NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

November 29, 1995

POWERPLANT GROUP FACTUAL REPORT

DCA-95-MA-054

A. ACCIDENT

Location:	Carrollton, Georgia
Date:	August 21, 1995
Time:	1250 Eastern Daylight Time
Airplane:	Atlantic Southeast Airlines, Embraer EMB-120, N256AS

B. POWERPLANT GROUP

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C. SUMMARY

On August 21, 1995, at about 1253 eastern daylight time, an Embraer EMB-120RT, N256AS, airplane operated by Atlantic Southeast Airlines (ASA) crashed after departing the Atlanta Hartsfield International Airport (ATL), Atlanta, Georgia. The flight was a scheduled passenger flight carrying 26 passengers and a crew of three operating under the provisions of Title 14 Code of Federal Regulations (CFR) Part 135. The flight was operating in accordance with instrument flight rules (IFR). While climbing through 18,000 feet, the flightcrew declared an emergency and initially attempted to return to Atlanta. The pilots advised they were unable to maintain altitude and were vectored toward West Georgia Regional Airport, Carrollton, Georgia, for an emergency landing. The airplane crashed while en route to Carrollton. The airplane was destroyed by impact forces and postcrash fire. The captain and seven passengers received fatal injuries.

The Powerplant Group arrived at the accident site on August 22, 1995, and examined the engines and propellers. One of the four blades on the left propeller was found fractured at approximately the 18-inch station. The fractured blade was immediately removed from the left propeller hub, and shipped to the Safety Board's, Materials Laboratory, Washington, D.C., for detailed examination.

Following the field portion of the investigation, the engines were transported to Pratt & Whitney Aircraft Services, Atlanta Georgia for disassembly and examination. The propellers were shipped to Hamilton Standard, South Windsor, Connecticut for disassembly and examination.

The examination of the turbine sections of both engines revealed that neither turbomachine had any preaccident failures or anomalies that would have prevented normal operation and that both turbomachines were operating as indicated by the uniform internal damage, rotational signatures and heat distress, and that the extent of the internal damage was greater on the right engine when compared to the left.

The examination of the propellers revealed that one blade on the left propeller incurred a transverse fracture at approximately the 18-inch station. Passengers on the accident flight reportedly heard a sound, and saw the left propeller not rotating and displaces toward the left wing. The passengers also reportedly saw a rotating shaft

protruding forward from the left engine. The outboard section of the fractured blade from the left propeller was later recovered near the flight path of the accident flight.

The examination of the right propeller did not reveal any preaccident failures or anomalies that would have prevented normal operation and that the damage and bending was characteristic of rotation at ground impact.

D. DETAILS OF THE INVESTIGATION

1.0 ENGINE DESCRIPTION

The EMB-120 airplane is powered by two Pratt & Whitney PW118 turbopropeller engines. The PW118 engine consists of a turbomachine and reduction gearbox (RGB) connected by a drive shaft and integrated structural intake case. The turbomachine is a three concentric shaft design incorporating a high and low pressure rotor (NH and NL, respectively) and a free turbine (NP) to drive the RGB. The high and low pressure rotors each have a single-stage, centrifugal-flow compressor, driven by a single-stage, axial-flow turbine. The RGB has a reduction ratio of 15.77:1 and is driven by a two-stage, axial-flow turbine. The engine is rated at 1,800 shaft horsepower at 33,300 NH rpm, or 100% rpm.

2.0 PROPELLER DESCRIPTION

The Hamilton Standard 14RF-9 is a variable pitch, double-acting, full-feathering, reversing propeller with four composite blades. The forged aluminum hub retains the blades, houses the oil transfer tube, and actuator group assembly.

Each propeller blade consists of a fiberglass airfoil filled with low density, polyurethane foam structurally bonded to an aluminum alloy spar. A nickel sheath and deice boot provides deicing and erosion protection for the fiberglass leading edge. The aluminum alloy spar incorporates a tapered bore (taper bore) in the shank for weight reduction and balance weight installation.

