage and rotated to the right about 45°.

Both engines displayed heavy impact and breakaway damage. The left engine was found near the cockpit wreckage. The right engine was close to the right side of the fuselage near FS 450.

The propeller assemblies had separated from their engines. The left assembly was found under the fuselage near the right engine. The right propeller assembly was found forward and to the right of the initial impact point.

The left wing separated from the center wing at WS 142 and came to rest in an upright position about 35 ft right of the cockpit wreckage. The tip of the wing extended about 3 ft over the edge of the ravine. The leading edge had been damaged moderately from WS 142 outboard to WS 43; however, the landing light assembly was intact and undamaged.

The right wing separated from the center at WS 85 and came to rest in an upright position aft of the empennage. The leading edge was oriented opposite the direction of impact, and the right wingtip was resting on the outboard end of the left horizontal stabilizer.

The wing panel planking between the front and rear spars and from WS 145 on outboard had buckled severely. The leading edge had been severely crushed and displaced aft from WS 142 outboard to and including the landing light cutout area. The landing light lens, bulb, and metal light deflector were missing.

The right wing trailing edge structure from WS 107 inboard to about WS 98 had been bent downward about 40°. The inboard edge of the aileron adjoins the wing structure at WS 107. The outboard corner of the trailing edge stringer and the rib structure at the WS 107 juncture had been torn with a portion of the torn skin bent downward.

The outboard end of the upper wing panel and associated rib structure at WS 107 (starting at a point about 7 ins. forward of the trailing edge corner to a point about 19 ins. forward of the trailing edge corner) had been buckled and rolled outward and downward. The stiffener, positioned about 12 ins. forward of the trailing edge stringer and parallel to the trailing edge stringer, had penetrated through the rib. (See Appendix G, figures 1 through 7.)

The landing gear and wing flaps were retracted. The left horizontal stabilizer had been compressed in a fore and aft direction from the tip inboard to about station 131. The left elevator was intact and attached to the stabilizer; the tip had been damaged on impact.

The right horizontal stabilizer's leading edge was severely crushed and displaced aft about 22 ins. at its inboard end. The stabilizer assembly was bent about 50° downward with the tip resting on the ground. The right elevator remained attached to the stabilizer and was damaged extensively.

The rudder assembly remained attached to the vertical stabilizer. The rudder was positioned 90° to the left of the vertical stabilizer centerline, and the left and right rudder stop bolts had been extended 5/16 in. and 7/16 in., respectively (measured from the top of the bolt lock nut). The right bolt was bent downward about 6°.

The fuselage tail cone assembly remained attached to the aft fuselage structure. The vertical trailing edge of the tail cone from a point 10 ins. down from the top rib had been bent to the left on about a 50° plane. The uppermost rib of the cone had been twisted to the right with a severe buckle at the rib and right skin juncture. The top rib also had been torn and buckled on the left side at the left side skin to rib juncture 12 ins. forward of the vertical trailing edge. Similar damage was also noted on the right side of the rib about 1 in. forward of the rib damage on the left side. (See Appendix G, figures 8 through 11.)

The cabin area broke open and disintegrated during the impact sequence. Except for the damaged throttle quadrant, pieces of each control wheel, and the pilot's attitude indicator, nothing remained of the cockpit. The trim control knobs were not recovered and the cockpit control settings could not be determined.

The elevator control cables had broken at the midsection area of the fuselage during the impact sequence. The control cables were traced aft from the control columns to the break area, and then, aft from that point to the empennage. Within the empennage area the control cables were intact and attached to the horn assembly. With the exception of damage noted in the area of the bulkhead at FS 63, no other evidence of damage to the control system was discovered.

The control cables are routed aft, in pairs, from the base of the control columns through an upper and lower race-track shaped holes in a bulkhead beneath the cockpit floor level at FS 63. At the point of passage through the hole, the paired cables are perpendicular to the bulkhead and are positioned horizontally, side by side. The examination of the holes showed that there were a series of equally spaced grooves on the bottom edge of the upper race-track hole. These markings were limited to the forward face of the hole except for a small area on the aft face. Similar damage was present on other areas of the holes' edges; however, it was much less marked, and there was no evidence of the grooving noted on the lower face of the hole. There was no evidence that the swaged fitting, which attached the cable to the base of the control column, impacted the forward face of the hole. It appeared that the damage to the hole edges was caused by contact with a cable.

In addition to the damage noted above, there was a gouge about 1/32 of an inch deep located about the midpoint of the right side of the upper race-track hole. The forward and aft surfaces of the bulkhead were lipped in the areas of the gouge, and the lipped areas appeared equal in size. The gouge contained grooves which appeared to be deeper and spaced farther apart than the grooves in the damage noted above. The gouge and the grooves within it were at an angle of about 50° to the cable. The damage appeared to have been caused by contact with a cable.

Except for the gouge at the midpoint of the right side of the upper hole, there was similar damage to the edge of the lower race-track hole. However, the damage noted on the lower hole was not as severe.

The metal right aileron control lock with bungee cord attached was found under the right wing aileron assembly just outboard of WS 232. (See Appendix F.) The portion of the lock which slides between the aileron and the trailing edge wing structure was covered with rugging to protect the wing and aileron when the lock is removed and inserted. The rug material on the side of the lock slide which interfaces with the trailing edge of the right wing had a marked depression at a point opposite the protruding trailing edge stringer. (See Appendix F.)

The metal rudder control lock with bungee cord and red streamer attached was found in the mud about 25 to 30 ft behind the empennage and to the left of the fuselage's centerline.

When the wreckage of the aft fuselage structure was removed, the metal elevator control lock fell out of the right side of the disrupted fuselage.

1.13 Medical and Pathological Information

Autopsies of the pilot, copilot, flight attendant, and the two company officials revealed no evidence of preimpact incapacitation. All persons had sustained multiple blunt force trauma. In addition, the captain and the company official, who had occupied the cockpit observer jumpseat, had sustained post-mortem burns.

1.14 Fire

The aircraft had about 1,700 lbs of 100 octane aviation gasoline onboard at impact. Although there was no evidence of in-flight fire, fire did erupt after the aircraft struck the ground.

1.15 Survival Aspects

The accident was not survivable. Except for the pilot and the observer, all persons were thrown free of the wreckage; most occupants were found down the side of the ravine, on the railroad tracks below, and to the south of the wreckage. According to the rescue workers, most of the passengers remained strapped in their seats. Although four passengers were found alive, three died shortly after being found and the fourth died about 0025 on December 14, after being taken to a hospital.

The airport fire department and security office were alerted immediately after the crash. The tower controller telephoned the Evansville City Fire Department at 1922:40. Fog prevented tower personnel from determining precisely the location of the fire.

The airport fire department dispatched two crash-fire-rescue (CFR) units to the accident scene. CFR-1, a 1971 Oshkosh Model MB-1 four-wheel drive vehicle, attempted to reach the crash scene via an off-airport route. The truck was blocked by cars temporarily, reentered the airport at the Eastview Drive gate, and proceeded to the radar antenna. Since the rescue personnel could not see the fire and had no knowledge of the precise location of the crash site, the vehicle did not reach the crash site.

CFR-2, a 3/4-ton Ansul dry chemical quick response truck, attempted to reach the aircraft via the airport perimeter road. The truck slid off the road, became stuck in the mud, and did not reach the accident site.

The Evansville Fire Department dispatched nine vehicles. Their personnel also were not aware of the precise location of the aircraft; consequently, none of the apparatus reached the site. The first department personnel to arrive on the scene were from the rescue squad.

The McCutcheonville Volunteer Fire Department dispatched three units at 1926. One unit, a 3/4-ton truck, went south along the railroad track and arrived at the scene about 18 to 20 min after the crash. The firefighters depleted the 5 gal supply of high expansion foam and 200 gals of water on localized fires near the right wing, the engine, and on burning rubber. The fire was described as slow burning and was not a metal fire.

The first persons on the accident scene were residents of the Melody Hill residential area. They reached the accident site about 10 to 15 min after the impact and before either the fire truck or the rescue personnel arrived. By this time the major fire had subsided and was either out or burning itself out.

1.16 Tests and Research

The Safety Board examined the engines and propeller assemblies at Piedmont Aviation, Inc., Winston-Salem, North Carolina. There was no evidence to indicate that the engines had malfunctioned before impact.

Examination of the propeller assemblies disclosed no evidence of preimpact malfunction or distress. Based on examinations of the domes and blade shim plates, the examiner concluded that the propeller blade angles were about 22° at impact. The low pitch stop for this propeller was 18°.

On January 4, 1978, the captain's electrically driven gyro-horizon instrument, Sperry Model H6-A S/N 2336, was examined at the Sperry facility in Phoenix, Arizona. Although dented and burned at the aft section, the following information was obtained:

- The pitch attitude was 85° (against the gyro gimbal stop).
- The roll axis was in the 20° right bank position.
- The glass face was broken.
- The caging shaft at the pull knob was bent slightly upward.
- The power flag was out of view and held there by the roll ring mask.
- The miniature airplane responded with movement of the pitch trim knob.

°There was a large amount of mud within the instrument.

°The inner gimbal, when removed from the outer gyro gimbal, displayed two broken pivots (pitch gimbal).

°The rear electrical plug was burned out.

°There were spiraling watermarks on the face of the gyro wheel.

A gyro motor bearing was replaced because rust had accumulated since it was removed from the accident site. The gyro motor was then excited by 3-phase voltage at about 50 volt a.c. The motor responded and ran up to high rpm rapidly.

Wingtip light bulbs and the left landing light bulb which were recovered at the wreckage site exhibited unbroken, but slightly stretched filaments.

1.16.1 Microscopic - Instrument Analyses

On January 6, 1978, the Safety Board delivered a section of the right aileron control lock, a section of the right aileron, and a section of right wing upper structure to the Federal Bureau of Investigation (FBI) Laboratory to determine by microscopic and instrumental analysis if any materials or paints from either the lock or the wing-aileron structure had impinged upon, or had been transferred from, one surface to the other. The analysis revealed no evidence of such impingement or transference.

On March 3, 1978, portions of the right aileron control lock's rugging material were sent to the FBI laboratory for microscopic analysis to ascertain if there was a positive relationship between the indentation in the rugging and the wing panel stringer which had penetrated the wing panel closure rib. (See Appendix G, figure 4.)

The FBI responded that the pile on one of the pieces of rugging was depressed, and the area corresponded in measurement to the fractured surface in the panel closure rib.

1.17 Additional Information

1.17.1 Construction and Use of External Control Locks

The rudder external control lock assembly was constructed from 1/8-gage aluminum sheet metal and 90° angle stock material. The lock is wedge-shaped, is approximately 15 ins. long, and has a horizontal sheet member positioned between two upper and two lower vertical sections at right angles to the horizontal sheet member. The four vertical angle sections extend 1 1/2 in. above and below the center horizontal member.

When the rudder control lock is in position, it rests entirely on the upper surface of the fuselage tail cone closure rib and, because of its design, displaces the rudder trailing edge about 1/2 in. to the left of the vertical stablizer centerline. (See figure 1.) The aft end of the lock is 2 ins. forward of the rudder trailing edge and fuselage tail cone trailing edge. The forward end of the lock is positioned adjacent to the vertical structural member within the cone assembly. (See figure 2.)

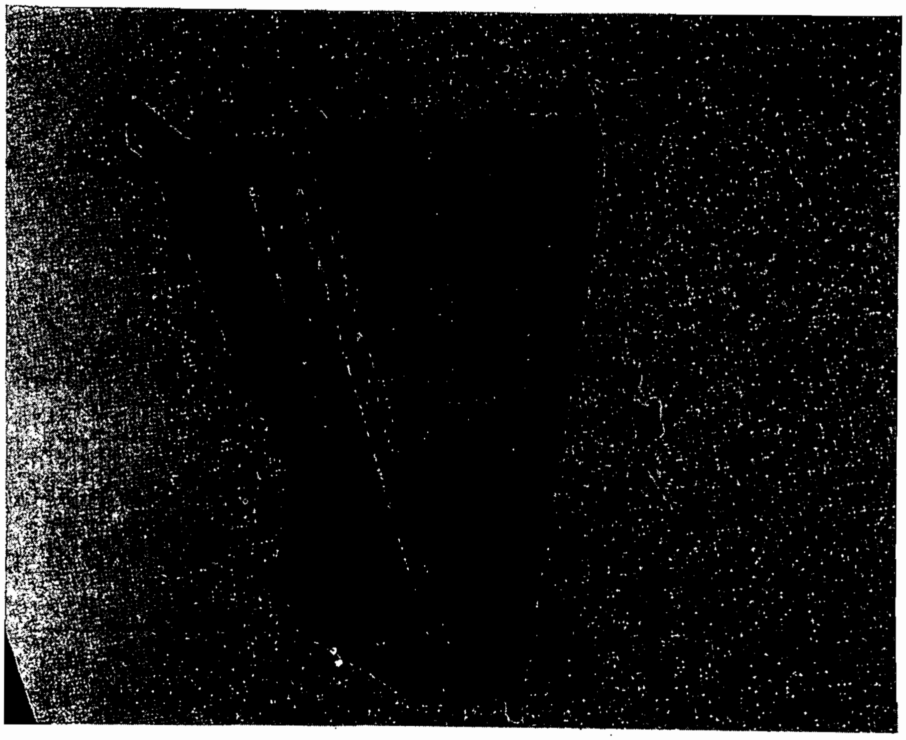

Figure 1. Upper side of the rudder control lock showing horizontal and vertical members. The forward end of the control lock is at the top of the picture.

