Taylor Monoplane (open cockpit version), G-BCRJ, 17 May 1998 at 1137 hrs

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Aircraft Type and Registration:	Taylor Monoplane (open cockpit version), G-BCRJ
No & Type of Engines:	Volkswagen 1600 (Peacock conversion) piston engine
Year of Manufacture:	1978 (rebuilt between 1990 and 1997)
Date & Time (UTC):	17 May 1998 at 1137 hrs
Location:	Andrewsfield, Essex
Type of Flight:	Private
Persons on Board:	Crew - 1 - Passengers - None
Injuries:	Crew - Fatal - Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence (with IMC and Night Rating)
Commander's Age:	51 years
Commander's Flying Experience:	536 hours (of which 14 hours were on type)
	Last 90 days - 21 hours
	Last 28 days - 16 hours
Information Source:	AAIB Field Investigation

Aircraft history

The aircraft was jointly owned by two people who entered into partnership some 3 to 4 years prior to the accident, whilst the aircraft was undergoing an extensive rebuild which was started in 1990 and completed in September 1997. The aircraft had been air tested by a PFA (Popular Flying Association) test pilot on 14 September 1997 and subsequently issued with a Permit to Fly. A few weeks later, however, the aircraft's engine began to suffer from low oil pressure which was subsequently cured after a complete engine strip and rebuild which required the replacement of several engine components. In March 1998 the engine developed a problem with the right magneto in that, reportedly, it would fail to produce sparks at high speed. The magneto was removed for examination and taken to an aircraft component overhaul organisation with the intention of having it tested. However, the magneto was a Lucas SR 4 unit which, although commonly used on this type of VW engine conversion, was not of an aeronautical type. The organisation could not therefore service it and so no rectification work was carried out at that time. Later, through a simple test using a slave set of magneto switches wired directly to the magnetos during an engine ground run, the joint owner demonstrated to the pilot that the fault was within the magneto itself and not associated with the switches or wiring in the aircraft. Both magnetos had been overhauled in 1996 during the aircraft's rebuild.

History of the flight

On the day before the accident, the pilot telephoned the co-owner and left a message on his answer machine stating that he was going to Andrewsfield on the following day to rewire the aircraft's magneto switches, and to carry out an engine ground run in order to attempt to rectify the problem with the right magneto. At approximately 1030 hrs on the morning of the accident, he arrived at the flying club and, after a conversation with the airfield manager, left to attend to the aircraft which was stored in a nearby hangar. It could not be later established precisely what work he carried out at that time, but it was reported by the airfield manager that he had lent him a soldering iron. Some time later the pilot returned to the clubhouse to collect keys that would allow him to operate the airfield refuelling pumps. The associated records showed that he refuelled G-BCRJ with 14 litres of fuel and that several other aircraft had also refuelled (and later flown successfully) from the same source. When he returned the keys, he asked the airfield manager if he could operate his aircraft 'non-radio' in the local area only. The aircraft had no installed radio and, although it was normal practice for the pilot to use a hand-held radio, he was not using it that morning. The airfield manager agreed and went outside the club house to watch the aircraft take off.

The weather at the time was fine with an easterly wind, good visibility and a surface temperature of 21°C. ATIS (Automatic Terminal Information Service) records from Stansted Airport, 8 nm to the west, showed the 1120 hrs weather was surface wind 070°/09 kt, visibility 10 km, cloud scattered at 3,500 feet, temperature +18°C, dewpoint +9°C and QNH 1027 mbs. The 1150 hrs weather showed no significant change. A pilot who had landed at Andrewsfield at 1110 hrs reported turbulence below 1,500 feet on approach and the Meteorological Office soaring forecast provided for glider pilots reported that thermals with vertical speeds of between 4 to 5 kt, and associated down draughts, could be expected that morning.