The initial taper bore design, known as "M" style, for the 14RF-9 blade had approximately a 3 1/2 inch diameter opening in the blade butt. The taper bore is symmetric to approximately 8 inches, and gives way to a more slender taper to about 18 inches. The later taper bore design, known as "N" style, incorporates an enlarged cavity or bellmouth, to approximately 6 inches and gives way to the same slender taper to about 18 inches. The "M" style taper bore design incorporates either a shotpeened and unshotpeened surface treatment whereas the "N" style taper bore design incorporates only the shotpeened surface treatment. Both taper bore designs are stuffed with lead wool for blade balancing; however if required, an "N" style blade may be weighted to the "M" category. A cork was inserted with sealant for lead wood retention in all blades manufactured before approximately April 1994 and subsequently eliminated. The taper bore is sealed at the butt end with a bore plug.

The 14RF-9 propeller installed on the EMB-120 is operated at the following ground, and flight propeller rpm settings:

	EMB-120
Ground range	50%-65% (650-845 NP rpm)
Climb above 12,000 feet	90% (1170 NP rpm)
Standard Cruise	85% (1,105 NP rpm)
Takeoff	100% (1,300 NP rpm)

3.0 ENGINE AND PROPELLER HISTORY

The following data were provided by Atlantic Southeast Airlines. The data documents the model numbers, serial numbers, total time and cycles for the engines and propellers:

	LEFT	STATUS	RIGHT	STATUS
Engine Model	PW118		PW118	
Engine S/N	115087		115305	
Total Time	21,538 Hrs.		15,292 Hrs.	
Total Cycles	21,432		16,300	
Propeller Model	14RF-9		14RF-9	
Blade No. 1 S/N	851653	+B	874892	ASB66 (7/27/95)
Blade No. 2 S/N	861398	PS-960	861950	+C
Blade No. 3 S/N	867601	+B	855120	
Blade No. 4 S/N	852549	ASB66 (7/27/95)	867998	+B

A blade marked PS960 indicates a repair procedure was performed in accordance with attachment "A" to 14-RF-FAA-232. The procedure was developed by Hamilton Standard and submitted to the Federal Aviation Administration (FAA) on April 8, 1994 for approval, and granted only for use by a Hamilton Standard repair station. The procedure includes a visual inspection of the taper bore, blend repair procedure and limits for mechanical damage removal, ultrasound inspection and blade marking requirements. The PS960 repair was superseded by the Hamilton Standard Component Maintenance Manual (CMM), revision 7, dated September 1, 1994.

A blade marked +B indicates that minor mechanical damage or corrosion pitting was locally blend repaired in accordance with the PS960 repair or the CMM, revision 7, shotpeened, marked and returned to service.

A blade marked +C indicates that major mechanical damage or corrosion pitting was removed by reaming in accordance with the CMM, revision 7, shotpeened, marked and returned to service.

4.0 ON-SITE INVESTIGATION

The airplane came to rest in the southwest corner of an open field. The cockpit and empennage were impact damaged, whereas the center section of fuselage was destroyed by postcrash fire. The right wing, engine, and propeller remained intact and adjacent to the wreckage. A blackened area of earth surrounded the wreckage. Ground scars extended from the main wreckage toward the east, across the field, to the southeastern edge were a path of damaged trees continued further east.

Two blades from the right propeller were retained in the hub and two blades had separated from the hub. One separated blade from the right propeller was found under the empennage within the fire burn area. The second separated blade from the right propeller was found approximately 80 feet northwest of the main wreckage, outside the fire burn area.

A portion of the left wing, nacelle, and left turbomachine was found along the wreckage path approximately 115 feet from main wreckage. The turbomachine had separated from the airframe and was laying adjacent to the nacelle with the associated wires, tubes, and cables attached. The turbomachine was inverted with the inlet facing the nacelle firewall.

The left propeller, reduction gearbox and forward section of nacelle had separated from the turbomachine and was found along the wreckage path approximately 335 feet from the main wreckage. The left propeller and RGB assembly was found resting the top of the RGB and the tips of the No. 3 and 4 propeller blades.

Left and right propeller components which included a propeller control unit, fiberglass blade fragments, blade foam, hub bearing races, blade retaining rings, and pieces of nickel sheathing were found along the wreckage path and among the damaged trees.