The aileron external control lock was constructed from 1/16-gage ferrous sheet stock material. The control lock is about 14 1/2 ins. long, 8 1/2 ins. wide at its aft end, and 3 ins. wide at its forward end. (See figures 3 and 4.) The design of the control lock is such that it retains the aileron by an upper and lower curved horizontal member that extends outboard from the vertical member. The aileron is held in the neutral position by (1) a left upper horizontal member which extends inboard from the vertical member and rests on the

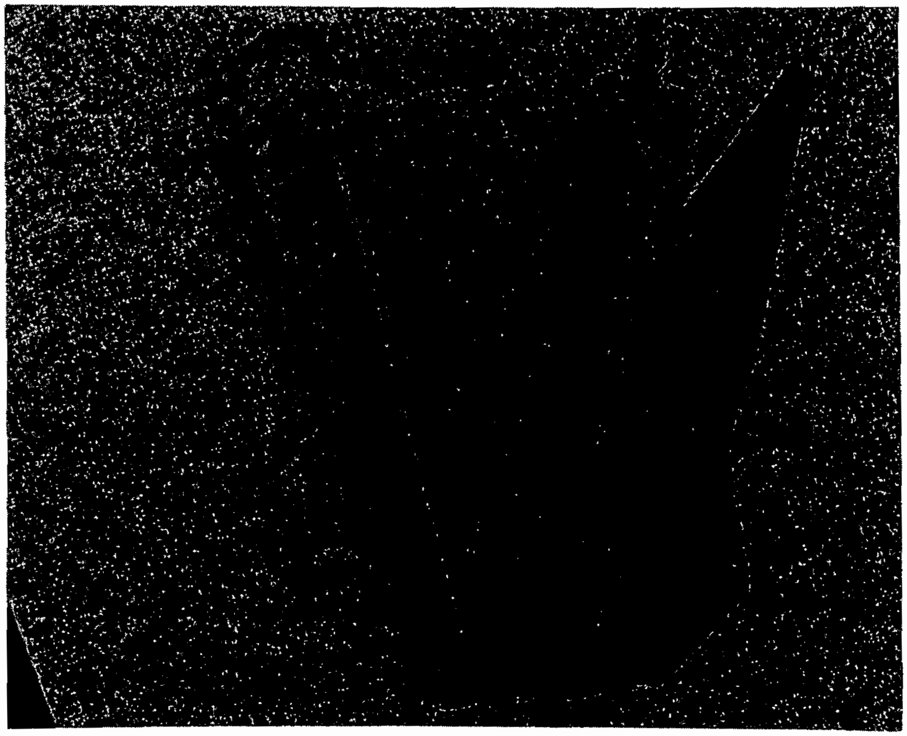

Figure 2. Lower side of the rudder control lock showing the horizontal and vertical members. The forward end of the lock is at the top of the picture.

upper surface of the wing panel; and (2) the retention of the outboard end of the wing panel trailing edge stringer. The area of trailing edge stringer retained by the control lock is 1 1/8 ins. by 7/8 in. No lower inboard horizontal member extends from the control lock vertical member in the area of the landing flap. This is to allow the extention and retraction of the landing flap with the control lock installed. The trailing edge of the control lock is enclosed.

There is a bungee cord which can be used to lock the ailerons from inside the aircraft. The aileron bungee is an elastic cord which can be fastened to the pilot's and copilot's control wheels in the cockpit and dampens the aileron's movement during gusty wind conditions.

The National Jet Services, Inc., standard operating procedure required the copilot to place the external rudder control lock on the aircraft, and the captain to put the internal aileron bungee cord on the control wheels whenever the engines were shut down. The procedure did not require the copilot to insert the external aileron control lock. Before departure, the copilot was required to remove and stow the rudder lock, and then help the flight attendant close the main door before proceeding to the cockpit.

Figure 3. Left (inboard) side of the right aileron control lock showing the inboard side of the vertical member, and the upper horizontal member which holds the wing structure. There is no lower horizontal member to permit operation of the flaps with the lock installed.

Figure 4. The right (outboard) side of the right aileron control lock showing the vertical member of the lock and the upper and lower horizontal members which hold the inboard end of the aileron.

The external control locks were to be stowed in an open-topped box in the aft baggage compartment. The box was located on the floor of the compartment, against the left fuselage wall, and just forward of the aft cargo door. The procedure required that the copilot place the rudder lock in this box after removing it from the rudder.

Two of Tri State Aero, Inc.'s, line personnel saw the DC-3 while it was being loaded. Both remained on the left side of the aircraft and were not in a position to see either the right wing or the aft section of the empennage. These witnesses stated that the aircraft's main passenger cabin door and rear baggage hatch were the only doors opened during the stop at Evansville.

One of these witnesses stated that the passenger door was opened by a man in civilian clothes and that this man went directly forward to the left wing and remained there talking to team personnel while the baggage was loaded. A second man, who was wearing a blue pilot's uniform cap and blue overcoat, got off the aircraft. He proceeded to the left wing for a few moments; the witness did not see this man proceed to the right wing; he said that the man helped to load the baggage.

The second of these witnesses also saw the man in civilian clothes and corroborated the first witness' testimony of his activities. He said another man wearing an airline-type uniform looked under the left wing and walked back into the aircraft. According to this witness, when the passengers came out to board "someone had already opened the rear baggage hatch." He said that "the second gentleman" to get off helped with the baggage and stayed until they completed loading.

Both witnesses stated that they did not see any of the men leave the aircraft with an external control lock in their possession, and that there was no control lock affixed to the left wing. One of these witnesses stated that he saw the DC-3's empennage as it taxied from the ramp. He saw the elevators move up and down, the rudder move left and right "about a foot in each direction." He did not observe the ailerons because he wasn't looking in that direction, he was "looking at the tail." He estimated that he was 200 to 300 ft from the tail of the aircraft when he saw the the rudder and elevators move.

1.17.2 National Jet Services Checklist Procedure

Item 5 on the before-takeoff checklist is: "Controls ... FREE FULL TRAVEL."

Although the amplified checklist does not contain instructions as to this item, the response is self explanatory. Item A-3 in the "General" section of the company's operating manual explains the use of the checklist, and states, in part, "All action items are normally to be accomplished from memory prior to the use of the checklist. This applies to all flight regimes whether it be before start, before takeoff or other."

The takeoff procedure requires the pilot flying to apply slight back pressure before reaching V_2 2/, rotate the airplane so as to become airborne at 84 kns, V_2, call for the gear verbally and by hand signal. The first officer is to call V_2 verbally and to indicate it by hand signal. The CAA-approved airplane flight manual states, in part, "In the DC-3, V_1 3/ = V_2," and V_1 is 84 kn indicated airspeed (KIAS). The captain is to maintain a positive climb and to accelerate to 96 KIAS. The first power reduction to 43.5 ins. of manifold pressure (hg.) and 2,600 rpm, "shall normally not be made until 400 (ft) is reached and an (K)IAS of at least 96 kns is attained."

The procedures also indicate that the aircraft is to be allowed to accelerate to 105 KIAS and that climb speed is to be maintained until at least 1,000 ft over the terrain.

1.17.3 Wake Turbulence

The Safety Board plotted the probable location of the wake vortexes generated by the departing DC-9 on runway 22. The calculations were based upon wake vortex characteristics as determined in Federal Aviation Administration (FAA) and industry tests; the surface wind conditions at the airport when the two aircraft departed; the takeoff performance of the DC-9; and the geographic location of the two runways involved.

Testimony at the Safety Board's public hearing and FAA Advisory Circular 90-23D disclosed that while some wake vortex would be generated when the DC-9 was rotated, the wing would not begin to generate a significant wake vortex until liftoff. A well defined, rolled up, vortex system would not be generated until the DC-9 reached about 50 ft a.g.l. The surface wind at the time of these takeoffs was 110° at 5 kns; therefore, the wake vortexes of the DC-9's wings would have drifted toward runway 18 in the direction of the surface wind. The right, or downwind, wing vortex would have preceded the left, or upwind wing vortex, and at a faster rate.

Correlation of the performance traces and radio transmission traces on the DC-9's flight data recorder with the radio transmissions on the air traffic control transcript disclosed that the DC-9 lifted off about 6,500 ft down runway 22 at 1919:36. The first significant right wing wake vortexes would have reached runway 18 about 2,900 ft beyond its threshold, or in the vicinity of the intersection with taxiway C, at about 1920:06, and would have drifted to the west of the runway by 1920:36.

2/ Takeoff safety speed.
3/ Critical engine failure speed.

The studies also disclose that vortex turbulence diminishes with time and that the vortex system will subside within 1 min 30 sec to 2 min after it was generated. Therefore, the left, or upwind wing vortexes probably would not have reached runway 18, except at, or close to, its intersection with runway 22.

Controller responsibilities concerning wake turbulence are set forth in ATC Handbook 7110.65. Paragraph 911 states, in part:

> Issue cautionary information to aircraft concerned, if, in your opinion, wake turbulence will have an adverse effect on it ....
>
> NOTE: ...Because it (wake turbulence) is unpredictable, the controller is not responsible for anticipating its existence or effect.

Based on current directives and regulations, the controller at Dress Regional Airport was not required to provide specific time or distance separation to the aircraft. The controller, however, did caution Air Indiana 216 of the possible existence of wake turbulence in the takeoff area.

1.17.4 DC-3 Performance Characteristics

The corrected takeoff gross weight for the aircraft was 26,811 lbs. The power-off stall speeds for that weight are: Flaps up--66 KIAS; flaps full down-- 62 KIAS. Although the airplane flight manual does not supply power-on stall speeds, the stall speed in the power-on configuration is reduced by the slipstream effect of the propeller blast over the wing section, and by the variable vector in the engine's thrust component which, in this instance, is downward.

Assuming a 26,680-lb takeoff weight, a temperature of 47°F, an altimeter setting 29.87 in; a 1.7-kn headwind component, and engines set at takeoff power before brake release, the manufacturer computed that it would require 1,790 ft and 26 sec to accelerate the aircraft to V_1 speed. The takeoff weight used in this computation was based on the weight developed during the on-scene investigation. Increasing this weight to 26,811 lbs would have a little effect on these figures.

A DC-3 test pilot, and former company DC-3 project manager also noted that pilot technique would introduce a variable into the distance noted above, and if a rolling takeoff was made or if the power was not advanced in the same manner as noted above, the takeoff distance would be greater than 1,790 ft.

Safety Board calculations based on these takeoff data indicated that the aircraft would reach 1,690 ft at 80 KIAS; 1,590 ft at 78 KIAS; and, 1,490 ft at 75 KIAS.

An FAA DC-3 flight examiner stated that a premature liftoff on takeoff could ensue if the aircraft had an aft c.g. and if the trim tab had not been centered after landing. He further noted that the controls on the aircraft are reasonably effective because, "DC-3's have been flown out of c.g. in many areas of the world for many years and that's why they are still around." The project manager noted that the aircraft could lift off prematurely at speeds below the power-off stall speeds since the power-on stall speed is lower than the power-off stall speed, and that level flight could be maintained at the power-off stall speeds. Under these circumstances, the aircraft would be in a high nose-up attitude, but "you'll still be able to fly the aircraft but not accelerate."

The DC-3 airplane was designed before the formulation of FAA airworthiness standards. The National Advisory Committee for Aeronautics (NACA), therefore, conducted a series of flight tests to determine the longitudinal and lateral stability characteristics, control characteristics, and stalling behavior of the aircraft. The test results, published in December, 1953 4/, disclosed that the aircraft satisfied most of the specifications for its type. However, the report stated that the airplane was "longitudinally unstable for certain conditions of airspeed and center-of-gravity position for the power on configurations."

The study noted that at normal rated power (43 in.hg. manifold pressure, or full throttle--2,550 rpm), clean condition (landing gear and flaps retracted) with the c.g. at its aft limit, the airplane would be longitudinally unstable, stick fixed, throughout the speed range.

A time history of a typical flaps-up takeoff with the c.g. at 26.5 percent MAC disclosed that elevator push forces near 70 lbs were recorded during the maneuver. The time history of the elevator push forces disclosed that the maximum force was reached at, or slightly below 44.5 kn. The push forces decreased with aircraft acceleration. At 69.5 kns the push force was about 30 lbs. From 87 kns to 104 kns the push forces ranged from 0 to 20 lbs, and no pull forces were recorded throughout the maneuver.

The effect of power on longitudinal trim disclosed that a reduction of power required a pull force on the elevator to maintain the trimmed condition, and a push force when power was applied. At an indicated airspeed of 78 kns, landing gear and flaps down, engines idling, an increase of engine power to takeoff power required a 15.3-lb push force on the elevator to maintain the airspeed and altitude.

The study examined the dynamic lateral and directional stability characteristics of the airplane at cruising conditions at airspeeds of

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4/ National Advisory Committee for Aeronautics, Technical Note 3088: Determination of the Flying Qualities of the Douglas DC-3 Airplane, by Arthur Assadourian and John A. Harper.

