AAIB Bulletin No: 6/98 **Ref: EW/C97/10/6** **Category: 1.3**

Aircraft Type and Registration:	Pierre Robin HR200/120B, G-BWPG	
No & Type of Engines:	1 Lycoming O-235-L2A piston engine	
Year of Manufacture:	1996	
Date & Time (UTC):	29 October 1997 at approximately 1820 hrs	
Location:	In the Cromarty Firth off Nigg Yard, Scotland	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - None
Injuries:	Crew - 1 Fatal	Passengers - N/A
Nature of Damage:	Aircraft damaged beyond economic repair	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	49 years	
Commander's Flying Experience:	8,600 hours (of which 92 were on type) Last 90 days - 65 hours Last 28 days - 30 hours	
Information Source:	AAIB Field Investigation	

History of the flight

The student, who was training for a night rating, had planned for a triangular night navigation exercise, to be flown at 2,000 feet, from Inverness, along the south coast of the Moray Firth to Kinloss, across the Firth to Tarbot Ness, returning to the airfield along the north coast of the Firth. (See Figure 1) He had started his night training at Aberdeen but because of circuit congestion there had decided to continue with his training at Inverness. The aircraft had been flown four times earlier that day. The instructor assigned to fly with him had flown it for one hour after midday to conduct a general flight test on another student. Later he had flown it for 40 minutes to conduct a dual check on a student before sending her on her first solo. The aircraft was flown by the instructor again at 1520 hrs for one hour in the local circuit. Throughout the day the aircraft had operated faultlessly. It had been refuelled after the solo flight with 59 litres of fuel and at 1600 hrs, after the fourth flight, a further 15 litres of fuel was added to fill the tanks to full.

At 1730 hrs the student, with the instructor seated on his right, started the engine for his night cross-country flight. He carried out the routine pre-flight and engine run-up checks before departing at 1745 hrs on the first leg of the exercise. Although lifejackets were available on the aircraft, neither occupant was wearing one. The weather was clear with visibility greater than 25 km. There was a light southerly wind and the surface temperature was +10°C.

The first leg to Kinloss was flown without incident. Lossiemouth ATC cleared the aircraft to enter the Kinloss Military Air Traffic Zone (MATZ) as it transited through the Kinloss overhead at 2,000 feet. From there the aircraft set out on the 15 nm second leg of the route across the Moray Firth towards Tarbot Ness. ATC informed the crew that the Tain Range, a danger area bordering the coast at their proposed turning point, was active. The student therefore turned the aircraft, to the left, half a mile short of Tarbot Ness in order to remain clear of the area. The instructor later stated that, as they entered the final leg of the route, it was possible to see lights close by Inverness Airport. The aircraft was flown direct towards these lights on a track that diverged slightly from the coastline.

As the aircraft flew 1.5 nm off shore abeam Fearn, with 13.5 nm to go to Inverness, engine power smoothly reduced to 1,000 RPM from the cruise power setting of 2,400 RPM. The rundown came without warning and with no apparent associated failures. The student had been carrying out his en-route checks meticulously and no carburettor icing, a possible cause for such a power loss, had been experienced. The instructor immediately checked that the fuel pump was 'ON', carburettor heat was selected to 'ON', the mixture was 'ON' and the fuel contents were sufficient. The student then repeated the same checks as a confirmation. Oil temperature and pressure indications were normal, fuel pressure was in the top 3/4s of its range and the fuel quantity read 'FULL' (indicating that a least 100 litres of fuel remained). When the crew actions failed to restore engine power, the instructor told the student to transmit a 'Mayday' call on the Lossiemouth ATC frequency. ATC responded immediately and informed them that a Search and Rescue (SAR) helicopter would be at their location in 8 minutes. The instructor selected the emergency code 7700 on the transponder and pushed the 'Ident' button.

The aircraft initially started to descend at approximately 500 feet per minute (fpm). By rapidly pumping the throttle the instructor was able to increase the engine power to 1,500 RPM and, at an indicated airspeed of 60 kt, the aircraft's decent rate was reduced to 50 fpm. The instructor then repeated all the 'cause of failure' checks once again. However, selection of various settings of the mixture control and checking the magnetos had no effect.

The aircraft had been heading for the Cromarty Gap from the time of the engine power loss. The instructor's intention was to aim for the brightly lit area of Nigg and to land on the mud flats beyond.