4.1 LEFT TURBOMACHINE

The left turbomachine was impact damaged; however, there was no heat damage to the exterior. The turbomachine was uniformly coated with an oily liquid, dirt, and organic debris. Fluid lines, bleed air ducting, wiring and cables were attached. The engine electronic control, torque signal conditioner, propeller control unit (PCU), and hydraulic pump were fractured from their respective mounting pad and recovered separately. The remaining airframe and engine-related controls and accessories were in place with impact damage.

The RGB was separated from the turbomachine at the inlet case and input drive housing. The forward housing and propeller shaft were intact. The rear housing was fractured. The RGB accessory drive cover was fractured on the right hand side.

The rear inlet case and accessory gearbox were fractured at approximately the 9 o'clock[1] position which separated the RGB scavenge oil filter housing and exposed the oil pump gearing and oil pump drive shaft. The RGB scavenge oil filter was retrieved from the wreckage path. The oil tank was fractured at approximately the 6 o'clock position.

The low pressure diffuser case pipes were deformed. The gas generator case, turbine support case, and exhaust case appeared undamaged.

The reduction gearbox scavenge chip detector had collected ferrous debris. The collected ferrous particles were greater in size and number than expected during a routine chip detector inspection. The RGB scavenge oil filter, which separated from the case, was contaminated with dirt and organic debris and was not examined. The main chip detector, main oil filter, and the fuel pump outlet filter were free of debris.

4.2 LEFT PROPELLER

The left propeller remained attached to the RGB output shaft flange. The outer surfaces of the propeller blades, spinner and bulkhead were coated with an oily liquid and dirt. The No. 1, 3, and 4 blades and a portion of the No. 2 blade were retained in the propeller hub.

The spinner and bulkhead were impact damaged. The spinner had an approximately 1¾ inch wide and 9 inch long circular dent extending from the nose toward the trailing edge, between the No. 1 and 2 blade. The spinner was removed to access the No. 2 blade retention hardware. None of the spinner retention screws

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[1]All positional references are in relation to view from aft looking forward.

were loose or missing. The spinner bulkhead was damaged. The magnetic sensor exciter to the propeller synchronizer was fractured at the mounting point. A small piece of the magnetic sensor exciter bracket was retained under the retention screw.

The propeller transfer tube was installed and extending out through the actuator yoke tail shaft. The tube was bent and the exposed section was fractured immediately aft of the splined section. The transfer tube end that normally extends aft of the splined section and interfaces with the propeller control unit was not located.

The interior of the propeller hub was visible through the No. 2 propeller blade socket following removal of the No. 2 blade. The propeller actuator yoke was fractured aft of the rear yoke ear flange. The axial position of the actuator yoke was measured through the No. 2 blade socket. The distance from the rear yoke aft face to the retaining bolt torque plate was approximately 3/4 to 1 inch for derived blade angle of approximately 69 to 61 degrees. For this yoke position, 1/8 inch of axial yoke movement is equal to approximately 4 degrees of blade angle change.

4.2.1 PROPELLER BLADE NO. 1

The No. 1 blade did not appear deformed; however, there was impact damage to the fiberglass and nickel sheath on the leading and trailing edges.

4.2.2 PROPELLER BLADE NO. 2

The remaining portion of the No. 2 blade was fractured transversely at approximately the 18-inch station or 7 to 8 inches radially outboard from the root of the fiberglass airfoil section. The trailing edge of the remaining portion of blade was fractured at approximately a 45-degree angle from the spar trailing edge to the root trailing edge. The leading edge of the remaining section of propeller blade appeared undamaged except immediately adjacent to the fracture plane.

The spar fracture surface was flat and was covered with a thin layer of dirt. Visual inspection of the blade spar fracture surface revealed two distinct areas of surface roughness where approximately 2/3 was relatively smooth and 1/3 was relatively rough. The rougher 1/3 of the blade spar fracture surface was on the camber side of the blade.