The airfield manager, along with one of the airfield directors, watched as the aircraft taxied for take off. As it passed the clubhouse the engine reportedly sounded normal and the aircraft proceeded to the hold for a take-off from grass Runway 09 (2,670 feet). The aircraft remained at the hold for approximately 5 minutes before lining up on the runway, where it held for a further minute, before starting its take-off run. The grass on the runway was short and the surface was hard and dry. The takeoff was described by observers as normal with the aircraft becoming airborne adjacent to the wind sock (1,400 feet from the start of the runway) and reaching a height of between 20 and 30 feet as it passed the clubhouse (1,850 feet from the start of the runway). The airfield manager stated that, as the aircraft passed the clubhouse, the engine sounded as if the throttle setting had been reduced but it continued to climb, albeit slowly, with the engine 'running very rough'. Although the aircraft gained height, it did so in a series of shallow climbs, interrupted by short periods of level flight and slight descents. At some point beyond the end of the runway, the pilot initiated a shallow turn to the right, banked at an angle estimated by witnesses to have been between 10° and 15°. With the aircraft now at between 200 and 300 feet, and with approximately 180° of the turn complete, the angle of bank was seen to increase to approximately 45°. The right wing was then seen to drop suddenly and the aircraft entered the beginning of a 70° to 80° nose down spiral descent to the right, before impacting the ground almost vertically within one complete rotation. Radar information recorded by the Stansted 10 cm radar confirmed the track of the aircraft's flight.

The airfield manager, who was also a fire officer, boarded the airfield fire truck and drove towards the scene. Initial location of the wreckage was difficult since the aircraft had crashed into a field of standing crop and could not be seen from ground level. However, the fire vehicle was eventually directed to the wreckage by radio transmissions made from an aircraft circling over the crash site. There was no fire, but the pilot had sustained fatal injuries.

Pilot's experience

The pilot had started his flying training in January 1987, flying Cessna 152 aircraft and had gained his PPL in the August of that year. He qualified for an IMC rating in July 1988. Most of his experience was on Cessna 150, 152, 172, and Piper PA28 aircraft. His most recent C of E (Certificate of Experience) was signed on 24 January 1998. In March and April 1996, he flew for 2:15 hours in a Luscombe aircraft, with the airfield manager, to gain some 'tail wheel' experience. He had no further experience on tail wheel aircraft until September 1997, when he first flew the Taylor Monoplane, but achieved some 15 hours and 26 flights in the aircraft prior to the accident. The pilot's most recent flight in the aircraft before the accident was on 13 February 1998.

Pathology

The pilot had a kidney stone problem in 1993 and post mortem examination revealed the presence of a further renal stone in his left kidney. The varying G-forces to which a pilot is exposed during flight may dislodge renal stones which in turn may cause renal colic, a well known cause of sudden incapacitation in flight. The fact that the renal stone had remained in the kidney, however, indicated that renal colic was unlikely, but the presence of one stone may suggest that other stones had been there. It is possible therefore that the pilot had renal colic, but the circumstances of the accident suggest that this was unlikely.

Stalling speed

Information published by the aircraft designer states that the aircraft's theoretical 1g stalling speed is 40 mph (34 kt). The stalling speed of a particular aircraft may differ from this theoretical value as a result of build quality and rigging etc. Information recorded as a result of an air test, conducted on the aircraft on 7 October 1997, showed that with power off, natural pre-stall buffet occurred at 42 kt and the aircraft stalled at 40 kt, with a slight right wing drop. The basic stalling speed of any aircraft is the stalling speed corresponding to the critical angle of attack in level flight. It may be defined as the speed below which a clean aircraft of a stated weight, with the engine throttled back, can no longer maintain level flight.

With the aircraft in a level turn at an estimated angle of bank of 45°, the stalling speed would have been increased from 40 kt to 47.6 kt. This could have been increased further if the aircraft had encountered one of the thermals predicted that day.

Site and wreckage examination

The aircraft had crashed into a flat field of standing rye, some 1.5 metres, close to the start of the downwind leg of the right hand circuit for Runway 09, some 0.4 nm/127°M from the point at which it was observed to become airborne (see Figure 1). Analysis of the ground marks, damage to the crop and the wreckage distribution indicated that the aircraft had struck the ground with a high rate of descent whilst in a 75° to 80° nose down and right wing low attitude, on a heading of approximately 050°M, and whilst rotating to the right. The aircraft had also been travelling slowly in a north-westerly direction, resulting in a wreckage trail of only some 14 metres in length. None of the wreckage protruded above the crop (Figure 2). The impact had severely damaged the right wing and caused the engine, complete with the firewall, instrument panel and the fuel tank, to break free from the fuselage; the fuel tank had split open. The remainder of the structure, with the exception of the cockpit, had suffered relatively minor damage. Initial on-site examination of the wreckage indicated that the aircraft had been complete and intact before striking the ground. The propeller had been turning at low speed and there had been no pre-impact disconnections in the primary flying controls. After recovery to the AAIB facility at Farnborough, the aircraft was examined in more detail, particularly the engine, ignition and fuel systems.