A heading directly for land was considered impractical as the aircraft would have been below the height of the cliffs as it approached the coastline. The aircraft over flew Nigg Pier, (see Figure 2) at a height the instructor believed was about 500 feet although it was clearly much lower than that, and descended into the sea between the pier and two moored oil tankers positioned alongside the Nigg oil terminal jetty. The student had removed both his and the instructor's headsets and unlatched the aircraft's canopy prior to the ditching during which the aircraft pitched inverted. The instructor released his harness and fell onto the unlatched canopy. He escaped from the submerged cockpit and eventually reached the surface, closely followed by his student. Both pilots assumed that the aircraft was in contact with the sea bed as all three wheels were still visible with only the cockpit under water. They both held onto the wings initially but after approximately one minute the aircraft sank leaving them no option but to swim towards the harbour wall some 200 to 300 metres away.

As both men swam together, the instructor spoke to the student and stressed the need to swim slowly and steadily. After a couple of minutes together, however, the student started to swim away in a more northerly direction. The instructor shouted to 'keep going for the wall' but received no reply. When he reached the harbour he quickly found a ladder to climb the sheer harbour wall. The first rung of the ladder was about 4 feet above his head and, as he struggled to pull himself clear of the water and climb the ladder, he heard the student shouting for help. In the darkness, the instructor could not see the student but shouted back and ran towards a tug moored some distance away. The crew of the tug helped him on board, switched on their lights and radioed for assistance. Moments later the SAR helicopter arrived to search the scene. However, all attempts to locate the student proved unsuccessful. The student, who did not survive, was found several weeks later.

Service history of the aircraft

The aircraft had been built in May 1996 and acquired by the operator shortly after it had been brought onto the British Register. Since that time it had always been serviced by the same maintenance organisation at Inverness and, at the time of the accident, had flown a total of 560 hours. Its first Annual Check had been performed in June 1997, at 315 hours, during which a fuel flow check had been conducted, the carburettor float bowl was flushed and the fuel entry filter inspected. Its last 50 hour Check was on 3 October, at 516 hours, and the operator had scheduled the next 50 hour Check for 30 October.

The aircraft had been reliable before the accident flight. Examination of its Technical Log revealed no significant unserviceability at any time, particularly with respect to engine and fuel systems. However, some days before the accident a single instance was noted of hesitancy in acceleration of the engine. As a result of this, extensive ground testing of the engine was performed, but the hesitancy was never

reproduced. Some engines are occasionally observed to be hesitant in acceleration if the throttle is moved forwards too quickly; the extensive tests were performed because this particular engine had not previously exhibited this trait.

The aircraft was kept in the operator's hangar at night and was subjected to a daily fuel drains check by the operator's hangar supervisor when he prepared the aircraft for flying. It was almost invariably fuelled from a bowser which was operated by the aircraft's operator and maintained by the fuel supplier, a major oil company. The required fuel sample taken from the bowser each day was a composite consisting of fuel from the drains of its two chambers and the delivery filter. These samples were retained for one week and, as a result, a sample from the day of the accident was available: this was found to be clear of water and particles; subsequent analysis showed that it met the specification for Avgas 100LL in all respects. An examination of the bowser filter showed it to be uncontaminated either by solid particles or water.

Recovery and examination of the aircraft

The aircraft was located on the day following the accident and was recovered during the following week. As found, the aircraft was intact and standing erect, on its landing gear, on the sea bed. It was recovered and taken to Inverness Airport for examination. Because of the nature of the accident, the investigation focussed on an examination of the fuel system since this was considered the most likely cause of the reported severe reduction in engine power.

The aircraft was relatively undamaged, with only slight distortion of the engine cowling and wheel spats, and breakage of the canopy transparency. As found, the throttle was closed, the mixture set to 'full rich', the magnetos were selected to 'both on' and the carburettor heat selected to 'hot' The fuel shut-off was in the 'open' position and the lightweight wirelocking, holding it in that position was still intact. When the engine cowling was removed, all the engine controls were seen to be correctly connected and matched the settings observed in the cockpit.

Examination of the fuel line from the firewall bulkhead to the carburettor revealed that, although the pipes were all intact and correctly connected, the closing plates of the engine driven fuel pump had corroded very severely and the pump had consequently lost its integrity. Apart from the corroded plates there was no significant defect in the pump and all fuel line joints were secure. The reported satisfactory fuel pressure up to the time of ditching indicated that this corrosion was not a causal factor in the accident.