147.5 kns, and 104 kns, by abruptly deflecting and releasing the rudder and aileron. In all cases, the resulting oscillations were damped satisfactorily, the time required to damp to one-half amplitude was about one cycle.

The NACA investigation of the stalling characteristics of the airplane disclosed that in the power-on condition, the left wing dropped abruptly and the nose fell. Isolated cases of aileron snatch 5/ were noted by the pilot. The project manager stated that if asymmetrical engine power or control forces caused the right wing tip to stall before the left, the aircraft would roll to the right.

The NACA made no tests to determine altitude loss during recovery. However, in power-on stalls with the airplane rolling abruptly, it reported that considerable altitude was required before control could be regained. Test data disclosed that at normal rated power, clean configuration, 25.5 percent MAC, and at a weight of about 26,200 lbs, the stall speed was about 62 kns.

Flight at indicated air speeds between maximum endurance speed and stall speed for all fixed-wing aircraft requires power settings which increase with a decrease in airspeed. Since the increase in required power setting with decreased velocity is contrary to the normal command of flight, the regime of flight between the speed of the minimum required power setting and the stall speed is termed the "region of reversed command 6/" or the back side of the power curve. Level flight in this regime requires that the aircraft be flown in a nose-high attitude to produce the proper angle of attack. Slower air speeds require higher angles of attack and higher power settings. Therefore, as the angle of attack is increased the power required to maintain level flight may equal the total power available. Under these conditions, the only way the aircraft can be accelerated from this point is to lower the nose and descend, particularly if the airspeed at which level flight is being conducted is close to the stall speed. Both the project manager and the flight examiner testified that if the DC-3 lifted off prematurely, or was rotated rapidly after takeoff, that the aircraft could have been placed into the region of reversed command.

5/ The control wheel is rotated violently toward the fully deflected position.

6/ The region of normal command exists at speeds above the maximum endurance speed. In this region, speeds greater than the speed for maximum endurance require increasingly higher power settings to achieve steady, level flight. Conversely, flight in the region of reversed command means that a higher airspeed will require a lower power setting and a lower airspeed will require a higher power setting to hold altitude. Aerodynamics for Naval Aviators, H. H. Hunt, Jr., 1960, pgs 353-357.

1.17.5 Additional Control Lock Data

The project manager stated that there have been several instances wherein the DC-3 has been flown and landed successfully with the aileron and rudder locks installed. In one instance involving a takeoff with the rudder and aileron locks installed, the pilots were not aware that the locks were on until they had climbed to almost 5,000 ft.

He also stated that because of control cable stretch, it might be possible to move the control wheel and rudder pedals slightly if the pilot attempted to use these controls with the locks installed, "but you do not get any movement on the control surfaces."

The Safety Board's accident records disclosed that from 1966 through 1975 there have been six accidents caused by failure to remove control locks before takeoff. One aircraft was damaged substantially; five were destroyed. In two of these accidents, persons were killed; both involved DC-3 aircraft. In one instance the elevator control lock was not removed, and, in the other, the elevator and rudder control locks were not removed.

2. ANALYSIS

The flightcrew was qualified in accordance with Federal and company regulations and procedures. The aircraft was maintained in accordance with Federal and company regulations and procedures. Electrical power was available throughout the flight, and there was no evidence of any aircraft structure, aircraft systems, aircraft instruments, or engine malfunctions before impact.

Based on the weather existing at takeoff and the fact that it was dark, there may have been little or no horizon available to the pilot for aircraft attitude reference or control. Although it is difficult to discount weather as a causal factor, there was no evidence to show that it affected the pilot's handling of the aircraft.

Since a DC-9 took off from a converging runway before Air Indiana 216 departed, it was necessary to determine if the DC-9's wake vortexes could have affected the takeoff. Although the exact time cannot be established, there is no doubt that Air Indiana 216's takeoff roll did not begin until well after the DC-9 lifted off. Witnesses estimated that the delay ranged from 40 sec to 2 min. Witnesses on the airport parking ramp were unanimous that Air Indiana 216 started a left turn about 2,500 ft beyond the threshold of runway 18 and was established on an eastbound heading before it reached taxiway B, about 3,125 ft beyond the threshold of runway 18.

At 1920:00 Air Indiana 216 acknowledged its takeoff clearance, and at 1921:33 the local controller cleared it to departure control. The aircraft was not on runway 18 when the takeoff clearance was acknowledged, and the controller said that, based on the 1920:00 transmission, 30 to 35 sec elapsed before the takeoff roll began. Therefore, takeoff was begun about 1920:30 to 1920:35, and using a 30-sec takeoff roll, the aircraft would have lifted off between 1921:00 and 1921:05.

The 1921:33 clearance was not issued until the controller estimated the DC-3 was 1/2 to 1 mile south of the field, or about 15 sec to 30 sec after he lost sight of the aircraft. Using a 22-sec midpoint, the controller lost sight of the aircraft about 1921:11. He did not see the turn which began 2,500 ft down the runway. According to witnesses the aircraft was in the air 2,000 ft down the runway; therefore, the controller must have lost sight of the aircraft about 5 seconds after it lifted off. Thus, the aircraft was airborne about 1921:06, and the takeoff began about 1920:36. Therefore, evidence indicates that the takeoff began between 1920:30 and 1920:40, and lift off took place between 1921:00 and 1921:10.

The DC-9's first significant wake vortexes would have reached runway 18 about 2,900 ft beyond its threshold at 1920:06, and would have diminished completely by 1921:06 to 1921:36. Therefore, not only did Air Indiana 216 lift off after the DC-9's wake vortexes had dissipated, but it did not even overfly the portion of runway 18 where the vortexes would have been located. The Safety Board, therefore, concludes that Air Indiana 216 did not encounter the wake vortex of the DC-9.

Since the manner in which the DC-3 was flown after takeoff could not be attributed to a wake vortex encounter, the Safety Board attempted to determine why these maneuvers occurred. In order to do this, the flightpath was examined to determine, if possible, the indicated airspeeds attained during the flight. Air Indiana 216's flightpath from takeoff to impact resembled a figure S. It passed through the trees 2,815 ft east of the takeoff runway on a northbound heading; it then turned right and crashed about 4,450 ft east of the takeoff runway on a heading of 200°. Evidence regarding the time interval between the tree strike and impact rule out any possibility of a long protracted flight east of the crash site. (See Appendix D.)

According to witnesses in the Tri State Aero, Inc., line shack, the DC-3 was airborne when it passed their position. Therefore, it must have lifted off at, or just beyond, the intersection of runways 18 and 9/27. Since there was no flight data recorder, the exact distance from takeoff to impact cannot be established; however, the distance can be reasonably approximated based on the following assumptions: The aircraft lifted off at runway 9/27; it began to turn left midway between taxiways B and D; it completed a symmetrical 180° turn to a 360° heading and struck the trees; and, flew due north to a point west of the impact site. It then made a symmetrical turn to the crash site. Based on these assumptions and the application of geometric equations, the ground distance traversed by Air Indiana 216 from takeoff to crash was about 8,700 ft.

The aircraft crashed at 1922:22. Consequently, the DC-3 was airborne between 72 to 82 sec, and this time interval is corroborated by witnesses. By applying surface wind vectors for these time intervals to the 8,700-ft ground distance, theoretical flightpath distances of between 9,430 and 9,530 ft and airspeeds between 69 to 77 kns were produced. However, had the actual turns been symmetrical, Air Indiana 216 would have flown considerably to the south of the intersection of runways 18 and 22. The witnesses on the airport ramp are unanimous that it did not. Therefore, the flightpath distance was less than that used to compute the speeds above. Based on the altitudes achieved by the aircraft, the low wind velocity, and outside air temperatures, the speeds noted above would be close to indicated airspeeds.

Based on these calculations, the flightpath described by the witnesses, the maneuvers performed by the aircraft en route to the crash site, and the short duration of the flight, the Safety Board concludes that shortly after liftoff, Air Indiana 216 either entered, or was placed into a high angle of attack, high drag mode of flight. It was being operated in the region of reversed command at a low altitude and the pilot was unable to escape from this flight regime.

In order to determine the cause of the accident, the Safety Board examined aircraft weight and balance, flight controls, takeoff performance capabilities, and the way the takeoff was made, all of which could have caused the flightcrew to permit their aircraft to enter this flight regime.

The testimony disclosed that the baggage was not loaded as shown on the company's load manifest. Except for some clothing bags, all the baggage evidently was placed in the aft baggage compartment H. This produced a c.g. well aft of the c.g. shown on the manifest, and aft of the optimum range, but probably forward of rearmost allowable limit. The new c.g. was probably within the 26.8 percent to 27.9 percent MAC range, and would produce control forces during the takeoff which the pilot might not expect or anticipate. In addition, the new c.g. was at or beyond the 26.5 percent MAC used in the NACA takeoff test. Consequently, the push forces required on the elevator to prevent a premature liftoff and subsequent pitchup would equal or exceed those recorded on that test. Unless the pilot was alert and recognized and countered these increased forces, his aircraft would lift off prematurely at a low indicated airspeed, continue to pitch up, and enter a high angle of attack, high drag flight envelope.

Besides the problems resulting from the new c.g. location, the evidence also disclosed that the pilot was to encounter additional control difficulties during the takeoff. The position of the external rudder and right aileron control locks at the crash site--behind the empennage and to the left of the fuselage's centerline--and the impact damage to the empennage and right wing indicated that these two locks may have been installed on their respective control surfaces during the flight. (See Appendix F.)

The ground depressions at the point of impact, the position of the right propeller assembly forward and to the right of the initial impact point, and the fact that the right wing failed in the aft direction and then rotated to the rear and to the right and struck the empennage indicate that the aircraft struck the ground in a nose-low, right-wing-down attitude.

Since there was no impact damage to the tail cone assembly, the external rudder control lock was in place at impact. Although the sturdily constructed lock protected the tail cone from direct impact by wing structure, it also transmitted the impact forces to it. This is substantiated by the cone's rotation to the left.

The 50° bend to the left of the tail cone's trailing edge, the twist to the right of the top closure rib, and the inward compression buckle at the right skin to rib juncture, and the tearing and left distortion on both sides of the closure rib at the precise end of the control lock when it is in position on the tail cone assembly further substantiate the fact that the rudder external control lock was installed on the aircraft when it crashed. (Appendix G, figures 8 through 11.)

A witness testified that he saw the elevator and rudder being moved as the aircraft taxied from the ramp. The ramp was not floodlit, it was dark and rainy, and he was almost 200 to 300 ft from the aircraft's tail when he saw the controls move. The Safety Board concludes that the physical evidence assumes a greater weight, and, therefore, the rudder control lock was installed when the aircraft taxied from the ramp.

When the right wing rotated aft and struck the empennage, it also struck the right horizontal stabilizer and forced the stabilizer down and aft. This force caused severe rearward crushing. During this sequence the inboard section of the right aileron separated from the wing, and the right aileron control lock fell from the wing.

Based on the damage to the aileron closure rib, to the upper wing panel closure rib, and to the upper wing panel in the area adjacent to the right aileron, the right aileron external control lock evidently was in position on the wing at impact. Although the wing panel and wing panel closure rib were compressed and bent heavily, there was no evidence of similar damage to the adjoining aileron closure rib. Also, since the wing panel and its closure rib did not receive any impact damage, the sturdily constructed control lock protected them from direct contact with the right wing, but transmitted the impact forces to the panel and closure rib. This contention is confirmed by the penetration of the support stringer through the wing panel closure rib and the forward bending of the outboard end of the stringer. In order for the stringer to be bent in this manner, it would have to hit a solid object. The solid object was the vertical member of the aileron control lock. (See Appendix G, figures 1 through 7.)

The conclusion that the right aileron control lock was in place is substantiated by the following: (1) The tear or gouge on the inboard top edge of the aileron closure rib, 13 ins. forward of the aileron's trailing edge, is located at a point which coincides with the forward end of the upper horizontal member of the right aileron control lock when it is installed on the wing. (See Appendix G, figure 7.) (2) The tearing and downward bending of the upper and lower skin on the outboard end of the wing panel's trailing edge stringer conforms closely in size and shape to the trailing edge area retained by the aileron control lock when it is installed on the wing. (See Appendix G, figures 5 and 6.) (3) The protrusion of a support stringer through the wing panel closure rib and a marked depression in the right aileron control lock's rug material at a point opposite the protruding stringer. (Appendix G, figures 3 and 4.) (4) The microscopic analysis of the aileron control lock's rug material disclosed that the depression in the rugging was similar in size and shape to the fracture area of the wing panel closure rib. Based on the evidence, the Safety Board concludes that the right aileron external control lock was positioned on the wing and aileron at impact.

The manner in which and the place at which the elevator lock was found affords positive proof that it was stowed in the aft baggage compartment during the flight. National Jet Services, Inc., procedures required that the copilot place the rudder lock on the aircraft and remove it before he reboards the plane. The procedure does not require that the external right aileron and elevator control locks be inserted.

