ACCIDENT

Aircraft Type and Registration:	Beech 76 Duchess, G-BMJT
No & Type of Engines:	2 Lycoming (LO/O)-360-A1G6D piston engines
Category:	1.3
Year of Manufacture:	1981
Date & Time (UTC):	10 April 2005 at 1649 hrs
Location:	Adjacent to Belfast City Airport, Northern Ireland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Flying Experience:	Approximately 3,000 hours (of which approximately 2,400 were on type) Last 90 days - Not known Last 28 days - Not known
Information Source:	AAIB Field Investigation

Summary

The aircraft took off from Belfast (City) Airport and the landing gear was retracted. Witnesses heard a sound similar to that of a reduction in engine power and shortly afterwards the aircraft turned to the left. It failed to gain any further height, struck some trees and crashed into a sports field, coming to rest against a substantial steel mesh fence. There was an immediate fire. The pilot escaped from the aircraft unassisted but suffered severe burns.

Maintenance activity prior to the flight to Belfast City

The aircraft was based at Ronaldsway Airport, Isle of Man. At some time prior to 8 April 2005 the pilot had become aware of an increase in the oil temperature of the left engine. He had contacted his maintenance organisation to discuss the defect and during this discussion it appears that the maintenance organisation suggested that the 'vernotherm' (a thermostat valve in the engine oil system) be replaced as an initial rectification action. A replacement valve was dispatched to allow the pilot to make arrangements to have the unit replaced locally.

The pilot arranged for an engineer to replace the valve during the afternoon of 10 April 2005. During the latter part of that morning the pilot contacted another engineer to discuss the problem and was advised that prior to replacing the valve it would be advisable for some simple inspections of the oil system be carried out to identify any obvious defects.

The first engineer met with the pilot at the aircraft to carry out the replacement of the valve. The oil cooler, piping and wiring were inspected for obvious defects; none were identified. The engineer then requested that the pilot run both engines in order to verify the readings observed by the pilot. The engines were run for approximately 20 minutes, slightly above idle rpm, although the actual rpm was not recorded nor were the relative positions of the throttles noted. During this period it was observed that although the left engine oil temperature was within the green band, half way between the 200º mark and the limit of the green band, it was considerably higher than the right, which had not yet reached the 200º mark. During this time the left engine oil pressure was observed to fluctuate for approximately 10 seconds before stabilising at a level comparable with the right engine. The left engine cylinder head temperature (CHT) was also observed to be higher than the right and the left fuel pressure gauge was reading off scale and the right fuel pressure gauge showed no reading.

After replacing the vernotherm a second ground run of the left engine was conducted. The engineer reported that the oil temperature, whilst still slightly higher than the right engine, now indicated below 200º. No fluctuation of oil pressure was observed during the second run; however, the fuel pressure remained off scale. An inspection of the engine was carried out after the run to verify that there were no leaks, and the aircraft was returned to its hangar. The variations in CHT and fuel pressure readings were brought to the attention of the pilot who confirmed that he was already aware of them; he has reported that the instruments were unreliable and difficult to maintain, although he had made efforts to correct these deficiencies.

History of flight

Following the completion of the maintenance activity the pilot arranged to carry out a short flight since he intended to fly the aircraft to France on 11 April 2005. A family friend had planned to travel to Belfast by ferry but he offered to fly her there instead, a flight of 20 to 30 minutes. She accepted the offer and the aircraft departed from the Isle of Man on the afternoon of 10 April 2005, and landed on Runway 22 at Belfast City Airport at 1614 hrs. The passenger subsequently reported that the flight had been uneventful.

The pilot and his passenger left the aircraft, which was parked on the ramp area and were taken to the terminal; the passenger then left the airport. The pilot paid the landing fees and returned in a minibus to his aircraft; also on the bus was the pilot of a Piper Chieftain. There was some general conversation between them before the pilot was dropped off at G-BMJT. The ground handling agent later removed the chocks from G-BMJT and checked that the pilot was able to start the engines unassisted, as he had been called away to another task.

The pilot requested start clearance at 1640 hrs. The Chieftain pilot, who was carrying out a pre-flight inspection of his own aircraft, watched the engines of G-BMJT start and reported that there had not been any apparent problem. At 1642 hrs the pilot requested taxi clearance and was given clearance to the holding position for Runway 22.

At 1645 hrs ATC passed an airways clearance to the pilot and asked if he was ready for departure; there was a gap in the traffic movements which would allow an opportunity for the aircraft to backtrack and depart. The pilot confirmed that he was ready and was given a clearance to enter, backtrack and line up Runway 22. ATC then gave him a local clearance to climb on runway track to an altitude of 1,500 ft before turning left on track.

