Montgomerie-Bensen B8MR, G-WHIR

AAIB Bulletin No: 10/98 **Ref: EW/C98/6/5/025** **Category: 2.3**

Aircraft Type and Registration:	Montgomerie-Bensen B8MR, G-WHIR
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	1994
Date & Time (UTC):	13 June 1998 at 2006 hrs
Location:	Coll, Isle of Lewis
Type of Flight:	Private
Persons on Board:	Crew - 1 - Passengers - None
Injuries:	Crew - 1 (fatal) - Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence (Gyroplanes)
Commander's Age:	34 years
Commander's Flying Experience:	76 hours (see text) Last 90 days - 5 hours Last 28 days - 2 hours
Information Source:	AAIB Field Investigation

History of the flight

It is not known at precisely what time the pilot arrived at the hangar on Stornoway Airport where the gyroplane was stored, however at about 1800 hrs he was seen lying on his back inside the cockpit. He appeared to be working on something on the underside of the cockpit top. Later, at about 1940 hrs, he was seen doing his preflight walk round check and shortly afterwards the engine was heard to start.

Although the Airport was closed, the pilot made 'blind' radio calls and the initial part of the flight has been deduced almost entirely from these calls. The gyroplane took off from Runway 36 at 1946 hrs and positioned left downwind for Runway 07. The pilot carried out a practice engine failure, landed at about 1950 hrs and took off again. He then carried out a 'touch-and-go' landing on Runway 07 and, at about 1954 hrs, transmitted that he was turning left to conduct visual flight rules (VFR) flying, for some 50 minutes, to the north of the Airport. At 1957 hrs, he reported that he was 1 nm to the north of Runway 18 at 1,000 feet agl and heading 360° at 70 mph. At 1957:35 hrs, he

transmitted that he was descending to 500 feet above ground level (agl); this was the last radio call recorded from G-WHIR.

The gyroplane had flown along the coast towards the village of Coll, which is about 3 nm to the north of the Airport. A witness to the accident lived in that village; he had held a Private Pilot's Licence and had expressed an interest in learning to fly the gyroplane. He had previously contacted the pilot and arranged to meet him in the hangar at Stornoway Airport at about 1730 hrs that evening in order to see the gyroplane. Although he had arrived at the hangar at the appointed time, the pilot was not there and so he had departed. Later that evening he was at home when he heard, and then saw, the gyroplane flying from the direction of the Airport; he estimated that it was initially at about 1,000 feet agl, but had then descended to about 500 feet agl as it approached the village. The main road through the village is orientated west/east and the witness's house was on the northern side of this road. He estimated that the local wind was from the east, at about 25 kt. The gyroplane passed over a house situated south of the road and then came to a brief hover over the road, heading east. It then carried out an orbit to the right, before again coming to a hover heading east over a garden to the north of the house. He thought that the pilot appeared to be leaning over the left side in a somewhat exaggerated manner. The gyroplane was drifting slowly forwards and to the right.

Several other witnesses also saw the final stage of the flight. Although, quite naturally, the detail and order of events varied, the accounts were largely in agreement. The engine noise increased and the gyroplane entered a steep climb at low speed. It appeared to "hang in the air" for a short time before it started to slide backwards and roll to the left. It appeared to turn almost completely upside down and fell in this attitude. At some stage during the initial part of this sequence the rotor blades were seen to come into contact with the propeller, which broke-up. The speed of the rotor blades was also seen to decrease. The gyroplane impacted the ground at the northern end of the rear garden of the house near which it had been hovering.

Meteorology

The 1950 hrs weather report for Stornoway Airport contained the following:

Surface wind	040°/14 kt
Visibility	80 km
Weather	Nil
Cloud	1 okta base 2,500 feet
Temperature	+10°C

Dew point +6°C

QNH 1012 mb

Pilot's flying experience

The pilot had started flying training on fixed wing aircraft in January 1989. He flew 3:45 hours at the beginning of that year, but had not flown again until January 1992. He flew solo for the first time in June 1994 and had accrued a total of 14:40 hours fixed wing flying up to that time.