In order to determine why the flightcrew failed to remove the control locks, the Safety Board examined the manner in which the stop at Evansville was conducted. Based on the time intervals involved in the stop, the entire passenger boarding and baggage loading process was probably completed within 6 to 7 mins. The testimony at the hearing disclosed that the aft cargo door was opened before the copilot got off, that it was still open when he reboarded the plane, and no one saw the copilot either approach the right wing or the empennage. Since the right aileron control lock was inserted contrary to the company's procedures, one might assume that the person who inserted this lock was not familiar with the procedure. Although the evidence does not permit an accurate explanation of how the control locks were inserted and overlooked, the timing and manner in which the stop was conducted rendered the flightcrew vulnerable to such an error.

The aircraft checklist required that the controls be exercised to assure freedom of operation before takeoff. Although the Safety Board cannot explain why this was not done, we note that this type of error in the DC-3 is not without precedence. The evidence disclosed that the aircraft can be flown with the nonoffset-type external aileron and rudder control locks installed. With these locks installed and the elevator free, the pilot had full pitch control. He could turn the aircraft through the use of differential engine power; however, if flight under these circumstances was to be achieved safely, it was vital that safe and adequate airspeeds be maintained, and this was not done.

Since the evidence indicated that the aircraft did not accelerate to the recommended airspeeds for safe operation, the aircraft's takeoff performance capabilities and the manner in which the flightcrew conducted the takeoff were analyzed. Air Indiana 216 entered runway 18 at taxiway F, the centerline of which intersects the runway 200 ft beyond the runway threshold. The pilot turned directly from the taxiway to the runway and after getting on the runway, taxied slowly forward "fishtailing" once or twice before the aircraft was properly aligned. A basic rule of thumb to estimate the distance required to line up an aircraft on a runway for takeoff is to use twice its fuselage length. The fuselage of the DC-3 is about 64 ft long; therefore, considering the manner in which the turn was executed, the takeoff roll began about 325 to 400 ft beyond the threshold of runway 18. If the takeoff had been made using optimum performance technique--engines stabilized at takeoff power before brake release--about 1,800 ft would have been required to accelerate to V_1 speed, and the aircraft would have lifted off at or slightly beyond 2,125 to 2,200 ft down runway 18. However, takeoff techniques of this type are rarely used in line operations. According to the former DC-3 project manager, if other methods of takeoff technique are used, the takeoff roll would be "normally longer .... Unless the pilot entered the runway at a very high rate ...." The evidence is conclusive that the pilot of Air Indiana 216 did not enter the runway at a high rate of speed, and that he did not use optimum takeoff performance techniques.

Air Indiana 216 was airborne when it passed in front of the Tri State Aero, Inc., line shack, 2,000 ft beyond the threshold of runway 18. If the pilot had used optimum takeoff techniques, the aircraft could not have reached V_1 speed and lifted off at or after V_1 speed, as required in the procedures. While it is not possible to fix the precise liftoff point and airspeed, the Safety Board concludes that the DC-3 lifted off prematurely and at a speed below V_1.

Because of the evidence of the premature liftoff, the elevator control system was examined for evidence of any malfunction which could have hindered aircraft control and produced this type of liftoff. The disruption of the control cables in the empennage was caused by impact forces. The examination of the damage noted on the race-track holes in the fuselage bulkhead at FS 63 disclosed no evidence to indicate that the swaged fittings impinged on the bulkhead surface and impeded the free movement of the elevator control surfaces. The gouging noted on the right side of the upper race-track hole appeared to be caused by the control cables as a result of impact forces sustained during the aircraft's breakup. The 50° angle of the gouge indicated that either the bulkhead was being displaced during the impact sequence and struck the cable at that angle, or the cable, due to the distortion and breakup of the fuselage during the impact sequence, was displaced to that angle and struck the side of the race-track hole. Although the Safety Board cannot rule out the possibility that the premature liftoff was caused by an elevator control malfunction, it concludes that there is no physical evidence to support this hypothesis.

The premature liftoff could have been caused by an improperly positioned elevator trim tab; improper wing flap setting; or the pilot could have pulled the aircraft off the ground early to counteract a sideways drift; however, the evidence leads to a different conclusion.

The aircraft's c.g. was well aft of 23 percent MAC and probably was about 26.8 percent to 27.9 percent MAC. Based on the NACA takeoff profile, elevator push forces of about 40 lbs to 50 lbs would be required to raise the tail, and push forces would have to be maintained in order to keep the aircraft on the ground until V_1 was reached. If, after the tail was raised, the forward pressure on the elevator was relaxed, the aircraft would rotate and become airborne prematurely in a tail low attitude. As it accelerated, the aircraft would continue to pitch up unless an opposing elevator input was made, and this nose-up moment would be further heightened as the aircraft climbed and the ground effect influences lessened. Unless this pitchup was arrested quickly, the aircraft would continue to pitch up and enter a nose-up, high drag flight envelope from which the aircraft could not be accelerated in level flight. The testimony of the witnesses who watched the takeoff confirms the premature liftoff and this type of trajectory. Therefore, based on the evidence, the Safety Board concludes that the premature liftoff was most probably the result of a pitchup and an early, inadvertent rotation caused by an aft c.g.

The witnesses all place the aircraft in a left bank of varying angles from 25° to 65° shortly after liftoff. With the controls locked, the bank angles described by the witnesses could have resulted only from a sustained turning or yawing moment. The Safety Board could not determine what caused the yaw and roll. The yaw and roll would increase the drag on the aircraft requiring additional nose-up correction to maintain altitude as the aircraft proceeded eastbound in a left bank. The only means of directional control was differential engine power, and any attempt to control the aircraft in this manner would decrease total available power and worsen the power versus drag relationship. The witness' statements indicate that, with one or two exceptions during the remainder of the flight, the aircraft was rarely more than 100 ft a.g.l.; it was rarely wings level; it was either climbing or descending; it was being flown at a high angle of attack; and, it was being flown at an airspeed that was at or below the power-off stall speed, but above the power-on stall speed. Power was not available to accelerate in level flight, and it was too low to descend and accelerate without crashing. The aircraft's flightpath and overall airspeed confirm the Board's conclusion that the aircraft had entered the region of reversed command.

The absence of a cockpit voice recorder made it impossible to fix the point in the flight that the captain discovered his aileron and rudder controls were locked. Probably the discovery coincided with the vital portion of the takeoff where the tail was being raised and liftoff was occurring. In addition, it probably served to mask or delay his appraisal of the increased elevator control forces required at this moment until it was too late and the aircraft was airborne. It is also possible that the identifiable emergency--the locked controls--completely occupied his attention to the point that he failed to perceive the onset of the more dangerous emergency--the continued upward pitching of his aircraft and its subsequent entry into the region of reversed command at too low an altitude to allow recovery.

The evidence disclosed that DC-3s have taken off successfully at higher gross weights and at c.g. locations which were at or beyond the rearmost limit. The captain had over 4,000 hrs in the DC-3. He had flown the aircraft under combat conditions in southeast Asia, and, therefore, he undoubtedly had operated the aircraft at takeoff weights and c.g. locations similar to these and possibly higher and further aft. His inability or failure to cope with the pitching moment created by the aft c.g. can only be attributed to the fact that he recognized the lateral control difficulties at, or just after, liftoff. Had he recognized them at any other point on the takeoff roll, he most certainly would have rejected the takeoff. The Safety Board, therefore, concludes that the effects of the external aileron and rudder control locks on their applicable control surfaces prevented the pilot from recognizing and preventing the pitchup caused by the rearward c.g., and, thus, were the major contributing factors in this accident.

3. CONCLUSIONS

3.1 Findings

1. The aircraft was certificated and maintained properly. The flightcrew were qualified to conduct the flight.

2. There was no evidence of any aircraft structure, aircraft system, or engine malfunctions before impact. Electrical power was available to the aircraft and to the captain's attitude indicator thoughout the flight.

3. The flight did not encounter the wake vortexes of the DC-9 which departed from runway 22.

4. The aircraft's c.g. was aft of that shown on the load manifest, was aft of the optimum c.g. range, and was probably within the 26.8 percent to 27.9 percent.

5. The external right aileron and rudder control locks were installed. The control locks were not discovered during the before-takeoff checklist and the control locks were in place when the aircraft crashed. The external elevator control lock was not installed and the elevator was free to travel.

6. The aircraft lifted off the ground prematurely and below V_1 speed. The early liftoff was caused by the rearward c.g.

7. The aircraft entered the flight envelope described as the region of reversed command shortly after takeoff, and remained within that envelope until it crashed.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was an attempted takeoff with the rudder and right aileron control locks installed, in combination with a rearward c.g., which resulted in the aircraft's rotating to a nose-high attitude immediately after takeoff and entering the region of reversed command from which the pilot was unable to recover. Contributing to the accident was the failure of the flightcrew to insure that the passenger baggage was loaded in accordance with the configuration contained on the load manifest. Their failure resulted in a rearward center of gravity that was aft of the optimum range, but forward of the rearmost limit.

4. RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board recommended, on May 11, 1978, that the Federal Aviation Administration:

> "Install an alerting feature on all existing and new equipment used for disseminating essential weather information in all air traffic control facilities, at positions which require timely information and at positions that are required to issue current weather information as a part of their air traffic control functions. (Class II, Priority Action) (A-78-34)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ ELWOOD T. DRIVER
Member

August 17, 1978

5. APPENDIXES

APPENDIX A

INVESTIGATION, HEARING, AND DEPOSITIONS

1. Investigation

At 2153 e.s.t. on December 13, 1977, the National Transportation Safety Board, Washington Office was notified of the accident by the Federal Aviation Administration. Parties to the accident investigation were the Federal Aviation Administration, Pratt and Whitney Division of United Technologies, Inc., and the Indiana State Police.

2. Hearing

A public hearing was held in Evansville, Indiana, from February 14 through February 16, 1978. Parties to the hearing were the Federal Aviation Administration, Professional Air Traffic Controllers Organization, National Jet Services, Inc., The University of Evansville, Aeronautics Commission of Indiana, and the McDonnell Douglas Corporation.

3. Depositions

Depositions were taken of selected witnesses in Miami, Florida, on March 22, 1978.

APPENDIX B

PERSONNEL INFORMATION

Captain Ty Van Pham

Captain Ty Van Pham, 42, was employed by National Jet Services, Inc., on October 15, 1977. He held an Airline Transport Pilot Certificate No. 586400328 with an airplane multiengine land rating (AMEL) and a type rating in DC-3 aircraft. The captain held a First Class Medical Certificate dated September 1, 1977, with the limitation requiring him to wear glasses "while exercising the privileges of his airman certificate."

Captain Pham's employment records with National Jet Services, Inc., disclosed that he had logged 9,100 flight-hours of which 4,600 hrs were DC-3 time. The National Jet Services, Inc. crew duty and flight time log disclosed that the captain had flown 47 hrs during the month of November and 27 hrs between the first and twelfth of December.

Captain Pham completed his last proficiency check flight on October 18, 1977, and his last line check flight on October 20, 1977.

First Officer Gaston Pacheco Ruiz

First Officer Gaston Pacheco Ruiz, 35, was employed by National Jet Services, Inc. on November 7, 1977. He held a Commercial Pilot Certificate No. 2024434 with airplane single and multiengine land and instrument ratings. He held a DC-3 type rating.

First Officer Ruiz held a First Class Medical Certificate dated October 28, 1977, with no limitations.

First Officer Ruiz's employment application with National Jet Services, Inc. disclosed that he had logged 1,330 flight-hours of which 80 hrs were in the DC-3. The first officer had flown 23 hrs during the first 9 days of December 1977 and had been off duty in excess of 24 hrs prior to reporting for this flight.

First Officer Ruiz completed his initial first officer check with National Jet Services, Inc. November 20, 1977. He completed line check flights on December 6, 7, and 9, 1977.

Flight Attendant Pamela A. Smith

Flight Attendant Pamela A. Smith, 24, completed initial training November 4, 1977. Her check flight was completed December 2, 1977, and she was certified as competent by the company's check stewardess on the same date. As of December 9, 1977, she had accumulated 15 hrs flight time.

APPENDIX C

AIRCRAFT INFORMATION

The aircraft was a Douglas DC-3 owned and operated by National Jet Services, Inc. The aircraft's serial number was 483F, and its registry number was N51071.

The aircraft was manufactured November 13, 1941, and had a total airframe time of 19,777 hrs. It was last overhauled on October 23, 1956, and had flown 9,500 hrs since that date.

The aircraft was powered by two Pratt and Whitney R-1830-94 engines. The total times on the engines were unknown. Takeoff rated and normal rated power for the engines were 1350 and 1100 horsepower respectively.

The left engine, serial No. P-138547, had flown about 814 hrs since overhaul (TSO); the right engine, serial no. P-145783, had flown about 534 hrs since TSO.

The engines were equipped with Hamilton Standard Propellers, Model No. 23E50-505, fitted with propeller blades of drawing No. 6565A-18. The TSO of the left propeller, serial No. P48444 was about 814 hrs, and that of the right propeller, serial No. 114847 was about 956 hrs. The total time on the propellers was unknown.

The aircraft was weighed by Rhoades Aviation, Columbus, Indiana, April 28, 1976. The empty weight of the aircraft was 18,651.5 lbs, and the empty weight moment was 4659 (4658544.25 inch pounds). The maximum allowable takeoff gross weight is 26,900 lbs, and the forward and aft center of gravity limits 11 percent to 28 percent MAC respectively.