At 1647 hrs G-BMJT was given take-off clearance and the pilot was advised that there was landing traffic at ten miles. The tower controller watched G-BMJT get airborne and then gave the inbound aircraft clearance to land. After becoming airborne the landing gear of G-BMJT was retracted. The controller's attention was drawn back to G-BMJT by a change in engine note, which he described as the sound of an engine running down. He looked up from his position in the tower and saw the aircraft airborne immediately in front of him. At around this time there was a brief radio transmission, believed to be from G-BMJT, which was blocked by the landing aircraft reading back his clearance. As the controller watched, the aircraft started to turn left, eventually through some 90 degrees, and passed around the side of the tower. He made a radio call to the pilot who he could see sitting up in the cockpit, but there was no response. The aircraft started to descend and he saw the wings level briefly before it crashed into trees and then dropped into a field. An immediate fire started on ground impact and he alerted the emergency and security services.

The aircraft had come to rest against a fence and the pilot was able to escape unassisted although he suffered severe burns in the post impact fire. Bystanders were able to assist him once he was clear of the aircraft and helped him to a safe area.

The tower controller contacted the Airport Fire Service (AFS) on a radiotelephony link and gave authorisation for a full deployment. The fire vehicles exited the airport through a security gate and, although the accident site was very close, had to travel several miles by road to reach it; the first vehicle arrived at the scene six minutes after the accident. The other emergency services were also alerted and arrived at the scene after a similar time.

Pilot information

The pilot obtained his Private Pilot's Licence in 1982. He purchased this aircraft in 1995 and had flown in excess of 2,000 hrs in it. He had completed his annual refresher training and flight tests on the aircraft.

The pilot was interviewed four months after the date of the accident while he was still in hospital. His recollection of the accident and the events leading up to it was understandably vague. He described experiencing an event immediately after lift off in which there was a bright flash after which he felt that he was temporarily blinded. He did however recollect sensing that the aircraft had asymmetric power following this event. His impression was that the aircraft was in flight for a period of time, perhaps reaching a height of 700 ft, but that he became aware that he was going to crash and aimed for a field.

Meteorological information

The synoptic situation around the time of the accident showed a weak warm sector covering Northern Ireland with a westerly airflow. Belfast (City) Airport departure information 'Romeo', valid at 1620 hrs and listened to by the pilot prior to departure, reported: surface wind from 260º at 13 kt, visibility 30 km, a few clouds at 2,500 ft, temperature 13ºC, dewpoint 5ºC and pressure 1025 hPa.

Aircraft information

The aircraft was a Beech Duchesses BE76 twin engine aircraft, constructed on 30 October 1980. It had originally been registered as ZS-KMI. It was transferred to the UK register on 4 December 1985 as G-BMJT, and had operated for a total of 2,582 hours to

21 February 2005 when the log books were last brought up to date. The aircraft was powered by two Lycoming O-360-A1G6D engines with opposite rotating Hartzell HC-M2YR-2CEUF constant-speed, fully-feathering propellers, which had been installed on the aircraft during manufacture. The aircraft had been owned and operated by the pilot since it had been transferred to the UK register.

The total useable fuel was 380 litres (100 USG). The landing gear takes about ten seconds to retract and approximately eight seconds to extend.

Performance

The aircraft is certificated in performance Category E; there is thus no requirement for positive climb performance to necessarily be available following a loss of one engine on takeoff. An engine failure or power loss soon after takeoff is a difficult situation to manage in a relatively small, low performance, twin engine aircraft such as this. The time at which a failure occurs and is recognised is critical, and at a low height the time available for decision making and taking action is short.

The minimum control speed in flight (V_{MCA}) for the aircraft is 65 kt, the stall speed at full power and 0º flap is around 70 kt, the recommended lift off speed is 71 kt with a 50 ft take-off speed of 80 kt, and the best rate of climb single engine speed (V_{YSE}) is 85 kt. The aircraft has a maximum take-off weight of 3,900 lbs (1,769 kg) and the estimated take-off weight for the accident flight was 3,400 lbs (1,545 kg).

At the estimated take-off weight the takeoff ground roll was calculated as 700 ft (215 m) and the take-off distance to 50 ft was 1,400 ft (425 m). The distance from the start of the runway to abeam the ATC tower is 3,800 ft (1,160 m). With an engine failure after takeoff at this weight, and with all the necessary immediate actions taken, a slight positive climb should just have been achievable.

Maintenance History

The airframe, engine and propeller logbooks confirmed that the aircraft had been maintained in accordance with CAP 411 (Light Aircraft Maintenance Schedule) by a single maintenance organisation since its transfer of registry, and that all of the required airframe maintenance had been carried out within the required time scales. The last inspection, an annual inspection, was completed on 3 March 2005 when the aircraft hours recorded were 2,582 hrs.

The engines fitted to the Beechcraft Duchess are subject to a 2,000 hour recommended overhaul life which, with the approval of the CAA, can be extended, provided that the continued satisfactory performance of the engines can be demonstrated. The CAA had approved an extension to the recommended overhaul life of the two engines fitted to this aircraft allowing their continued operation.

Both propellers had been overhauled and zero lifed in March 2001. The right hand propeller was removed again in July 2002 for rectification of an oil leak. By 21 February 2005, when the log books were last updated, the propellers had each accumulated 610 hours since overhaul.