The blade taper bore was "M" style and exhibited circumferential, and parallel scratches on the inner diameter. The circumferential scratches extended for approximately 180 degrees, centered on the face side of the taper bore. An adhesive-like material was visible inside the taper bore which formed a ring around the inner diameter approximately 1/4 inch inboard of the fracture surface.

The remaining portion of the No. 2 blade was removed. The blade retention bolts, blade heater leads were intact and securely fastened. The blade retaining ring, blade seal, seal spacer, support ring, bearing balls with retainer, inner bearing race, outer bearing race, outer bearing race retainer were intact and appeared undamaged. The pitch change pin and bearing were intact and undamaged. The remaining portion of the No. 2 blade was shipped to the Safety Board's Materials Laboratory, Washington, D.C. for detailed examination. The separated portion of the No. 2 blade was not recovered from the accident site but was subsequently recovered at a remote site by a local resident.

4.2.3 PROPELLER BLADE NO. 3

The No. 3 blade was cocked relative to the hub with the blade seal displaced, and the blade retention hardware damaged. The blade retaining ring was fractured at the through bolts and was loose on the blade shank. The blade shank was damaged. An oily liquid was found around the No. 3 propeller blade, hub socket and on the forward face of the spinner bulkhead. The No. 3 propeller blade was bent 17 inches inboard of the tip, approximately 45 degrees, flat-wise, toward the camber side. The rear section of airfoil from the spar to the trailing edge and from the tip inboard to approximately 20 inches separated with the remaining length of trailing edge split.

4.2.4 PROPELLER BLADE NO. 4

The No. 4 propeller blade did not appear deformed; however, the blade had nicks and gouges with leading and trailing edge damage. The No. 4 blade was labeled "852549" and twice with "ASB66" and dated respectively.

4.2.5 PROPELLER CONTROL UNIT

The PCU which separated from the RGB mount pad, was nicked and gouged on the outer surface. The feather solenoid was fractured and separated at the mounting flange. The ballscrew was found extended approximately 2.5 inches from the drive gear surface. The ballscrew end of the PCU where the transfer tube enters was clogged with dirt. The identification plate was attached with part number 782490-12 and serial number 900273 inscribed on the plate. The PCU power and condition levers were fractured at their respective mechanical linkage connection.

4.3 RIGHT TURBOMACHINE

The engine was impact damaged with no external fire damage. The engine was found with the propeller, propeller control unit, airframe related generators, oil lines, bleed air ducting, and miscellaneous airframe related components attached. The engine related controls and accessories were in place and intact.

The input housing of the reduction gearbox was fractured around the entire circumference and the reduction gearbox was held in place by the engine mounts, external lines and linkages. The front inlet case, rear inlet case/accessory gearbox, low pressure diffuser case, gas generator case, and turbine support case appeared undamaged.

The main chip detector, RGB scavenge chip detector, and RGB scavenge oil filter displayed fine ferrous debris. The main oil filter appeared free of debris and the fuel pump outlet filter was clean.

4.4 RIGHT PROPELLER

The right propeller, remained attached to the RGB output shaft flange. Propeller blades No. 1 and 4 were retained within the propeller hub assembly. Propeller blades No. 2 and 3 were separated from the right propeller hub assembly. The No. 2 blade was found under the empennage, and the No. 3 blade was found approximately 80 feet northwest of the main wreckage.

The right spinner, and bulkhead remained attached to the propeller. The right spinner was scratched, buckled, dented and torn around the No. 2 and 3 blade sockets. The bulkhead and electrical contact rings were intact. The electrical connectors to both the brush block and the magnetic sensor were attached. The magnetic sensor exciter for propeller "Synchrophasing" was intact and the magnetic sensor was attached to the brush black mounting bracket. The deice contact brush housing was attached to the mounting bracket but the mounting bracket separated from gear case at the attachment bolts.

The interior of the right propeller hub was visible through the No. 2 and 3 blade sockets. The No. 2 and 3 blade sockets to the right propeller hub were gouged from the inner-most edge of the socket to the outer surface of the hub. The pitch change actuator yoke was fractured. The blade retention hardware for the No. 1 and 4 blades was fractured with the fragments of the retention hardware missing. The distance from the forward yoke ear wear plate aft face to the retaining bolt torque plate was approximately 4.25 inches for a derived blade angle of approximately 32 degrees.