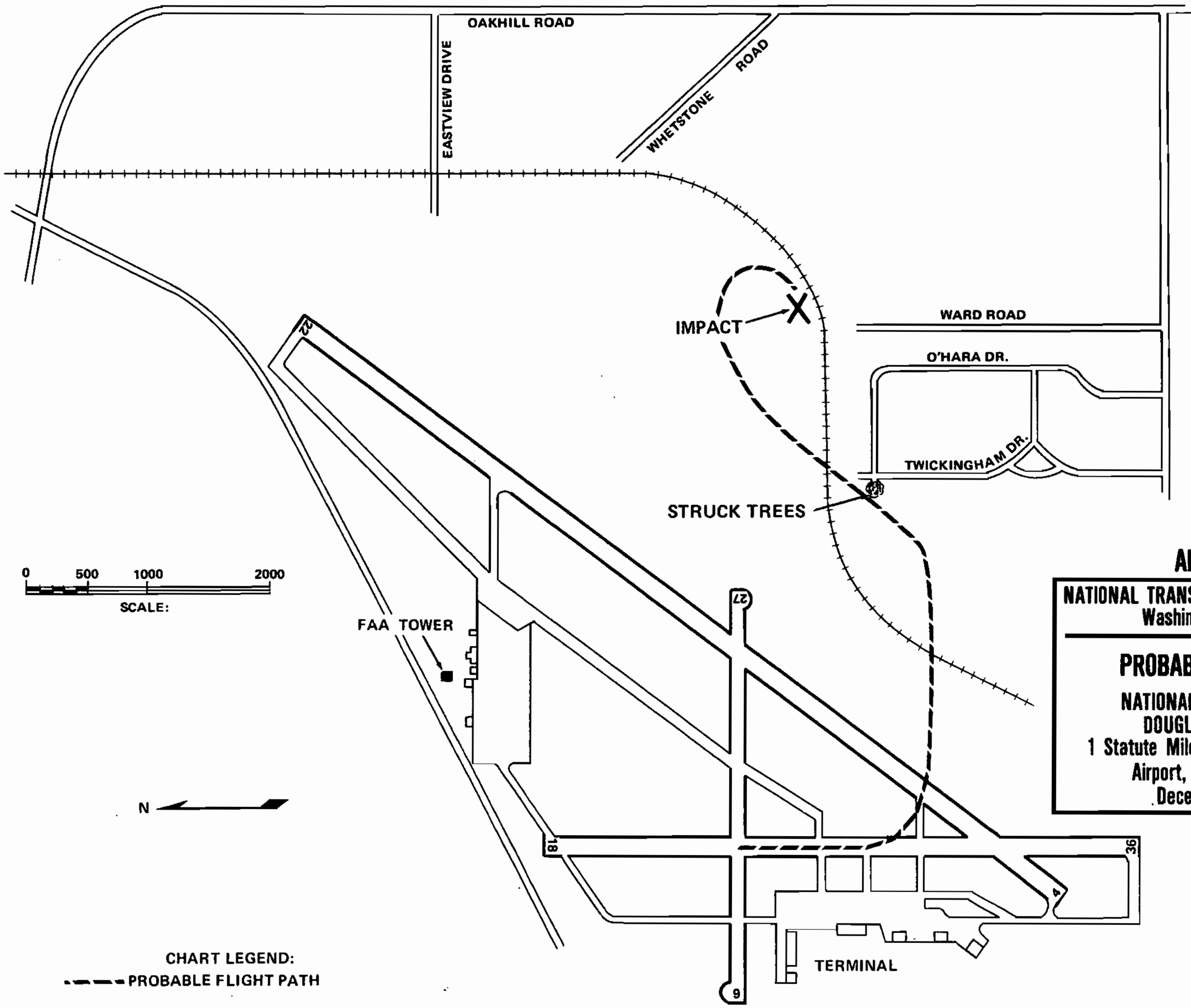
The aircraft was equipped with an Emergency Locator Transmittor (ELT). The tower controller's did not hear an ELT signal after the accident, nor was a signal detected on the tower's ATC tape recordings. At the time of the accident, 121.5 MHz was being monitored in the tower and on the speaker.

APPENDIX D

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C. 20594

PROBABLE FLIGHT PATH

NATIONAL JET SERVICES INC.
DOUGLAS DC-3 N51071
1 Statute Mile east of Dress Regional
Airport, Evansville, Indiana
December 13, 1977

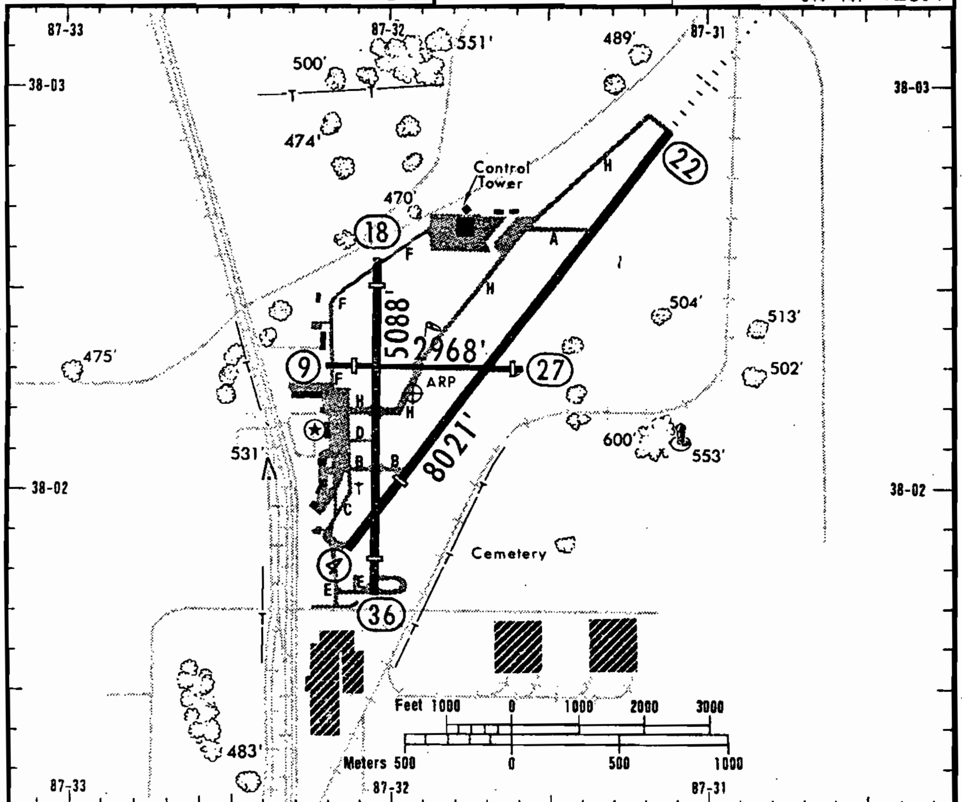


APPENDIX E

EVANSVILLE, IND.
EVANSVILLE DRESS REG'L APT.
Elev 418' N38 02.2 W087 31.9
Var 01°E EVV

(11-1) DEC 2-77 *Jeppesen Approach Chart*

ATIS 120.2	EVANSVILLE Approach (R) 126.4
EVANSVILLE Ground 121.9	Departure (R) 142°-043° 126.6
	044°-141° 126.4



ADDITIONAL RUNWAY INFORMATION

RWY		USABLE LENGTHS LANDING BEYOND Threshold	Glide Slope	TAKE-OFF	WIDTH
4	HIRL REIL VASI-L	6709'			150'
22	HIRL SSALR		7021'		
9 ❶	MIRL	2488'			100'
27		2868'			
18 ❶	MIRL	4667'			150'
36		4538'			

❶ Maximum GWT 50,000 lbs.

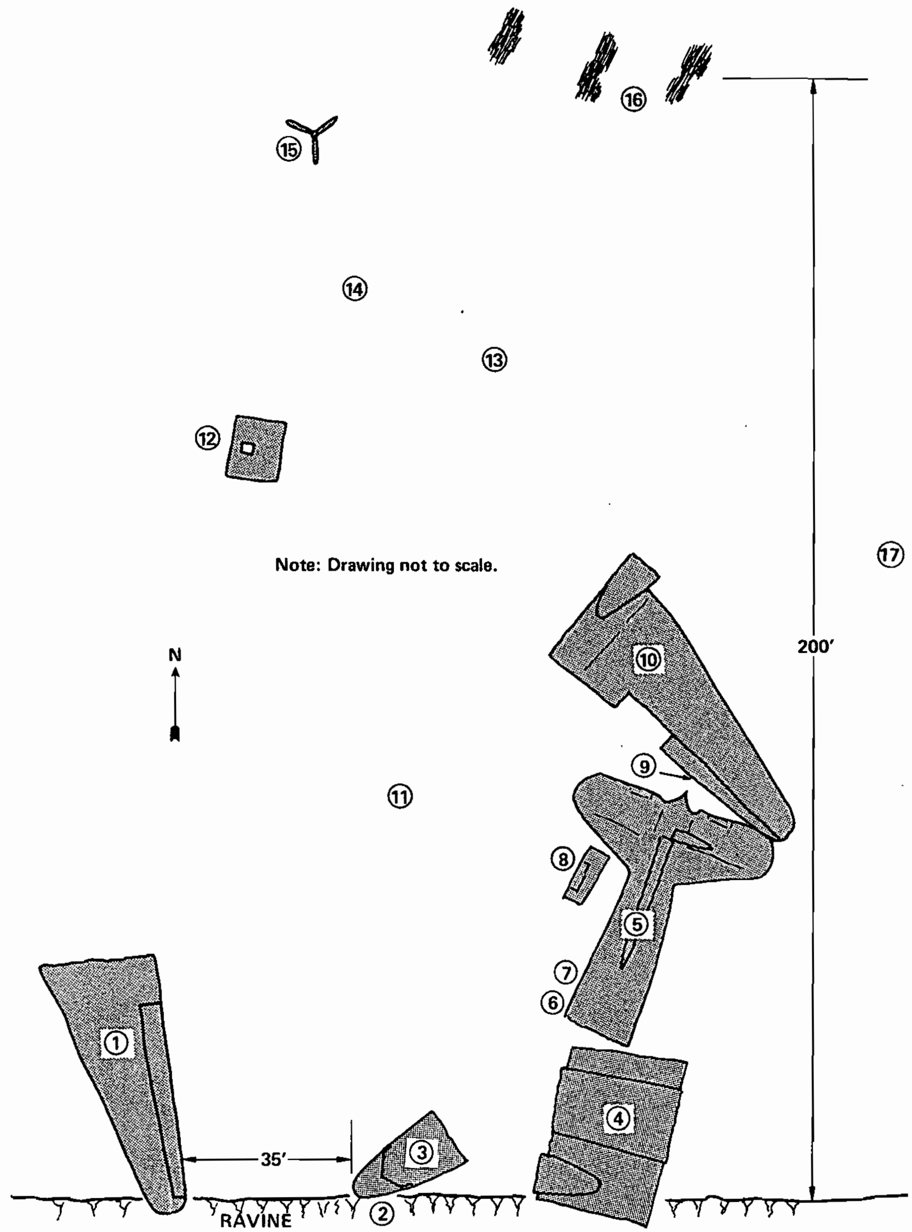
	TAKE-OFF [1] AIR CARRIER (FAR 121, 123 & 129) If Wx below Lndg Mim, T/o Altn Req.	[2] GENERAL		FOR FILING AS ALTERNATE Precision	Non-Precision
1 & 2 Eng	1/4	1	A B C D	600-2	800-2
3 & 4 Eng		1/2			

[1] Rwys 9, 27 & 36, 200 ceiling-1 required. Rwys 18 & 22, 600 ceiling-1 required or charted minimums with a minimum climb of 205' per NM to 1000'.

[2] FAR 135: Rwy 22, 1/2 mile.

AMEND 2

CHANGES: VASI-L rwy 4, landing length rwy 27.