A review of the correspondence between the owner and the maintenance organisation showed the owner to be extremely fastidious regarding the aircraft's maintenance requirements and defect rectification.

Airport information

Runway 22 at Belfast City Airport has a Take-Off Run Available (TORA) of 5,797 ft (1,767 m) and a width of

200 ft (61 m). The airport is located in a part industrial, part residential area with expanses of open water to the north and west. Immediately to the south of the airport is a recreation area with sports fields.

Once the AFS had left the airport there was no fire cover until they returned. The airport was declared closed and a NOTAM was issued. The one aircraft on short final approach already cleared to land was allowed to continue; four other inbound aircraft subsequently diverted to their alternate airfields. The airport reopened at 1839 hrs.

Recorded information

Recordings of the communications between the aircraft and ATC were available for the investigation. There was a single brief transmission from G-BMJT after takeoff which was blocked by a transmission from another aircraft. There were also two subsequent brief carrier wave only transmissions which may have been from G-BMJT. There was not enough information in these transmissions to allow an analysis of the engine/ propeller noise.

Wreckage and impact information

Accident Site

The aircraft had come to rest on an approximate heading of 040°M in the boundary hedge of a football field. The hedge was approximately three metres high and within the hedge was a substantial steel framed fence. Immediately in front of the fence was a railing designed to separate spectators from the field, through which the aircraft had passed before hitting the hedge. The railings were constructed of steel tubing similar to scaffolding poles. The aircraft's passage through these obstacles disrupted the airframe resulting in an intense post crash fire. Due to the location of the crash site, by the time the AFS were able to control the fire a significant portion of the aircraft had been destroyed. The fire destroyed the left wing, the outboard section of the right wing and the majority of the aircraft fuselage with the exception of the empennage.

Examination of the accident site showed that the aircraft had flown through a line of trees on the opposite side of the field, approximately 75 m from its resting point, in a wings level attitude at a height of approximately 15 m. In passing through the tree line the aircraft had removed a significant number of branches from the trees which were carried into the football field, a large number of these were found to be broken into approximately 35 cm lengths. Due to their relatively uniform size it is probable that these branches were broken by the action of a normally rotating propeller. Ground marks showed that the aircraft first made contact with the ground approximately 55 m from the tree line in a slightly nose down attitude and banked slightly to the right, the initial point of contact being the right wing tip followed by the right engine and propeller. These marks also indicate that the right propeller was turning at impact. The aircraft finally came to rest in the hedge approximately 20 m from the first point of impact. The left aileron was lying approximately 20 m from the tree line, together with portions of the left wing tip. Scoring made by the flap hinges indicated that the aircraft was on a heading of approximately 124ºM when the airframe made contact with the ground. Further ground marks indicate that the right engine and its propeller made a significant impact with the ground six metres from the initial impact mark; it is probable that the right propeller separated from the engine at this point. The scoring produced by the flap hinges indicate that after this impact the aircraft began to turn to the right. When the aircraft hit the spectator rail the aircraft rotated rapidly to the right swinging the left wing through the railing and hedge.

The left wing had been substantially destroyed by fire; the remaining structure consisted primarily of the spar and undercarriage. The position of the left engine and propeller relative to the remaining wing structure indicated that these were attached to the wing when the aircraft came to rest. The left propeller was found in the feathered position, with the spinner cap detached and wedged under the lower engine cowling. The left propeller appeared to have little rotational damage and this, together with the witness marks found on the blades, indicate that the left propeller had little or no rotation as the aircraft passed through the tree line and hit the ground.

The right wing had been destroyed outboard of the engine nacelle, with only the wing spar and control cables present. A three foot section of the right wing tip was found propped against the remains of the rear fuselage. It was not possible to confirm if this had been placed in this position by some person or as a result of the crash. The right aileron was detached from the right wing. It was sooted, but did not show signs of being subjected to the post crash fire indicating that it was not attached to the wing when the aircraft came to rest. The proximity of the aileron to the main wreckage and the sooting indicate that the aileron had separated from the wing after the aircraft had hit the ground. The inner wing, engine nacelle and engine were complete; however the right propeller had separated from the engine and was lying one metre forward of the engine, in the feathered position. The ground marks and damage to the right propeller blades indicate that the propeller was rotating normally as the aircraft passed through the tree line and when the aircraft hit the ground.

The aircraft's nose and cockpit sections had been subject to intense heat which had led to the destruction of the structure. The undercarriage appeared to be in the retracted position. The flaps had been heavily damaged which prevented confirmation of their position during the crash. Due to the fire damage no estimation of the position of the cockpit controls could be made on site. The instrument panel had been destroyed and the remains of the aircraft instrumentation had been subjected to significant heat damage. The integrity of the aircraft control cables was verified as far as was possible prior to recovering the aircraft to the AAIB.