Flow checks of the fuel line from the tank to the firewall bulkhead showed that it was clear of obstructions and fuel flowed under gravity. A further test showed that, although it was filled with water, the electric boost pump still functioned and increased the flow rate. The fuel shut-off lever wirelocking was broken as it was turned to the 'off' position and the valve was found to operate correctly. The contents of the fuel tank were removed, mainly by siphon through the filler neck with the residue pumped out through the fuel line. Some 17 gallons of Avgas fuel were recovered in this way together with about 8 gallons of water. Examination of the flexible fuel lines within the engine compartment revealed no defects and the fine mesh, 'finger' type, filter at the fuel entry to the carburettor was intact and uncontaminated with foreign particles.

The carburettor was removed from the engine for more detailed examination. It was observed to be undamaged although there was some salt encrustation in the venturi and around the main jet nozzle. The carburettor upper housing was removed and the float bowl found to be filled with water and salt sediment. The float valve was checked and found to flow freely. The content of the float bowl was poured into a container and appeared to be clear of particles other than salt crystals. The fuel nozzle was removed and its bore and the power jet were observed to be clear of obstructions. The fuel channel between the mixture metering valve and the power jet was then flushed by pouring clean fuel into the mixture metering sleeve and into the power jet nozzle well (see Figure 3). A sizeable particle was seen in the carburettor fuel bowl sump after this process. This particle was taken and measured using a travelling microscope which showed that it was of irregular shape, large enough not to pass through the power jet and able to partially occlude it.

When viewed under the microscope, the particle appeared to be an insect and it was subsequently identified as the thorax of a type of fly found in Northern Europe and North America. An assessment indicated that the opportunities for such a foreign object to enter the carburettor appeared to be limited to those times when the carburettor float bowl had been opened, via the fuel inlet and float valve whilst the finger filter was removed, or via the float bowl breather bores whilst the carburettor was immersed in water after the ditching. It was further observed that the path to the fuel channel, via the mixture metering valve, was difficult under all circumstances for such an object.

Tests

Because of the unusual nature of the foreign object and the possibility that it might have been immersed in fuel for up to 18 months (the age of the aircraft), a test was performed to assess its durability in fuel. After identification the thorax was immersed in Avgas in a glass container and protected from light. Over a period of three months its surface appearance changed considerably and its structure became

less cohesive. It is not known whether the period in air, for identification, radically altered the decomposition rate.

The thorax was established as being negatively buoyant in both Avgas and water.

Analysis

The reported characteristics of the power reduction experienced were consistent with a sudden partial blockage of the carburettor power jet. If the blockage had affected the fuel inlet to the carburettor, and thereby reduced the fuel level in the float bowl, it is considered unlikely that pumping the throttle could have consistently sustained about 1500 RPM over the protracted period reported.

Although the foreign object found appeared to have suitable characteristics to cause a blockage of the main jet, the likelihood that it was responsible for the loss of power must be considered inconclusive by virtue of its deterioration during fuel immersion test.

Company instructions

At the time of the accident, those flying club members wishing to fly over water whilst undertaking dual instruction, solo flights or pleasure flights, had to comply with the company Flying Order Book Instructions. The paragraph relating to 'FLIGHT OVER WATER' is reproduced below:

> "Solo training flights in single-engine aircraft will not be authorised if the track puts the aircraft outside of gliding distance from land. All single-engine aircraft operated by the company will have on board sufficient serviceable lifejackets for the number of occupants. All occupants will be briefed on their correct use before over-water flight."

The company also published a Training Operations Manual. This was introduced recently by the company when they were approved by the CAA to conduct Flying Instructor Courses. It was used only by candidates taking the course so that they would become accustomed to working with the more formalised Manual. This Training Operations Manual included the following paragraph relating to 'Flying over the Sea':

> "For flights over water which are out of gliding distance from land upon which a safe landing can be made, lifejackets must be carried. Consideration must also be given to flying at the greatest height permissible in order that a safe landing can be made in the event of an engine failure. In single-engine aircraft when flying over water lifejackets should be worn (un-inflated) at all times....."

The view of the company and the instructor on the accident flight was that he had to comply with the Flying Order Book, not the Training Operations Manual. However, as a result of this accident the company has issued a notice to all club members stating that the 'Training Operations Manual' would be adopted for use by all members and would replace the 'Flying Order Book'.

Survival

The aircraft carried two crew lifejackets which were packaged in plastic wallets and stowed behind the pilots' seats. These jackets, which were not of the 'constant wear' type, were not worn by the crew and they did not attempt to don them after the power loss or during the subsequent descent into the sea. (A trial subsequently carried out in a similar aircraft with both pilot seats occupied showed that it was possible, with some difficulty after first unfastening the restraint harness, to remove a lifejacket from its container and don it in approximately one minute). Since the accident the company have ordered 'constant-wear' lifejackets for use in all their aircraft.