4.4.1 PROPELLER BLADE NO. 1

The No. 1 blade was bent (large radius) approximately 45 degrees, opposite the direction of rotation. The blade fiberglass airfoil was cracked, fragmented and coated in dirt. The blade spar remained intact along its length to the lightning strap. The lightning strap was separated. The fiberglass airfoil was fractured at about mid-span, from the leading to trailing edge at approximately a 45 degree angle. Most of the fiberglass airfoil material with missing outboard of the mid-span fracture line.

4.4.2 PROPELLER BLADE NO. 2

The blade shank had spherical indentations and gouges around the outer diameter obliterating the part number; however, serial number 861950 was readable. The fiberglass airfoil was destroyed by postcrash fire. The blade pitch change pin and bearing were attached. The blade inner race was missing; however, a piece of the inner bearing race was found along the wreckage path.

4.4.3 PROPELLER BLADE NO. 3

The No. 3 blade had separated from the right propeller hub. Most of the fiberglass airfoil was missing. The blade spar was bent opposite the direction of rotation with the lightning strap curled approximately 180 degrees at the tip. The blade pitch change pin and bearing were attached and the inner bearing race was on the blade shank.

4.4.4 PROPELLER BLADE NO. 4

The No. 4 blade was bent (large radius) approximately 45 degrees, opposite the direction of rotation. The blade fiberglass airfoil was cracked, fragmented and coated in dirt. The blade spar remained intact along its length to the lightning strap. The lightning strap was separated. The fiberglass airfoil was fractured at about mid-span, from the leading to trailing edge at approximately a 90 degree angle. All of the fiberglass airfoil material with missing outboard of the mid-span fracture line.

4.4.5 PROPELLER CONTROL UNIT

The right propeller control unit in place on the RGB, with the mechanical linkage and electrical connectors remained attached.

5.0 ENGINE TEARDOWN

The Powerplant Group disassembled and examined the turbine sections of both turbomachines on August 25, 1995, at Pratt & Whitney Aircraft Services, Atlanta Georgia. Following the disassembly and examination, the Group returned the engines to the operator. The propellers were not disassembled. The propellers were boxed and shipped to Hamilton Standard, South Windsor, Connecticut for disassembly and examination. The teardown of the left and right propellers are reported under separate cover.

5.1 LEFT ENGINE

5.1.1 RGB, ACCESSORY GEARBOX, ACCESSORIES

The RGB was not disassembled. The RGB was separated from the front inlet case at the input drive housing. The forward housing was intact; however, the rear housing was fractured around the lower circumference exposing the left hand helical gear and the No. 10 and 11 bearings. The gear teeth on the left hand helical gear were circumferentially gouged. The right hand helical and pinion gear were not in the RGB; however they were recovered. The No. 13 bearing seat had static imprint marks consistent with the profile of the pinion gear teeth. The other visible gearing and bearings appeared undamaged by the event. The RGB output shaft rotated freely smoothly and continuously when rotated by hand. The accessory gearbox was not disassembled. The accessory gearbox gearing rotated smoothly and continuously with rotation of the high pressure rotor. The engine related controls and accessories were not removed.

5.1.2 FIRST AND SECOND STAGE POWER TURBINE

The second stage power turbine disc, blades, vane, shrouds and abradable airseal were intact. The downstream[2] side of the second stage disc had circumferential rubbing and scoring to the inner rim of the blade platforms. The exhaust duct inner cone outer rim also had circumferential rubbing and scoring. The second stage vane airfoils displayed metallic splatter. The second stage blade tip shrouds had circumferential scoring. The second stage power turbine shroud also displayed circumferential scoring. The abradable airseal displayed circumferential scoring. The airseal rotor knife edges also displayed circumferential scoring.

The first stage power turbine disc, blades, vane ring and airfoils were intact. The first stage blade tip shroud upstream edges had circumferential rubbing. The first stage shroud also displayed circumferential scoring. The first stage vane ring downstream side also had circumferential rubbing. The first stage blade and vane airfoils displayed metallic splatter. The abradable airseal displayed circumferential scoring. The airseal rotor knife edges also had circumferential scoring.