Detailed examination of the wreckage

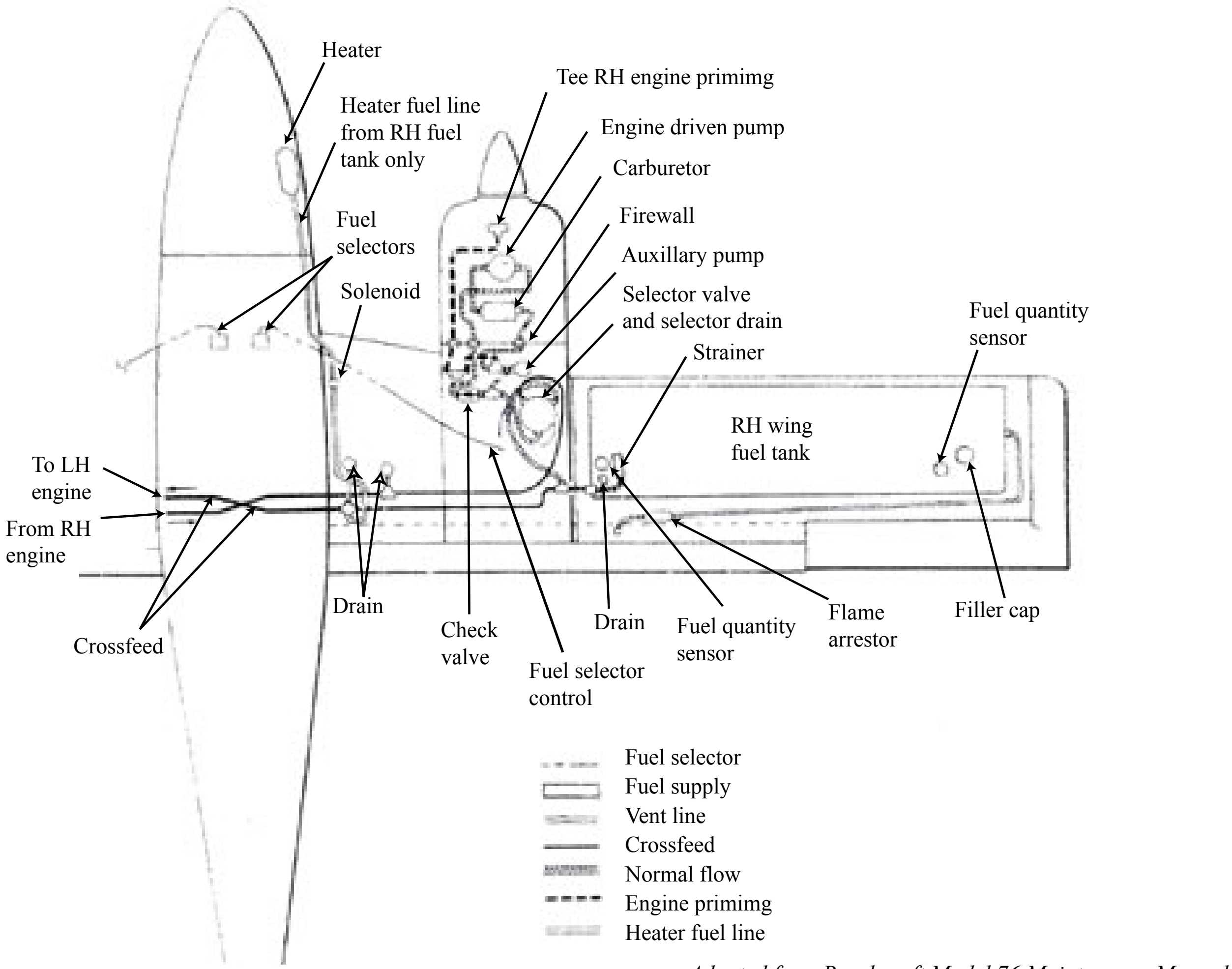
Based on the initial witness statements the investigation primarily focused on the engines, propellers, fuel system and associated controls. The intensity of the post crash fire had destroyed a significant portion of cockpit including most of the instrumentation; control levers and supporting structure. Detailed examination of the remaining aircraft instrumentation failed to identify any readings which may have been attributable to the aircraft's attitude, airspeed or engine condition immediately prior to impact.

Controls

The continuity of the aircraft flight and engine control cables was verified. The flap actuator was recovered, measurement of the exposed thread confirmed that the flaps were fully retracted at the time of impact. During the examination of the wreckage, two pairs of control levers were found attached to the remains of their hinge points and cables. These were identified as being the left and right engine carburettor heat and cowl flap controls. Both pairs showed a relative displacement between the left and right engine controls. The orientation of this displacement indicated that the cowl flap of the left engine was selected towards the CLOSED position relative to the right engine and that the left engine carburettor heat was selected towards the ON position relative to the right engine. The remaining engine control cables, throttle, mixture and propeller, were located, but due to the destruction of the associated levers and hinges no estimation of their position immediately prior to impact could be made. Measurement of the distance between the remaining cable rod ends and their locating clamps showed that these control cables had the same relative displacement, indicating that both the left and right engine had been selected to similar settings prior to impact.