Detailed examination

Fuel system

This examination revealed the fuel system to have been serviceable, with the fuel cock set to ON, and free from blockage or contamination by debris, or corrosion. There was no evidence of long term contamination by water. Little evidence of fuel remained in the system, traces being discovered only in the supply hose to the carburettor. Deformation of the float and protruding wire fuel quantity indicator suggested that the tank had been almost full at the time of impact, although this could have been a non-valid indication due to the aircraft's attitude at impact. A strip examination of the carburettor several days after the accident revealed no physical defects although a small quantity (less than 1 cc) of clear liquid was present. Although smelling of fuel, this liquid was identified as water. It was not established if the pilot had performed a water drain check before starting the engine, but it was determined that the aircraft had not flown since 13 February and had been hangared with the fuel tank less than full. During this dormant period, the weather consisted of lengthy periods of rain with attendant high humidity, conditions which can induce water vapour to condense, or come out of solution in the fuel.

Magneto system

The engine fitted to this aircraft was basically a 1600 cc VW air cooled 'flat four' car engine, converted to aeronautical use by the installation of a twin magneto ignition system. This is a recognised and popular conversion for various 'Permit to Fly' category aircraft and is known as the Peacock conversion, after the designer. A strip examination of the engine revealed it to be in good mechanical condition, generally consistent with low running hours since rebuild. It was notable, however, that seven of the eight spark plugs required only minimal torque to unscrew; the remaining plug was loose and there was evidence of gas blow-by on two plugs. All eight plugs were tested and found serviceable.

The two magnetos fitted to this engine were mounted on a flat aluminium plate which was bolted to the rear of the engine, and extended below the crankcase. Both magnetos were mounted on the forward side of this plate, and thus were located directly beneath the engine. Both were driven directly from the crankshaft by a double row chain which ran between the rear of the plate and the firewall, with the chain exposed to the engine compartment environment. When examined, both magnetos were securely bolted to the mounting plate, with no evidence that either had slipped from their set positions before or during the accident, but the chain connecting the magneto and crankshaft sprockets was found to be very loose (see Figure 3). The distributor cap on the right magneto had been shattered in the impact and there was no evidence of a gasket between the magneto body and the cap. (Notes in the engine conversion construction manual stated that a gasket should be used, and sealed once the distributor cap has been bolted in place, to prevent engine oil entering the magneto during use). The left magneto had remained intact, but most of the ignition harnesses were damaged in the impact. The left magneto (Bendix/Scintilla SALN-21) was fitted with an impulse coupling, whereas the right magneto (Lucas SR4) was direct drive. When turning the engine, to check the ignition timing, it was observed that the action of this impulse coupling allowed the chain to jump a tooth pitch on the drive sprocket, thus retarding the ignition timing for that magneto. It was established that the timing was correct for the Lucas magneto, but incorrect for the Bendix magneto, by several sprocket tooth pitches. The original drawings for the installation included a chain tensioner, but this was not fitted to G-BCRJ. Advice sought from the PFA, who assisted with the examination of the engine, was to the effect that use of a tensioner was optional with this conversion, but in that case the installation would require setting up with a minimum of slack in the chain, and frequent checking as the chain stretched with wear, to avoid imprecise timing. After removal, both magnetos were bench-tested.

Magneto tests

The Lucas magneto was initially tested without a distributor cap and it was demonstrated that a satisfactory spark was consistently produced by the coil, at all speeds tested (idle to max engine RPM). As all fragments of the broken distributor cap, including the central carbon brush, were not recovered it was not possible to establish its serviceability prior to the accident. This magneto was also tested with a new cap, and ran satisfactorily for approximately one hour. At the conclusion of this test, it was noticed that the central carbon brush had left a distinct witness mark on the rotor arm at its normal point of contact; however such a mark that was not present when the magneto was first inspected at the accident site. The Bendix magneto was tested in the 'as found' condition, with the exception of the replacement of the harness, and this also performed satisfactorily.