Two days later he started gyroplane training, the first 5 flights of which were flown solo in G-WHIR. Dual training was in both the Parsons and the Air Command 2 seat gyroplanes. He passed the General Flying Test in June 1996, by which time he had flown 25:40 hours dual and 14:30 hours solo. Between that time and the accident flight he had flown a further 21:25 hours, which increased his total gyroplane experience to 61:35 hours. His last flight prior to the accident flight was on 6 June 1998.

Medical and pathology

The pilot died of multiple injuries and no evidence was found of any pre-existing medical condition which would have contributed to the accident.

Initial examination of wreckage

The AAIB initial examination took place in the secure compound of Stornoway Police Station. Examination of the rotor and the propeller blades confirmed that both rotor blades had struck the three propeller blades and that at the time of the strikes both sets of blades had been rotating, the propeller substantially faster than the rotor. One of the three propeller blades had then broken away from the propeller hub, and parts of this blade were recovered from gardens some 85 metres to the south of the accident site. Both rotor blades were found to exhibit severe downward distortion approximately one metre from the rotor mast and within these areas both blades had delaminated. There were also deep rotational rub marks on the lower surfaces of both rotor blades which had been caused by blade contact with the top of the rotor spin-up drive system that was mounted just below, and to the rear of, the rotor head.

It was noted that the fuel tank contents sight-tube, which was made from transparent PVC (polyvinylchloride) reinforced with nylon mesh, was disconnected from the lower fuel tank outlet pipe and that the 'jubilee' clip which had secured the PVC tube to the outlet pipe was missing. Specialist examination of the negatives of photographs taken at the accident site prior to the removal of the wreckage confirmed that the fuel tank contents PVC sight-tube had disconnected from the lower fuel tank outlet pipe. It was also noted that the PVC tube had split around approximately half the circumference in the area that was just above where the jubilee clip had clamped the tube onto the lower tank outlet pipe. Although the sight-tube had split circumferentially, the nylon mesh reinforcement within the tube had remained intact. The PVC tube had also shrunk to the extent that it was approximately 25 mm shorter than the minimum length required to connect the upper and lower tank outlet pipes, and the lower third of the tube had become brittle and had been heavily stained dark brown by fuel contact (Photograph 1). With the lower end of the PVC sight-tube disconnected, fuel would have drained from the fuel tank until the level of the fuel in the tank had reached the level of the lower outlet pipe. This would have left some 9 litres of usable fuel in the 64 litre tank. In the area where the PVC tube had been connected to the lower fuel tank outlet pipe, there was evidence of fuel staining and debonding of the gyroplane's registration transfer, indicating that there had been a long term fuel 'weep' in this area (see Photograph 1). Approximately 50 cm to the rear of the lower sight-tube/fuel tank outlet pipe union was the exposed engine exhaust system which would be extremely hot when the engine was running. A small quantity of fuel, approximately 2 litres, was found in the fuel tank, but a strong smell of fuel was noted at the accident site two days after the accident.

Detailed wreckage examination

The wreckage was transported to Farnborough for detailed examination. Both rotor blades were examined to determine whether their delamination had initiated due to, or had been caused by, the accident sequence. Examination determined that the delamination of both rotor blades had occurred as a result of both blades having been severely deflected downwards, beyond their design limits. The flying control system was examined and showed no evidence of a pre-impact control restriction or disconnect. The pilot's four strap restraint harness was examined and found to be serviceable, but it appeared mal-adjusted and would have been a very loose fit on the pilot.

The engine together with the fuel, electrical and throttle systems from the gyroplane were taken to the manufacturer's authorised United Kingdom distributor where an examination and test run was carried out. During this test the engine operated normally, with no system problems other that those induced by impact damage. It was noted during the fuel system examination that all of the piping from the fuel tank to the engine was of the same type as that used on the fuel tank contents sight-tube, and that it had also shrunk, become brittle and discoloured.