Fuel System

The aircraft was fitted with a 51.5 gallon fuel tank in each wing. Each engine is equipped with a fuel selector valve which is located aft of the engine firewall in the engine nacelles. This selector has three positions which are selectable from the cockpit, ON, CROSSFEED and OFF (see Figure 1). In the ON position the selector allows the engine to consume fuel from the fuel tank in the same wing, in the CROSSFEED position the fuel flow from the same wing is closed and fuel flows from the opposite wing tank via cross feed pipes. In the OFF position, both the cross feed and the normal fuel supplies are closed. During take off both fuel selector valves would normally be selected to the ON position. If the aircraft experienced an engine failure after take off then the Emergency Check List requires that the fuel selector for the inoperative engine is selected to the OFF position.



Adapted from Beechcraft Model 76 Maintenance Manual

Figure 1

Fuel System Schematic

Examination of the remains of the fuel selector levers located on the cockpit floor showed that both levers were in the CROSSFEED position. There was a significant witness mark in the left fuel lever track at the CROSSFEED position which was likely to have been made by the fuel lever during the impact sequence; the left fuel lever was jammed in this position. The right fuel lever remained free to move and had not left any identifiable witness marks in its track and therefore its selected position at impact could not be confirmed.

Due to fire damage the aircraft fuel system could not be fully reconstructed; however, both the left and right fuel selectors were recovered and examined. The right engine selector remained within the engine nacelle together with its associated pipe work. When removed the valve was found to be in the ON position with the remains of the melted fuel filter bowl preventing any further movement of the valve plate. The left engine fuel selector was attached to the remains of the left wing by the selector cable, its locating structure having been destroyed in the fire. The valve was found to be in the CROSSFEED position; the remains of the fuel filter bowl prevented any movement of the valve plate.

Right Engine

Due to the post crash fire both the carburettor and dual magneto on each engine had been substantially destroyed and no tests to verify any pre-existing defect with these units could be carried out. The forward end of the crankshaft had broken during the impact sequence allowing the right propeller and starter gear to separate from the engine. The engine cylinder heads were removed and no abnormalities were observed in the cylinder bores, pistons, connecting rods or crankshaft. The crankshaft could not be rotated by hand due to fire damage to the forward crankshaft oil seal and the accessory gear train which had not been removed.

The engine oil cooler and the remaining pipes were examined; the cooler matrix was intact and no blockages or obstructions were found within it. No pre-crash defects could be identified in the remains of the oil feed and return pipes.

Left engine

As with the right engine, the post crash fire had severely damaged the engine's dual magneto and carburettor which prevented meaningful examination or testing. It was possible to confirm that the common drive shaft of the dual magneto was intact, making a failure of both magnetos themselves unlikely. The carburettor venturi was unobstructed and the throttle valve was in place, and had probably been functional at impact. Fuel supply to the carburettor is from two supply pipes, one for the engine driven mechanical pump and one for the electric pump, and both of these supply pipes were connected, although the pipes themselves were burned. The float chamber into which they fed was holed and burned, precluding any meaningful examination. The engine driven fuel pump was also burned, however the mechanical drive to the diaphragm was intact.

A significant quantity of oil was drained from the engine prior to disassembly; this oil showed little sign of thermal distress. The oil filter was disassembled and although the paper element had charred in the fire, there was no evidence of metallic debris or other particles within the element. The engine oil pump could not be turned by hand, further disassembly of the pump showed that one of the gear elements was partially seized in its bearing. The input drive spline and gear elements showed no evidence that the pump had failed in operation. It was concluded that the condition of the pump was as a result of the impact sequence and subsequent fire. Removal of the valve gear covers showed all of the valves, rockers and push rods to be in place and undamaged. Examination of the cylinder heads and pistons revealed no abnormalities, all piston rings were in place and complete. After removal of the pistons the connecting rods and crankshaft were visually examined, no significant defects were observed and the crankshaft was found to be free to rotate with no perceivable binding or roughness.

The engine oil cooler and the remaining pipes were examined; however the cooler matrix was found to have been breached as a result of the post crash fire. No pre-crash defects could be identified in the remains of the oil feed and return pipes

Propellers

The Hartzell HC-M2YR-2CEUF propeller fitted to the Beechcraft Duchess is a constant speed unit which uses a spring, supplemented by an air charge to move the propeller piston towards the propeller hub; this moves the propeller blades towards the feathered position in the absence of an opposing force. In normal operation the propeller governor provides a metered supply of pressurised oil through the engine crankshaft to the opposite side of the propeller piston to control the pitch of the propeller against the action of the spring and the air charge. The governor provides variable oil pressure to the propeller to maintain the pilot selected engine rpm by increasing or decreasing the propeller pitch as the airspeed of the aircraft changes. In the event of loss of oil pressure to the propeller during normal operation, either due to the pilot manually selecting FEATHER with the propeller control lever, or due to mechanical failure, the propeller blades will be driven to the feathered position by the action of the spring and air charge, ensuring that the propeller produces the minimum aerodynamic drag in the event of an engine failure. If the propeller were to feather during normal shutdown procedures, significant difficulties would arise during the subsequent engine start. In order to prevent this, the propeller is fitted with a pair of pitch locks which are held in the 'closed' position by a circumferential spring. At engine speeds greater than 800 rpm centripetal forces move the locks to the open position allowing the propeller to operate through its full range of movement and, in the event of a loss of propeller oil pressure, allowing the propeller to feather. At engine speeds below 800 rpm, as in ground operation, the propeller governor will position the propeller blades to the fine pitch position and the locks close. They then prevent a sleeve on the piston shaft from passing the lock and thus prevent the blades moving towards the feathered position when the oil pressure decreases on engine shutdown.