LEGEND:

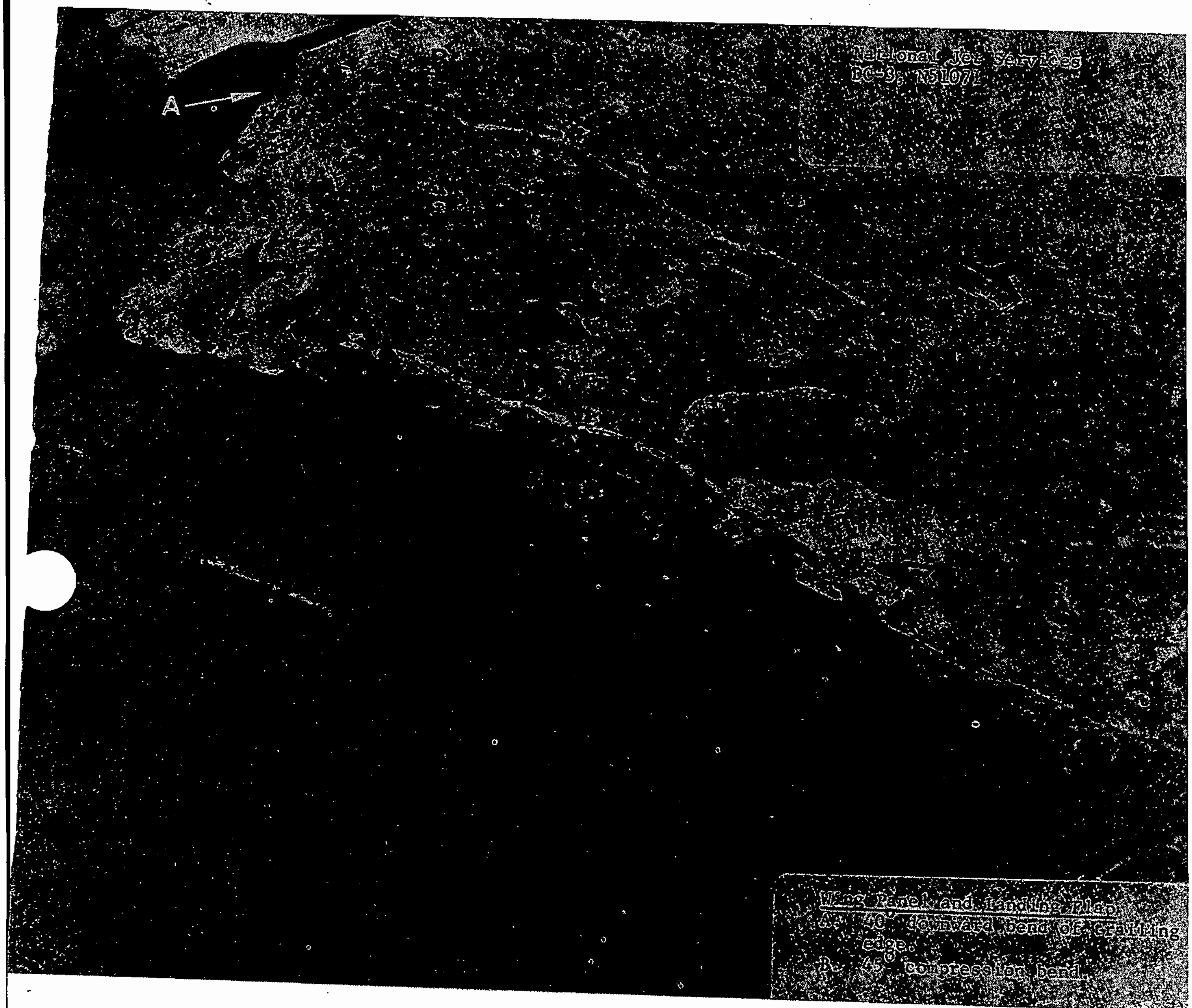
1. LEFT WING ASSEMBLY
2. LEFT ENGINE
3. COCKPIT WRECKAGE
4. WING CENTER SECTION WRECKAGE
5. AFT FUSELAGE STRUCTURE
6. RIGHT ENGINE
7. LEFT PROPELLER
8. INBOARD SECTION OF RIGHT AILERON
9. RIGHT AILERON GUST LOCK ASSEMBLY
10. RIGHT WING
11. ARM CHAIR TYPE SEAT ASSEMBLY
12. FORWARD RIGHT SECTION OF FUSELAGE WITH FIRST CABIN WINDOW
13. WING FLAP SECTION
14. ENGINE COWLING
15. RIGHT PROPELLER ASSEMBLY
16. INITIAL POINT OF GROUND IMPACT
17. RUDDER GUST LOCK ASSEMBLY

APPENDIX F

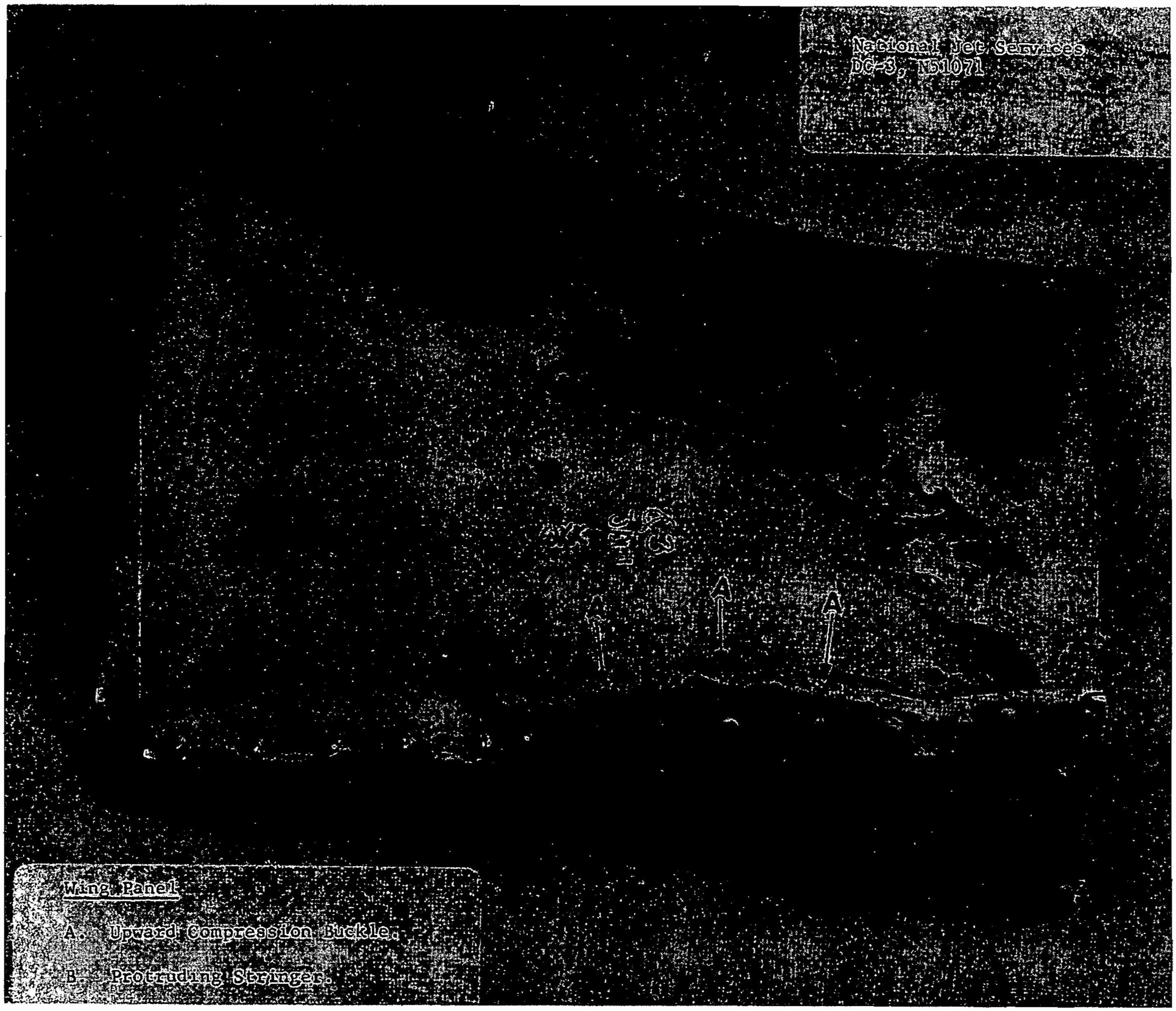
NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C.

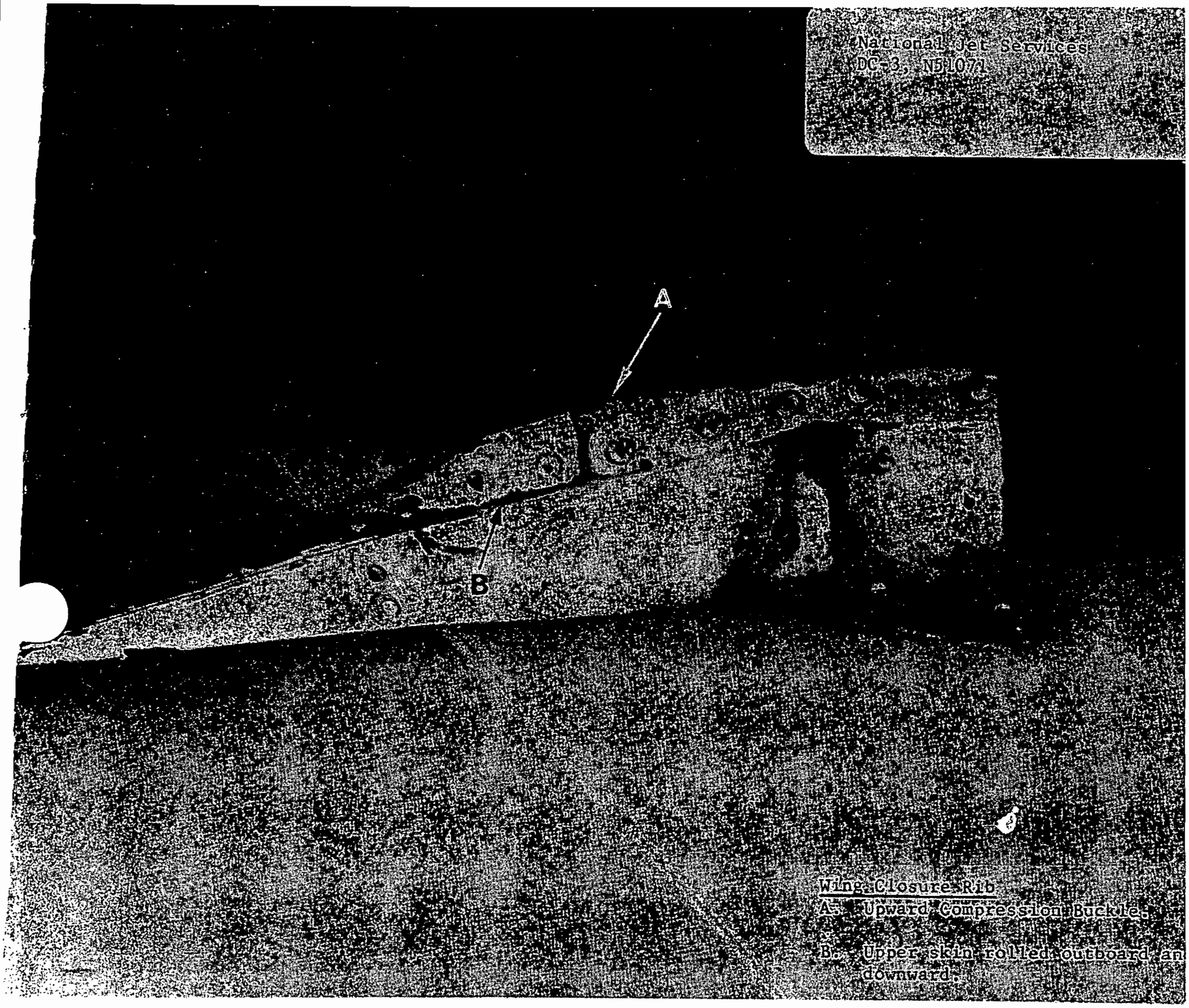
WRECKAGE DISTRIBUTION CHART
NATIONAL JET SERVICES INC. DC-3
N51071
DRESS AIRPORT
EVANSVILLE, INDIANA
DECEMBER 13, 1977
DCA 78-AA-004