The No. 6 and 7 bearings appeared undamaged by the event. The airseal stators displayed circumferential scoring. The airseal rotor knife edges also displayed circumferential scoring.

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[2] Upstream and downstream references are in relation to gas path flow from the compressor inlet to exhaust.

5.1.3 LOW PRESSURE TURBINE AND COMPRESSOR

The low pressure turbine disc, blades and vanes were intact. The low pressure turbine blade leading edges and vane trailing edges displayed metallic splatter. The low pressure rotor turned freely by hand. Blackened organic debris adhered to the outer span, pressure side of the vane airfoils.

The low pressure impeller was not removed and was observed through the compressor inlet. The compressor inlet and impeller were coated with organic debris. The low pressure impeller blade leading edges were circumferentially nicked and gouged up to 1/3 inches deep. The blade tips were randomly deformed opposite the direction of rotation. The impeller shroud also had circumferential scoring.

5.1.4 HIGH PRESSURE TURBINE

The high pressure turbine disc and blades were intact The high pressure turbine blade tips displayed circumferential rubbing. The high pressure turbine shroud also displayed circumferential rubbing. The high pressure turbine blade and vane airfoil trailing edges displayed metallic splatter. The high pressure turbine vane ring and shroud were not removed. The high pressure rotor turned freely by hand.

The high pressure compressor impeller was not examined.

5.2 RIGHT ENGINE

5.2.1 RGB, ACCESSORY GEARBOX, ACCESSORIES

The RGB was not disassembled. The input housing was fractured around the circumference. The RGB output shaft could not be rotated by hand. The accessory gearbox was not disassembled. The accessory gearbox gearing rotated smoothly and continuously with rotation of the high pressure rotor. The engine related controls and accessories were not removed.

5.2.2 FIRST AND SECOND STAGE POWER TURBINE

The upstream side of the second stage power turbine disc outer rim displayed circumferential rubbing, with frictional heat discoloration and material smearing. The second stage power turbine blades were fractured at varying heights from the root to approximately 1/4 span. The second stage blade leading edges displayed circumferential machining up to approximately 3/16 inches deep. The second stage power turbine vane ring inner drum also displayed circumferential rubbing and machining. The vane airfoils displayed gouges and circumferential machining.

The first and second stage power turbine shrouds were obliterated. The interstage baffle was deformed and separated from the vane ring inner drum . The baffle upstream and downstream faces displayed circumferential rubbing and scoring, with frictional heat discoloration. The abradable airseal displayed circumferential machining and frictional heat discoloration. The airseal rotor knife edges also displayed circumferential machining and heat discoloration.

The first stage power turbine blades were fractured adjacent to the blade roots. The disc downstream side displayed circumferential rubbing, with frictional heat discoloration. The first stage vane ring separated from the integral No. 6 and 7 bearing housing when removed. The first stage vane airfoil pressure sides had metallic splatter. The airfoil trailing edges were gouged and fractured up to approximately 1/3 inch deep.

The No. 6 and 7 bearing appeared undamaged by the event. The airseal stators displayed circumferential scoring, with frictional heat discoloration. The airseal rotor knife edges also displayed circumferential scoring and frictional heat discoloration.

5.2.3 LOW PRESSURE TURBINE AND COMPRESSOR

The downstream side of the low pressure turbine disc outer rim displayed circumferential rubbing and scoring. The low pressure turbine blades were fractured at approximately 1/3 to 1/2 span, and displayed burning and erosion to the blades and blade coating. The low pressure turbine vane ring also displayed circumferential rubbing and scoring. The low pressure rotor could not be rotated by hand. The low pressure turbine vane airfoils displayed severe burning and fracturing. The shroud was coated with metallic splatter.

The low pressure impeller was not remove but observed through the compressor inlet. The impeller blade leading edges were circumferentially nicked and gouged up to approximately 1/8 inch deep. The low pressure compressor shroud also displayed circumferential scoring.