The fuel tank contents transparent PVC sight-tube was submitted for specialist examination. From this examination it was concluded that the following sequence of events had occurred:-

a) As a result of prolonged exposure to AVGAS or MOGAS, the PVC material had shrunk due to loss of plasticiser causing a decrease in the length and cross-section of the sight-tube, and an increase in its hardness and brittleness.

b) The decrease in length had induced axial tension in the tube between the two jubilee clips attaching it to the upper and lower tank outlet pipes, and this had assisted in decreasing the cross-sectional dimension of the tube at the lower end where it would have been in almost continuous contact with fuel.

c) This decrease in cross-sectional dimension of the tube had allowed the lower jubilee clip to slacken and fuel leakage to occur. Hoop tension stresses would have been generated in the PVC material due to shrinkage. Attempts to stop the leak by tightening the jubilee clip would have resulted in cracking of the brittle tube wall (Photograph 2).

d) As shrinkage due to loss of plasticiser continued, the axial tension in the tube would have increased and, although the PVC wall had cracked circumfrentially, the nylon reinforcing mesh had remained intact allowing the tube to pull off the lower tank outlet pipe.

History of problems with PVC tubing in fuel systems

The problems of using PVC tubing in fuel systems have been well documented and the Popular Flying Association (PFA) had produced a document entitled 'Owner's Handbook for Ultralight Gyroplanes'. Chapter 10 of this document is entitled 'The fuel tank and fuel system' and Paragraph (iv) of this states:

"If sight-glasses or fuel-level devices are installed, they must be in good working order. Where clear plastic is used as a sight-tube, for instance, every care must be taken to ensure that the tube is not hardened - by loss of its plasticiser - and that it is forming a good seal on to its pipe-stubs from the tank. Petrol is quite quickly able to 'leach' out the plasticiser from PVC-based flexible tubing which then becomes brittle

and discoloured. Both 'beer-hose' and mesh-reinforced tubing (for example, 'Griflex'), being PVC, are susceptible to this attack."

The following is an extract from pages 2 & 3 of this Chapter:

"If a sight-gauge is installed, it should always be possible to observe the level of fuel in the tank without having to assume a difficult or dangerous posture in flight. Connections to valves and other fittings are very likely to become loose, allowing the ingress of air or the escape of fuel. Where such tube has been used vertically between two stubs on the fuel-tank as a sight-gauge, as mentioned earlier, it has also been known to contract in length as its plasticiser is leached out, finally pulling off its attachment stubs after protracted use. If it is used in this mode, it should always be installed with slight slackness, never a taut fit. Basically, owners and Inspectors should take the view that - if some form of reinforced plastic tube must be used - it needs to be replaced at least annually, whatever the application. But consider the rate of degradation actually noted and judge whether the application demands more frequent renewal. After all, none of these types of tube is expensive and such trivial cost as is associated with the short lengths employed on gyroplanes is a small price to pay for increased reliability and safety. Black, fuel-proof tubing, as sold by most DIY motorists' shops, is:

a) much more flexible than most plastic tubes,

b) less prone to embrittlement,

c) more durable overall,

and d) not much more expensive.

So owners have very little reason not to use it for most applications and inspectors should ask for its use except where transparency is vital."

The type of PVC tubing used in the fuel system of this gyroplane is readily available from hardware and car accessory shops and is manufactured to a wide variety of specifications, including a specification for use in fuel systems, but visually all such types of PVC tubing look identical. The tube's manufactured specification is only marked on the reel on which it is supplied and not on the tubing itself. Once the tubing has been cut from its supply reel there is no method, other than by chemical analysis, of determining its material specification. However there is flexible transparent tubing available that is manufactured for use in fuel systems which has identification markings embossed every 30 cm along its length, eg 'B.A.I - URETHANE', which is a polyurethane-based tubing.