APPENDIX G



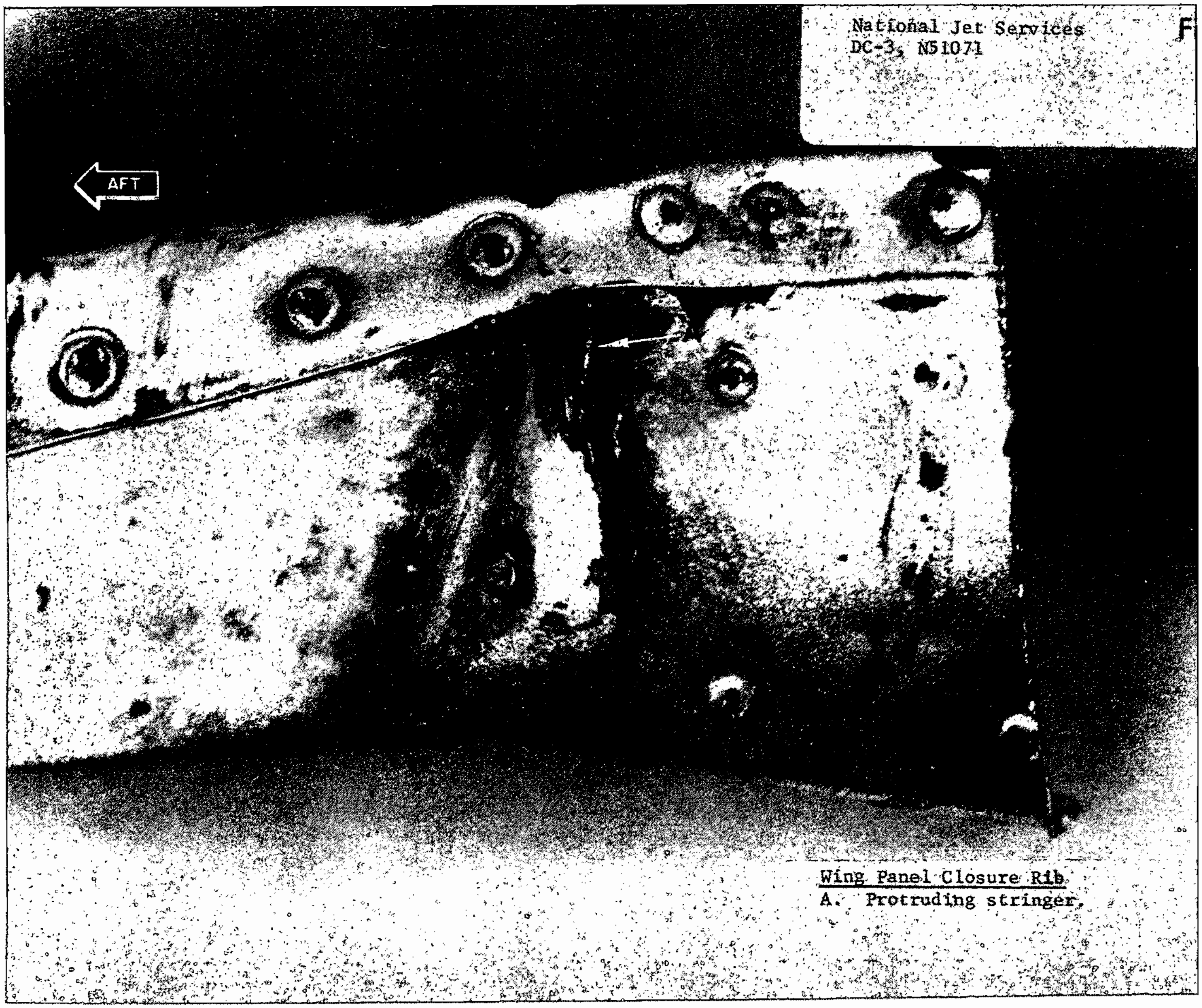
Wing Panel and landing flap
A: 40° downward bend of trailing edge.
B: 45° compression bend.


National Jet Services
DC-3, N51071
A
A
Wing Panel
A. Upward Compression Buckle.
B. Protruding Stringer.

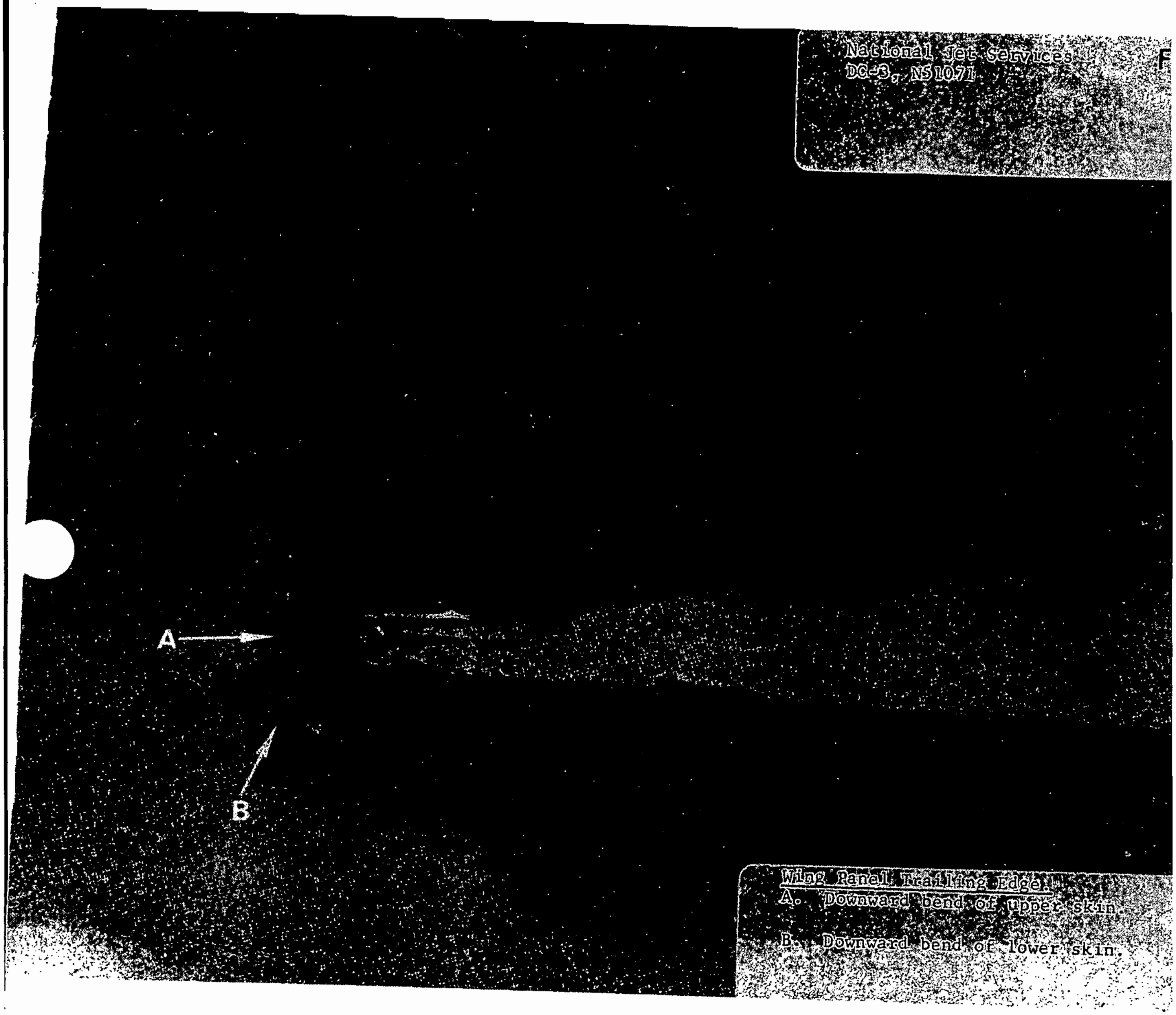


<u>Wing Closure Rib</u>
A. Upward Compression Buckle.

B. Upper skin rolled outboard an
downward.

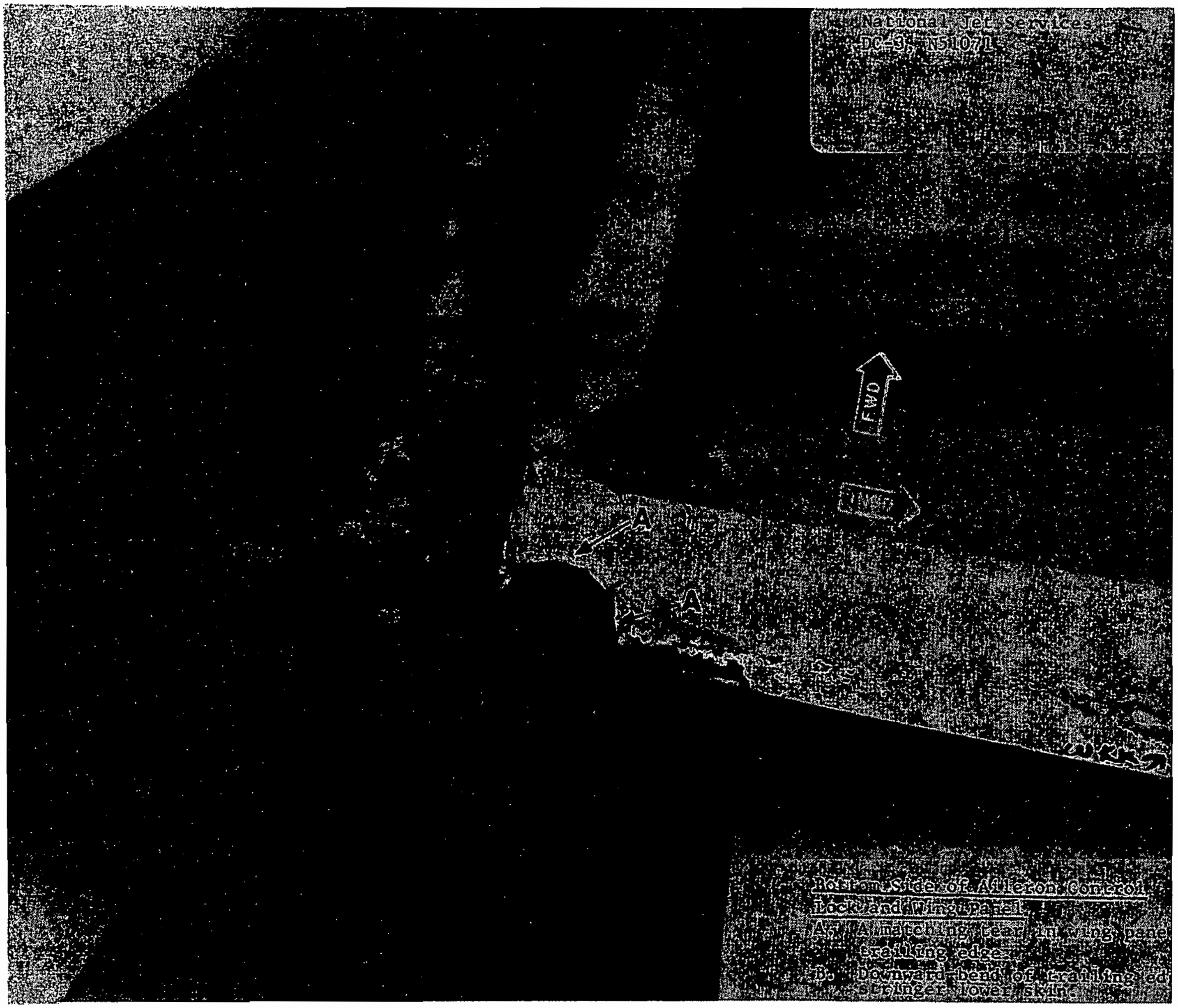


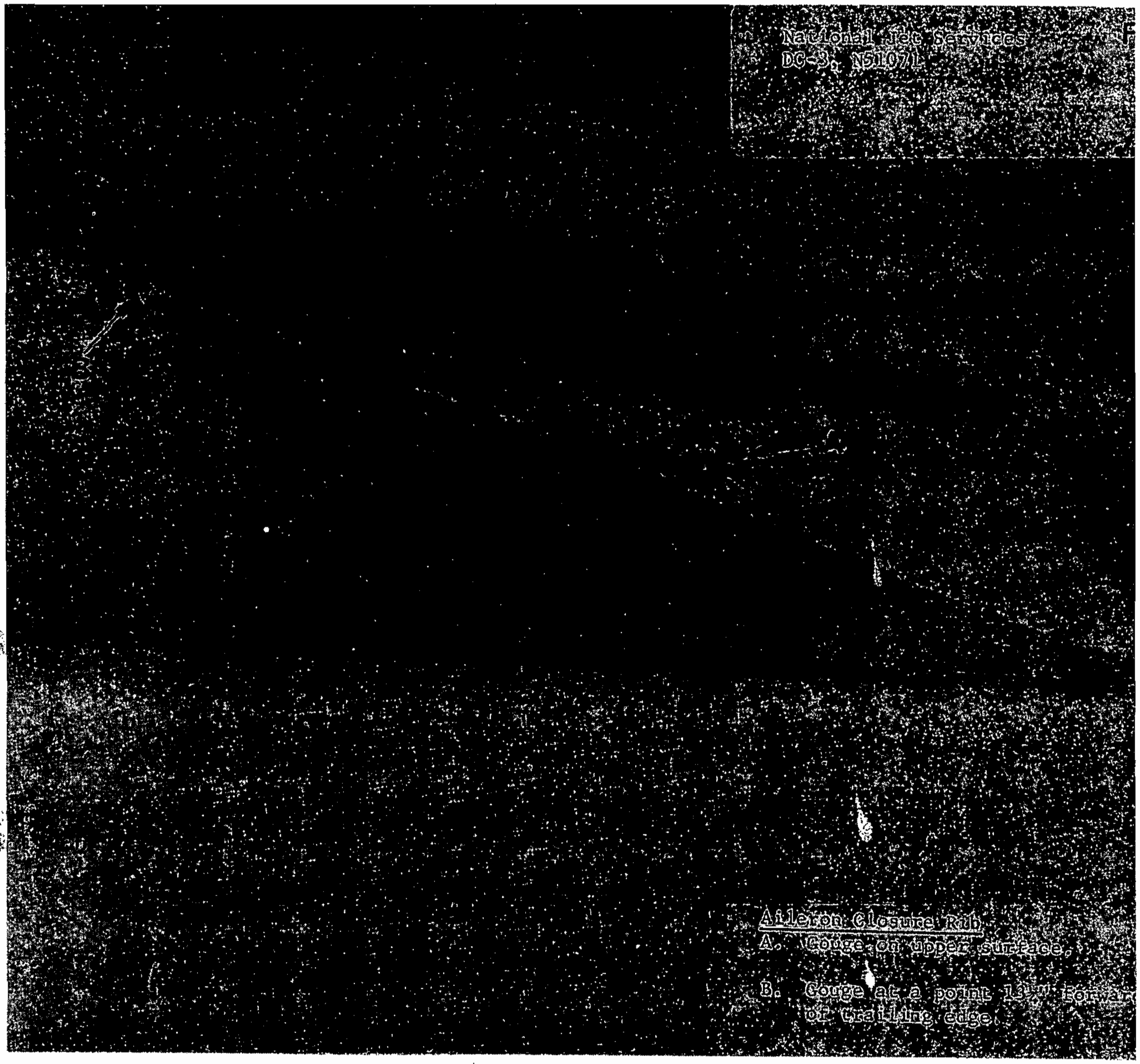
Wing Panel Closure Rib
A. Protruding stringer.