The right propeller

Examination of the right propeller showed it to be complete. The damage to the blades was indicative of some rotation at the point of initial impact. On removal of the spinner cap, the propeller air valve was found in place and the air charge still present. Examination of the propeller cylinder revealed one witness mark. The most likely cause of this witness mark was identified as the corresponding propeller counter weight. It is likely that during the impact with the ground, the blades were displaced, forcing the counterweight to contact the cylinder. The position of the witness mark clearly shows that at the time of impact the right propeller was in a fine pitch position. Given that the propeller was found at the crash site in the fully feathered position, and separated from the engine, at some time during the crash sequence the propeller was subject to sufficient force to drive the blades to the feathered position possibly despite the pitch locks being closed.

On disassembly of the feathering spring and piston, one of the pitch locks, together with both of its locating bolts was found in the base of the piston. The lock appeared to be undamaged; the two bolts had clearly been pulled from their locating holes. The threads of these bolts were heavily contaminated with the remains of the thread material from the locating holes. The piston sleeve which engages with the pitch locks was inspected, however no damage associated with the sleeve being forced through the locking mechanism could be identified.

No other abnormalities were observed during the disassembly of the remaining right hand propeller components.

The left propeller governor and propeller

On removal from the engine accessory housing the propeller governor input shaft could not be turned by hand. When disassembled, the internal components of the governor were found to have suffered from heat damage as a result of the post crash fire. They did not, however, exhibit indications associated with any existing pre crash defect. The input drive shaft and pump gears were complete with no damage to the gear elements or the drive spline. The gear elements were jammed by the remains of a plastic plug from the unfeathering port which appears to have melted as a result of the post crash fire. The unfeathering function of the governor was not used on this aircraft and the external union for this facility was securely wire locked in place. The oil inlet and outlet ports and internal cavities were free from obstructions.

The left propeller was complete with the exception of the spinner cap which was found under the left engine at the crash site, and the air valve located under the cap. The fasteners securing the spinner cap to the spinner remained in situ together with small sections of the spinner cap material confirming that the cap had become detached from the spinner during the crash sequence. Approximately four of the last threads in the locating hole for the air valve had been stripped. It is therefore likely that the propeller air valve was pulled from the propeller as a result of the impact sequence.

Examination of the propeller after removal of the spinner revealed no witness marks or damage. Prior to disassembly of the propeller, a pressurised air supply was connected to the oil inlet to function the propeller through its pitch range. When the air pressure was increased, the propeller blades moved smoothly through approximately half of their full range of movement before stopping, further application of pressure failed to move the blades towards the fine pitch stop. The air pressure was removed and the blades returned smoothly to the fully feathered position.

The propeller was then dismantled. The propeller cylinder was found to contain an appropriate quantity of apparently suitable oil, which was clean and bright in colour. The cylinder should be part filled with hydraulic oil to MIL-H-5606 specification. During removal of the feathering spring, the remains of one of the propeller pitch locks was found in the base of the propeller piston together with one of its retaining bolts. The remaining bolt had been partially pulled from its housing and had been distorted. The pitch lock was found in two pieces, having failed across an area of minimum wall thickness adjacent to one of the machined slots used to allow the lock to move under the influence of centrifugal forces in normal operation. (See Figure 2.)

Figure 2

The pitch lock was identified as being part number A-1590. This is an uncoated weight with an open design of slot. It is no longer available, having been replaced on an attrition basis with coated weights, part numbers B-317 and B-318 as appropriate for the propeller. These parts have a different slot design.

The presence of the broken pieces of pitch lock in the base of the cylinder, depending on its orientation, could have provided a mechanical restriction to the forward movement of the propeller piston preventing the propeller from moving to the fully fine position when the function test was carried out. This was the only plausible explanation for the observed restriction when the propeller was first tested.

Subsequent metallurgical examination of the fractured surface of the pitch lock showed it to be cracked by a fatigue mechanism which had then been finally fractured in overload. There was a distinct change in direction of the fracture at the final overload, which was over about 60% of the cross sectional area, indicative of a different loading mechanism. The fatigued portion of the surface was contaminated with corrosion deposits, including traces of sodium, chlorine and cadmium. The orientation of the fracture surface suggested that an element of torsion had occurred.

Metallurgical examination of the bolts which secured the pitch lock showed them to have corrosion deposits due to oxidation of the base material. They also showed evidence of impact underneath the heads, caused by the pitch lock weights. The impact features showed that both parts of the broken pitch lock weight were in position when the impact on the bolts occurred. There was fretting or wear damage to the cadmium plated steel disc on which these parts were assembled, and this was thought to be the source of the cadmium found on the fracture surface.