Maintenance history

The gyroplane was built from a kit by the owner/pilot and first flown in April 1994. In October 1997 the owner had transported the gyroplane, by road, to a PFA Inspector for an Annual Inspection and Permit to Fly Renewal Inspection. During this inspection, the PFA Inspector had rectified various minor defects, including changing one of the tyres that had deteriorated due to age. The Inspector had assessed the gyroplane to have been in very good condition, with the exception of the fuel tank contents sight-tube. The tube was found to be stained brown in colour, making it difficult to see the actual fuel level. The Inspector had also noticed that the jubilee clips that attached the ends of this tube to the outlets of the fuel tank were in poor condition. These points had been brought to the owner's attention, whereupon he had assured the Inspector that he would replace them when he returned to Stornoway. However, examination of the wreckage indicated that this had unfortunately not been done. With this assurance from the owner, the PFA Inspector had certified the gyroplane as serviceable and had recommended to the PFA that its Permit to Fly be renewed. The PFA Inspector stated that he would have renewed the jubilee clips at that time, but had not done so due to time constraints and the non-availability of replacement parts.

Video film

Early in 1997, Grampian Television had filmed the pilot and G-WHIR at Stornoway Airport. A copy of the associated video tape was made available to the AAIB. It showed the pilot carrying out his pre-flight checks and manoeuvring the gyroplane, both on the ground and in the air. Apparently he felt that the main display sequence would be enhanced if flown by a friend, who had more experience of flying display routines.

In the light of findings during the subsequent examination of the wreckage, one aspect of the filmed pre-flight check appeared to be of potential significance. The pilot had given particular attention to the fuel tank sight-tube and had made a detailed examination of the lower end. His actions appeared consistent with some concern about a possible fuel leak from this area. However, the pilot's friend mentioned in the previous paragraph felt that it would have been brought to his attention by the owner if he had been concerned.

Previous accident

After the owner's friend had landed at the end of the filmed flight, a ground accident had occurred when the gyroplane had rolled over onto its side. It is understood that the main resultant damage was to the rotor and propeller blades, which were damaged beyond repair. The rotor and propeller blades were subsequently replaced and it was reported that the rotor head bearing had also been

replaced. However, there were no entries in the airframe or engine log books recording this accident, or of any associated repair or replacement, and the accident had not subsequently been formally reported to the AAIB, PFA or the CAA, although it had apparently been reported to an off-duty controller at the time.

Discussion

The evidence indicated that at some stage during the accident flight the fuel tank contents transparent PVC sight-tube had become disconnected from the lower fuel tank outlet pipe, which would have allowed fuel to have been lost from the fuel tank. However, because of the position of the lower fuel tank outlet pipe, it would not have been possible to lose the total contents of the tank, since at least approximately 9 litres of usable fuel would have remained to supply the engine. Nevertheless, it was considered possible that during the final hover manoeuvre the pilot, whilst looking down from the left-hand side of the gyroplane for a possible ground reference, had noticed the leaking fuel and the disconnected sight-tube, which may have been 'flailing' in the airflow. Directly aft of the lower fuel tank outlet was the engine's hot exhaust system. The close proximity of any fuel leakage to the hot exhaust may have concerned and distracted the pilot and he may have inadvertently allowed the gyroplane to adopt a nose high attitude before it started to slide backwards; a manoeuvre from which he did not recover. At some stage during the rearwards slide, roll to the left and resultant invertion of the gyroplane, the rotor speed had decayed and the rotor blades became negatively loaded, allowing them to deflect downwards to the extent that they had contacted the propeller, which was still at that stage being driven by the engine.

Safety recommendation

In view of these findings, the following Safety Recommendation has been made to the Civil Aviation Authority (CAA) and the Popular Flying Association (PFA):

> **98-56** In order to avoid fuel leakage problems from PVC tubing due to associated shrinkage and embrittlement in service the CAA, in conjunction with the Popular Flying Association, should require replacement of such tubing, where fitted, with alternative tubing manufactured from identifiable material of a type suitable for use in aircraft fuel systems; in addition, the CAA should consider whether wider action on this problem is required.