5.2.4 HIGH PRESSURE TURBINE

The high pressure turbine was not removed. The high pressure turbine blades were fractured adjacent to blade roots, and displayed burning and heat erosion to the blades and blade coating. The high pressure rotor could not be rotated by hand. The high pressure turbine vane airfoils were burned and fractured.

6.0 PROPELLER TEARDOWN

The Powerplant Group reconvened on September 15, 1995, at United Technologies, Hamilton Standard, Windsor Locks, Connecticut, where the left and right propellers were disassembled and examined. The left propeller assembly was placed on a table in the "as received" condition and the blade angles were measured at the 42-inch station with a protractor.

6.1 LEFT PROPELLER

The bulkhead was removed. An oily liquid was found between the bulkhead and hub flange. The break-away torque of the four bulkhead attachment bolts when viewed clockwise, aft looking forward from the No. 1 blade, were 20 pound-inches, 30 pound-inches, 30 pound-inches and 20 pound-inches, respectively. The torque according to the 14RF-9 Component Maintenance Manual should be 50 to 65 pound-inches.

The 24 bulkhead-mounted propeller balance screws were in place, with eight screws retaining balance washers. The maximum structural limits of 72 grams per screw and 576 grams per propeller not to exceed eight screws, may be used for balancing according to the Hamilton Standard Service Bulletin 14RF-9-61-13. The location and number of balance washers per bulkhead screw when viewed clockwise, aft looking forward from the No. 1 blade, were as follows:

SCREW	WASHERS
3	10
4	10
5	10
6	5
7	7
20	8
21	12
23	4

The actuator (P/N 790202, S/N 900614) and pitch change yoke were in place; however, the aft shank of the pitch change yoke was fractured through 360 degrees immediately aft of the aft yoke ears. The distance from the forward surface of the torque plate to a point on the aft surface of the yoke, midway between the yoke ears, was measured through the hub bores and was found between 1 1/32 inches and 1 3/32 inches. The eight yoke ear wear plates, four anti-torque arms, and eight phenolic anti-rotation inserts were in place. The aft end (feather stop) of the pitch lock screw (acme screw) was measured at 1 5/8 inches from the aft nut face.

The oil transfer tube (P/N 814782-1, S/N 3A), forward of the splined end fracture, end plug and seal, and cotter pin appeared to be undamaged. The oil transfer tube o-rings, and back-up rings also appeared to be undamaged.

6.1.1 PROPELLER BLADE NO. 1

The blade angle at the 42-inch station as measured by protractor was 53 degrees. The blade retention hardware for the No. 1 propeller blade was in place with the heater boot electrical connections intact. The blade and butt plug were removed. The inner and outer bearing races were intact with spherical imprints. The taper bore was "M" style with a shotpeened surface finish with no observable scratches or gouges. A lead wool plug was visible at the bottom of the taper bore.

The pitch change pin on the blade butt and its associated retention hardware were intact. The raised pad on the butt end, where the pitch change pin was mounted, had a rectangular imprint tangential to the pitch change pin roller. The tangent of the pitch change pin, formed by the long side of rectangular imprint, relative to the tangent of the taper bore opening, formed by the edge of the raised pad, was 116.5 degrees. The blade angle at the 42-inch station, associated with the formation of the imprint, as reported by Hamilton Standard was approximately 63.5 degrees.

6.1.2 PROPELLER BLADE NO. 2

The No. 2 propeller blade was not examined at the propeller teardown as it had been removed for detailed examination at the Safety Board's Materials Laboratory.

6.1.3 PROPELLER BLADE NO. 3

The blade angle at the 42-inch station was not measured by protractor. The No. 3 blade was not removed from the hub; however, the blade butt plug was removed. The heater boot electrical connection was intact. The taper bore was "N" style with a shotpeened surface finish with no observable scratches or gouges. A lead wool plug was loose in the taper bore.

The pitch change pin on the blade butt and its associated retention hardware were intact. The raised pad on the butt end, where the pitch change pin is mounted, had a curved imprints around the pitch change pin. Tangent lines to the curved imprints around the pitch change pin relative to the tangent of the taper bore opening, formed by the edge of the raised pad, was from 113 to 133 degrees. The blade angles at the 42-inch station, associated with the formation of the imprints, as reported by Hamilton Standard was approximately 60 to 80 degrees.