Whilst the operator of the aircraft involved in this accident had ensured that lifejackets were available to its occupants, there are currently no requirements for lifejackets to be carried in aircraft not engaged in public transport operations, nor are there any requirements for 'approval' of lifejackets for use in such aircraft. In situations when the occupants of light aircraft are faced with the probability of having to ditch in the water, it is not realistic to expect them to don lifejackets (if carried) whilst concentrating on making a survivable ditching. It is, therefore, unlikely that an occupant will attempt to put on a lifejacket which is not being worn at the time that a ditching emergency starts, until after the ditching has actually occurred. Once ditching has occurred the situation, as in this case, is likely to demand an urgency for escape from the aircraft which will preclude an opportunity to locate and don lifejackets.

Whilst there are currently no requirements to carry lifejackets for those General Aviation aircraft with Public Transport Category Certificates of Airworthiness engaged in training on overwater flights, the CAA publish a General Aviation Safety Sense Leaflet (No 21) entitled 'Ditching'. In this leaflet, the contents of which are only advisory, it is stated that:-

> 'The principal cause of death after ditching is by drowning, usually brought on by hypothermia.'

It also states that:-

> "In many cases, the deceased persons were found to have no lifejacket, neither worn nor available to them. It is vital TO WEAR a suitable lifejacket whilst flying over water."

The leaflet also describes the following features which, amongst others, are highly desirable in a lifejacket:-

- That they are of the 'continuous wear' type and sufficiently rugged and durable to prevent tearing and other damage during normal use.

- A spray hood or plastic face mask which can be pulled over the face and lobes of the jacket reducing heat loss through the head and reducing the amount of water flowing across the face.

- A light or strobe light with the battery being activated by pulling a toggle or by immersion in sea water.

- A whistle for attracting attention.

Also included in the leaflet is a table detailing the symptoms of extended exposure to water at different temperatures. For example, at water temperatures of +9°C a survivor can be expected to lose the use of their hands and forearms within 20 minutes. Loss of mental activity occurs within 60 minutes and hypothermia and death occur within 90 minutes. An updated edition of this Leaflet, No 21A, is about to be published by the CAA and it is intended to include information on suitable types of lifejacket.

General experience shows that, within that proportion of the population of General Aviation aircraft in which lifejackets are carried, many are of types which would be uncomfortable and/or obstructive if worn throughout a flight. Of those types which might be comfortable for in-flight wear, some would need to be replaced frequently if they were to retain their reliability.

Reliance has thus far been placed on good practice and a sense of self preservation to encourage those intending to undertake overwater flights in light (particularly single engined) aircraft to equip themselves properly against the remote chance that they will have to ditch. As is clearly demonstrated by this accident, such reliance may be misplaced. The content of the CAA's 'Ditching' leaflet indicates that in both club and privately owned aircraft ditchings, the incidence of lifejackets not being carried or worn is substantial. In this particular accident, had the student been wearing a suitable lifejacket which he had inflated after escaping from the aircraft, he would almost certainly have survived since it would have extended the time which the tug and the SAR helicopter had available to locate him whilst he was still alive.

Safety recommendation

As a result of these findings, it is recommended that:-

Recommendation 98-34

The CAA should introduce a requirement for the carriage and wearing of suitable types of lifejackets by the occupants of General Aviation aircraft which have Certificates of Airworthiness in the Public Transport Category, especially those used for training, whilst conducting flights, wholly or partly, over the sea.