Examination of the piston sleeve, which normally engages with the pitch lock weights when the engine is shut down, showed 'shouldering' of the pitch lock contact face together with two pairs of parallel scores 180 degrees apart. These score marks were the consequence of at least one heavy engagement with the pitch locks. Comparison of the scoring with the pitch locks shows that this was likely to have been the result of the sleeve being forced through the pitch locks prior to them becoming fully open. The symmetry of the score marks also suggests that the lock weight was unbroken at this time. In normal operations the pitch locks close when the engine speed approaches idle; at these speeds the propeller governor has already driven the propeller to the fine position, placing the piston sleeve beyond the locks prior to their closure. When the engine is shut down, the reducing oil pressure allows the feathering spring to move the piston sleeve until it makes contact with the closed locks. In this situation contact is made between the end of the piston sleeve and the side face of the pitch locks and no opportunity for scoring or shouldering of the sleeve should exist.

The propeller log book confirmed that it had been overhauled in March 2001 by a CAA approved organisation. A review of the complete work pack for the propeller revealed that the pitch locks had been inspected for cracks using a Magnetic Particle Inspection technique and were found to be free of defects. A visual inspection only is required. After inspection the locks were reinstalled in the propeller. No other defects with the propeller components were identified during the overhaul process.

Most propeller overhaul shops seem to have very few problems with these pitch locks; however, there was some anecdotal evidence that the earlier design, as fitted to this aircraft, could jam and this would occasionally result in repairs in the field. In such cases the propeller would go into feather on shutdown, and sometimes, when the propeller was investigated, one of the pitch locks was found broken and sometimes also one of the retaining bolts would have pulled out of the assembly by stripping the internal aluminium thread. Marks were often found under the heads of the bolts. Fitting the later design of pitch lock was an effective cure.

Witnesses

There were a number of witnesses in the vicinity of the aircraft who either heard or saw parts of the accident flight. They variously described a normal take off, with a drift to the left followed by a distinct turn to the left with bank angles from 10º to 20º. Some people saw puffs of black smoke coming from one or both engines and one witness described a thin stream of white smoke or vapour from the left engine. Estimates of the maximum height attained varied from 80 to 200 ft. The propellers were generally described as turning although some persons observed them turning at different speeds from each other. One witness, a pilot with extensive twin engine experience, particularly noted that after lift off the right propeller appeared to be turning more slowly than the left which struck him as odd because the aircraft then began to roll to the left. Witnesses who could hear the aircraft heard the sound of an engine running down, and one witness further along the flight path described an engine as faltering, briefly recovering and then going quiet. Two witnesses who observed the final part of the flight reported that the left propeller was not turning and the described the aircraft as 'gliding'.

Analysis

The pilot's recollections were limited and separate events have probably overlapped. No evidence of aircraft flight control failure was identified during the examination of the aircraft. Due to damage caused by the post crash fire no investigation could be carried out which could verify the correct functioning of either engine ignition systems or carburettors. The position of the engine and propeller controls relative to each other suggests that both the left and right engines had been selected to similar settings prior to impact. No mechanical abnormalities associated with a significant loss power were identified in either the left or right engine during the strip and investigation. There was evidence from the accident site examination that the left propeller was not turning under power at the time of impact with the trees whereas other evidence indicates that the right propeller was turning. Without more definite evidence the behaviour of the aircraft may help to provide an indication of the nature of the problem.

The pilot was very familiar with the aircraft so it is likely that he would have noticed anything unusual prior to departure. It is not known precisely from where along the runway his take-off run started, so an estimation of whether the aircraft achieved its expected performance during takeoff was not possible. Several witnesses heard a change in engine note soon after takeoff, earlier than would be expected for a normal reduction to climb power. The aircraft was then seen to turn to the left from a low level, despite the fact that the pilot had acknowledged a clearance to climb ahead to 1,500 ft. A loss of power from the left engine, which was not corrected for with an early application of right rudder, would result in a yaw and roll to the left; this seems to be the most plausible explanation for this manoeuvre.

With a loss of power at an early stage after takeoff there are several options which may be open to the pilot, one of which is to close both throttles and to accept a landing ahead. This option is only available for as long as directional control is maintained; also, if the landing gear has already been retracted it may result in a wheels up landing. Another option is to control the aircraft, establish a climb, fly a circuit and return to land. This requires prompt action by the pilot to ensure that sufficient airspeed is maintained, which will allow directional control to be achieved, and that the propeller is feathered and any additional drag is reduced. If these conditions cannot be met it is unlikely that the aircraft will be able to climb.

When interviewed four months after the accident the pilot could not recollect whether he had carried out any actions to secure the engine. The relative position of the cowl flap and carburettor heat controls for the engines indicates that the left engine cowl flap was in a closed position and that carburettor heat was selected towards the ON position. The position of the left engine fuel lever, its associated witness mark and the fuel selector valve position showed that the left engine was drawing fuel from the right fuel tank at the time of impact. The variation in the position of these controls when compared to the right engine might indicate that the pilot may have been attempting to troubleshoot a problem associated with the left engine.