Magneto wiring

Examination of the wiring between the magnetos, their two panel mounted switches and the tachometer

revealed this to have been installed to a very low standard of workmanship. The two switches were commercially available miniature double pole/'double throw' units which had recently been installed in place of a Bendix key switch, and the toggles of which were unguarded. These switches were fitted with hollow pins at the rear for insertion and solder attachment of wires. Although the left toggle was broken, both switches were serviceable and found in the ON position. It was readily apparent that the two 'p' leads and two earth wires from the magnetos, and several other wires associated with the tachometer, had been inexpertly soldered to the sides of these pins, and that none had been supported or sleeved to minimise the risk of shorting. All four wires from the magnetos were found disconnected. The two earth wires had failed their respective pins, but the two 'p' leads had disconnected at the solder joints, with both showing evidence of 'dry joints'. It was not established if either had disconnected before, or during, the impact. Also found disconnected at the tachometer were the 'live' (left magneto 'p' lead with both switches ON) and earth wires. These wires are attached to the instrument by a push fit of small cylindrical wire terminations onto two round pins protruding from its rear face, and it was evident that the 'live' wire termination was uninsulated. The undamaged/unstrained condition of the wire ends, terminations and pins suggested that these wires were not connected prior to the accident. Examples of this wiring are shown in Figure 4, Figure 5 and Figure 6.

Documentation

This aircraft had been issued with a Permit to Fly (PTF) by the CAA, and the required Certificate of Validity (CoV valid for 12 months) was issued by the PFA on 16 October 1997. The PTF is issued subject to CAA Conditions and, provided there is a current CoV, remains valid from the date of issue until revoked. Two of these conditions, considered relevant to this accident, are reproduced below:

> Condition 5 *The aircraft shall be maintained in an airworthy condition and operated in accordance with the procedures and limitations contained in the appropriate technical publications and manufacturers instructions and recommendations for the types and model of aircraft, or in compliance with the limitations specified in the Document associated with this Permit.*

> Condition 6 *No alterations, modifications or replacements shall be made to this aircraft or to its engines, propellers, or equipment, unless approved by the CAA or other Organisations approved by the CAA for the purpose*

> Condition 8 *A Flight Release Certificate shall be issued and in force certifying that the aircraft has been inspected and is fit for flight. This Certificate shall only be issued by such persons as are authorised by the CAA. The certificate shall be re-issued after maintenance, repairs and/or inspections, or because the airworthiness condition of the aircraft has been altered. After pilot maintenance for those items listed in document reference PFA/PM/- the issue of a Flight Release Certificate is not required.*

No records were found in the aircraft's documentation relating to the maintenance activities reported to have been carried out on this aircraft since 16 October 1997, activities which were not listed in Document PFA/PM/-.

Discussion and conclusions

Operational aspects

The aircraft appeared to have suffered a significant power loss shortly after lift-off which reduced the aircraft's performance to the extent that a climb was barely achievable. The pilot, however, had managed to achieve a climb to approximately 200 to 300 feet by periodically sacrificing altitude for speed, a manoeuvre necessary as the aircraft must have been close to the stall on several occasions during the climb. Complete loss of engine power just after take off in any single engined aircraft leaves the pilot with a single option, a forced landing. It is usually taught during the PPL syllabus to either land back on to the runway if at all possible or in the area generally beyond, keeping the aircraft under control by flying at an appropriate speed and by making shallow turns through small angles if height permits. With a partial loss of power, however, several options are open to the pilot; in this case either to land back on the runway remaining and risk an overrun into the adjacent field at slow speed; or to force-land the aircraft in one of the numerous fields of standing crop off the end of the runway; or attempt to 'nurse' the aircraft back to the airstrip by manoeuvring to complete an abbreviated visual circuit. Had either of the first two options been chosen, the aircraft would possibly have been damaged but it is probable that the pilot would have survived the relatively slow speed forced landing. The pilot's decision to attempt to turn back in an aircraft with marginal performance in gusty/turbulent conditions placed him in a position where loss of control could lead to an impact with the ground, in a near vertical attitude, with little or no chance of survival.

Engine findings

Although this accident resulted from a loss of control, it appeared to have been precipitated by a partial loss of power from the engine. Examination of the wreckage identified several factors which singly, or collectively, could have caused the engine to lose power during the take off. In summary, these were the small quantity of water found in the carburettor, the very low standard of workmanship associated with the magnetos and tachometer wiring, the loose timing chain, and an apparently unresolved problem with the right magneto, possibly associated with oil contamination. The evidence, however, suggested that at some time between starting the engine and taking off, the left magneto may have become retarded. It could not be positively established if the magnetos had been checked prior to the takeoff, but in view of the problems which the pilot had experienced with the right magneto, it is considered probable that he did check the magnetos before the take off and presumably judged their performance acceptable for flight. However, if the right magneto had subsequently faltered due to the unresolved previous problem, or as a result of wiring failure/shorting, and the timing of the left magneto become retarded (as found after the accident) due to the loose timing chain 'jumping' several associated drive sprocket teeth, then the engine would not have produced full power during/after the take off.