DHC-1 Chipmunk 22, G-BHRD, 21 January 1997

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Aircraft Type and Registration:	DHC-1 Chipmunk 22, G-BHRD
No & Type of Engines:	1 de Havilland Gipsy Major 10 MK.2 piston engine
Year of Manufacture:	1952
Date & Time (UTC):	21 January 1997 at 1035 hrs
Location:	Field, East of Burford, Oxon
Type of Flight:	Private
Persons on Board:	Crew - 2 - Passengers - None
Injuries:	Crew - Minor - Passengers - N/A
Nature of Damage:	Extensive damage to airframe and engine
Commander's Licence:	Private Pilot's Licence with IMC and Night Ratings
Commander's Age:	34 years
Commander's Flying Experience:	270 hours (of which 137 were on type)
	Last 90 days - 10 hours
	Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and AAIB examination of the engine

The aircraft was on a flight from Brize Norton for the purposeof a general handling and refresher exercise for the front seatpilot. The flight proceeded uneventfully until the aircraft wasabout to rejoin the Brize Norton circuit when, at a height ofabout 1,000 ft agl and with the airfield in sight, the enginenote changed, as if a spark plug had fouled. The pilot decidedto lean the mixture in an attempt to clear the plug, however ashe started to move the mixture lever the engine started to vibrateand to run even more roughly, with an attendant drop in oil pressure.The throttle was then adjusted, but this had no effect on thevery rough running engine. The engine then stopped and the frontseat pilot observed the propeller detach and pass over the aircraft.Approximately 5-6 seconds had elapsed between the onset of therough running and the propeller departing from the aircraft. Therear seat pilot took control and turned the aircraft in an attemptto find a suitable landing field, having assessed that it wouldnot be possible to reach the airfield. A Mayday call was transmittedto

Brize Norton. The selected field had power cables running acrossit, but the pilot was able to avoid these. However, the fieldwas freshly cultivated, with the result that the main landinggear wheels 'dug in', causing the aircraft to 'nose-over' aftera ground roll of approximately 45 feet. The occupants, who sufferedonly minor injuries, remained trapped in the inverted aircraftuntil assisted from it by ground witnesses.

Subsequent examination of the engine revealed that the crankshafthad failed within the No 2 main bearing journal. As a result,the front section of the crankshaft complete with the propellerand No 1 piston and connecting rod assembly had separated fromthe engine after associated rupture of the front of the crankcase.

Both portions of the crankshaft were subjected to a metallurgicalexamination which revealed that the failure had occurred as aresult of high cycle torsional fatigue. Initiation was at theforward end of the second main bearing journal and had progressedaft along a helical path. However, as the torsional crack hadprogressed, lateral bending stresses had been induced in the oppositewall of the journal, leading to low cycle, high stress fatiguecracks. These had progressed rapidly and coalesced to producethe actual separation. No cracks were found in the remaining mainbearing journals or in the crank journals. The bearing surfacesand the bearing shells yielded no evidence to indicate that therehad been any lubrication problems. However, it was noted thatoil sludge had accumulated in the bores and oilways of the crankshaft,and in the crank journals, as a result of a centrifuging process.Such deposits are often an indication of low utilisation, andcan lead to corrosion, although there was no evidence in thiscase of the fatigue crack having initiated from a corrosion pit.Additional examination of the initiation region failed to revealany evidence of machining abuse. Finally, hardness tests wereconducted on the surface and core material, the results showingthat there had been no surface hardening process, such as nitriding,carried out on the crankshaft. The actual hardness values wereconsistent with a steel strength of around 57 tonnes/in^2.

The engine serial number was 11763 and the UK design authorityfor the Gypsy engine series was able to confirm that it had beenbuilt by de Havilland in May 1952 and exported to their Australiansubsidiary. Information from the aircraft owners indicated thatthe engine had been imported from Malaysia into the United Kingdomin 1979 having achieved 562 operating hours, although it was notclear whether this was from 'new', or overhaul. It was installedin G-BHRD in 1980, and had achieved approximately 1400 hours atthe time of the accident. The diameters of the crank pins andmain bearing journal pins were measured after the accident, andwere found to be nominally 1.97 inches and 2.05 inches respectively.These were the 'standard' diameters, and thus indicated that thecrankshaft had never been re-ground.

In 1959, Modification 2602, applicable to Gypsy Series 10 engines,introduced a crankshaft made from an improved material (S106 steel)and which was nitrided. Nitride surface hardening improves thefatigue resistance of the component. The engine manufacturer haddesignated this modification as "strongly recommended",but it had not been mandated by the airworthiness authorities.Earlier marks of Gypsy Major engines continued to use the non-nitridedcrankshafts. In 1960 another modification, No 2661, specifiedthat the magneto timing should be retarded by 3° for enginesfitted with pre-mod 2602 crankshafts. The stated reason was to:"..reduce the peak pressures attained during engine running,and consequently the stresses to which the crankshaft is subject"(*sic*). Documentation submitted by the aircraft owners indicatedthat the engine ignition timing was last checked, in accordancewith the provisions of Modification 2661, in November 1995.

Although crankshaft failures have occurred in the past on GypsyMajor engines for a variety of reasons, there does not seem tobe a history of failures associated with mis-timed engines fittedwith non-nitrided crankshafts. The CAA database had records ofonly two Gypsy crankshaft failures since 1976, involving an Austerand a Tiger Moth. The Royal Air Force database, which extendsback to the early 1970s, had no record of any crankshaft failurein their Chipmunk fleet. However, much of the archived informationhad been deleted, and so it was not possible to establish howmany of the RAF aircraft had been equipped with the nitrided shafts.The Army Air Corps fleet of Chipmunk aircraft, shortly to be retired,have had no reported crankshaft failures over 37 years. All theseaircraft currently have the nitrided crankshafts. The lack ofany significant crankshaft failure history amongst military Chipmunkaircraft is perhaps surprising since most of these engines wereequipped with the cartridge engine start system which acceleratedthe engine from rest to idle RPM over a very short period, therebyimposing a significant torsional stress on the crankshaft.

In the case of G-BHRD, the failure resulted from a single crackthat had grown over a long (but otherwise undefined) period. Crackinitiation was not due to corrosion, nor could it be associatedwith the low engine utilisation since 1980. This lack of any obviouscause for the fatigue and the lack of cracks elsewhere on thecrankshaft raised the question of some unrecorded event such asa propeller strike having occurred at some stage during the lifeof the engine.