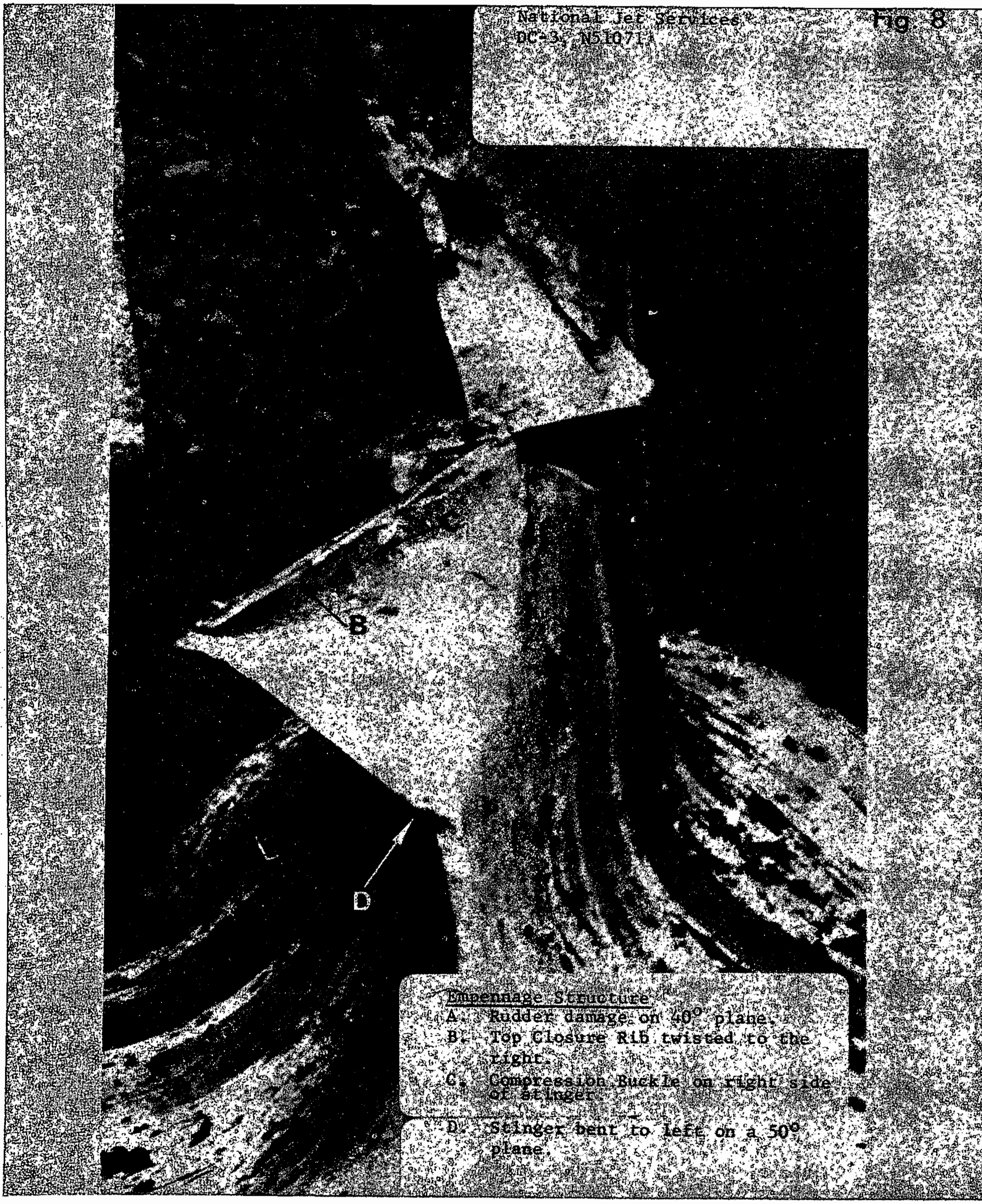


Wing Panel Trailing Edge.
A. Downward bend of upper skin.

B. Downward bend of lower skin.

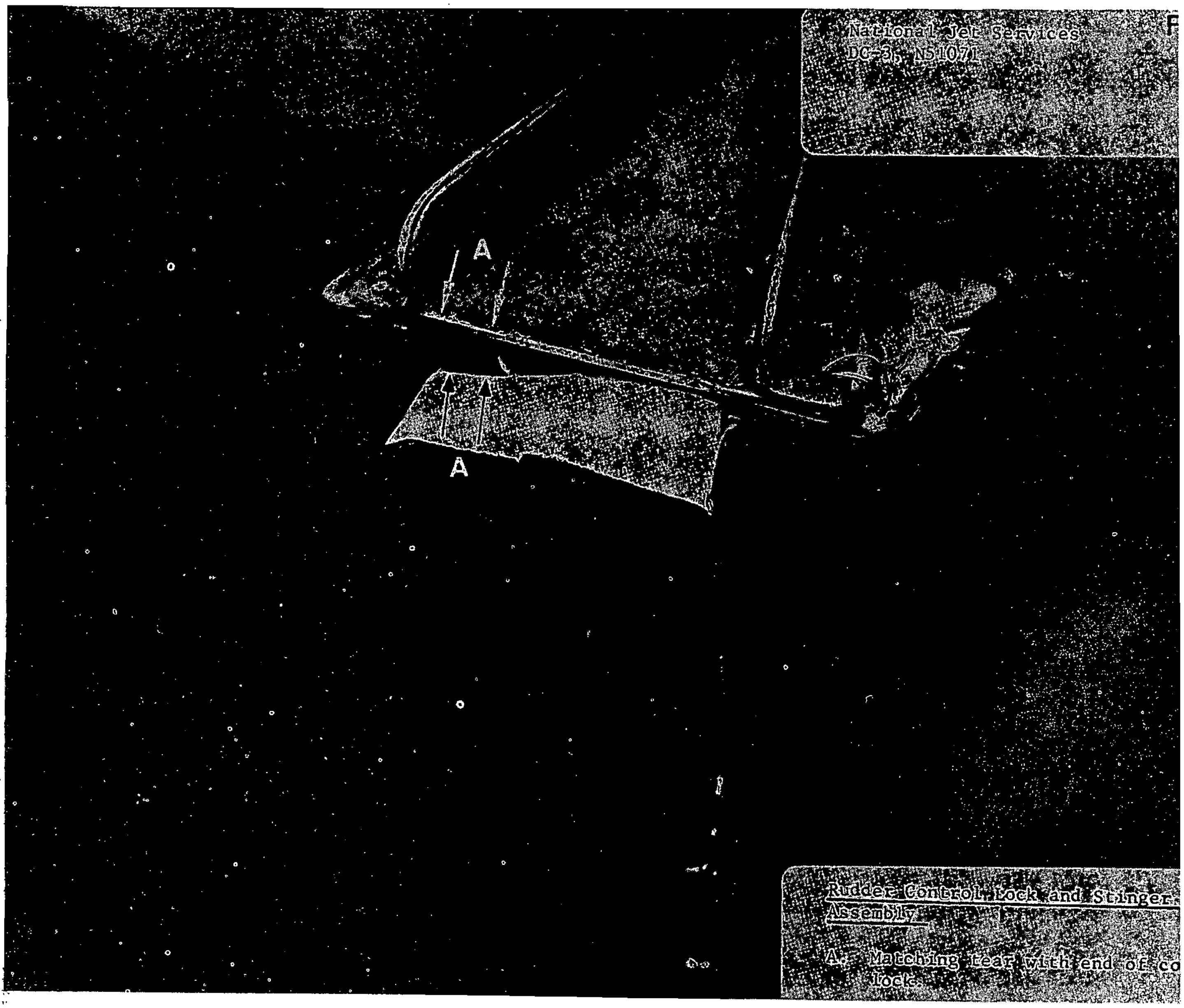

National Jet Services
DC-3, N51071
FWD
A
A
Bottom Side of Aileron Control
Lock and Wing Panel
A. A matching tear in wing pane
trailing edge.
B. Downward bend of trailing ed
stringer lower skin.

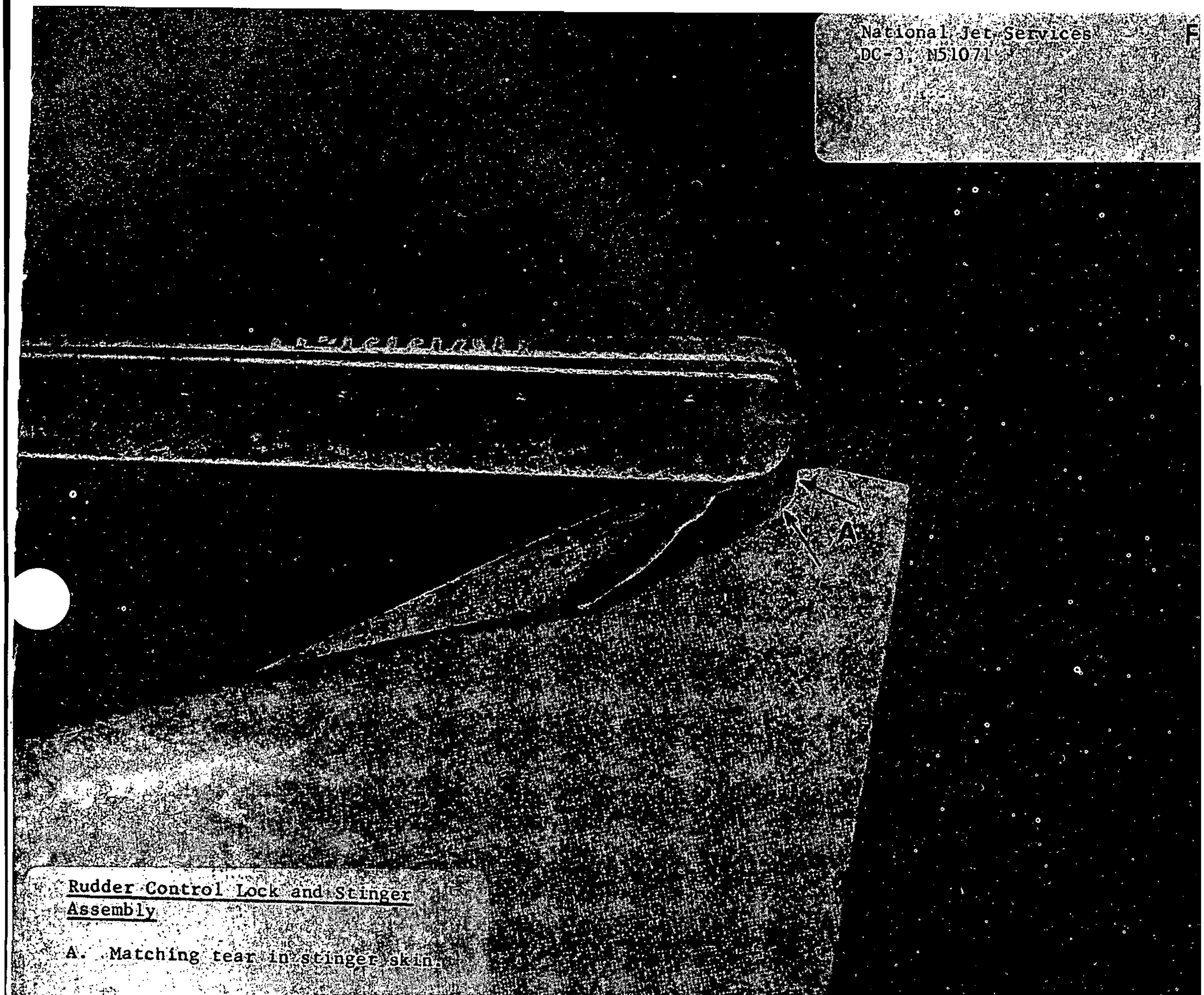

National Jet Services
DC-3, N51071
Aileron Closure Rib
A. Gouge on upper surface.
B. Gouge at a point 13" Forwar
of trailing edge.



Empennage Structure
A. Rudder damage on 40° plane.
B. Top Closure Rib twisted to the right.
C. Compression Buckle on right side of stinger
D. Stinger bent to left on a 50° plane.


National Jet Services
DC-3, N51071
C
B
Stinger Assembly
A. Right twist of top closure rib.
B. Compression Buckle.
C. Matching tear with forward end
of control lock.


National Jet Services
DC-3, N51071
A
A
Rudder Control Lock and Stinger
Assembly
A. Matching tear with end of co
lock.



Rudder Control Lock and Stinger Assembly

A. Matching tear in stinger skin.

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