On this occasion if there was a loss of power before sufficient speed or height was attained then continued flight may not have been possible, closing the throttles and landing ahead may have been the only option. However the aircraft deviated from the runway track soon after the problem developed thereby effectively removing this option; furthermore the landing gear had already been retracted. The pilot's next possible option was to keep the aircraft flying or, if he could not, to attempt a forced landing off the airfield. The witnesses reported that the aircraft did not achieve a climb and there is some evidence that during the turn power from the right engine may also have reduced; this may have been for a technical reason or as a result of action by the pilot, either intentional or inadvertent.

After turning past the control tower there was an open area of ground ahead of the aircraft and it is possible that the pilot, unable to achieve a climb, decided to attempt a forced landing. This accords with his recollection that he realised that he was going to crash and aimed for a field. However, before the open ground there was a line of tall trees, which the aircraft failed to clear. The damage to the tree tops indicates that the wings were approximately level at the time the aircraft went through them; however, after hitting the trees there was no longer a possibility of a controlled landing.

The aircraft crashed into a grass field, right wing slightly low and travelled forwards through some iron railings into a strong steel mesh fence. The collision with these structures was the reason that the aircraft was so badly disrupted. The post impact fire was severe and although the pilot was able to escape he suffered serious burns. The AFS arrived at the scene as quickly as was possible but could not have been in time to help the pilot out of the aircraft had he required assistance.

The ground marks indicate that the right propeller was rotating on impact, and that the right engine and propeller hit the ground early in the crash sequence with sufficient force to break the right engine crankshaft and release the right propeller. Witness marks on the right propeller indicate that the blades were in a fine pitch setting at the time of impact. At some point in the crash sequence the propeller blades were driven towards the feathered position, overloading two of the pitch lock bolts and allowing one of the lock sections to be released and the propeller to move into the fully feathered position.

Based on the witness marks and control positions, it is likely that the left propeller was not selected to FEATHER by the pilot prior to impact. At some point in the crash sequence the propeller blades were driven towards the feathered position.

The shouldering and scoring present on the left propeller piston sleeve indicates that the pitch lock mechanism within the left propeller did not experience the same impact conditions as that of the right propeller. The existence of fatigue and the repetitive nature of the shouldering indicate that a problem existed before takeoff on the accident flight, although it is clear from the impact marks on the bolts that the final fracture of the lock was a result of ground impact.

It is possible that because of the corrosion found on the bolts, or for some other reason, the pitch locks had not opened and closed freely, resulting in contact with the sleeve and loads in the lock which may have generated the fatigue. During the ground impact the sleeve made heavy contact with the cracked but intact lock, causing the final overload failure. From the nature of the fatigue fracture of the pitch lock weight it appears this part had been subjected to an unusual, repetitive, and moderately high stress loading. This would be consistent with the lock not sliding properly due to contamination with the corrosion deposits found on the retaining bolts. The reason for the corrosion was not identified, however light corrosion of these bolts is reportedly sometimes found when propellers are overhauled. It is possible that the hydraulic oil absorbed moisture - the MIL-H-5606 oil specified is known to do this, and it is also possible that traces of salt (brine) were introduced when the propeller was charged with air or nitrogen. This would explain the traces of sodium and chlorine found on the fracture face.

Because the design of the lock, part A-1590 appears to be more susceptible to jamming than its later replacements, and because its design is more susceptible to cracking, the following safety recommendation is made:

Safety Recommendation 2005-138

It is recommended that the FAA, in collaboration with Hartzell, ensure that all Hartzell propellers in service that are fitted with part A-1590 pitch locks should have these replaced by part B-317 or B-318 pitch locks, as appropriate, at the next overhaul.

Conclusion

The engine indications observed before the accident flight have not been explained. However, the pilot has reported that the instruments were unreliable and difficult to maintain, although he had made efforts to correct these deficiencies. It is therefore possible that the anomalies reported by the engineer who fitted the replacement vernotherm were 'normal' erroneous indications and that the pilot had been concerned about an increase in the left engine's oil temperature, which was at least improved by the fitting of the replacement part.

It is possible to conclude that there was a defect within the left propeller, prior to the takeoff on the accident flight. However the evidence is conclusive that this had no effect upon the flight. No other defect with the aircraft was found. It must be noted that some possible defects would be very difficult to identify after the post crash fire, and in particular the carburation and ignition systems could not be verified. It is therefore not possible, on the basis of the available technical evidence, to account for a power loss.

The pilot's recollections were also insufficient to provide an explanation for the accident. The loss of directional control was most likely to have been caused by a loss of power and although the pilot was able to regain some control, he could not apparently get the aircraft to achieve a climb. It is possible that the nature of the failure made continued flight impossible and occurring as it did, at the most critical time during takeoff, the pilot was then in a very difficult situation.