6.1.4 PROPELLER BLADE NO. 4

The blade angle at the 42-inch station as measured by protractor was 53.3 degrees. The blade retention hardware for the No. 4 propeller blade was in place with the heater boot electrical connections intact. The blade and butt plug were removed. The inner and outer bearing races were intact with spherical imprints. The taper bore was "M" style with a smooth surface finish with observable scratches and gouges. A lead plug was visible at the bottom of the taper bore.

The pitch change pin on the blade butt and its associated retention hardware were intact. The raised pad on the butt end, where the pitch change pin was mounted, was smooth.

6.2 RIGHT PROPELLER

The actuator, pitch change yoke, and aft shank of the pitch change yoke were in place; however, the pitch change yoke was fractured through 360 degrees aft of the forward yoke ears. Fragments of the aft yoke ears were loose in the hub. The forward end of the aft shank of the pitch change yoke was also fractured through 360 degrees. The No. 1 hub bore was deformed.

6.2.1 PROPELLER BLADE NO. 1

The No. 1 blade was not removed; however, the blade butt plug was removed. The inner and outer bearing races had spherical imprints. The taper bore was "N" style with a smooth surface finish with observable scratches and gouges. A cork was visible inside the taper bore. The pitch change pin on the blade butt and its associated retention hardware were intact.

6.2.2 PROPELLER BLADE NO. 2

Blade, S/N 861950, was in the No. 2 blade position as reported by ASA. The blade and butt plug were removed. The taper bore was "M" style with a shotpeened surface finish with no observable scratches or gouges. A lead wool plug was loose in the taper bore. The pitch change pin on the blade butt and its associated retention hardware were intact. The raised pad on the butt end, where the pitch change pin was mounted, was smooth. The pitch change pin on the blade butt and its associated retention hardware were intact.

6.2.3 PROPELLER BLADE NO. 3

Blade, S/N 855120, was in the No. 3 blade position as reported by ASA. The blade and butt plug were removed. The taper bore was "M" style with a shotpeened surface finish with observable scratches and gouges. A lead plug was visible at the bottom of the taper bore. The pitch change pin on the blade butt and its associated retention hardware were intact.

6.2.4 PROPELLER BLADE NO. 4

The No. 4 blade and butt plug were removed. The taper bore was "N" style with a shotpeened surface finish with no observable scratches or gouges. A lead wool plug was loose in the taper bore. The pitch change pin on the blade butt and its associated retention hardware were intact.

6.3 PROPELLER CONTROL UNITS

6.3.1 LEFT ENGINE PCU

The left engine PCU (P/N 782490-12, S/N 900273) was marked with the part number suffix "P7-P8/P10-P15", which indicates, as reported by ASA and Hamilton Standard that the part was manufactured as a P/N 782490-12 P7 and subsequently modified in accordance with the Hamilton Standard Service Bulletin 14RF-9-61-39, -43, -51, and -60 respectively.

The dirt packed in the ballscrew end of the PCU was removed exposing the splined end of the oil transfer tube. The forward end of the splined end of the oil transfer tube was fractured. The splines did not appear to be damaged.

6.3.2 RIGHT ENGINE PCU

The right engine PCU (P/N 782490-12, S/N 851235) was marked with the part number suffix "-7P4/P6/-12P2/P4-5/P8/P10-P14", which reportedly indicates the PCU was initially a part number 782490-7, and subsequently modified in accordance with the Hamilton Standard Service Bulletin 14RF-9-61- 4, and -5, and subsequently altered to a part number 782490-12, and subsequently modified in accordance with the Hamilton Standard Service Bulletin 14RF-9-61-26, -32, -39, -43, and -51 respectively.

The extension of the ball screw from the nut to the end of the quill was measured at found to be 1 13/16 inches. The ball screw extension reportedly is consistent with an approximate blade angle of 22.62 degrees.

[redacted]

Jerome D. Frechette
Powerplant Group Chairman