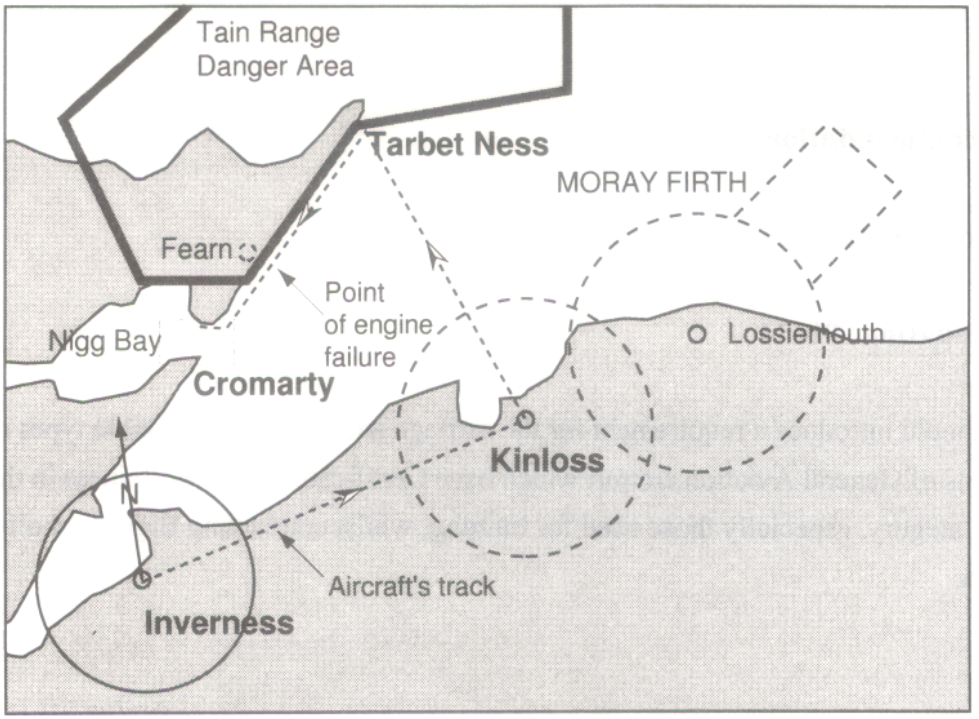

Figure 1 G-BWPG - Navigation excercise track and ditching position

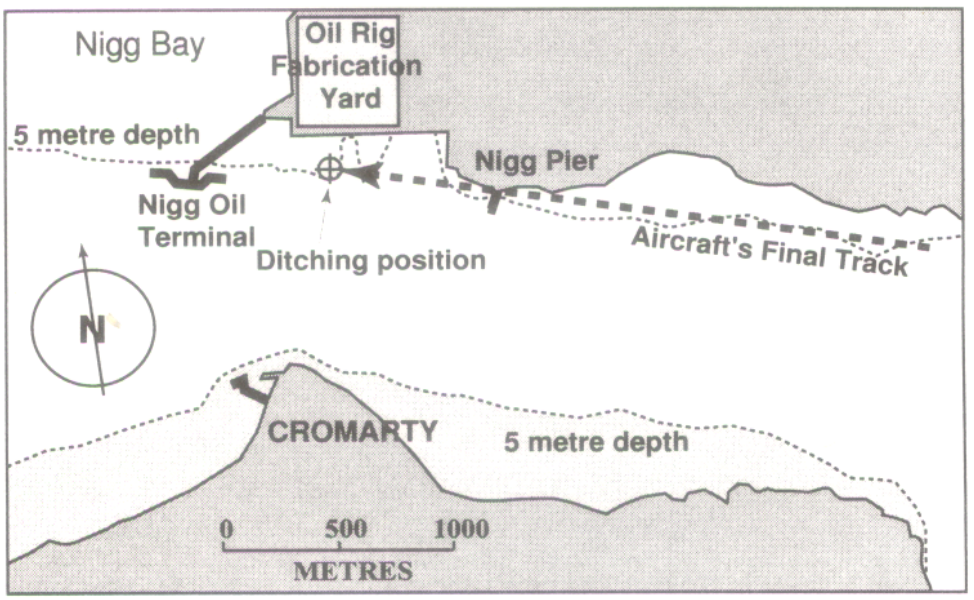

Figure 2 Expanded scale map of ditching position

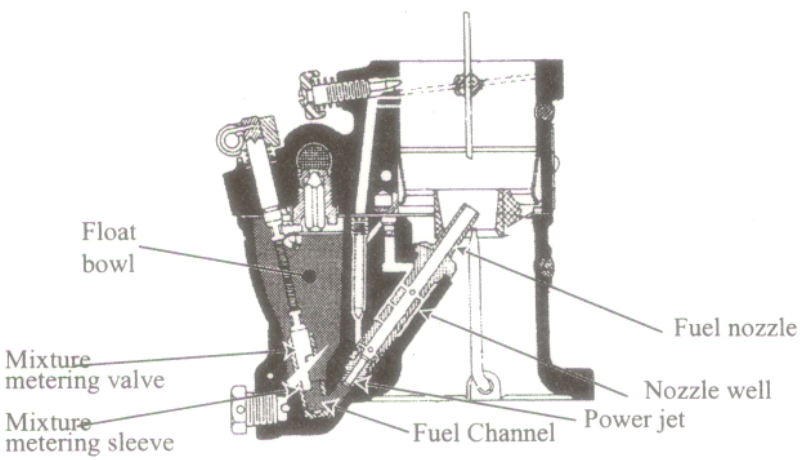

Figure 3 Section through carburettor